NASA CONTRACTOR REPORT

NASA CR-61326

HANDBOOK FOR ESTIMATING TOXIC FUEL HAZARDS

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GCA Corporation
GCA Technology Division
Bedford, Massachusetts

April 1970

Final Report

Prepared for

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

FACILITY FORM 602

N70-30506
(ACCESSION NUMBER)

347
(PAGES)

CR-61326
(NASA CR OR TMX OR AD NUMBER)

1
(THRU)

(CODE)

20
(CATEGORY)

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CR-61326		

4. Title and Subtitle	5. Report Date
HANDBOOK FOR ESTIMATING TOXIC FUEL HAZARDS	April 1970
	6. Performing Organization Code
7. Author(s) R. K. Dumbauld, J. R. Bjorklund, H. E. Cramer and F. A. Record	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address GCA Corporation GCA Technology Division Bedford, Massachusetts	11. Contract or Grant No. NAS8-21453
	13. Type of Report and Period Covered Contractor, Final Report
12. Sponsoring Agency Name and Address Aero-Astrodynamics Laboratory George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The objective of the work under this contract was to prepare a Toxic Fuel Hazard Estimation Handbook that can be conveniently used, with readily-obtainable meteorological data, to predict concentration and dosage fields downwind from primary ground-level and elevated source emissions arising from operations at Cape Kennedy. The Handbook consists principally of (1) computer programs and instructions for the machine calculation of downwind concentration, dosage, and deposition fields, and (2) graphs, nomograms, and tables for the rapid manual estimation of ground-level concentration and dosage fields for selected sources and simplified atmospheric conditions. The Handbook also includes a description of the mathematical diffusion models used, procedures for obtaining requisite meteorological inputs for the diffusion models, and worked examples for selected release modes and meteorological regimes.

Much of the development of the diffusion models for use in the Handbook and the formulation of procedures for the selection of meteorological model inputs were carried out concurrently under Contract NAS8-30503.

Mr. Charles K. Hill of the Atmospheric Dynamics Branch of the Aero-Astrodynamics Laboratory at Marshall Space Flight Center was the Contracting Officer's Representative. Mr. John W. Kaufman, Chief of the Atmospheric Dynamics Branch and Contracting Officer's Representative for Contract NAS8-30503, also assisted in planning the Handbook. Mr. William W. Vaughan, Chief of the Aerospace Environment Division, provided guidance throughout the entire program.

The following professional staff members of the GCA Technology Division Environmental Sciences Laboratory made important contributions to this report: Dr. J. E. Faulkner, Mr. R. H. Huerta, Mr. R. C. Martin and Mr. R. N. Swanson.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
	FOR PUBLIC RELEASE: E. D. Geissler E. D. Geissler Director, Aero-Astrodynamics Laboratory

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
UNCLASSIFIED	UNCLASSIFIED	496	

*For sale by the Clearinghouse for Federal Scientific and Technical Information
Springfield, Virginia 22151

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INTRODUCTION

1.1 BACKGROUND

This handbook provides a complete documentation of the computerized and graphical procedures for estimating toxic fuel hazards at Kennedy Space Center that were developed under two concurrent contracts (Contracts Nos. NAS8-21453 and NAS8-30503). A detailed description of the generalized diffusion models and the meteorological data used to develop these procedures is given in the Final Report under Contract NAS8-30503 (Record, et al., 1970). The procedures outlined in this handbook for estimating toxic fuel hazards are applicable both to planning and research studies and to real-time operational problems. Because the methodology is new and the requisite input information with respect to source parameters and meteorological parameters is at present only partially complete, it is expected that the contents of the handbook will be revised as new information becomes available and experience is gained in the prediction of toxic fuel hazards.

1.2 ORGANIZATION OF THE HANDBOOK

The main body of the handbook contains five major topical sections. Section 2, following this Introduction, contains the generalized diffusion model equations used in the KSC multi-layer construct. This construct forms the basic framework for calculating concentration, dosage, and deposition fields associated with the emission of toxic materials from normal and abnormal launches, vehicle destructs, fuel leaks and spills, and other operations at Kennedy Space Center. Section 3 contains a description of the multi-layer construct and lists the mathematical formulas for the various diffusion models used in the construct. The organization of the computer program for the multi-layer construct and the requisite meteorological and source inputs are outlined in Section 4. Graphical procedures for estimating ground-level concentrations and dosages for various release modes of toxic fuel materials are described in Section 5.

There are six appendices to the handbook. Appendix A contains the user's instructions for the computer program. A complete listing of the computer program is contained in Appendix B and the flow chart for the computer program is presented in Appendix C. Sample output of the program is shown in Appendix D. Appendix E contains completely worked example cases illustrating the application of the computer program to toxic fuel hazard problems. Appendix F explains the use of nomograms for estimating certain meteorological inputs to the computer program.

SECTION 2

GENERALIZED CONCENTRATION AND DOSAGE MODELS

The generalized concentration and dosage models given below are described in detail in Section 1 of the Final Report under Contract No. NAS8-30503 (Record, et al., 1970). The generalized models are presented here because they form the basis of the computerized multi-layer diffusion model, developed for use in estimating toxic fuel hazards at Kennedy Space Center, which is described in the following sections of this report. The form of the generalized models is similar to that of the Gaussian plume equations given by Pasquill (1962, p. 190). However, additional terms have been added to account for the effects of mesoscale factors, such as the depth of the surface mixing layer, vertical wind shear and precipitation scavenging. The equations also contain provision for variations in source dimensions, source emission time, and in meteorological structure along the downwind cloud trajectory. Subsets of equations are available for calculating the buoyant rise of material caused by the generation of heat during the emission process and surface deposition due to the gravitational settling of heavy particles or droplets.

The generalized models are given first for nearly instantaneous releases in which the cloud of toxic material is detached from the source after a few seconds or, at the most, a few minutes. This condition is typical of normal and abnormal launches, hot spills, and vehicle destruct situations. Adaptation of the generalized model to continuous source emission, which occurs with cold fuel spills and fuel leaks, is outlined at the end of this section.

2.1 GENERALIZED CONCENTRATION MODEL

The generalized concentration model is expressed as the product of five modular terms:

$$\text{Concentration} = \{\text{Peak Concentration Term}\} \times \{\text{Alongwind Term}\} \times \{\text{Lateral Term}\} \times \{\text{Vertical Term}\} \times \{\text{Depletion Term}\}$$

The mathematical formulas given below for the various terms are written according to conventional usage. Specifically, the concentration model is referred to a Cartesian coordinate system with the origin at $x = 0$, $y = 0$ and $z = H$, where H is the effective height of the source. The direction of x is along the mean azimuth wind direction, y is normal to the mean wind direction in the plane of the horizon, and z is directed vertically with $z = 0$ at ground level. The distribution of concentration along each of the three coordinate axes is assumed to be Gaussian. None of the above assumptions is required. The model equations are easily transformed to a polar coordinate system or other systems, and other distribution functions may be substituted for the Gaussian function.

The Peak Concentration Term refers to the concentration at the point $x = 0$, $y = 0$, $z = H$ and is defined by the expression

$$\frac{Q}{(2\pi)^{3/2}\,\sigma_x\,\sigma_y\,\sigma_z} \qquad (2\text{-}1)$$

where

Q = source strength

σ_x = standard deviation of the alongwind concentration distribution

σ_y = standard deviation of the crosswind concentration distribution

σ_z = standard deviation of the vertical concentration distribution

The Alongwind Term is defined by the expression

$$\exp\left[-\frac{1}{2}\left(\frac{x-\bar{u}t}{\sigma_x}\right)^2\right] \qquad (2\text{-}2)$$

where

$\bar{u}$ = mean wind speed

t = time of cloud travel

The Lateral Term is defined by the expression

$$\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \tag{2-3}$$

The Vertical Term is given by the expression

$$\exp\left[-\frac{1}{2}\left(\frac{H-z}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{H+z}{\sigma_z}\right)^2\right] + \sum_{i=1}^{\infty}\left\{\exp\left[-\frac{1}{2}\left(\frac{2iH_m-H-z}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{2iH_m-H+z}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{2iH_m+H-z}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{2iH_m+H+z}{\sigma_z}\right)^2\right]\right\} \tag{2-4}$$

where

H = effective source height

H_m = height of the top of the mixing layer

The multiple reflection terms following the summation sign stop the vertical cloud growth at the top of the mixing layer and change the form of the vertical concentration distribution from Gaussian to rectangular.

The Depletion Term refers to the loss of material by simple decay processes, precipitation scavenging, or gravitational settling. The form of the Depletion Term for each of these processes is:

(Decay) $$\exp[-kt] \tag{2-5}$$

(Precipitation Scavenging) $\exp\left[-\Lambda t\right]$ (2-6)

(Gravitational Settling)

$$\exp\left[-\frac{1}{2}\left(\frac{H-\left(V_s x/\bar{u}\right)}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{2H_m-H+\left(V_s x/\bar{u}\right)}{\sigma_z}\right)^2\right] \quad (2-7)$$

where

k = decay coefficient or fraction of material lost per unit time

t = time

Λ = washout coefficient or fraction of material removed by scavenging per unit time

V_s = settling velocity

When Equation (2-7) is used for the Depletion Term, the Vertical Term given by Equation (2-4) is set equal to unity. This causes the cloud axis to be inclined downward at the angle $\tan^{-1}\left(V_s/\bar{u}\right)$ with respect to the horizon, following W. Schmidt's sedimentation hypothesis (see Pasquill, 1962, p. 226); material that deposits on the ground surface is retained and not reflected. The vertical growth of the cloud is stopped at the top of the mixing layer and reflected toward the ground by the second exponential term in Equation (2-7). The depletion by gravitational settling of material containing a size distribution is calculated by partitioning the distribution into various settling-velocity categories, solving Equation (2-7) for each settling velocity, and superposing the solutions.

2.2 GENERALIZED DOSAGE MODEL

The generalized dosage model is similar in form to the generalized concentration model and is defined by the product of four modular terms:

Dosage = {Peak Dosage Term} x {Lateral Term}

x {Vertical Term} x {Depletion Term}

The Peak Dosage Term is given by the expression

$$\frac{Q}{2\pi \bar{u} \sigma_y \sigma_z} \tag{2-8}$$

where

Q = source strength

$\bar{u}$ = mean wind speed

σ_y = standard deviation of the crosswind dosage distribution

σ_z = standard deviation of the vertical dosage distribution

The remaining terms in the generalized dosage model are defined in the same manner as the corresponding terms for the generalized concentration model which are given by Equations (2-3), (2-4), (2-5), (2-6) and (2-7).

2.3 SUBSET OF EQUATIONS FOR σ_y, σ_z and σ_x

The following subset of equations is used to define the distance dependence of the standard deviations of the crosswind, vertical and alongwind distributions in the generalized concentration and dosage models described above:

$$\sigma_y \{x\} = \left[\sigma_A'^2 \{\tau\} \, x_r^2 \left(\frac{x+x_y}{x_r} \right)^{2\alpha} + \left(\frac{\Delta\theta' x}{4.3} \right)^2 \right]^{1/2} \tag{2-9}$$

where

$\sigma_A' \{\tau\}$ = standard deviation of the azimuth wind angle in radians at height H for the release time τ

x_r = unit reference distance

x_y = virtual distance

$$= x_r \left(\frac{\sigma_{yo}}{\sigma_A' \{\tau\} x_r} \right)^{1/\alpha}$$

σ_{yo} = standard deviation of the crosswind distribution at the source

α = lateral diffusion coefficient of the order of unity

$\Delta\theta'$ = azimuth wind direction shear in radians within the layer containing the cloud

$$\sigma_z \{x\} = \sigma'_E \, x_r \left(\frac{x+x_z}{x_r} \right)^{\beta} \qquad (2\text{-}10)$$

where

σ'_E = standard deviation of the wind elevation angle in radians at height H

x_z = virtual distance

$$= x_r \left(\frac{\sigma_{zo}}{\sigma'_E \, x_r} \right)^{1/\beta}$$

σ_{zo} = standard deviation of the vertical distribution at the source

β = vertical diffusion coefficient of the order of unity

$$\sigma_x \{x\} = \left[\left(\frac{L\,\{x\}}{4.3} \right)^2 + \sigma_{xo}^{\,2} \right]^{1/2} \qquad (2\text{-}11)$$

where

$L\,\{x\}$ = alongwind cloud length when the center of the cloud is at distance x from the source

$$= \frac{0.28\,(\Delta u)\,(x)}{\bar{u}}$$

Δu = wind speed shear within the layer containing the cloud

σ_{xo} = standard deviation of the alongwind distribution at the source

In Equation (2-9) above, σ'_A is expressed as a function of the release time τ. Values of σ'_A for nearly instantaneous releases are difficult to measure directly, but can be calculated from the following semi-empirical relationship (Cramer, et al., 1964):

$$\sigma'_A \{\tau\} = \sigma'_A \{\tau_o\} \left(\frac{\tau}{\tau_o}\right)^{1/5} \tag{2-12}$$

where τ_o is ≤ 10 minutes. The standard deviation of the wind elevation angle σ'_E is assumed independent of the release time τ because of the relatively narrow frequency range in the power spectrum of the vertical wind velocity component that contains significant amounts of turbulent energy. This assumption is generally valid at heights ≤ 100 meters above the ground surface. In the presence of large convective cells and at heights of the order of 1 kilometer, the assumption that σ'_E is independent of τ likely does not hold. However, the effect on the accuracy of ground-level concentration and dosage estimates is thought to be slight.

The source dimensions σ_{xo}, σ_{yo}, σ_{zo} in the above subset refer to a stabilized cloud or plume that has just reached equilibrium with ambient atmospheric conditions following the completion of the emission phase. These source dimensions are best estimated from direct measurements or observations. The virtual distances x_y, x_z are used to adjust the lateral and vertical terms of the generalized models for the initial source dimensions σ_{yo} and σ_{zo}. Two virtual distances are employed to facilitate the treatment of asymmetrical sources where $\sigma_{yo} \neq \sigma_{zo}$. The height of the stabilized cloud above ground level, when the emission mode is accompanied by the release of significant amounts of thermal energy, must be estimated from observations or by means of a mathematical formula for buoyant plume rise such as that given in Section 4.3 below.

2.4 MODEL FORMULAS FOR GROUND DEPOSITION CAUSED BY PRECIPITATION SCAVENGING AND GRAVITATIONAL SETTLING

The total amount of material deposited on the ground surface by precipitation scavenging, at some distance x, is given by the expression

$$\frac{\Lambda Q}{\sqrt{2\pi}\,\sigma_y\,\bar{u}} \left\{\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\right\} \left\{\exp\left[-\Lambda\left(\frac{x}{\bar{u}} - t_1\right)\right]\right\} \tag{2-13}$$

where t_1 is the time at which the precipitation begins. The principal assumptions made in deriving the above expression are:

- The rate of precipitation is steady over an area that is large compared to the horizontal dimension of the cloud of toxic material
- The precipitation originates at a level above the top of the toxic cloud so that hydrometeors pass vertically through the entire cloud
- The time duration of the precipitation is sufficiently long so that the entire alongwind length of the toxic cloud passes over the point x

Engelmann (see Slade, 1968, pp. 208-221) discusses the general problem of calculating the amount of material removed by precipitation scavenging and recommends values of the coefficient Λ that may be combined with precipitation rates to obtain estimates of total surface deposition.

The total deposition due to the gravitational settling of heavy particles or droplets with settling velocity V_s, at a downwind distance x from the source and on the projection of the alongwind cloud axis on the ground plane, is given by the expression

$$\frac{Q}{\sqrt{2\pi}\,\sigma_y} \frac{d}{dx} \left\{ \frac{1}{\sqrt{2\pi}\,\sigma_z} \int_{-\infty}^{o} \left\{ \exp\left[-\frac{1}{2}\left(\frac{H-\left(V_s x/\bar{u}\right)-z}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{2H_m-H+\left(V_s x/\bar{u}\right)-z}{\sigma_z}\right)^2\right]\right\} dz \right\} \tag{2-14}$$

After the integration and differentiation are performed, the above expression becomes

$$\frac{Q}{2\pi\,\sigma_y}\left\{\left[\frac{\beta H+\left(1-\left(\frac{\beta x}{x+x_z}\right)\right)V_s(x+x_z)/\bar{u}}{\sigma_z\,(x+x_z)}\right]\exp\left[-\frac{1}{2}\left(\frac{H-\left(V_s x/\bar{u}\right)}{\sigma_z}\right)^2\right]\right.$$

$$+\left[\frac{\beta\left(2H_m-H\right)-\left(1-\left(\frac{\beta x}{x+x_z}\right)\right)V_s(x+x_z)/\bar{u}}{\sigma_z\,(x+x_z)}\right] \tag{2-15}$$

$$\left.\exp\left[-\frac{1}{2}\left(\frac{2H_m-H+\left(V_s x/\bar{u}\right)}{\sigma_z}\right)^2\right]\right\}$$

2.5 ADAPTATION OF THE GENERALIZED MODELS TO CONTINUOUS SOURCE EMISSION

The generalized concentration and dosage models respectively discussed in Sections 2.1 and 2.2 above are applicable to cases in which the source is nearly-instantaneous. Treatment of cold spills and fuel leaks that occur near ground level requires that these models be adapted for use in predicting concentrations downwind from continuous sources.

The generalized concentration model for continuous source emission is given by the product of four terms

Concentration = {Peak Concentration} x {Lateral Term}
x {Vertical Term} x {Depletion Term}

The <u>Peak Concentration Term</u> is given by the expression

$$\frac{Q}{2\pi\,\bar{u}\,\sigma_y\,\sigma_z} \tag{2-16}$$

where

Q = source strength in units of total mass released per unit time

$\bar{u}$ = mean wind speed at the effective source height

σ_y = standard deviation of the crosswind concentration distribution

σ_z = standard deviation of the vertical concentration distribution

The Lateral Term, Vertical Term and the subset of equations defining σ_y and σ_z are respectively given by Equations (2-3), (2-4), (2-9) and (2-10). The Depletion Term is given by Equations (2-5, (2-6) and (2-7), depending on the depletion mechanism. The expression for the Peak Concentration Term given by Equation (2-16) is very similar to the Peak Dosage Term in Equation (2-8) except for the definition of source strength and the mean wind speed.

SECTION 3

THE KSC MULTI-LAYER DIFFUSION MODEL

3.1 THE MULTI-LAYER CONCEPT

The meteorological structure at Kennedy Space Center between ground level and 5 kilometers, the top of the reference air volume for hazard estimation, is usually comprised of several layers with distinctive wind, temperature and humidity fields (Record, et al., 1970). A typical daytime vertical profile at KSC shows an easterly sea-breeze circulation in the surface layer, a transition zone, and a regime of westerly winds at the top of the reference volume. Large horizontal spatial variations in wind regimes also occur in the surface layer, usually as a consequence of the land-water interface.

If the generalized diffusion models described in Section 2 are to be of practical use in hazard estimation at KSC, a way must be found to adapt them to the vertical and horizontal variations in meteorological structure that typically occur in the reference air volume. The vertical stratification problem in the reference volume is handled by applying the models to individual layers in which the meteorological structure is reasonably homogenous. Layer boundaries are placed arbitrarily at the points of major discontinuities in the vertical profiles of wind, temperature, and humidity. For simplicity, it is assumed that there is no flux of material across layer boundaries due to turbulent mixing. Provision is made, however, for the flux of material across layer boundaries as a result of gravitational settling or precipitation scavenging.

Step changes in the meteorological structure of layers, at some arbitrary time or downwind distance from the point of release, are accommodated by stopping the transport and diffusion processes in the layers affected by the change in structure, calculating new sets of initial source and meteorological model input parameters, and re-starting the transport and diffusion process with the new inputs.

Two geometries are involved in the multi-layer concepts outlined above. The first is the layer geometry used with the Cartesian coordinate system of the generalized models in which the x-axis is along the mean wind direction in the layer. The second geometry refers to a basic reference grid for the area surrounding KSC that is referred to fixed spatial coordinates. Transformation equations that relate the two geometries are easily written.

The above concepts have been used to develop a multi-layer construct, based on the generalized diffusion models, for application to the toxic fuel hazard problem at KSC. Mathematical specifications for the various layer models used in the KSC multi-layer construct are given below. These specifications provide the foundation for the computer programs that constitute the principal methods for estimating toxic fuel hazards at KSC. The seven layer models first described refer principally to the transport, dispersal, and depletion of toxic material formed as the result of normal and abnormal launches, vehicle destruct, and hot fuel spills. The use of the multi-layer diffusion program for estimating concentration fields downwind from cold fuel spills and surface fuel leaks is described at the end of the section.

3.2 MODEL 1

In this layer model, the source extends vertically through the entire layer and turbulent mixing is occurring. It is assumed that the vertical distribution of toxic material is uniform with height and that the distributions of toxic material along the x- and y-layer coordinates are Gaussian.

3.2.1 Dosage Equation for Model 1

The dosage equation for Model 1 in the K^{th} layer is

$$D_K\{x_K, y_K, z_K\} = \frac{Q_K}{\sqrt{2\pi}\,\bar{u}\{z_K\}\,\sigma_{yK}} \left\{ \exp\left(\frac{-y_K^2}{2\sigma_{yK}^2}\right)\right\} \tag{3-1}$$

In the above expression

Q_K = source strength in units of mass per unit layer depth

The quantity $\bar{u}\{z_K\}$ in Equation (3-1) is the mean wind speed in meters per second at the height z_K for which the dosage is to be estimated. In the surface layer (K = 1), this term is defined as follows:

$$\bar{u}\{z_K, K=1\} = \bar{u}_R \left(\frac{z_K\{K=1\}}{z_R}\right)^p \tag{3-2}$$

where

$\bar{u}_R$ = mean wind speed measured at the reference height z_R

p = power-law exponent for the wind speed profile in the surface layer

$$= \log\left(\frac{\bar{u}_{TK}\{K=1\}}{\bar{u}_R}\right) \Big/ \log\left(\frac{z_{TK}\{K=1\}}{z_R}\right)$$

$\bar{u}_{TK}\{K=1\}$ = mean wind speed at the top of the surface layer $z_{TK}\{K=1\}$

For layers above the surface layer (K > 1),

$$\bar{u}\{z_K, K>1\} = \bar{u}_{BK} + \left(\frac{\bar{u}_{TK} - \bar{u}_{BK}}{z_{TK} - z_{BK}}\right) \left(z_K - z_{BK}\right) \tag{3-3}$$

where

$\bar{u}_{TK}$ = mean wind speed at the top of the layer z_{TK}

$\bar{u}_{BK}$ = mean wind speed at the base of the layer z_{BK}

The standard deviation of the crosswind dosage distribution σ_{yK} is defined by the expression

$$\sigma_{yK} = \left\{ \left[\sigma'_{AK} \{\tau_K\} \, x_r \left(\frac{x_K + x_{yK}}{x_r} \right)^{\alpha_K} \right]^2 + \left[\frac{\Delta\theta'_K x_K}{4.3} \right]^2 \right\}^{1/2} \tag{3-4}$$

where

$\sigma'_{AK}\{\tau_K\}$ = mean layer standard deviation of the wind azimuth angle in radians for the cloud stabilization time τ_K

In the surface layer (K = 1),

$$\sigma'_{AK}\{\tau_K, K=1\} = \frac{\sigma'_{AR}\{\tau_K\} \left[\left(z_{TK}\{K=1\} \right)^{m+1} - \left(z_R \right)^{m+1} \right]}{(m+1) \left(z_{TK}\{K=1\} - z_R \right) \left(z_R \right)^m} \tag{3-5}$$

where

$\sigma'_{AR}\{\tau_K\}$ = standard deviation of the wind azimuth angle in radians at height z_R and for the cloud stabilization time τ_K

$$= \sigma_{AR}\{\tau_{oK}\} \left(\frac{\tau_K}{\tau_{oK}} \right)^{1/5} \left(\frac{\pi}{180} \right)$$

$\sigma_{AR}\{\tau_{oK}\}$ = standard deviation of the wind azimuth angle in degrees at height z_R and for the reference time period τ_{oK}

m = power-law exponent for the vertical profile of the standard deviation of the wind azimuth angle in the surface layer

$$= \log \left(\frac{\sigma'_{ATK}\{\tau_K, K=1\}}{\sigma'_{AR}\{\tau_K\}} \right) \Bigg/ \log \left(\frac{z_{TK}\{K=1\}}{z_R} \right)$$

$$\sigma'_{ATK}\{\tau_K, K=1\} = \sigma_{ATK}\{\tau_{oK}, K=1\} \left(\frac{\tau_K}{\tau_{oK}} \right)^{1/5} \left(\frac{\pi}{180} \right)$$

$\sigma_{ATK}\{\tau_{oK}, K{=}1\}$ = standard deviation of the wind azimuth angle in degrees at the top of the surface layer z_{TK} for the reference time period τ_{oK}

For layers above the surface layer (K > 1),

$$\sigma'_{ATK}\{\tau_K, K>1\} = \left(\sigma'_{ATK}\{\tau_K\} + \sigma'_{ABK}\{\tau_K\}\right)/2 \tag{3-6}$$

where

$$\sigma'_{ATK}\{\tau_K\} = \sigma_{ATK}\{\tau_{oK}\}\left(\frac{\tau_K}{\tau_{oK}}\right)^{1/5}\left(\frac{\pi}{180}\right)$$

$\sigma_{ATK}\{\tau_{oK}\}$ = standard deviation of the wind azimuth angle in degrees at the top of the layer for the reference time period τ_{oK}

$$\sigma'_{ABK}\{\tau_K\} = \sigma_{ABK}\{\tau_{oK}\}\left(\frac{\tau_K}{\tau_{oK}}\right)^{1/5}\left(\frac{\pi}{180}\right)$$

$\sigma_{ABK}\{\tau_{oK}\}$ = standard deviation of the wind azimuth angle in degrees at the base of the layer for the reference time period τ_{oK}

x_K = downwind distance from the source

y_K = crosswind distance from the axis of the cloud

x_{yK} = crosswind virtual distance

$$= x_r\left(\frac{\sigma_{yo}\{K\}}{\sigma'_{AK}\{\tau_K\}\, x_r}\right)^{1/\alpha_K}$$

$\sigma_{yo}\{K\}$ = standard deviation of the lateral source dimension in the layer

α_K = lateral diffusion coefficient in the layer

$\Delta\theta'_K$ = vertical wind direction shear in the layer

$$= \left(\theta_{TK} - \theta_{BK}\right)\left(\pi/180\right)$$

θ_{TK} = mean wind direction in degrees at the top of the layer

θ_{BK} = mean wind direction in degrees at the base of the layer

3.2.2 Concentration Equation for Model 1

The concentration equation for Model 1 in the K^{th} layer is given by the expression

$$\chi_K\{x_K, y_K, t\} = \frac{D_K\, \bar{u}\{z_K\}}{\sqrt{2\pi}\, \sigma_{xK}} \left\{ \exp\left[\frac{-\left(x_K - \bar{u}_K t\right)^2}{2\sigma_{xK}^2}\right]\right\} \tag{3-7}$$

where

$\bar{u}_K$ = mean cloud transport speed in the layer

$$\bar{u}_K\{K=1\} = \frac{\bar{u}_R\left[\left(z_{TK}\{K=1\}\right)^{1+p} - \left(z_R\right)^{1+p}\right]}{\left(1+p\right)\left(z_{TK}\{K=1\} - z_R\right)\left(z_R\right)^p}$$

$$\bar{u}_K\{K>1\} = \left(\bar{u}_{TK} + \bar{u}_{BK}\right)/2$$

t = time after cloud stabilization

σ_{xK} = standard deviation of the alongwind concentration distribution in the layer

$$= \left[\left(\frac{L\{x_K\}}{4.3}\right)^2 + \sigma_{xo}^2\{K\}\right]^{1/2} \tag{3-8}$$

$L\{x_K\}$ = alongwind cloud length in the layer at distance x_K from the source

$$= \begin{cases} \dfrac{0.28\left(\Delta\bar{u}_K\right)\left(x_K\right)}{\bar{u}_K} & ; \quad \Delta\bar{u}_K \geq 0 \\ 0 & ; \quad \Delta\bar{u}_K \leq 0 \end{cases} \tag{3-9}$$

$\Delta\bar{u}_K$ = vertical wind speed shear in the layer

$\Delta\bar{u}_K\{K=1\} = \bar{u}_{TK}\{K=1\} - \bar{u}_K$

$\Delta\bar{u}_K\{K>1\} = \bar{u}_{TK} - \bar{u}_{BK}$

$\sigma_{xo}\{K\}$ = standard deviation of the alongwind source dimension in the layer

The above equation for $L\{x_K\}$ is based on results reported by Tyldesley and Wallington (1965) who analyzed ground-level concentration measurements made at distances of 5 to 120 kilometers downwind from instantaneous line-source releases.

The peak concentration χ_{PK} at distance x_K and at an arbitrary distance $y_K \neq 0$ from the cloud centerline is given by

$$\chi_{PK}\{x_K, y_K, t = x_K/\bar{u}_K\} = \frac{D_K \bar{u}\{z_K\}}{\sqrt{2\pi}\,\sigma_{xK}} \tag{3-10}$$

Similarly, the maximum peak concentration χ_{MPK} at distance x_K on the cloud centerline $y_K = 0$ is given by the equivalent expressions

$$\chi_{MPK}\left\{x_K, y_K = 0,\ t = x_K/\bar{u}_K\right\} = \frac{D_K\ \bar{u}\ \{z_K\}}{\sqrt{2\pi}\ \sigma_{xK}}\ \frac{1}{\{\text{LATERAL TERM}\}} \qquad (3\text{-}11)$$

$$= \frac{Q_K}{2\pi\ \sigma_{yK}\ \sigma_{xK}} \qquad (3\text{-}12)$$

3.3 MODEL 2

Layer model 2 refers to the same source configuration as Model 1 in which the source extends vertically through the entire depth of the layer and the distribution of toxic material is uniform with height. In Model 2, however, it is assumed that no turbulent mixing is occurring. Consequently, there is no dilution of the cloud due to turbulent expansion. The dosage and concentration equations for Model 2 are given by Equations (3-1) and (3-7), respectively, with the following substitutions:

$$\sigma_{yK} = \sigma_{yo}\{K\} \qquad (3\text{-}13)$$

$$\sigma_{xK} = \sigma_{xo}\{K\} \qquad (3\text{-}14)$$

3.4 MODEL 3

This layer model differs from Models 1 and 2 in that the vertical extent of the source is less than the depth of the layer. The model equation thus contains vertical expansion terms.

3.4.1 Dosage Equation for Model 3

The dosage equation for Model 3 in the K^{th} layer is given by the expression

$$D_K\left\{x_K, y_K, z_{BK} < z_K < z_{TK}\right\} = \frac{Q_K}{2\pi\,\sigma_{yK}\,\sigma_{zK}\,\bar{u}\left\{z_K\right\}}\left\{\exp\left[\frac{-y_K^2}{2\sigma_{yK}^2}\right]\right\}$$

$$\left\{\exp\left[\frac{-\left(H_K - z_K\right)^2}{2\sigma_{zK}^2}\right] + \exp\left[\frac{-\left(H_K - 2z_{BK} + z_K\right)^2}{2\sigma_{zK}^2}\right]\right.$$

$$+ \sum_{i=1}^{\infty}\left\{\exp\left[\frac{-\left(2i\left(z_{TK} - z_{BK}\right) - \left(H_K - 2z_{BK} + z_K\right)\right)^2}{2\sigma_{zK}^2}\right] + \right. \tag{3-15}$$

$$\exp\left[\frac{-\left(2i\left(z_{TK} - z_{BK}\right) + \left(H_K - z_K\right)\right)^2}{2\sigma_{zK}^2}\right] + \exp\left[\frac{-\left(2i\left(z_{TK} - z_{BK}\right) + \left(H_K - z_K\right)\right)^2}{2\sigma_{zK}^2}\right]$$

$$\left.\left. + \exp\left[\frac{-\left(2i\left(z_{TK} - z_{BK}\right) + \left(H_K - 2z_{BK} + z_K\right)\right)^2}{2\sigma_{zK}^2}\right]\right\}\right\}$$

where

Q_K = source strength or total mass of material in the layer

H_K = effective source height or height of the centroid of the stabilized cloud

σ_{zK} = standard deviation of the vertical dosage distribution in the layer

The remaining terms are the same as those in Equation (3-1) for Model 1.

The standard deviation of the vertical dosage distribution is defined by the expression

$$\sigma_{zK} = \sigma'_{EK}\, x_r \left(\frac{x_K + x_{zK}}{x_r}\right)^{\beta_K} \tag{3-16}$$

where

σ'_{EK} = mean standard deviation of the wind elevation angle in radians for the layer

x_{zK} = vertical virtual distance in the layer

β_K = vertical diffusion coefficient in the layer

In the surface layer (K = 1),

$$\sigma'_{EK}\{K=1\} = \frac{\sigma_{ER}\left[\left(z_{TK}\{K=1\}\right)^{q+1} - \left(z_R\right)^{q+1}\right]}{(q+1)\left(z_{TK}\{K=1\} - z_R\right)\left(z_R\right)^q}\left(\frac{\pi}{180}\right) \tag{3-17}$$

where

σ_{ER} = standard deviation of the wind elevation angle in degrees at the height z_R

q = power-law exponent for the vertical profile of the standard deviation of the wind elevation angle in the surface layer

$$= \log\left(\frac{\sigma_{ETK}\{K=1\}}{\sigma_{ER}}\right) \Big/ \log\left(\frac{z_{TK}\{K=1\}}{z_R}\right)$$

$\sigma_{ETK}\{K=1\}$ = standard deviation of the wind elevation angle in degrees at the top of the surface layer

Above the surface layer (K > 1),

$$\sigma'_{EK}\{K>1\} = \left(\sigma_{ETK} + \sigma_{EBK}\right)\left(\pi/360\right) \tag{3-18}$$

where

σ_{ETK} = standard deviation of the wind elevation angle in degrees at the top of the layer

σ_{EBK} = standard deviation of the wind elevation angle in degrees at the base of the layer

The vertical virtual distance x_{zK} is given by the expression

$$x_{zK} = x_r \left(\frac{\sigma_{zo}\{K\}}{\sigma'_{EK}\, x_r} \right)^{1/\beta}$$

where

$\sigma_{zo}\{K\}$ = standard deviation of the source vertical dosage distribution

3.4.2 Concentration Equation for Model 3

The concentration equation for Model 3 is the same as that for Model 1 which is given by Equation (3-7) in Section 3.2.2. Equations (3-10) and (3-11) in Section 3.2.2 also give the peak concentration and maximum peak concentration for Model 3. The Model 1 formula for maximum peak concentration given by Equation (3-12) does not apply to Model 3 because no provision is made for the vertical terms.

3.5 MODEL 4

In this layer model, a simple step change in layer structure is assumed to occur at a predetermined time t* subsequent to the generation of the cloud at the source. Model 4 is applied in the calculation of dosage and concentration fields after time t* under the following assumptions:

- The boundary between adjacent layers is eliminated and the layers are replaced by a single layer L
- Turbulent mixing is occurring in layer L
- The cloud is fully adjusted to the new meteorological structure in layer L
- Reflection occurs at the upper and lower boundaries of L

Under these assumptions, the contribution to the dosage and concentration fields in layer L from the source in the K^{th} layer can be expressed as a simple box model formula. The total contribution to a receptor position in layer L is found by summing the contribution from all K layers.

3.5.1 Dosage Equation for Model 4

The dosage equation for Model 4 for the contribution from the cloud in the K^{th} layer to the receptor position in the layer L is

$$D_{LK}\{x_L, y_L, z_L\} = \frac{Q_K \left(z_{TK} - z_{BK}\right)}{\sqrt{2\pi}\ \bar{u}\{z_L\}\ \sigma_{yLK}\left(z_{TL} - z_{BL}\right)} \left\{\exp\left[\frac{-y_L^{\ 2}}{2\sigma_{yLK}^{\ 2}}\right]\right\} \tag{3-19}$$

In the above expression

Q_K = source strength in units of mass per unit layer depth ($g\ m^{-1}$) for the source in the layer K

In Model 4 the quantity $\bar{u}\{z_L\}$ is the mean wind speed in meters per second at the height z_L for which the dosage is to be estimated. If the layer L is the surface layer (L = 1), this term is defined by the expression

$$\bar{u}\{z_L, L=1\} = \bar{u}_{RL}\left(\frac{z_L\{L=1\}}{z_R}\right)^{p_L} \tag{3-20}$$

where

$\bar{u}_{RL}$ = mean wind speed at the reference height z_R in the new surface layer L

p_L = power-law exponent for the wind speed profile in the surface layer (L = 1)

$$= \log\left(\frac{\bar{u}_{TL}\{L=1\}}{\bar{u}_{RL}}\right) \Big/ \log\left(\frac{z_{TL}\{L=1\}}{z_R}\right)$$

$\bar{u}_{TL}\{L=1\}$ = mean wind at the top of the surface layer $z_{TL}\{L=1\}$

For layers above the surface layer (L > 1),

$$\bar{u}\{z_{LK}, L>1\} = \bar{u}_{BL} + \left(\frac{\bar{u}_{TL} - \bar{u}_{BL}}{z_{TL} - z_{BL}}\right)\left(z_L - z_{BL}\right) \tag{3-21}$$

where

$\bar{u}_{TL}$ = mean wind speed at the top of the layer z_{TL}

$\bar{u}_{BL}$ = mean wind speed at the base of the layer z_{BL}

The crosswind distance from the axis of the cloud to a receptor, y_L, is given by the expression

$$y_L = \left(y_j - y_{SK}\right) \sin \theta'_L - \left(x_j - x_{SK}\right) \cos \theta'_L \qquad (3\text{-}22)$$

where

x_j, y_j = position of the receptor with respect to the origin of the reference coordinate system

x_{SK}, y_{SK} = coordinates of the cloud centroid in the K^{th} layer at time t^* with respect to the origin of the reference coordinate system

$x_{SK} = x_i - x^*_K \sin \theta'_K$

$y_{SK} = y_i - x^*_K \cos \theta'_K$

x_i, y_i = coordinates of the real source in the K^{th} layer with respect to the origin of the reference coordinate system

$x^*_K = \bar{u}_K t^*$

$\theta'_L = \left(\theta_{TL} + \theta_{BL}\right)\left(\pi/360\right)$

θ_{TL} = mean wind direction in degrees at the top of the layer z_{TL}

θ_{BL} = mean wind direction in degrees at the base of the layer z_{BL}

$\theta'_K = \left(\theta_{TK} + \theta_{BK}\right)\left(\pi/360\right)$

The standard deviation of the crosswind dosage distribution σ_{yLK} in the L^{th} layer is defined by the expression

$$\sigma_{yLK} = \left\{\left[\sigma'_{AL}\{\tau_L\}\left(x_L + x^*_{yKL}\right)^{\alpha_L}\right]^2 + \left[\frac{\Delta\theta'_L x_L}{4.3}\right]^2\right\}^{1/2} \qquad (3\text{-}23)$$

where

$\sigma'_{AL}\{\tau_L\}$ = mean layer standard deviation of the wind azimuth angle in radians for the effective cloud stabilization time τ_L

In the surface layer (L = 1),

$$\sigma'_{AL}\{\tau_L, L=1\} = \frac{\sigma'_{ARL}\{\tau_L\}\left[\left(z_{TL}\{L=1\}\right)^{m_L+1} - \left(z_R\right)^{m_L+1}\right]}{\left(m_L+1\right)\left(z_{TL}\{L=1\} - z_R\right)\left(z_R\right)^{m_L}} \tag{3-24}$$

where

$\sigma'_{ARL}\{\tau_L\}$ = standard deviation of the wind azimuth angle in radians at height z_R and for time τ_L

$$= \sigma_{ARL}\{\tau_{oL}\}\left(\frac{\tau_L}{\tau_{oL}}\right)^{1/5}\left(\frac{\pi}{180}\right)$$

$\sigma_{ARL}\{\tau_{oL}\}$ = standard deviation of the wind azimuth angle in degrees at height z_R and for the reference time period τ_{oL}

m_L = power-law exponent for the vertical profile of the standard deviation of the wind azimuth angle in the surface layer L = 1

$$= \log\left(\frac{\sigma'_{ATL}\{\tau_L, L=1\}}{\sigma'_{ARL}\{\tau_L\}}\right) \Big/ \log\left(\frac{z_{TL}\{L=1\}}{z_R}\right)$$

$$\sigma'_{ATL}\{\tau_L, L=1\} = \sigma_{ATL}\{\tau_{oL}, L=1\}\left(\frac{\tau_L}{\tau_{oL}}\right)^{1/5}\left(\frac{\pi}{180}\right)$$

$\sigma_{ATL}\{\tau_{oL}, L=1\}$ = standard deviation of the wind azimuth angle in degrees at the top of the surface layer z_{TL} for the reference time period τ_{oL}

For layers above the surface layer (L > 1),

$$\sigma'_{AL}\{\tau_L, L>1\} = \left(\sigma'_{ATL}\{\tau_L\} + \sigma'_{ABL}\{\tau_L\}\right)\Big/2 \tag{3-25}$$

where

$$\sigma'_{ATL}\left\{\tau_L\right\} = \sigma_{ATL}\left\{\tau_{oL}\right\}\left(\frac{\tau_L}{\tau_{oL}}\right)^{1/5}\left(\frac{\pi}{180}\right)$$

$\sigma_{ATL}\left\{\tau_{oL}\right\}$ = standard deviation of the wind azimuth angle in degrees at the top of the layer for the reference time period τ_{oL}

$$\sigma'_{ABL}\left\{\tau_L\right\} = \sigma_{ABL}\left\{\tau_{oL}\right\}\left(\frac{\tau_L}{\tau_{oL}}\right)^{1/5}\left(\frac{\pi}{180}\right)$$

$\sigma_{ABL}\left\{\tau_{oL}\right\}$ = standard deviation of the wind azimuth angle in degrees at the base of the layer for the reference time τ_{oL}

The wind direction shear in radians in the layer is given by the expression

$$\Delta\theta'_L = \left(\theta_{TL} - \theta_{BL}\right)\left(\pi/180\right)$$

The crosswind virtual distance in the L^{th} layer due to source (cloud) originating in the K^{th} layer is given by the equation

$$x^*_{yKL} = x_r\left(\frac{\sigma^*_{yKL}}{\sigma'_{AL}\left\{\tau_L\right\} x_r}\right)^{1/\alpha_L}$$

where

σ^*_{yKL} = crosswind source dimension in layer L due to source (cloud) originating in the K^{th} layer

$$= \left\{\left[\left(\sigma^*_{xK}\right)^2 \sin^2\left(\theta'_K - \theta'_L\right)\right] + \left[\left(\sigma^*_{yK}\right)^2 \cos^2\left(\theta'_K - \theta'_L\right)\right]\right\}^{1/2}$$

σ^*_{xK} = alongwind standard deviation of the dosage distribution in the K^{th} layer at time t*

σ^*_{yK} = crosswind standard deviation of the dosage distribution in the K^{th} layer at time t*

α_L = lateral diffusion coefficient in the layer

The downwind distance from the point where the change in layer structure occurs for the source (cloud) in the K^{th} layer to the point where the dosage is to be calculated, x_L, is given by the expression

$$x_L = -\left(x_j - x_{SK}\right) \sin \theta'_L - \left(y_j - y_{SK}\right) \cos \theta'_L \tag{3-26}$$

3.5.2 Concentration Equation for Model 4

The concentration equation for Model 4 is given by the expression

$$\chi_{LK}\{x_L, y_L, t\} = \frac{D_{LK}\, \bar{u}\{z_L\}}{\sqrt{2\pi}\, \sigma_{xLK}} \left\{ \exp\left[- \frac{\left(x_L - \bar{u}_L (t-t^*)\right)^2}{2\sigma_{xLK}^2} \right] \right\} \tag{3-27}$$

where

$\bar{u}_L$ = mean wind speed in the layer

$$\bar{u}_L\{L=1\} = \frac{\bar{u}_{RL}\left[\left(z_{TL}\{L=1\}\right)^{p_L+1} - \left(z_R\right)^{p_L+1}\right]}{\left(p_L+1\right)\left(z_{TL}\{L=1\} - z_R\right)\left(z_R\right)^{p_L}}$$

$$\bar{u}_L\{L>1\} = \left(\bar{u}_{TL} + \bar{u}_{BL}\right)/2$$

σ_{xLK} = standard deviation of the cloud alongwind concentration distribution in layer

$$= \left[\left(\frac{L\{x_{LK}\}}{4.3} \right)^2 + \left(\sigma^*_{xKL} \right)^2 \right]^{1/2}$$

$L\{x_{LK}\}$ = alongwind length of cloud in layer at distance x_L

$$= \begin{cases} \dfrac{0.28 \left(\Delta\bar{u}_L\right)\left(x_L\right)}{\bar{u}_L} & ; \quad \Delta\bar{u}_L \geq 0 \\ 0 & ; \quad \Delta\bar{u}_L \leq 0 \end{cases} \tag{3-28}$$

$\Delta\bar{u}_L$ = vertical wind speed shear in the layer

$$\Delta\bar{u}_L \{L=1\} = \bar{u}_{TL}\{L=1\} - \bar{u}_{RL}$$

$$\Delta\bar{u}_L \{L>1\} = \bar{u}_{TL} - \bar{u}_{BL}$$

σ^*_{xKL} = alongwind source dimension in layer L due to source (cloud) originating in the K^{th} layer

$$= \left\{ \left[\left(\sigma^*_{xK}\right)^2 \cos^2\left(\theta'_K - \theta'_L\right) \right] + \left[\left(\sigma^*_{yK}\right)^2 \sin^2\left(\theta'_K - \theta'_L\right) \right] \right\}^{1/2}$$

The peak concentration χ_{PL} at distance x_L and at an arbitrary distance $y_L \neq 0$ from the cloud centerline is given by

$$\chi_{PL}\{x_L, y_L, t = x_L/\bar{u}_L\} = \frac{D_{LK}\, \bar{u}\{z_L\}}{\sqrt{2\pi}\, \sigma_{xLK}} \tag{3-29}$$

and the maximum peak concentration χ_{MPL} at distance x_L on the centerline $y_L = 0$ by the expression

$$\chi_{MPL}\left\{x_L, y_L = 0, t = x_L/\bar{u}_L\right\} = \frac{D_{LK}\,\bar{u}\left\{z_L\right\}}{\sqrt{2\pi}\,\sigma_{xLK}} \quad \frac{1}{\{\text{LATERAL TERM}\}}$$

$$= \frac{Q_K}{2\pi\,\sigma_{yLK}\,\sigma_{xLK}} \tag{3-30}$$

3.6 MODEL 5

The use of Model 4 above does not permit estimation of the dosage and concentration fields in the transition period between the time t* and the time at which material originating in the K^{th} layer becomes rectangularly distributed in the vertical throughout the layer L. Layer Model 5 contains vertical terms which permit estimation of the dosage and concentration fields in and after the transition period. The same assumptions applied in deriving Model 4 are used in deriving Model 5 with the exception that the cloud need not be fully adjusted to the new meteorological structure in layer L. However, the cloud in the K^{th} layer must be uniformly distributed in the vertical prior to time t*.

3.6.1 Dosage Equation for Model 5

The dosage equation for Model 5 is given by the expression

$$D_{LK} = \frac{Q_K}{2\sqrt{2\pi}\, \bar{u} \left\{ z_L \right\} \sigma_{yLK}} \left\{ \exp\left[-\left(\frac{y_L^2}{2\sigma_{yLK}^2} \right) \right] \right\}$$

$$\left\{ \sum_{i=0}^{\infty} \left[\mathrm{erf}\left(\frac{2i\left(z_{TL}-z_{BL}\right)-z_{BK}+z_L}{\sqrt{2}\,\sigma_{zLK}} \right) + \mathrm{erf}\left(\frac{2i\left(z_{TL}-z_{BL}\right)+z_{TK}-z_L}{\sqrt{2}\,\sigma_{zLK}} \right) \right. \right.$$

$$\left. + \mathrm{erf}\left(\frac{2i\left(z_{TL}-z_{BL}\right)+2z_{BL}-z_{BK}-z_L}{\sqrt{2}\,\sigma_{zLK}} \right) + \mathrm{erf}\left(\frac{2i\left(z_{TL}-z_{BL}\right)-2z_{BL}+z_{TK}+z_L}{\sqrt{2}\,\sigma_{zLK}} \right) \right] \tag{3-31}$$

$$+ \sum_{i=1}^{\infty} \left[\mathrm{erf}\left(\frac{-2i\left(z_{TL}-z_{BL}\right)-z_{BK}+z_L}{\sqrt{2}\,\sigma_{zLK}} \right) + \mathrm{erf}\left(\frac{-2i\left(z_{TL}-z_{BL}\right)+z_{TK}-z_L}{\sqrt{2}\,\sigma_{zLK}} \right) \right.$$

$$\left. \left. + \mathrm{erf}\left(\frac{-2i\left(z_{TL}-z_{BL}\right)+2z_{BL}-z_{BK}-z_L}{\sqrt{2}\,\sigma_{zLK}} \right) + \mathrm{erf}\left(\frac{-2i\left(z_{TL}-z_{BL}\right)-2z_{BL}+z_{TK}+z_L}{\sqrt{2}\,\sigma_{zLK}} \right) \right] \right\}$$

where

σ_{zLK} = standard deviation of the vertical dosage distribution in the layer for the source (cloud) originating in the K^{th} layer

The remaining terms are the same as those in Equation (3-19) for Model 4.

The standard deviation of the vertical dosage distribution is defined by the expression

$$\sigma_{zLK} = \sigma'_{EL}\, x_r \left(\frac{x_L}{x_r} \right)^{\beta_L} \tag{3-32}$$

where

σ'_{EL} = mean standard deviation of the wind elevation angle in radians for the layer

β_L = vertical diffusion coefficient in the layer

x_r = unit reference distance

In the surface layer (L = 1),

$$\sigma'_{EL}\{L=1\} = \frac{\sigma_{ERL}\left[\left(z_{TL}\{L=1\}\right)^{q_L+1} - \left(z_R\right)^{q_L+1}\right]}{\left(q_L+1\right)\left(z_{TL}\{L=1\} - z_R\right)\left(z_R\right)^{q_L}} \left(\frac{\pi}{180}\right) \tag{3-33}$$

where

σ_{ERL} = standard deviation of the wind elevation angle in degrees at the reference height z_R

q_L = power-law exponent for the vertical profile of the standard deviation of the wind elevation angle in the surface layer

$$= \log\left(\frac{\sigma_{ETL}\{L=1\}}{\sigma_{ERL}}\right) \Big/ \log\left(\frac{z_{TL}\{L=1\}}{z_R}\right)$$

$\sigma_{ETL}\{L=1\}$ = standard deviation of the wind elevation angle in degrees at the top of the layer z_{TL}

Above the surface layer (L>1),

$$\sigma'_{EL}\{L>1\} = \left(\sigma_{ETL} + \sigma_{EBL}\right) \left(\pi/360\right) \tag{3-34}$$

where

σ_{ETL} = standard deviation of the wind elevation angle in degrees at the top of layer z_{TL}

σ_{EBL} = standard deviation of the wind elevation angle in degrees at the base of the layer z_{BL}

The multiple reflection terms following the summation signs in Equation (3-31) simulate reflection of the cloud at the top and base of layer L.

3.6.2 Concentration Equation

The concentration equation for Model 5 is the same as that for Model 4 given by Equation (3-27). The peak concentration and maximum peak concentration respectively given by Equations (3-29) and (3-30) also apply to Model 5.

3.7 MODEL 6

This model is used to calculate the amount of material deposited on the surface by precipitation scavenging in the K^{th} layer. The assumptions made in deriving the model are stated in Section 2.4. The ground-level deposition WD_K due to precipitation scavenging, for the case in which the vertical distribution of toxic material in the layer is uniform with height (Models 1 and 2), is given by the expression

$$WD_K\left\{x_K, y_K, z=0\right\} = \frac{\Lambda\, Q_K\left(z_{TK}-z_{BK}\right)}{\sqrt{2\pi}\,\sigma_{yK}\,\bar{u}_K}\left\{\exp\left[-\frac{1}{2}\left(\frac{y_K}{\sigma_{yK}}\right)^2\right]\right\}\left\{\exp\left[-\Lambda\left(\frac{x_K}{\bar{u}_K}-t_1\right)\right]\right\} \tag{3-35}$$

where

t_1 = time precipitation begins

Λ = percent of material removed per unit time

For the case in which the vertical extent of the source is less than the depth of the layer (Model 3), the term $\left(z_{TK}-z_{BK}\right)$ in Equation (3-35) is set equal to unity.

When changes in layer structure occur at time t^*, the ground deposition WD_L due to precipitation scavenging in the L^{th} layer is given by the expression

$$WD_L\left\{x_L, y_L, z=0\right\} = \frac{\Lambda Q_K\left(z_{TL}-z_{BL}\right)}{\sqrt{2\pi}\,\sigma_{yLK}\,\bar{u}_L}\left\{\exp\left[-\frac{1}{2}\left(\frac{y_L}{\sigma_{yLK}}\right)^2\right]\right\}$$

$$\left\{\exp\left[-\Lambda\left(\frac{x_L}{\bar{u}_L} + t^* - t_o\right)\right]\right\} \qquad (3\text{-}36)$$

The above equations give the contribution to total deposition at the ground from precipitation scavenging in the K^{th} or L^{th} layer. Total ground deposition is obtained by summing the contributions from all layers through which precipitation is falling at points on the reference grid coordinate system. The height of the top of the uppermost layer through which precipitation is falling z_{lim} must be supplied as an input to the computer program. The height z_{lim} must correspond to the height of one of the layers selected for the dosage or concentration calculations.

The dosage or concentration at a point in space, assuming precipitation scavenging occurs, is obtained by multiplying the appropriate dosage or concentration equation by the exponential term in Equation (3-35) or (3-36) containing the coefficient Λ.

3.8 MODEL 7

This model is used to calculate the ground deposition due to gravitational settling. The basic source configuration is an area source of finite lateral extent and unit vertical extent. Other source configurations are treated by summing the deposition at the ground resulting from a number of basic sources arranged to simulate the desired configuration. The model is essentially a tilted plume model in which the effects of wind shear are taken into account. The axis of a particle or droplet cloud of a given settling velocity intersects the ground plane at a distance from the source and at an angle from the mean surface wind direction that are proportional to the total angular wind shear and the residence time of the settling material in the layers between the source and the ground surface. In any layer the inclination of the cloud axis from the horizontal is given by $\tan^{-1} V_s/\bar{u}$, where V_s is the particle or droplet settling velocity and $\bar{u}$ is the mean transport wind speed in the layer. In all cases, material released in the K^{th} layer and dispersed upwards by turbulence is assumed to be reflected downwards at the interface of the K^{th} and $(K + 1)^{th}$ layers. The basic model is used to calculate the ground-level deposition pattern for a single value of the settling velocity. The total deposition pattern is obtained by summing the results for all settling velocities representative of the particle or droplet size distribution of the released material on a reference coordinate grid system.

In the computer program, provision is made for calculating deposition from a source which fills the layer in the vertical and for a source in which the vertical extent is less than the depth of the layer. These models are described below.

3.8.1 Gravitational Deposition Model for a Source that Extends Vertically through Entire Layer

Ground-level deposition by gravitational settling for a source that extends vertically through the entire layer and in which the material is uniformly distributed in the vertical is calculated from the following expression for an area source at height H_{nK}

$$DEP_{nK} = \frac{f_i\, Q_K\, T_K}{2\pi\, \sigma_{ynK}\, \zeta_K} \left\{ M_{nK} + N_{nK} \right\} \left\{ \exp\left[-\frac{1}{2} \left(\frac{y_s}{\sigma_{ynK}} \right)^2 \right] \right\} \qquad (3\text{-}37)$$

where

f_i = fraction of particles or droplets with settling velocity V_s

Q_K = source emission rate in layer K

T_K = source emission time in layer K

ζ_K = number of elementary sources in layer K for simulating a uniform vertical distribution

y_s = lateral distance from the deposition axis of particles or droplets with settling velocity V_s

= $R_s \sin \phi_s$

R_s = radial distance in the horizontal plane from the source to a receptor

ϕ_s = angle between the axis of the ground-level deposition pattern and the radial connecting source and receptor for settling velocity V_s

The terms M_{nK} and N_{nK} are vertical terms that include provision for reflection from the boundary between the K^{th} and $(K + 1)^{th}$ layers. These terms are defined by the expressions

$$M_{nK} = \left\{ \frac{\bar{\beta}_K H_{nK} + \left((1-\bar{\beta}_K) V_s x_s / \bar{u}_{nK} \right)}{\sigma'_{EnK} \left(x_s \right)^{1+\bar{\beta}_K}} \right\} \left\{ \exp\left[-\frac{1}{2} \left(\frac{H_{nK} - \left(V_s x_s / \bar{u}_{nK} \right)}{\sigma'_{EnK} \left(x_s \right)^{\bar{\beta}_K}} \right)^2 \right] \right\} \qquad (3\text{-}38)$$

$$N_{nK} = \left\{ \frac{\bar{\beta}_K \left(2z_{TK} - H_{nK} \right) - \left((1-\bar{\beta}_K) V_s x_s / \bar{u}_{nK} \right)}{\sigma'_{EnK} \left(x_s \right)^{1+\bar{\beta}_K}} \right\} \left\{ \exp\left[-\frac{1}{2} \left(\frac{2z_{TK} - H_{nK} + \left(V_s x_s / \bar{u}_{nK} \right)}{\sigma'_{EnK} \left(x_s \right)^{\bar{\beta}_K}} \right)^2 \right] \right\} \qquad (3\text{-}39)$$

where

$$x_s = R_s \cos \phi_s$$

$\bar{u}_{nK}$ = mean wind transport speed in the layer between H_{nK} and the ground

$$= \frac{\left(X_{nK}^2 + Y_{nK}^2\right)^{1/2}}{H_{nK}} \quad V_s$$

$$X_{nK} = \frac{\bar{u}_{HK}}{V_s \, b_K} \left\{ \sin\left[b_K\left(H_{nK} - z_{BK}\right) + S\theta'_{K-1}\right] - \sin\left(S\theta'_{K-1}\right) \right\}$$

$$+ \sum_{i=1}^{K-1} \left\{ \frac{\bar{u}_i}{V_s \, b_i} \left[\sin\left(S\theta'_i\right) - \sin\left(S\theta'_{i-1}\right) \right] \right\}$$

$$Y_{nK} = \frac{\bar{u}_{HK}}{V_s \, b_K} \left\{ \cos\left[b_K\left(H_{nK} - z_{BL}\right) + S\theta'_{K-1}\right] - \cos\left(S\theta'_{K-1}\right) \right\}$$

$$+ \sum_{i=1}^{K-1} \left\{ \frac{-\bar{u}_i}{V_s \, b_i} \left[\cos\left(S\theta'_i\right) - \cos\left(S\theta'_{i-1}\right) \right] \right\}$$

$$S\theta'_{K-1} = \sum_{i=1}^{K-1} \Delta\theta'_i$$

$$S\theta'_K = \sum_{i=1}^{K} \Delta\theta'_i$$

$$b_K = \frac{S\theta'_K - S\theta'_{K-1}}{z_{TK} - z_{BK}}$$

The quantity $\bar{u}_{HK}$ is the mean layer wind speed between the height H_K and the base of the K^{th} layer. The following expressions define the mean layer wind speeds in the surface layer (K = 1) and the layers above the surface layer (K > 1):

$$\bar{u}_{HK}\{K=1\} = \frac{\bar{u}_R\left[\left(H_{nK}\{K=1\}\right)^{1+p} - \left(z_R\right)^{1+p}\right]}{\left(1+p\right)\left(H_{nK}\{K=1\} - z_R\right)\left(z_R\right)^p} \qquad (3\text{-}40)$$

$$\bar{u}_{HK}\{K>1\} = \left[\left(\frac{\bar{u}_{TK} - \bar{u}_{BK}}{z_{TK} - z_{BK}}\right)\left(\frac{H_{nK} - z_{BK}}{2}\right)\right] + \left[\frac{\bar{u}_{BK}}{2}\right] \qquad (3\text{-}41)$$

The mean standard deviation of the wind elevation angle in radians in the layer between H_{nK} and the base of the K^{th} layer is given by the expressions

$$\sigma'_{EnK}\{K=1\} = \frac{\sigma_{ER}\left[\left(H_{nK}\{K=1\}\right)^{1+q} - \left(z_R\right)^{1+q}\right]}{\left(1+q\right)\left(H_{nK}\{K=1\} - z_R\right)\left(z_R\right)^q}\left(\frac{\pi}{180}\right) \qquad (3\text{-}42)$$

$$\sigma'_{EnK}\{K>1\} = \frac{1}{H_{nK}}\left\{\left[\sigma'_{EnK}\{K=1\}\right] + \left[\sum_{i=2}^{K-1} \sigma'_{Ei}\left(z_{Ti} - z_{Bi}\right)\right]\right.$$

$$(3\text{-}43)$$

$$\left. + \frac{\pi\left(H_{nK} - z_{BK}\right)}{360}\left[\left(\frac{\sigma_{ETK} - \sigma_{EBK}}{z_{TK} - z_{BK}}\right)\left(H_{nK} - z_{BK}\right) + \sigma_{EBK}\right]\right\}$$

The vertical diffusion coefficient in the layer between H_{nK} and the base of the K^{th} layer is given by the terms

$$\bar{\beta}_K \{K=1\} = \beta_K \tag{3-44}$$

$$\bar{\beta}_K \{K>1\} = \frac{1}{H_{nK}} \left\{ \left[\sum_{i=1}^{K-1} \beta_i \left(z_{Ti} - z_{Bi} \right) \right] + \left[\beta_K \left(H_{nK} - z_{BK} \right) \right] \right\} \tag{3-45}$$

The standard deviation of the crosswind distribution of material downwind from the source, σ_{ynK}, is given by the expression

$$\sigma_{ynK} = \left\{ \left[\sigma'_{AnK} \left(x_r \right) \left(\frac{x_s + x_{yK}}{x_r} \right)^{\bar{\alpha}_K} \right]^2 + \left[\Delta Y_K \right]^2 \right\}^{1/2} \tag{3-46}$$

where

σ'_{AnK} = mean standard deviation of the wind azimuth angle in radians in the layer between H_{nK} and the ground

$$\sigma'_{AnK}\{K=1\} = \frac{\sigma_{AR} \left[\left(H_{nK}\{K=1\} \right)^{1+m} - \left(z_R \right)^{1+m} \right]}{\left(1+m \right) \left(H_{nK}\{K=1\} - z_R \right) \left(z_R \right)^m} \left(\frac{\pi}{180} \right)$$

$$\sigma'_{AnK}\{K>1\} = \frac{1}{H_{nK}} \left\{ \left[\sigma'_{AnK}\{K=1\} \right] + \left[\sum_{i=2}^{K-1} \sigma'_{Ai} \left(z_{Ti} - z_{Bi} \right) \right] + \frac{\pi \left(H_{nK} - z_{BK} \right)}{360} \left[\left(\frac{\sigma_{ATK} - \sigma_{BTK}}{z_{TK} - z_{BK}} \right) \left(H_{nK} - z_{BK} \right) + \sigma_{ABK} \right] \right\}$$

x_{yK} = lateral virtual distance in the layer

$$= x_r \left(\frac{\sigma_{yo}\{K\}}{\sigma_{AnK} \; x_r} \right)^{1/\bar{\alpha}_K}$$

$$\Delta Y_K = \frac{\sigma'_{EnK} \left(x_s \right)^{\beta_K} \; Y_{nK}}{H_{nK}}$$

The mean lateral diffusion coefficient in the layer between H_{nK} and the surface is given by the terms

$$\bar{\alpha}_K\{K=1\} = \alpha_K \tag{3-47}$$

$$\bar{\alpha}_K\{K>1\} = \frac{1}{H_{nK}} \left\{ \left[\sum_{i=1}^{K-1} \alpha_i \left(z_{Ti} - z_{Bi} \right) \right] + \left[\alpha_K \left(H_{nK} - z_{BK} \right) \right] \right\} \tag{3-48}$$

The number of elementary sources ξ_K required to simulate a uniformly distributed source in the vertical is given by the expression

$$\xi_K = \left(z_{TK} - z_{BK} \right) \Big/ \Delta h_K \tag{3-49}$$

where

Δh_K = vertical separation of elemental area sources in the K^{th} layer

$$= R\sigma'_{EH}\left(X_{HK}^{2} + Y_{HK}^{2}\right)^{1/2}\left(1 + \frac{V_s}{\bar{u}_{HK}}\right)^{1/2}$$

R = a constant value depending on the accuracy desired in simulating a vertical line source configuration. A value of $R = 0.45$ yields deposition estimates that are within 10 percent of the true value

$$\sigma'_{EH} = \sigma'_{EnK} \text{ with } H_{nK} = \frac{1}{3}\left(z_{TK} - z_{BK}\right) + z_{BK}$$

$$X_{HK} = X_{nK} \text{ with } H_{nK} = \frac{1}{3}\left(z_{TK} - z_{BK}\right) + z_{BK}$$

$$Y_{HK} = Y_{nK} \text{ with } H_{nK} = \frac{1}{3}\left(z_{TK} - z_{BK}\right) + z_{BK}$$

$$\bar{u}_{HK} = \bar{u}_{nK} \text{ with } H_{nK} = \frac{1}{3}\left(z_{TK} - z_{BK}\right) + z_{BK}$$

The angle between the axis of the ground-level deposition pattern and the radial connecting source and receptor for settling velocity V_s is defined by the expression

$$\phi_s = \left|\theta_1 - 180 + \Phi_s - \theta_R\right| \quad \left(0 < \theta_1 < 180\right)$$

$$\phi_s = \left|\theta_1 + 180 + \Phi_s - \theta_R\right| \quad \left(180 < \theta_1 < 360\right) \tag{3-50}$$

where

θ_1 = mean wind direction at the reference height z_R

θ_R = angle between north and a line connecting source and receptor

$$\Phi_s = \tan^{-1}\left(\frac{Y_{nK}}{X_{nK}}\right)$$

3.8.2 Gravitational Deposition Model for a Volume Source in the K^{th} Layer

For a volume source at height H_{SK} in the K^{th} layer, the ground-level deposition from gravitational settling is given by the expression

$$DEP_{SK} = \frac{f_i Q_{SK}}{2\pi \sigma_{ySK}} \left\{ M_{SK} + N_{SK} \right\} \left\{ \exp\left[-\frac{1}{2}\left(\frac{y_{SK}}{\sigma_{ySK}}\right)^2 \right] \right\} \tag{3-51}$$

where the subscript SK indicates that the parameters refer to a single source in the K^{th} layer. The subset of equations which define the SK subscripted parameters is the same as the subset defining the terms in Equation (3-37) except the following substitution is made for the term x appearing in Equations (3-38) and (3-39):

$$x_s = R_{SK} \cos \phi_{SK} + x_{zSK} \tag{3-52}$$

where

x_{zSK} = the vertical virtual distance for the volume source

$$= x_r \left(\frac{\sigma_{zo}\{SK\}}{\sigma'_{ESK}\ x_r} \right)^{1/\beta_K}$$

σ'_{ESK} = mean standard deviation of the wind elevation angle in the layer between H_{SK} and the ground

$\sigma_{zo}\{SK\}$ = vertical source dimension of the volume source

In using Equation (3-51), deposition patterns from all values of V_{SK} representative of the particle or droplet size distribution of the volume source are summed on a reference coordinate system to obtain the total deposition pattern.

3.9 USE OF THE MULTI-LAYER CONSTRUCT FOR COLD SPILLS AND FUEL LEAKS IN THE SURFACE LAYER

The multi-layer construct can be used, through adaptation of model inputs, to estimate concentration fields downwind from cold spills at the surface and fuel leaks near ground-level. As mentioned in Section 2.5 above, the concentration model for continuous source emission is similar in form to the dosage model for instantaneous sources. In the computer program, Model 3 described in Section 3.3 above can thus be used as a concentration model for surface spills and leaks if proper adjustments are made in values of the input parameters. The adjustments include the requirement that σ_A, σ_E and $\bar{u}$ be specified at source height. Also, the reference value of σ_A must be adjusted to an averaging time τ. The averaging time τ will usually be either the source emission time, or a period for which toxicity levels have been established. The requisite adjustments in meteorological and source input parameters when Model 3 is used to calculate concentration fields downwind from cold spills and fuel leaks are described in Sections 4.2.2 and 4.3.2 below.

SECTION 4

DESCRIPTION OF THE COMPUTER PROGRAM FOR THE KSC MULTI-LAYER DIFFUSION MODEL

The equations for the multi-layer construct given in Section 3 have been programmed for machine calculations. This section describes the general organization of the program as well as the meteorological and source inputs required for various types of toxic fuel hazard problems. As explained below, the primary emphasis has been placed on machine calculations of toxic fuel hazards arising from normal and abnormal launches and vehicle destructs in a reference volume that extends vertically from the earth's surface to a height of 5 kilometers and extends laterally to maximum distances of the order of 100 kilometers from Kennedy Space Center. At present, calculations of the hazard arising from cold surface spills and fuel leaks are made in the program by using the dosage form of the multi-layer model for a volume source. While this procedure gives the appropriate estimates of ground-level concentrations, certain alterations in the source and meteorological inputs are required. For future use, it would probably be desirable to modify the program so that the cold-spill and fuel-leak calculations can be made directly as a program option. There was not time to accomplish this under the present contract.

4.1 ORGANIZATION OF THE COMPUTER PROGRAM

The computer program for the KSC multi-layer diffusion model is written in FORTRAN V and has been run on the UNIVAC 1108 machine at the University of Utah Computer Center. The program contains 22 subroutines, including the main driver, and requires 33280_{10} executable case locations.

Figure 4-1 shows in block diagram form the seven diffusion models and the five major logic sections of the computer program. Section 1 provides for

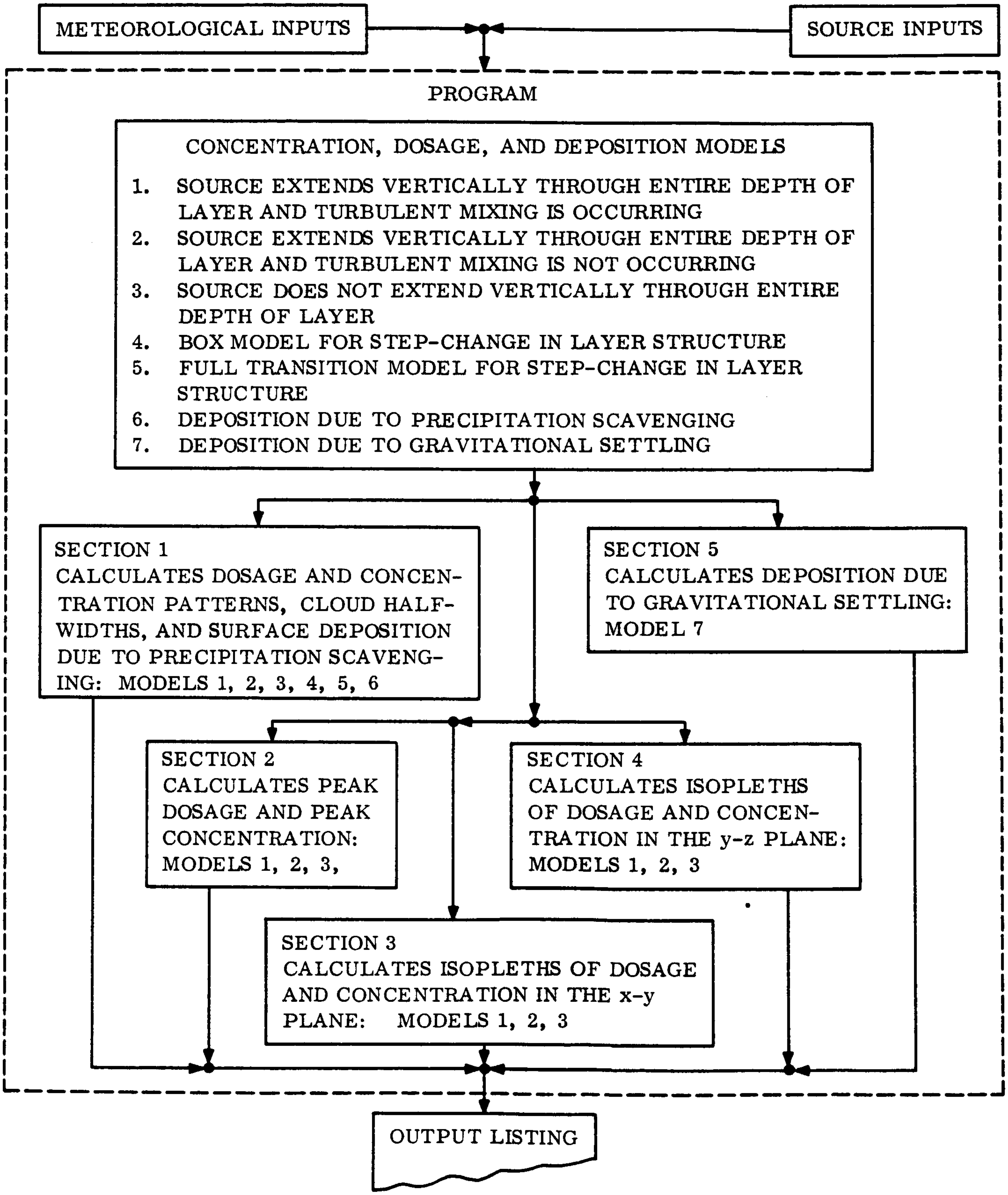

FIGURE 4-1. Block diagram of the computer program for the KSC multi-layer diffusion model.

calculations of concentration and dosage at selected points referenced to a three-dimensional coordinate system. The origin of this system can be located at any convenient point in the ground plane and either Cartesian or polar coordinates may be used. If Cartesian coordinates are employed, the positive y-axis is directed toward true north and the positive x-axis is directed toward east. In the polar coordinate system, north is 0 degrees and east is 90 degrees. The maximum number of receptor locations that can be specified in the ground plane is 10,000. Additionally, a maximum of 100 receptor locations may be specified along the vertical above each receptor point in the ground plane. Section 1 of the program also contains transformation equations that relate the cloud-layer geometry, which is referenced to the layer mean wind direction, to the ground-plane reference grid. As shown in Figure 4-1, Logic Section 1 uses Models 1 through 6 to calculate layer concentration and dosage patterns, surface deposition due to washout or precipitation scavenging, and cloud half-widths.

Section 2 of the computer program contains the logic for calculating maximum concentrations and peak dosages for Models 1, 2 and 3. The logic required to calculate concentration and dosage isopleths for Models 1, 2 and 3 is in Sections 3 and 4 of the program; Section 3 refers to isopleths in the x-y plane while Section 4 refers to isopleths in the y-z plane. Logic Sections 1 through 4 can be combined, if desired, in a single execution. The logic in Section 5 provides for calculations of surface deposition due to gravitational settling from Model 7. The deposition is calculated at the receptor locations specified for the ground-plane reference grid mentioned above.

A detailed explanation of the operation of the computer program is given in Appendix A and a complete program listing is given in Appendix B. The program flow chart is contained in Appendix C. A sample problem including input card formats and a listing of the program output is given in Appendix D. Appendix E contains example program calculations of toxic fuel hazards arising from normal launch, vehicle destruct, and a surface cold spill. Assembly time for the program is 30 seconds and the maximum run time experienced for the example calculations described in Section 6 is 3.5 minutes.

4.2 METEOROLOGICAL INPUTS

4.2.1 Multi-Layer Construct

Meteorological inputs for the multi-layer construct are listed in Table 4-1. Selection of meteorological inputs begins with the assignment of layer boundaries based on the vertical profiles of wind, temperature, and humidity within this volume. The vertical profiles used to determine layer boundaries may be either observed or forecast, and should be representative of the structure within a reference volume. Except for the cold spill and fuel-leak problems, the reference volume at Kennedy Space Center extends to a height of 5 kilometers and extends horizontally to a maximum distance of about 100 kilometers. Spatial or temporal variations in structure within the volume may be accommodated by step changes in model inputs, as explained in Sections 3.5 and 3.6. Layer boundaries are assigned principally on the basis of KSC radiosonde, Jimsphere, and 150-meter tower data. Vertical profiles of wind speed, wind direction, temperature, and dewpoint are inspected for major discontinuities, and layer boundaries are assigned to isolate regions of different thermal stability and wind shear. It should be noted that the assignment of layer boundaries removes the necessity for specifying the depth of the mixing layer H_m as a separate model input. When a ground-based temperature inversion exists, the top of the surface layer is assumed to coincide with the top of the inversion. The procedure for subdividing the atmosphere into layers is illustrated in Appendix E of this report and in Section 3 of the Final Report under Contract No. NAS8-30503 (Record, et al., 1970). After the layer boundaries have been specified, values of wind speed, wind direction and potential temperature are assigned at the top and bottom of each layer, and at a reference height within the surface layer. The

TABLE 4-1

METEOROLOGICAL INPUT PARAMETERS FOR MULTI-LAYER CONSTRUCT

Parameter	Definition
$\sigma_{AR}\{\tau_{oR}\}$	Standard deviation of wind azimuth angle in degrees at z_R for reference time τ_{oR}
σ_{ER}	Standard deviation of wind elevation angle in degrees at z_R
$\bar{u}_R$	Mean wind speed at z_R
z_R	Reference height in surface layer
$\sigma_{ATK}\{\tau_{oK}\}$, $\sigma_{ABK}\{\tau_{oK}\}$	Standard deviation of wind azimuth angle in degrees at the top and base of the K^{th} layer for reference time τ_{oK}
σ_{ETK}, σ_{EBK}	Standard deviation of wind elevation angle in degrees at the top and base of the K^{th} layer
$\bar{u}_{TK}$, $\bar{u}_{BK}$	Mean wind speed at the top and base of the K^{th} layer
θ_{TK}, θ_{BK}	Mean azimuth wind direction in degrees at the top and base of the K^{th} layer
Θ_{TK}, Θ_{BK}	Potential temperature at the top and base of the K^{th} layer
z_{TK}, z_{BK}	Height of the top and base of the K^{th} layer
α_K	Lateral diffusion coefficient in the K^{th} layer
β_K	Vertical diffusion coefficient in the K^{th} layer
Λ	Washout coefficient
z_{lim}	Height interval through which precipitation falls
t_1	Time precipitation begins
t^*	Time at which change in layer structure occurs

potential temperatures are used to calculate the effective source height in the layer when heat is generated during the release mode. This calculation is performed outside the program.

Values of the turbulence parameters σ_A and σ_E must also be specified at the reference height z_R and at all layer boundaries. For general application at Cape Kennedy, z_R is assigned a value of 18 meters, corresponding to the lowest measurement height on the NASA 150-meter Meteorological Tower. The parameters $\sigma_{AR}\{\tau_{oR}\}$ and σ_{ER} are obtained from Figures 4-2 and 4-3, using the 18-meter mean wind speed and the temperature difference ΔT between 3 meters and 60 meters as predictors. In the absence of an observed ΔT, the following guidelines can be used to select an appropriate ΔT value. Under strong insolation, temperature differences of -2 to -1 degrees Celsius may be anticipated. Zero temperature differences occur during the morning and afternoon transition times and in the presence of overcast skies with moderate or strong winds. Estimates of the times of occurrence of the two diurnal transition periods throughout the year are given by the curves in Figure 4-4. Positive values of ΔT occur at night during periods of clear skies and light winds. According to Figures 4-2 and 4-3, $\sigma_{AR}\{\tau_{oR}\}$ and σ_{ER} are relatively insensitive to the magnitude of ΔT under stable conditions.

Model input values for $\sigma_A\{\tau_{oK}\}$ and σ_E at the top of the surface layer (K = 1) and, possibly, at the top of the K = 2 layer are obtained from the following expressions:

- Under all stability conditions

$$\sigma_{ATK}\{\tau_{oK}\} = \sigma_{AR}\{\tau_{oR}\}\left(\frac{z_{TK}}{z_R}\right)^{-p} , \quad K = 1 \qquad (4\text{-}1)$$

$$\sigma_{ATK}\{\tau_{oK}\} = \sigma_{ARK}\{\tau_{oK}\}\left(\frac{z_{TK}}{z_{BK}}\right)^{-p} , \quad K = 2 \qquad (4\text{-}2)$$

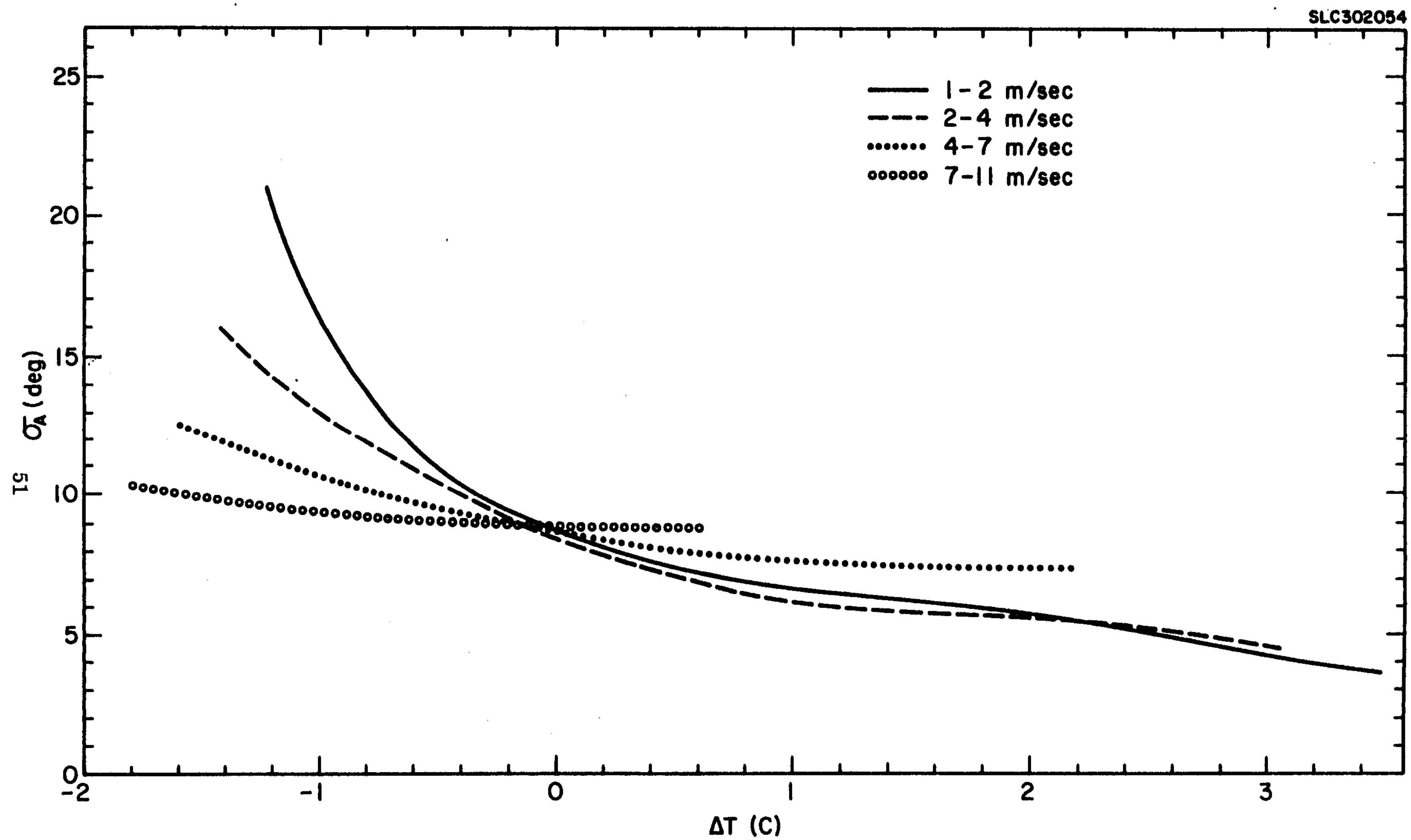

FIGURE 4-2. Dependence of σ_A at 18 meters on stability and wind speed at 18 meters. ΔT is the temperature at 60 meters minus the temperature at 3 meters.

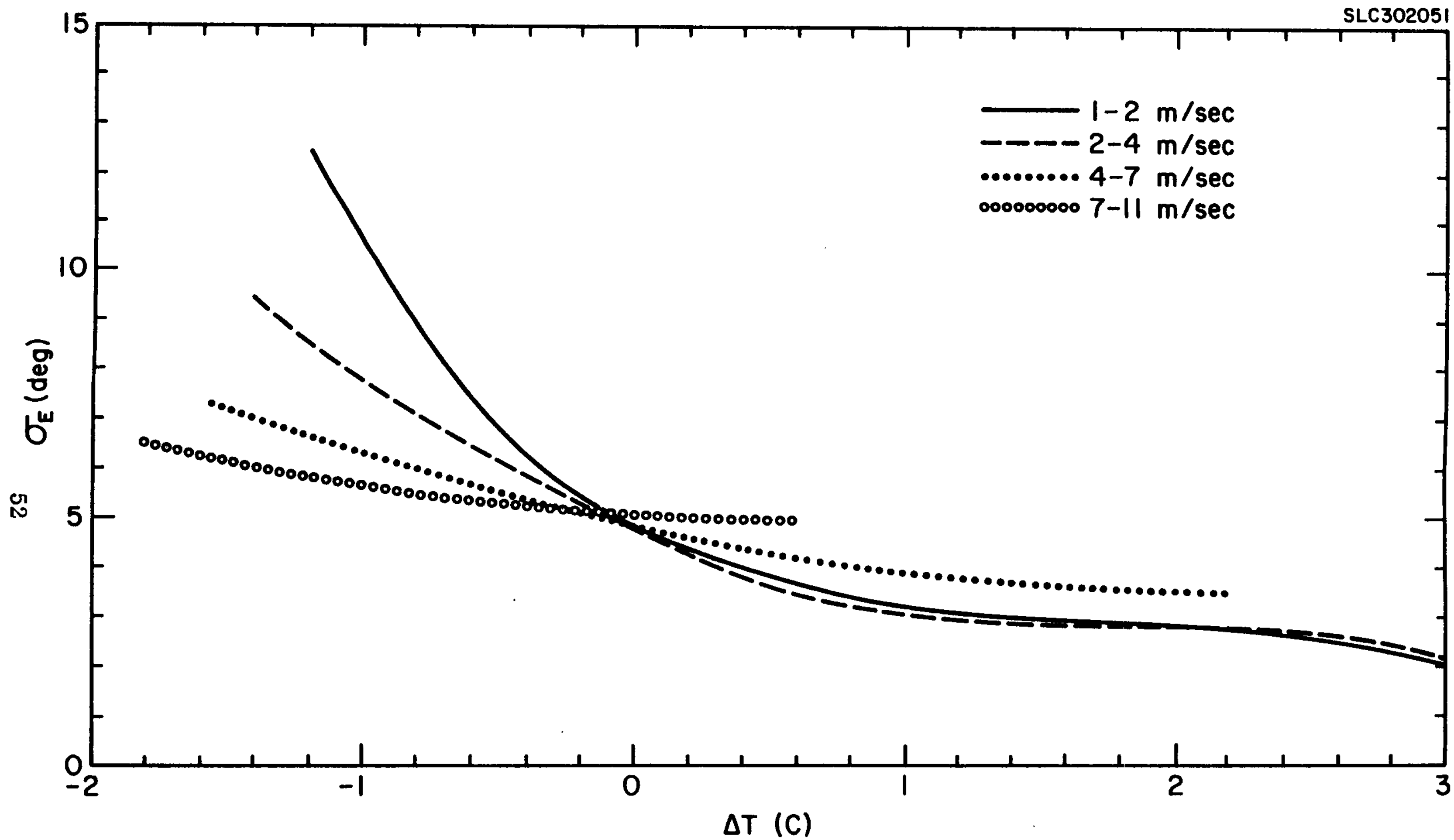

FIGURE 4-3. Dependence of σ_E at 18 meters on stability and wind speed at 18 meters. ΔT is the temperature at 60 meters minus the temperature at 3 meters.

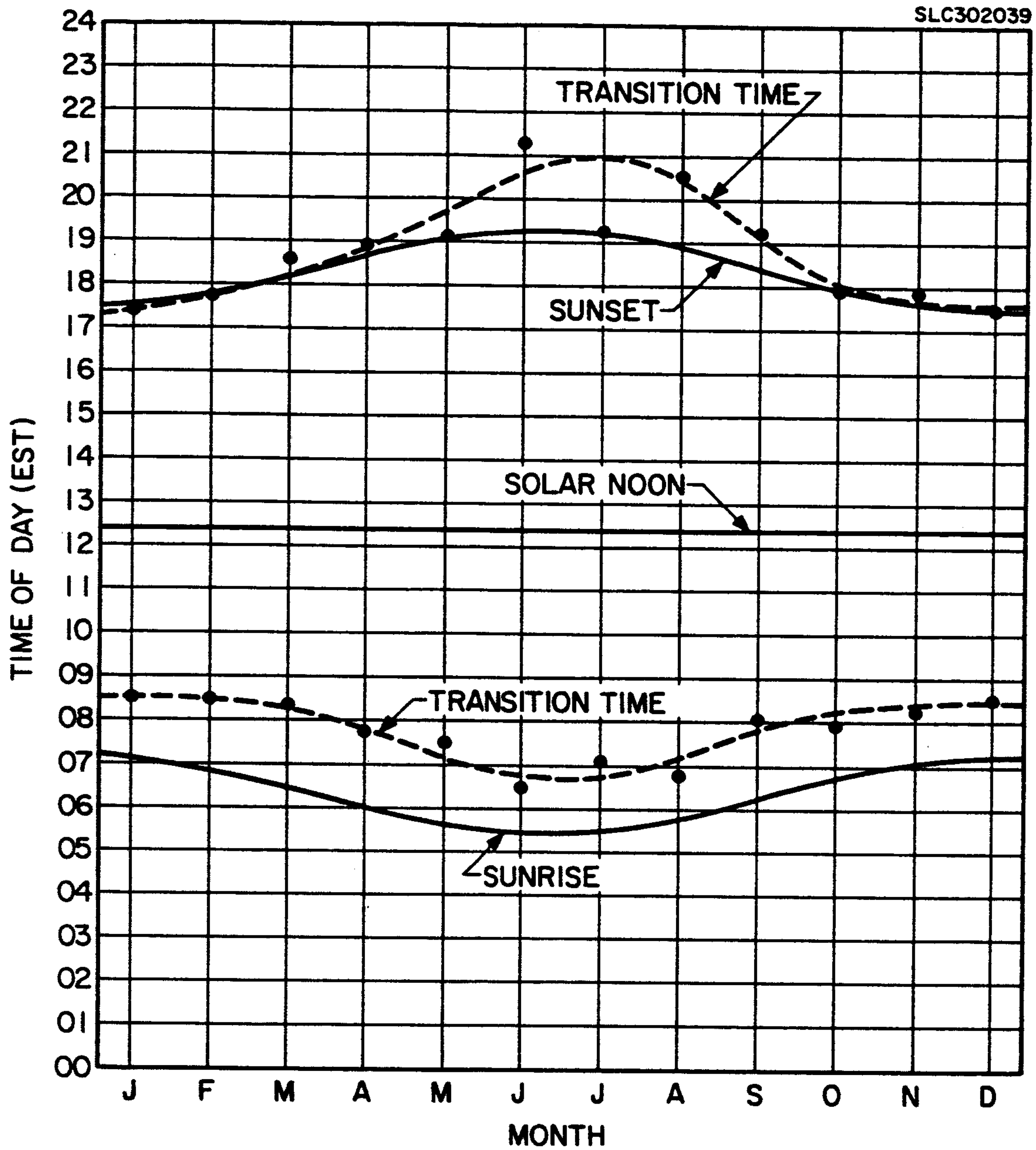

FIGURE 4-4. Seasonal variations in the time of transition from lapse to inversion (above) and from inversion to lapse (below) with respect to sunset and sunrise.

where $\sigma_{ARK}\{\tau_{oK}\}$ for K = 2 and $\sigma_{ATK}\{\tau_{oK}\}$ for K = 1 are equivalent

- Under unstable conditions

$$\sigma_{ETK} = \sigma_{ER} \left(\frac{z_{TK}}{z_R} \right)^{0.3-p} \quad , \quad K = 1 \tag{4-3}$$

$$\sigma_{ETK} = \sigma_{EBK} \left(\frac{z_{TK}}{z_{BK}} \right)^{0.3-p} \quad , \quad K = 2 \tag{4-4}$$

where $\sigma_{EBK}\{K=2\} = \sigma_{ETK}\{K=1\}$

- Under near-neutral and stable conditions

$$\sigma_{ETK} = \sigma_{ER} \left(\frac{z_{TK}}{z_R} \right)^{-p} \quad , \quad K = 1 \tag{4-5}$$

$$\sigma_{ETK} = \sigma_{BTK} \left(\frac{z_{TK}}{z_{BK}} \right)^{-p} \quad , \quad K = 2 \tag{4-6}$$

where $\sigma_{EBK}\{K=2\} = \sigma_{ETK}\{K=1\}$

In the above expressions, the quantity p is the exponent in the power-law relationship for the vertical profile of mean wind speed as defined by

$$\bar{u}_{TK} = \bar{u}_R \left(\frac{z_{TK}}{z_R} \right)^{p} \quad , \quad K = 1 \tag{4-7}$$

$$\bar{u}_{TK} = \bar{u}_{BK} \left(\frac{z_{TK}}{z_{BK}} \right)^{p} \quad , \quad K = 2 \tag{4-8}$$

The requisite turbulence inputs for layers K = 1, K = 2 may be calculated from the above expressions or by means of the nomograms given in Appendix F. For simplicity, the meteorological inputs for the reference height z_R are generally assumed to be representative of the base of the surface layer. However, values for some other height may be calculated from the power-law expressions for the layer K = 1 given above if desired. Above the surface layers, turbulent mixing is assumed negligible; σ_A and σ_E are consequently set equal to zero at the boundaries of layers in which no turbulent mixing is occurring. In the computer program, these zero inputs are interpreted as $\sigma_A = 0.5$ degrees and $\sigma_E = 0.1$ degrees. Also, in the program, wind speeds less than 0.1 meters per second, supplied as inputs to the program, or obtained through use of the power-law expression for the vertical profile of mean wind speed in the program, are interpreted as $\bar{u} = 0.1$ meters per second.

The diffusion coefficients α_K, β_K are set equal to unity for all releases.

Calculations of the effects of precipitation scavenging require specification of the washout coefficient Λ, the height interval through which precipitation falls z_{lim}, and the time after release at which the precipitation starts t_1. Existing knowledge of Λ is summarized by Engelmann (see Slade, 1968, pp. 213-220). In the absence of reliable estimates of Λ, a value of $\Lambda = 10^{-3}$ is suggested for hazard calculations. This maximizes the rate of removal of material by precipitation scavenging and may therefore lead to overestimates of surface deposition resulting from this process.

4.2.2 Surface Cold Spill and Fuel Leak

As explained in Section 3.9, the dosage form of Model 3 is used in the computer program to calculate concentration fields downwind from surface cold spills and fuel leaks that occur near ground level. The meteorological inputs given in Table 4-1, which refers only to the surface layer (K = 1), must be adapted for this purpose.

For correct application of Model 3 to cold spills and fuel leaks, values of σ_A, σ_E and $\bar{u}$ actually used in the program must apply at the height of release H. The mean wind speed $\bar{u}$ at release height H can be calculated from the power-law relationship

$$\bar{u}\{H\} = \bar{u}_R \left(\frac{H}{z_R}\right)^p \tag{4-9}$$

where the value of p is given by Figure 4-5. Appropriate values of σ_A and σ_E at H can be found from the following expressions:

- Under all stability conditions

$$\sigma_A\{\tau_o, H\} = \sigma_{AR}\{\tau_o\} \left(\frac{H}{z_R}\right)^{-p} \tag{4-10}$$

- Under unstable conditions

$$\sigma_E\{H\} = \sigma_{ER} \left(\frac{H}{z_R}\right)^{0.3-p} \tag{4-11}$$

- Under near-neutral and stable conditions

$$\sigma_E\{H\} = \sigma_{ER} \left(\frac{H}{z_R}\right)^{-p} \tag{4-12}$$

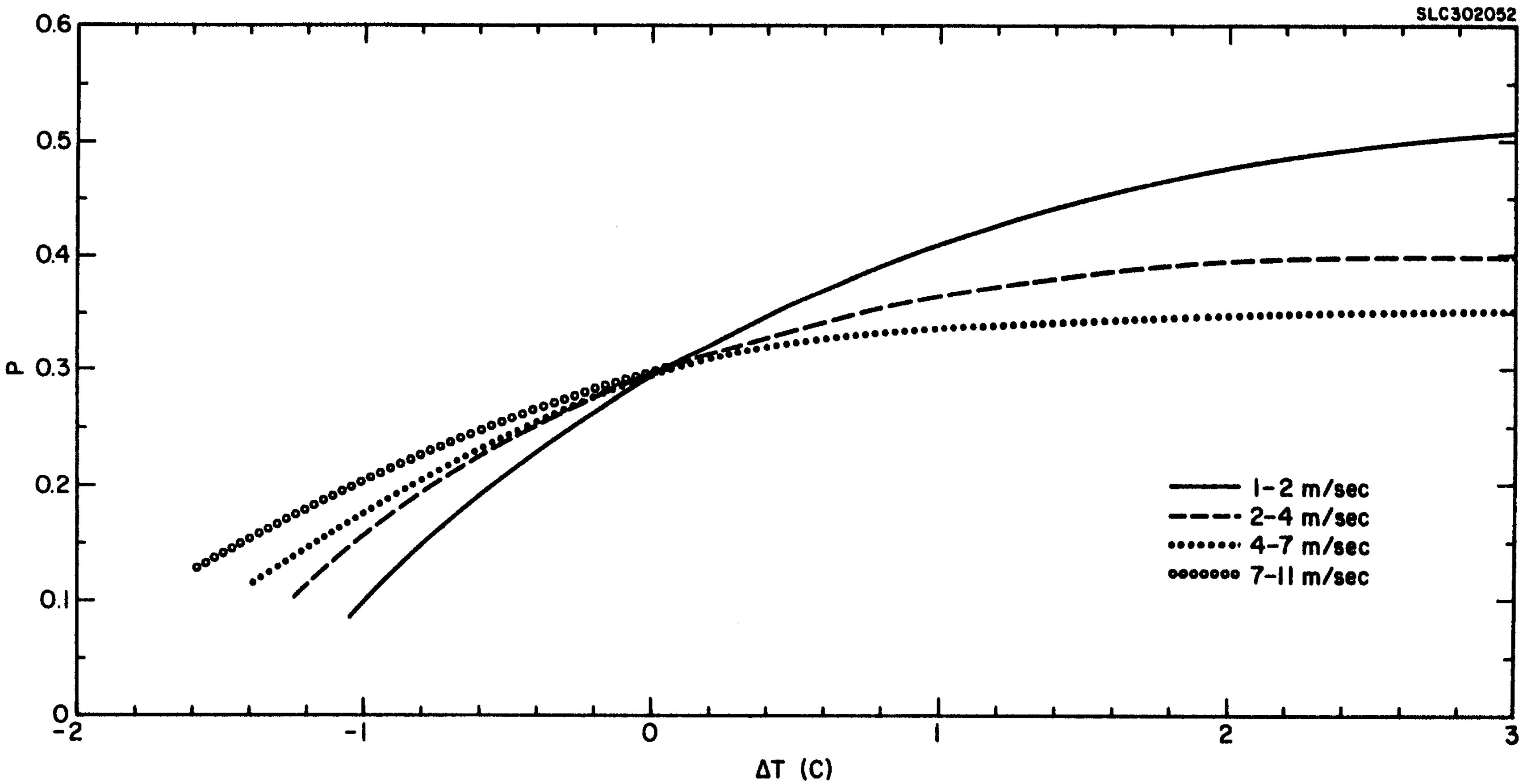

FIGURE 4-5. Dependence of p on stability and the wind speed at 18 meters. ΔT is the temperature at 60 meters minus the temperature at 3 meters.

The nomograms in Appendix F can also be used to calculate $\sigma_A\{\tau_o, H\}$, $\sigma_E\{H\}$, and $\bar{u}$ $\{H\}$ from the values of these parameters at the reference height z_R.

Adaptation of the computer program meteorological inputs of Table 4-1 for the multi-layer construct to hazard calculations for surface cold spills and fuel leaks is shown in Table 4-2. Values used for meteorological parameters from Table 4-1 in these calculations are entered in the second column of Table 4-2. The asterisk superscript denotes that a substitute or dummy value is required for the cold spill and fuel leak applications.

4.3 SOURCE INPUTS

4.3.1 Normal and Abnormal Launch, Vehicle Destruct

Source input parameters to the multi-layer diffusion model program are listed in Table 4-3 for normal and abnormal launch and vehicle destruct. The units for the source strength Q_K in each layer depend on the source configuration and the layer model used. When the source fills the layer, Q_K is expressed in terms of the total mass per unit depth of the layer. For a volume source, Q_K is simply the total mass available for downwind transport and dispersion. When ground deposition due to gravitational settling is calculated (see Section 3.8) for a source that fills the layer, Q_K is given by the mass released per unit time. The vehicle residence time T_K in the layer is used to convert the source strength for this special case into the units required by Equation (3-37). For calculating ground deposition due to gravitational settling downwind from a single volume source in the layer, the source strength Q_{SK} is expressed in terms of total mass released.

TABLE 4-2

METEOROLOGICAL INPUT PARAMETERS FOR SURFACE COLD SPILL AND FUEL LEAK HAZARD CALCULATIONS

PARAMETERS		DEFINITION
From Table 4-1	Substitution	
$\sigma_{AR}\{\tau_{oR}\}^*$	$\sigma_A\{\tau_o, H\}$	Standard deviation of wind azimuth angle in degrees at height of source H for reference time τ_o
$\sigma_{ER}{}^*$	$\sigma_E\{H\}$	Standard deviation of wind elevation angle in degrees at height of source H
z_R	z_R	Reference height of 18 meters
$\sigma_{ATK}\{\tau_{oK}\}^*$, $\sigma_{ABK}\{\tau_{oK}\}^*$	$\sigma_A\{\tau_o, H\}$	
$\sigma_{ETK}{}^*$, $\sigma_{EBK}{}^*$	$\sigma_E\{H\}$	
$\bar{u}_{TK}{}^*$, $\bar{u}_{BK}{}^*$	$\bar{u}\{H\}$	Mean wind speed at height of source H
θ_{TK}, θ_{BK}	θ_{TK}, θ_{BK}	Mean wind direction at the top and base of the surface layer
z_{TK}, z_{BK}	$z_{TK}\{K=1\}$, $z_{BK}\{K=1\}$	Height above ground of the top and base of the surface layer
α_K		Lateral diffusion coefficient
β_K	1.0	Vertical diffusion coefficient

TABLE 4-3

SOURCE INPUT PARAMETERS FOR NORMAL AND ABNORMAL LAUNCH, VEHICLE DESTRUCT

PARAMETER	DEFINITION
Q_K, Q_{SK}	Source strength expressed either as total mass of material in the K^{th} layer or as the total mass per meter of layer depth
H_K, H_{SK}	Effective height of source above ground
τ_K	Source emission time or cloud stabilization time
$\sigma_{xo}\{K\}$	Alongwind source dimension
$\sigma_{yo}\{K\}$	Crosswind source dimension
$\sigma_{zo}\{K\}$	Vertical source dimension
k	Decay coefficient
V_s	Settling velocity
f_i	Fraction of material with settling velocity V_s
T_K	Residence time of vehicle in layer K

Because of the large amounts of thermal energy that may be released during normal or abnormal launch, vehicle destruct, or hot spills, it is essential to have a satisfactory method of estimating the buoyant rise of material thus released. The following formula, after Briggs (see Record, et al., 1970), is recommended for use in estimating the buoyant cloud rise Δh:

$$\Delta h = 8.0 \left(\frac{Q'}{\Delta \Theta} \right)^{1/3} \tag{4-13}$$

where

Δh = cloud rise (meters)

Q' = energy released (kilocalories)

$\Delta \Theta$ = change in potential temperature over Δh

If the gradient of potential temperature with height is used instead of $\Delta \Theta$, the expression for Δh becomes

$$\Delta h = 4.76 \left(\frac{Q'}{\partial \Theta / \partial z} \right)^{1/4} \tag{4-14}$$

The effective height of the source H_K is thus given by

$$H_K = h + \Delta h \tag{4-15}$$

where h = height of source before the cloud is affected by buoyant rise. Equation (4-14) fits cloud rise data from high-explosive detonations recently published by Church (1969). Susko, Kaufman, and Hill (1968) have shown that the plume rise formula for continuous sources given by Morton, Taylor, and Turner (1956) provide satisfactory estimates of the buoyant rise of exhaust plumes from statically fired rocket engines.

In Table 4-3, H_{SK} is the effective height above ground of a single volume source comprised of heavy particles or droplets and is used in the calculation of deposition at the ground due to gravitational settling (see Equation (3-51)). The height H_{SK} is also calculated from Equation (4-15) with H_{SK} substituted for H_K.

The time τ_K required for the cloud to become stabilized immediately following the emission process is dependent on the mode of release. In the case of a vehicle destruct or hot spill, τ_K is of the order of 100 seconds. For normal launches, the time required for cloud stabilization is approximately the same as the vehicle residence time in the layer.

The source dimensions σ_{xo}, σ_{yo} and σ_{zo} appearing in Table 4-3 also depend on the mode of release. Reliable source dimensions are probably best obtained from photographic measurements or observations of actual releases. Gifford (see Slade, 1968, pp. 103-105) discusses the quantitative use of plume observations to determine cloud dimensions. Under the assumptions that the distribution of material within the plume is Gaussian and the visible edge of the plume represents one-tenth of the axial concentration, the standard deviation of the concentration distribution is obtained by multiplying the observed plume dimension by the factor 1/4.3.

The use of Model 7 to calculate ground deposition due to gravitational settling requires that the distribution of settling velocities be specified. When the size distribution of the material is known, the distribution is partitioned into categories and the settling velocity is calculated for each category. Van der Hoven (see Slade, 1968, pp. 202-203) discusses the calculation of settling velocity and gives settling velocities for particles of density 2.5 and 5 grams per cubic centimeter. Johnson (1954, p. 230) presents a table of settling velocities for water droplets.

4.3.2 Surface Cold Spill and Fuel Leak

As mentioned previously, the dosage form of Model 3 is used to calculate concentration fields downwind from cold surface spills and fuel leaks that occur near ground level. The source inputs listed in Table 4-2 must be adapted for this purpose for the source in the surface layer K = 1.

Since fuel leaks and evaporation from surface spills are semi-continuous sources, the source strength Q must be expressed in terms of mass per unit time. In the case of the surface spill, the release height is set equal to zero. For a fuel leak, the height at which the leak occurs is used.

For correct application of Model 3 to cold spills and fuel leaks, the source emission time τ must be adjusted for emission times greater than ten minutes. According to Hino (1968), and others, time-mean concentrations downwind from continuous sources are inversely proportional to the square root of the time τ, for values of τ ranging from about 10 to 60 minutes. For $\tau < 10$ minutes, a one-fifth power law is applicable (see Equation (2-12)). The computer program contains a routine that adjusts $\sigma_A\{\tau\}$ for source emission times less than 10 minutes according to the one-fifth power law, but has no provision for adjusting $\sigma_A\{\tau\}$ for source emission times greater than 10 minutes. Thus, when source emission times exceed 10 minutes, the following substitute value of τ must be used in the program:

$$\tau \text{ (input value)} = \left(\tau_o\right)^{-3/2}\left(\tau\right)^{5/2} \qquad (4\text{-}16)$$

where τ_o = reference time period between 10 and 60 minutes

τ = source emission time > 10 minutes for cold spills and fuel leaks

The use of Equation (4-16) to obtain the input value of τ causes the program to adjust $\sigma'_A\{\tau\}$ according to the expression

$$\sigma'_A\{\tau\} = \sigma'_A\{\tau_o\}\left(\frac{\tau}{\tau_o}\right)^{1/2} \quad 10 \text{ min} < \tau < 60 \text{ min} \qquad (4\text{-}17)$$

The source dimension σ_{yo} for surface spills can be obtained by dividing the crosswind dimension of the spill by 4.3. The vertical source dimension, σ_{zo}, is usually small. In the example hazard calculations in Section 5 and Appendix E, σ_{zo} has been arbitrarily set equal to 1 meter. The values of σ_{yo} and σ_{zo} in the case of a fuel leak are also likely to be small. In the absence of detailed observations, a value of 1 meter for both σ_{yo} and σ_{zo} is suggested for use in hazard calculations.

Adaptation of the computer program source inputs of Table 4-3 for the multi-layer construct to hazard calculations for surface cold spills and leaks is shown in Table 4-4. Values used for the source parameters from Table 4-3 in these calculations are entered in the second column of Table 4-4. The asterisk superscript denotes that a substitute value is required for the cold spill and fuel leak applications.

TABLE 4-4

SOURCE INPUT PARAMETERS FOR SURFACE COLD SPILL AND FUEL LEAK HAZARD CALCULATIONS

PARAMETERS		DEFINITION
From Table 4-3	Substitution	
Q_K , Q_{SK}	Q	Source strength in terms of mass per unit time
H_K , H_{SK}	H	Release height
τ_K^*	τ	Source emission time
$\sigma_{xo}\{K\}$	σ_{xo}	Alongwind source dimension
$\sigma_{yo}\{K\}$	σ_{yo}	Crosswind source dimension
$\sigma_{zo}\{K\}$	σ_{zo}	Vertical source dimension
k	k	Decay coefficient

SECTION 5

GRAPHICAL PROCEDURES FOR ESTIMATING GROUND-LEVEL CONCENTRATIONS AND DOSAGES

Graphs and tables are given in this section for estimating ground-level concentrations and dosages resulting from normal and abnormal launches, vehicle destruct, fuel spills and fuel leaks. The estimates refer only to sources contained within the surface layer. The graphs give estimates of axial concentration and dosage as a function of travel distance, and the tables give the widths of selected isopleths. In addition, nomograms are presented that provide box-model estimates of axial concentration and dosage from quasi-instantaneous sources as a function of mixing depth for maximum travel distances of 100 kilometers. No allowance is made for depletion or for changes in atmospheric structure that may occur during cloud travel.

5.1 SELECTION OF STABILITY CATEGORIES

For convenience, atmospheric conditions within the surface layer at KSC are described by stability categories similar to those used by Gifford (1961), Pasquill (1961), and Turner (1969). In preparing the graphs and tables of Sections 5.2 and 5.4, seven stability categories were used based on an analysis of meteorological data collected at NASA's 150-meter Tower Facility (Record, et al., 1970). The first step in developing the stability categories for KSC was to abstract values of the meteorological parameters σ_A, σ_E and p from Figures 4-2, 4-3 and 4-5, respectively, for selected ΔT values and for the four wind speed classes. The results are shown in Table 5-1. The temperature differences ΔT in the column headings of the table refer to heights of 3 and 60 meters. The wind speed and ΔT classes in Table 5-1 were then combined into the seven stability categories shown in Table 5-2. Average values of σ_A, σ_E and p for each stability category, which are shown in Table 5-3, were used to calculate concentration and

TABLE 5-1

VALUES OF σ_A, σ_E AND p FOR SELECTED STABILITY AND WIND SPEED CLASSES

Wind Speed at 18m (m sec^{-1})		STABILITY CLASS				
		Very Unstable ($\Delta T=-1.4C$)	Slightly Unstable ($\Delta T=-0.8C$)	Near-Neutral or Transitional ($\Delta T=0C$)	Slightly Stable ($\Delta T=0.4C$)	Very Stable ($\Delta T=2.0C$)
1-2	σ_A(deg)	25	14	8.5	7.5	5.5
	σ_E(deg)	15	9	5	4	3
	p	0.05	0.15	0.29	0.35	0.47
2-4	σ_A(deg)	16	12	8.5	7.5	5.5
	σ_E(deg)	9.5	7	5	4	3
	p	0.07	0.19	0.29	0.33	0.39
4-7	σ_A(deg)	12	10	8.5	8	7
	σ_E(deg)	7	6	5	4.5	3.5
	p	0.12	0.20	0.29	0.32	0.34
7-11	σ_A(deg)	10	9.5	8.5	8.5	--
	σ_E(deg)	6	5.5	5	5	--
	p	0.15	0.22	0.29	--	--

TABLE 5-2

KEY TO STABILITY CATEGORIES

Wind Speed at 18 m (m sec^{-1})	STABILITY CLASS				
	Very Unstable (ΔT=-1.4C)	Slightly Unstable (ΔT=-0.8C)	Near-Neutral or Transitional (ΔT=0C)	Slightly Stable (ΔT=0.4C)	Very Stable (ΔT=2.0C)
1-2	I	II	V	VI	VII
2-4	II	III	V	VI	VII
4-7	III	IV	V	V	VI
7-11	IV	V	V	V	--

TABLE 5-3

METEOROLOGICAL INPUTS FOR EACH STABILITY CATEGORY

	CATEGORY						
	I	II	III	IV	V	VI	VII
σ_A (deg)	25	15	12	10	8.5	7.5	5.5
σ_E (deg)	15	9	7	6	5	4	3
p	0.05	0.11	0.15	0.18	0.29	0.34	0.42

dosage fields. For fuel leaks and surface spills, 10-minute values of σ_A and σ_E at the 18-meter reference height were obtained from Table 5-3 and used as model inputs. For the normal launch, it was assumed that σ_A varied with height as z^{-p}. Wind speed was assumed to vary with height as z^p throughout the surface layer in all calculations.

5.2 CONCENTRATION AND DOSAGE FIELDS FROM A NORMAL LAUNCH

Figures 5-1 and 5-2 give the maximum normalized concentrations and dosages, respectively, from a normal launch, as a function of travel distance, for the seven stability categories. In this case, the source extends vertically through the entire surface mixing layer. The source strength has been assumed invariant with height and the initial cloud diameter has been assumed to be 1250 meters. The maximum concentration and dosage values thus apply to all heights within the mixing layer.

In the calculations, the 10-minute σ_A values were reduced by the one-fifth power-law to values appropriate for the time required for cloud stabilization, τ, in the surface layer. The values of τ were assumed equal to the residence time of the vehicle, in this case a Saturn V, in the layer, and were determined from Figure E-7 of Appendix E. The values of τ used for each mixing height are given in Table 5-4.

Tables 5-5 and 5-6, respectively, give the widths of selected normalized concentration and dosage isopleths.

To obtain actual concentration levels, the normalized values in Figure 5-1 and Table 5-5 are multiplied by Q, where Q is the amount of material released per meter of height. To obtain actual dosage levels, the normalized values in Figure 5-2 and Table 5-6 are multiplied by $Q/\bar{u}$, where Q is again the amount of material released per meter, and $\bar{u}$ is the wind speed at a height of 18 meters.

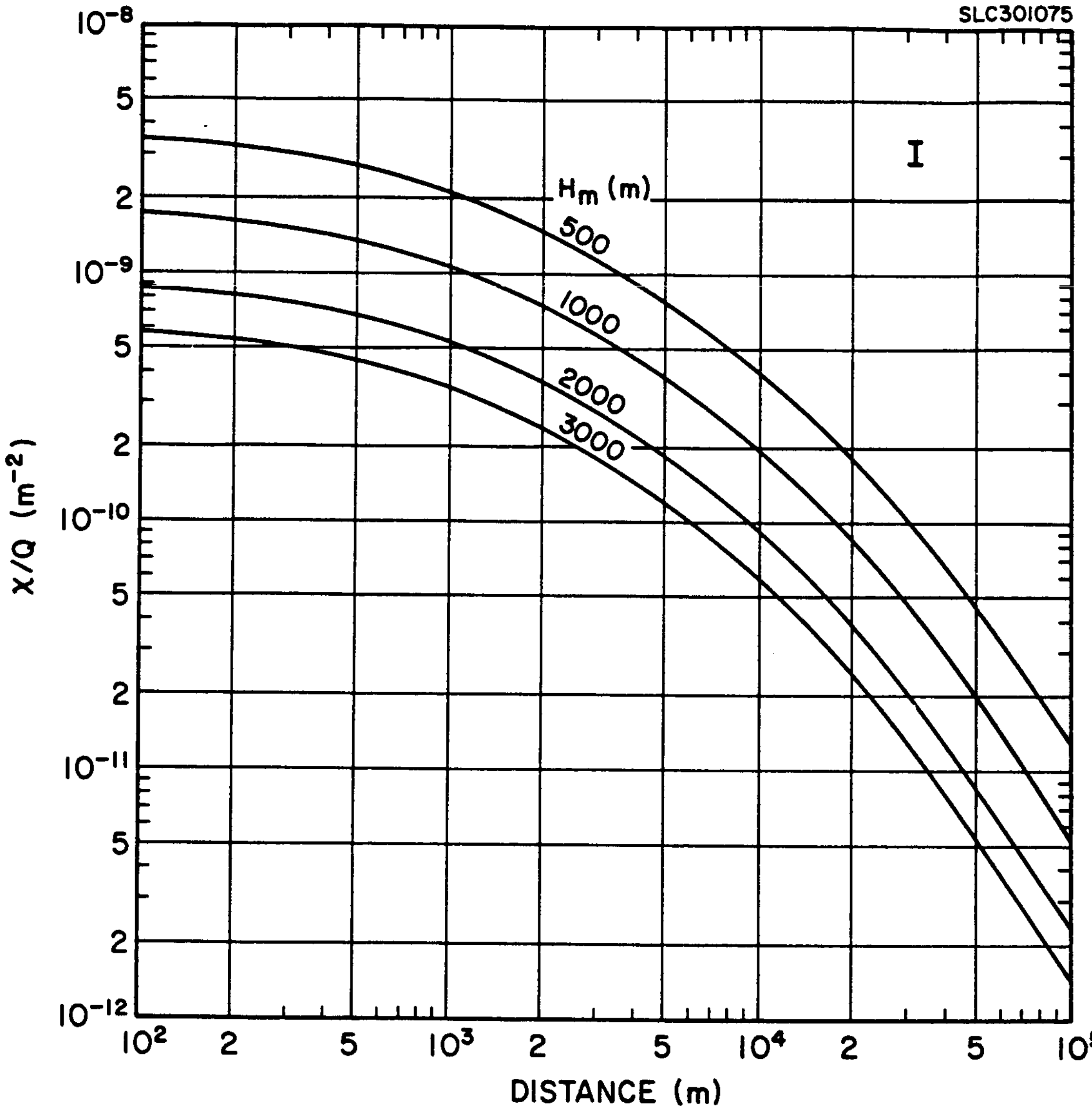

FIGURE 5-1. Normalized maximum concentration as a function of travel distance from a normal launch for Stability Category I. H_m is the depth of the surface mixing layer.

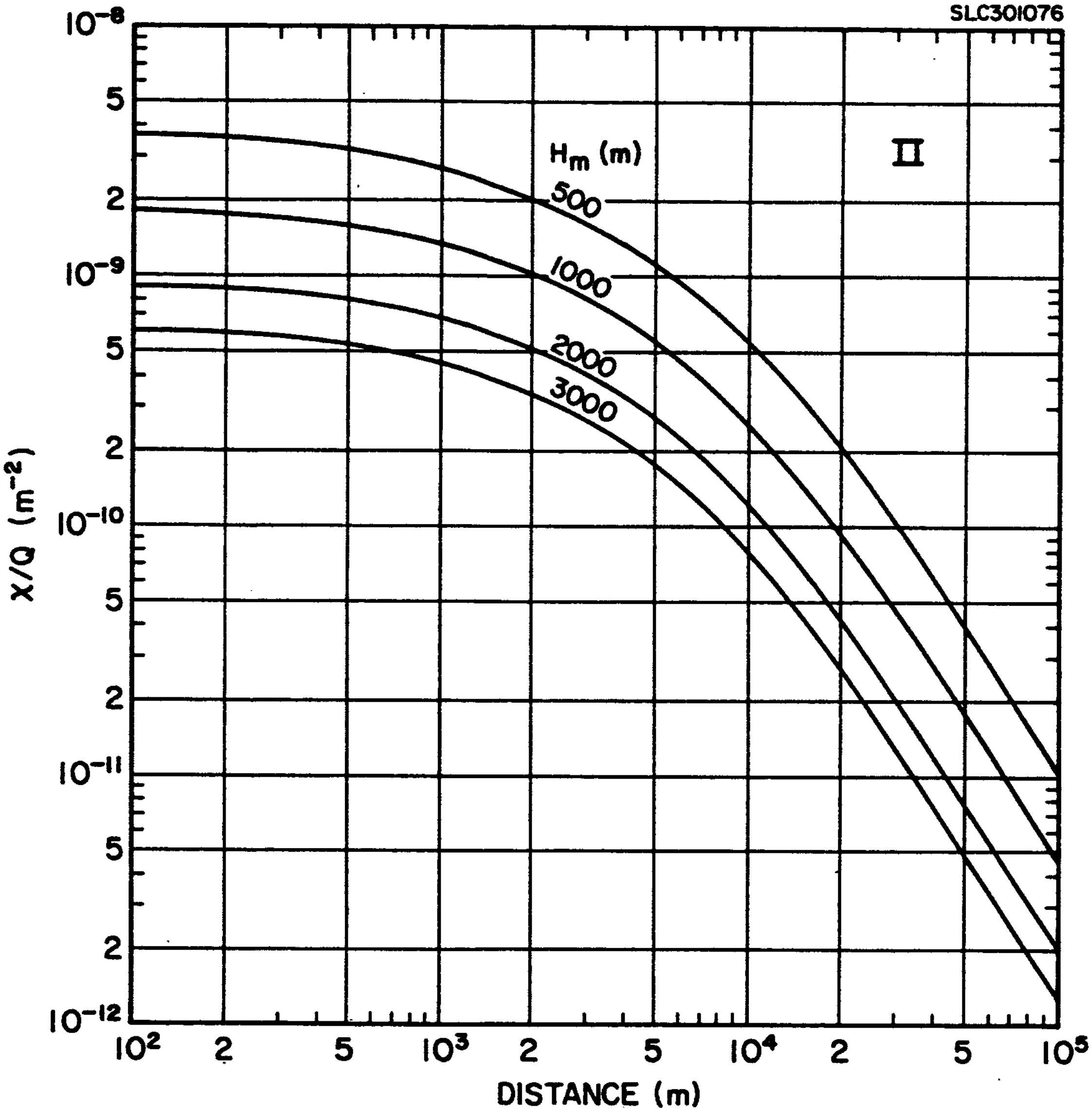

FIGURE 5-1. (Continued) Stability Category II

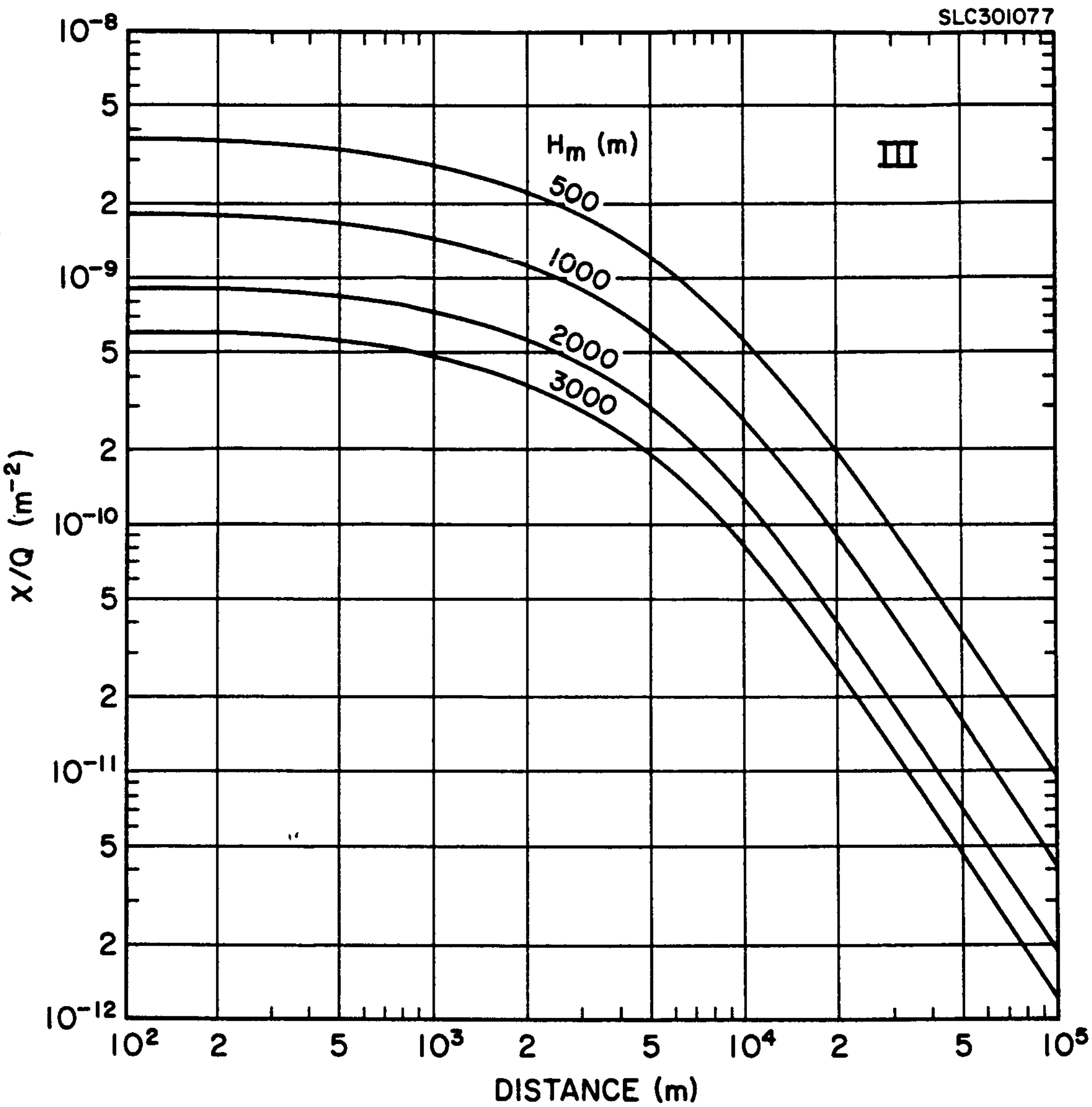

FIGURE 5-1. (Continued) Stability Category III

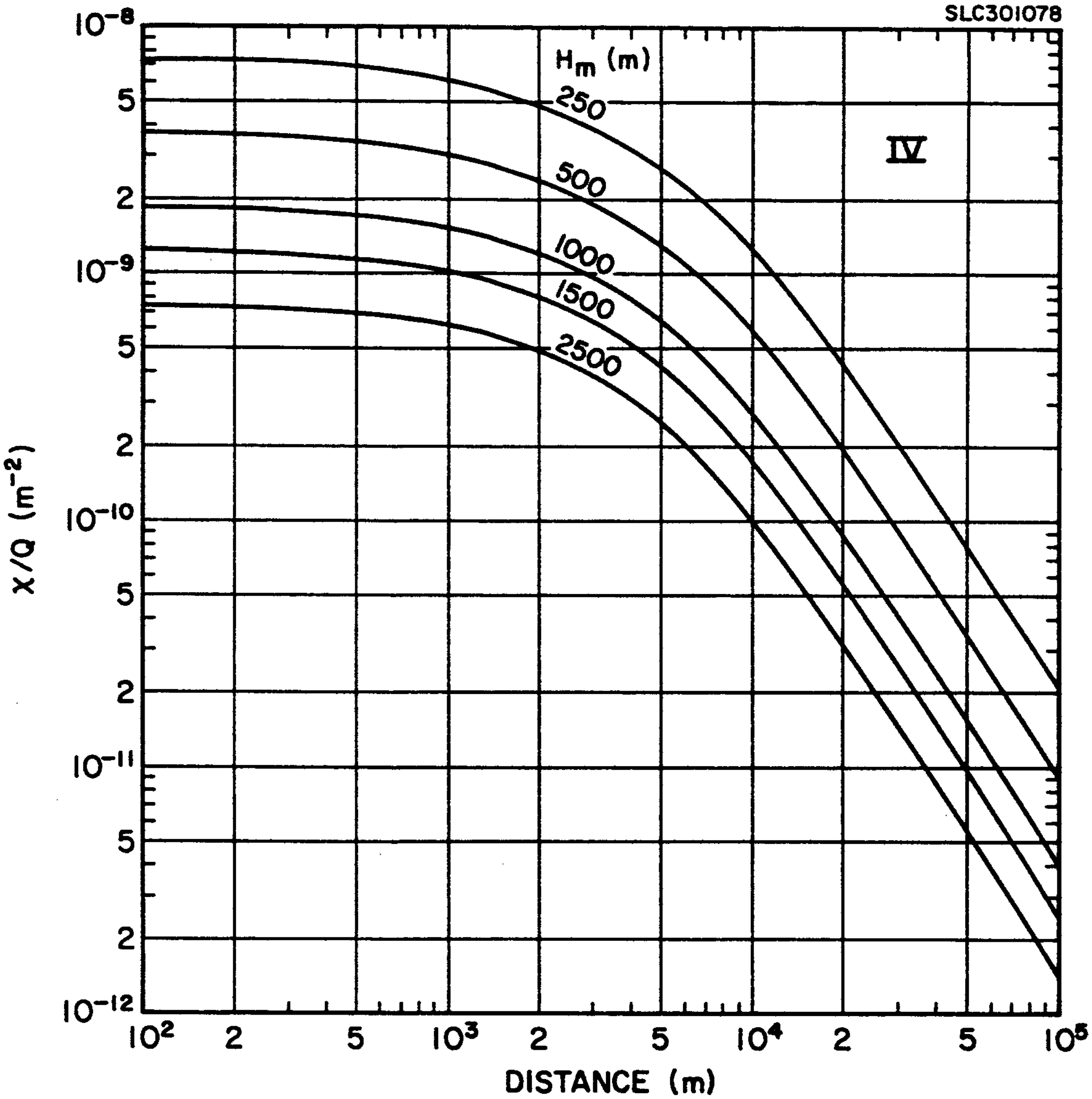

FIGURE 5-1. (Continued) Stability Category IV

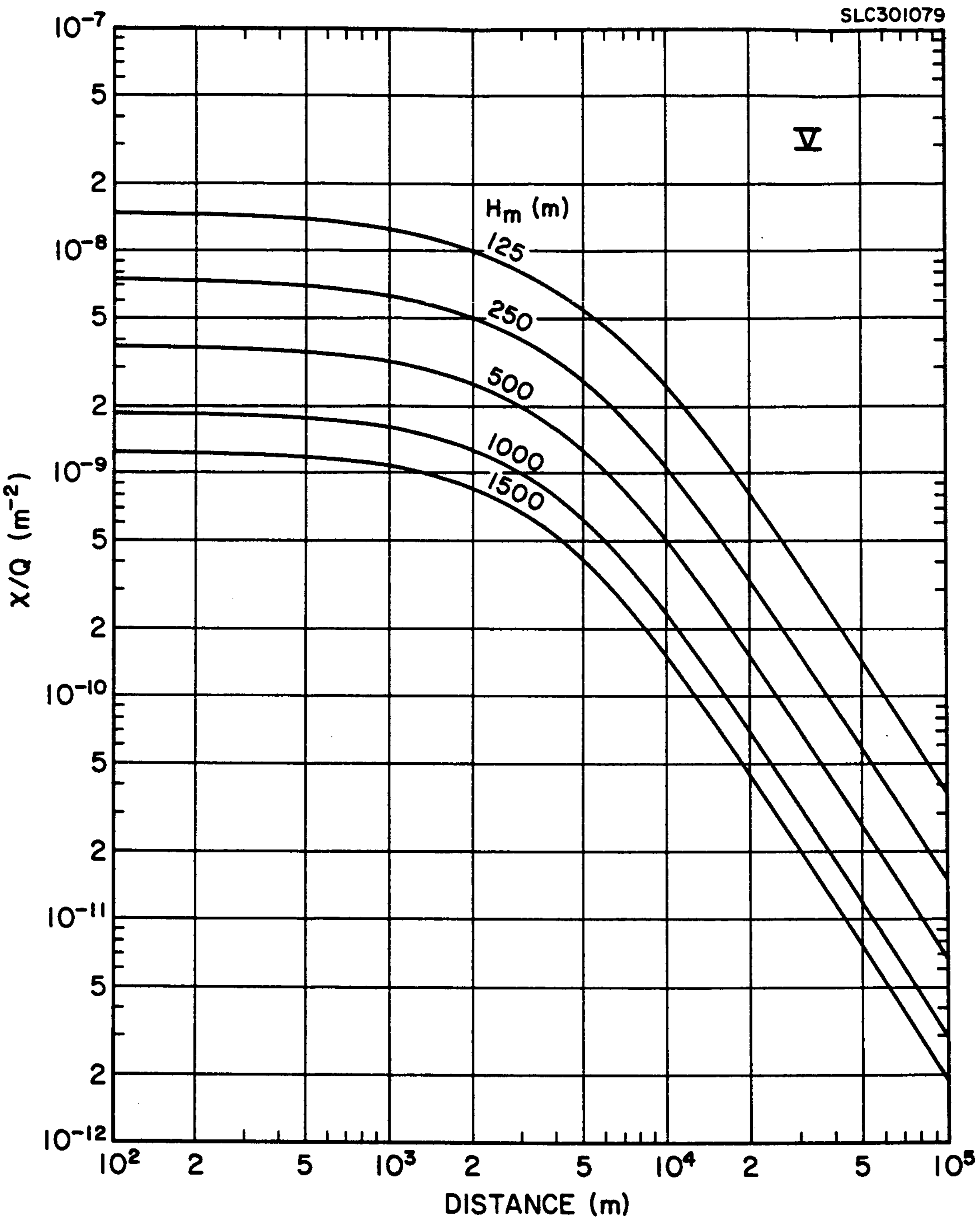

FIGURE 5-1. (Continued) Stability Category V

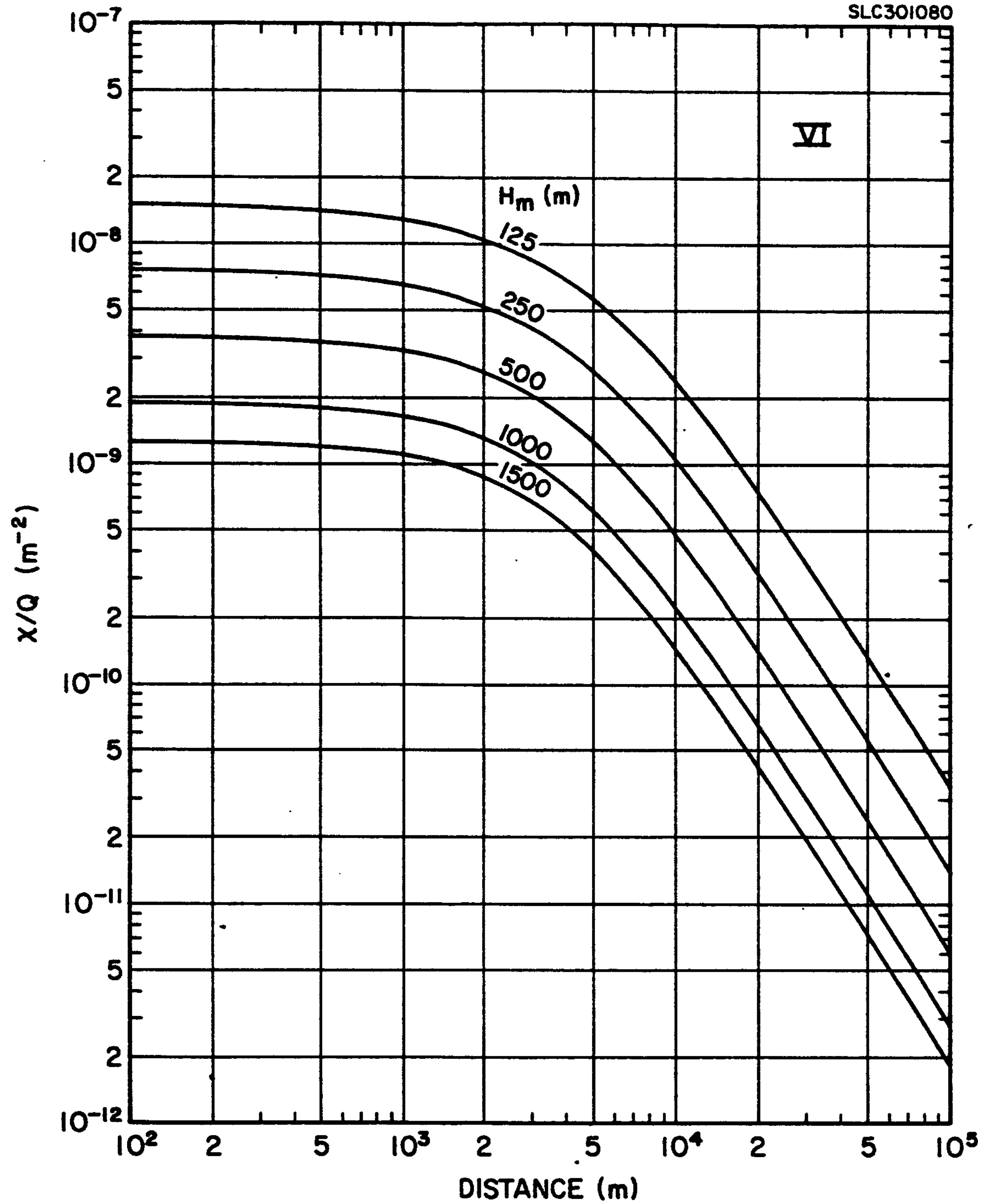

FIGURE 5-1. (Continued) Stability Category VI

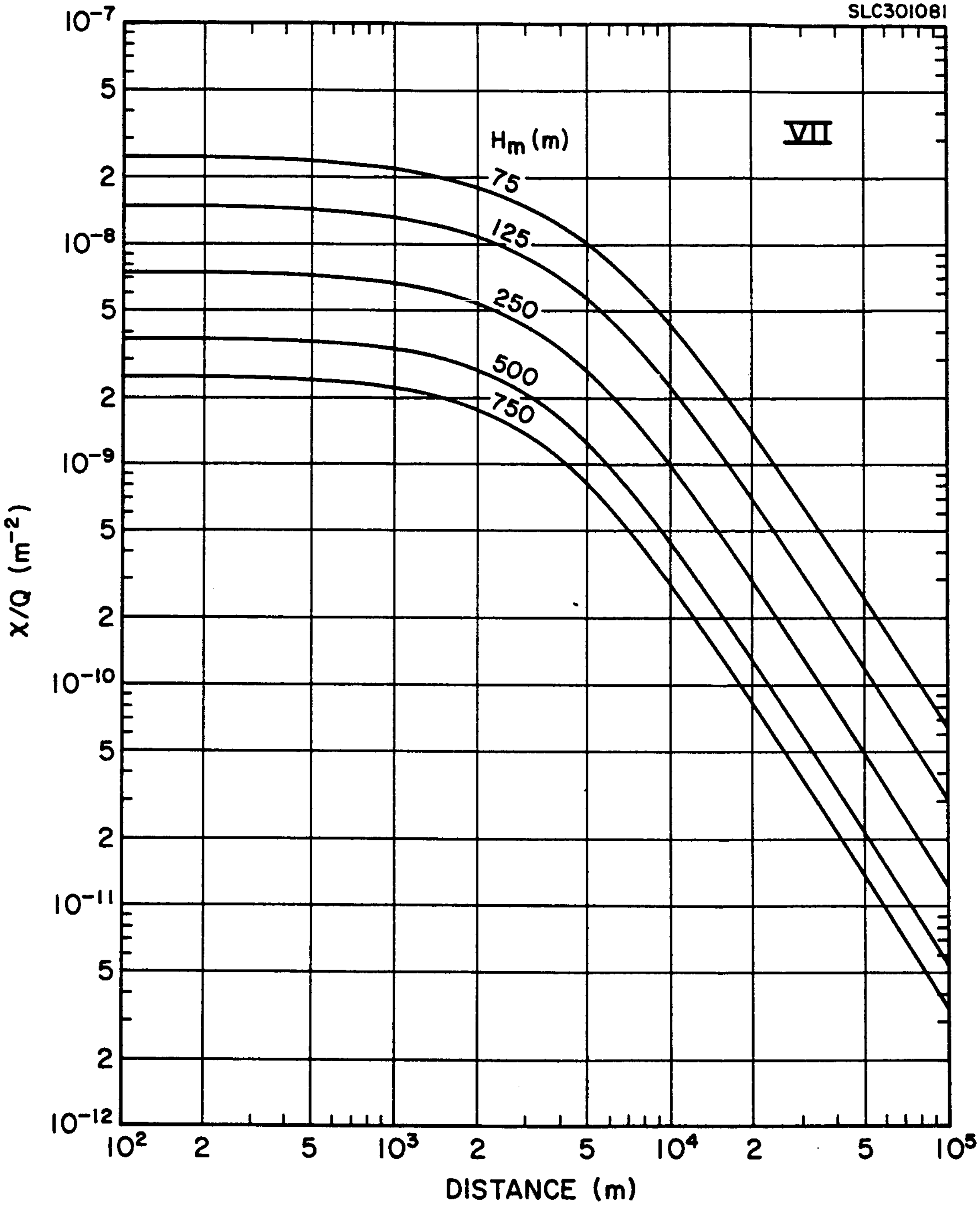

FIGURE 5-1. (Continued) Stability Category VII

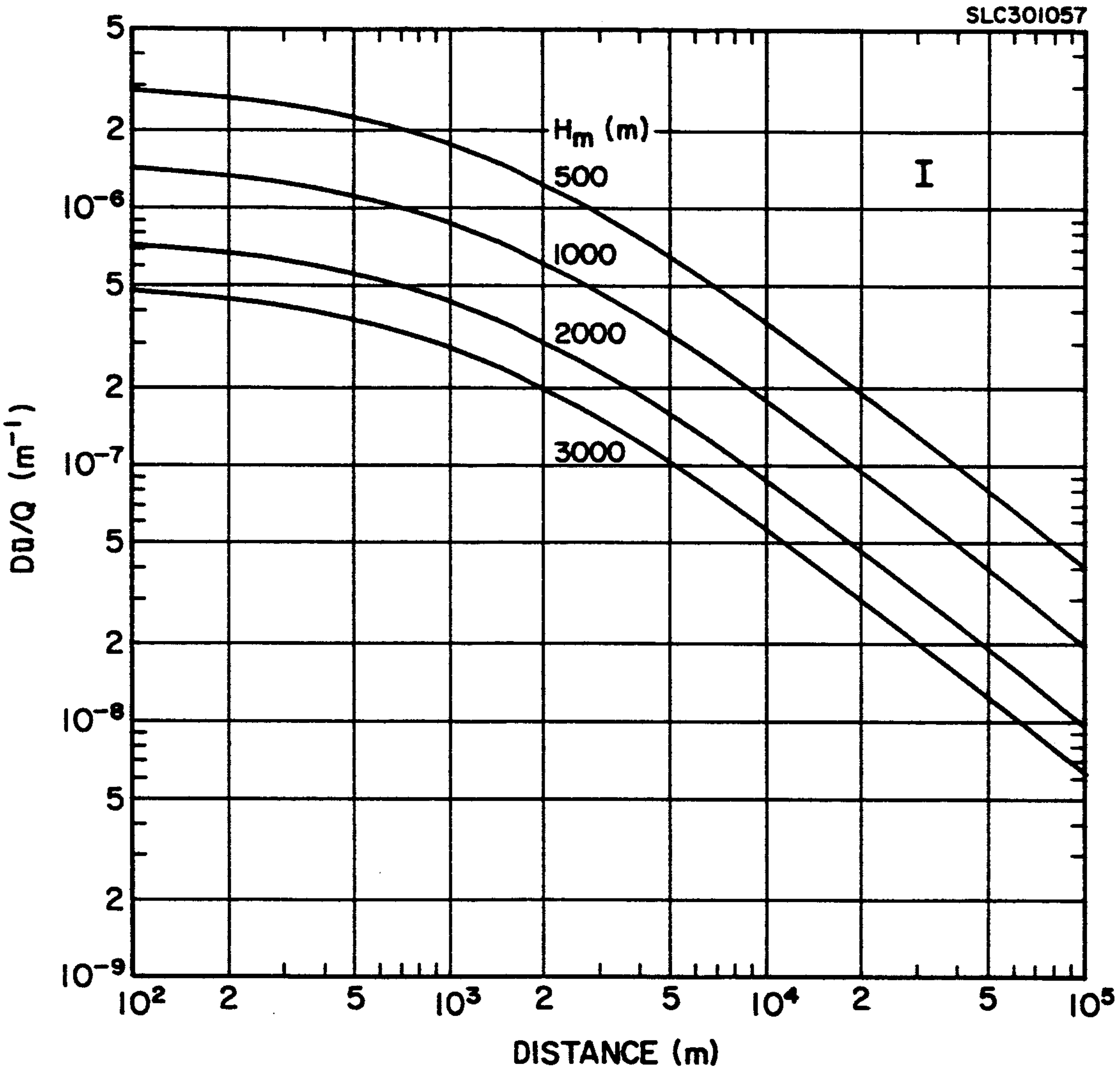

FIGURE 5-2. Normalized maximum dosage as a function of travel distance from a normal launch for Stability Category I. H_m is the depth of the surface mixing layer.

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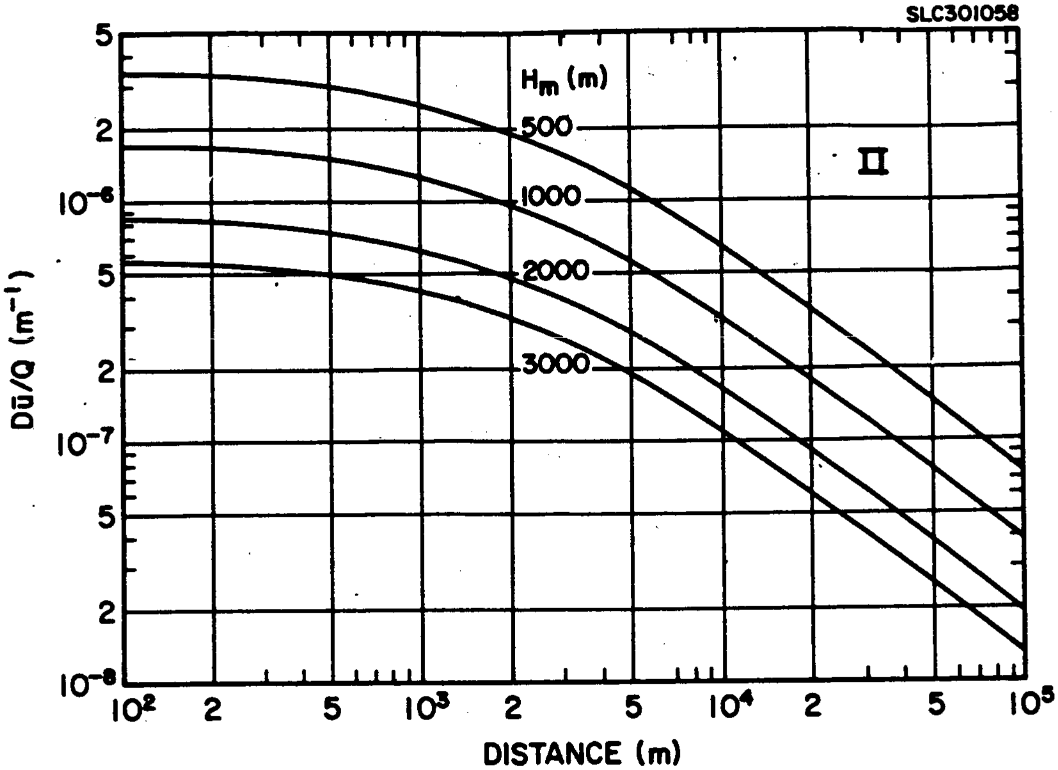

FIGURE 5-2. (Continued) Stability Category II

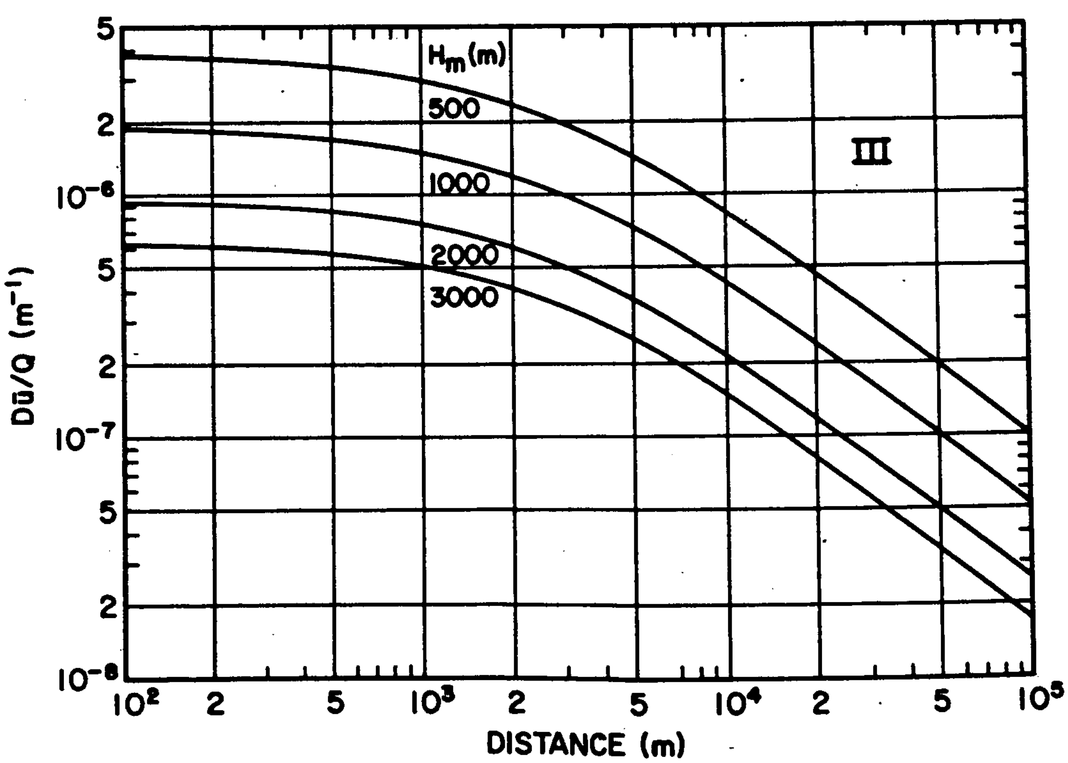

FIGURE 5-2. (Continued) Stability Category III

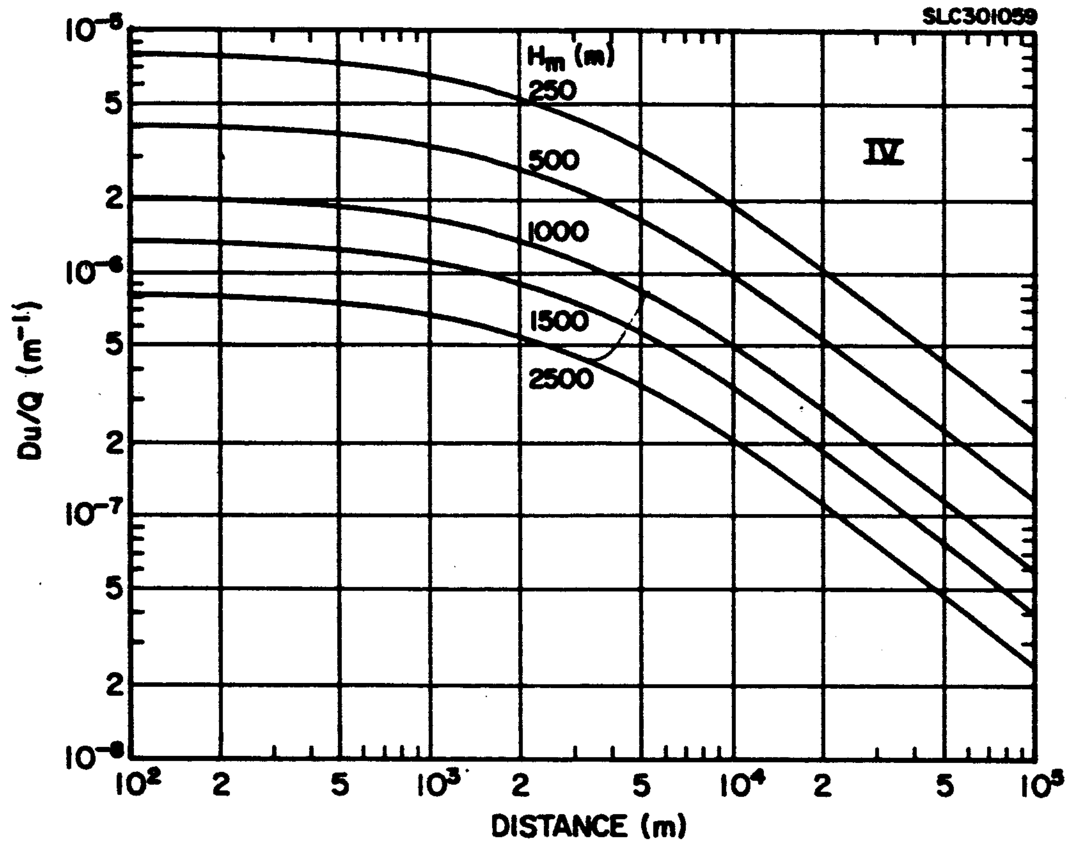

FIGURE 5–2. (Continued) Stability Category IV

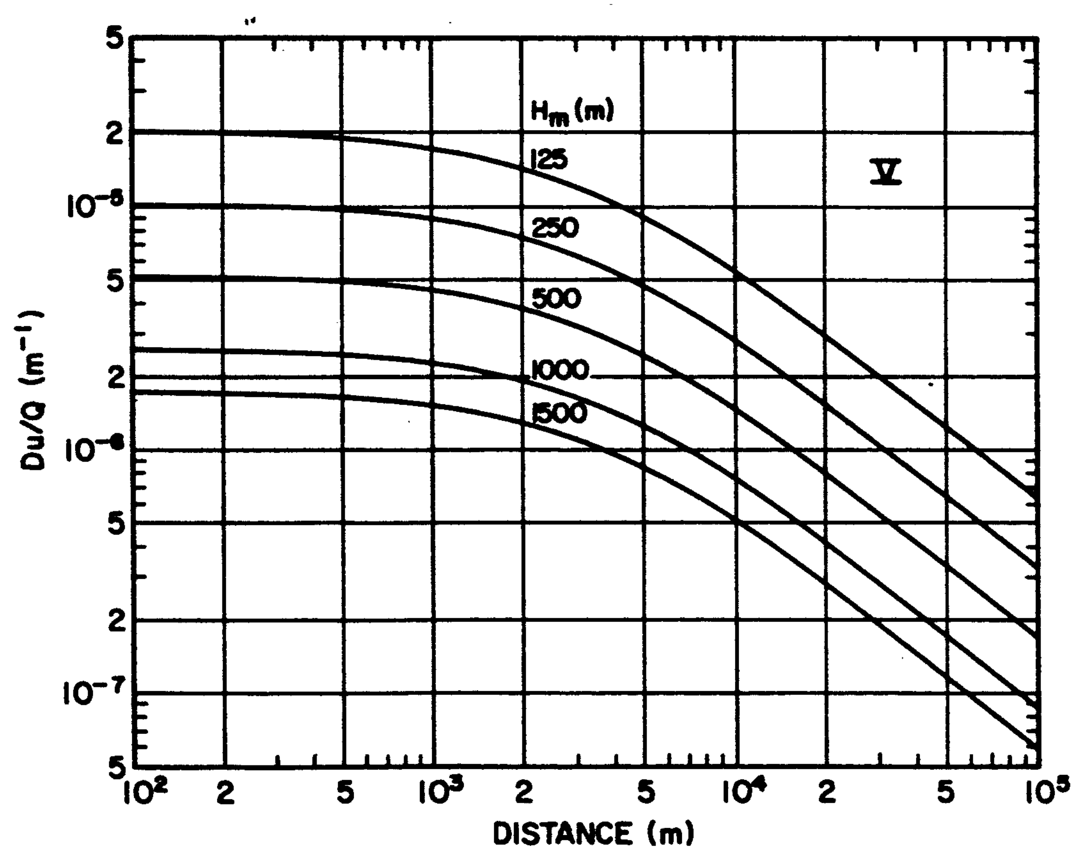

FIGURE 5–2. (Continued) Stability Category V

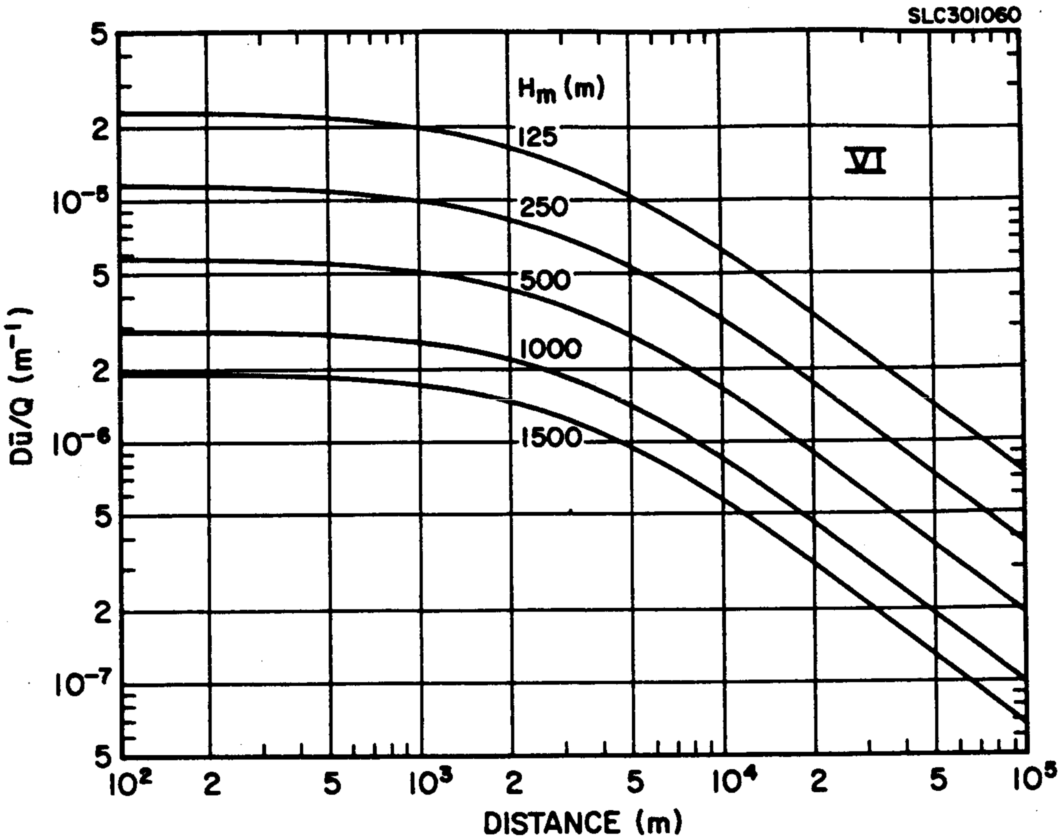

FIGURE 5-2. (Continued) Stability Category VI

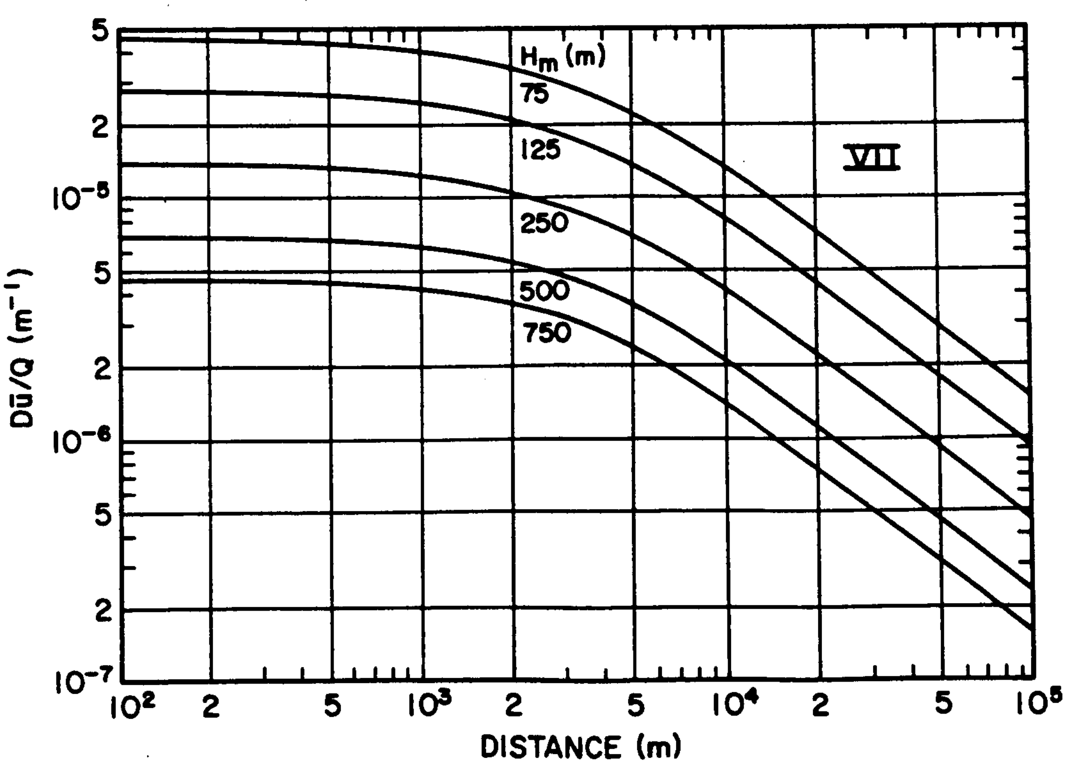

FIGURE 5-2. (Continued) Stability Category VII

TABLE 5-4

RESIDENCE TIME OF A SATURN V VEHICLE WITHIN THE SURFACE LAYER

Depth of Surface Layer H_m (m)	75	125	250	500	750	1000	1500	2000	2500	3000
Residence Time or τ (sec)	13	15	18.5	22.5	25	27.5	33	37.5	42	44.5

TABLE 5-5

ISOPLETH WIDTHS IN KILOMETERS OF NORMALIZED CONCENTRATION VERSUS TRAVEL DISTANCE DOWNWIND FROM A NORMAL LAUNCH

STABILITY CATEGORY I

Distance (km)	$\chi \bar{u}/Q$						Distance (km)	$\chi \bar{u}/Q$					
	10^{-9}	$5x10^{-10}$	10^{-10}	10^{-11}	10^{-12}	10^{-13}		$5x10^{-10}$	10^{-10}	$5x10^{-11}$	10^{-11}	10^{-12}	10^{-13}
	H_m = 500 m							H_m = 2000 m					
0.5	1.1	1.5	2.0	2.6	3.1	3.6	0.5	0.6	1.6	1.8	2.3	2.9	3.3
1	1.3	1.7	2.5	3.3	3.9	4.4	1	0.4	1.9	2.2	2.9	3.6	4.2
2	1.3	2.1	3.3	4.5	5.4	6.2	2	0	2.4	2.9	3.9	5.0	5.9
4	0	2.6	4.8	6.9	8.4	9.7	4		3.0	4.1	5.9	7.7	9.2
8		1.3	7.3	11.3	14.2	16.6	8		2.7	5.5	9.2	12.8	15.5
10		0	8.3	13.3	17.0	19.9	10		0	5.8	10.7	15.2	18.6
20			10.6	22.4	29.8	35.7	20			0	15.9	25.8	32.9
40			0	35.2	52.0	64.6	40				14.2	41.9	57.6
80				42.1	86.4	114.	80				0	58.7	97.5
100				33.7	99.8	137.	100					59.9	114.
	H_m = 1000 m							H_m = 3000 m					
0.5	0.6	1.1	1.8	2.5	3.0	3.4	0.5	0	1.4	1.7	2.2	2.8	3.3
1	0.4	1.3	2.2	3.1	3.7	4.3	1		1.6	2.0	2.7	3.5	4.1
2	0	1.3	2.9	4.2	5.2	6.0	2		2.0	2.6	3.7	4.9	5.8
4		0	4.0	6.4	8.0	9.4	4		2.2	3.5	5.5	7.5	9.0
8			5.5	10.3	13.4	16.0	8		0	4.1	8.5	12.3	15.2
10			5.9	12.0	16.0	19.1	10			3.5	9.8	14.6	18.2
20			0	19.4	27.8	34.1	20			0	13.3	24.5	32.0
40				27.0	47.0	60.8	40				0	38.4	55.4
80				0	73.6	105.	80					47.2	91.8
100					82.2	125.	100					40.5	106.

TABLE 5-5 (Continued)

STABILITY CATEGORY II

Distance (km)	$\chi \bar{u}/Q$ 10^{-9}	$5x10^{-10}$	10^{-10}	10^{-11}	10^{-12}	10^{-13}	Distance (km)	$\chi \bar{u}/Q$ $5x10^{-10}$	10^{-10}	$5x10^{-11}$	10^{-11}	10^{-12}	10^{-13}
	H_m = 500 m							H_m = 2000 m					
0.5	1.0	1.3	1.8	2.3	2.8	3.1	0.5	0.7	1.4	1.6	2.0	2.5	2.9
1	1.1	1.5	2.1	2.7	3.2	3.6	1	0.6	1.6	1.8	2.3	2.9	3.3
2	1.3	1.8	2.6	3.4	4.1	4.7	2	0.3	1.9	2.2	2.9	3.7	4.3
4	1.2	2.2	3.5	4.9	5.9	6.8	4	0	2.4	3.0	4.0	5.2	6.1
8	0	2.2	5.2	7.6	9.4	10.9	8		2.6	4.0	6.0	8.1	9.8
10		1.5	5.8	8.9	11.1	13.0	10		2.1	4.2	6.9	9.5	11.5
20		0	7.0	14.2	18.8	22.5	20		0	0	9.6	15.4	19.6
40			0	21.1	31.7	39.6	40				7.0	24.1	33.4
80				21.8	51.2	69.0	80				0	32.2	55.5
100				10.2	58.5	82.1	100					31.7	64.6
	H_m = 1000 m							H_m = 3000 m					
0.5	0.7	1.0	1.6	2.2	2.6	3.0	0.5	0.2	1.3	1.5	1.9	2.4	2.8
1	0.6	1.1	1.8	2.5	3.0	3.5	1	0	1.4	1.7	2.2	2.8	3.3
2	0.3	1.3	2.2	3.2	3.9	4.5	2		1.6	2.0	2.7	3.5	4.2
4	0	1.2	3.0	4.4	5.5	6.4	4		1.9	2.6	3.8	5.0	6.0
8		0	4.0	6.8	8.7	10.3	8		1.1	3.2	5.5	7.7	9.5
10			4.3	7.9	10.3	12.2	10		0	3.0	6.2	9.0	11.1
20			0	12.0	17.1	20.9	20			0	8.0	14.4	18.7
40				15.4	27.9	36.3	40				0	21.7	31.6
80				0	42.2	62.0	80					24.9	51.4
100					46.3	73.1	100					19.0	59.1

TABLE 5-5 (Continued)

STABILITY CATEGORY III

Distance (km)	$\chi \bar{u}/Q$ 10^{-9}	$5x10^{-10}$	10^{-10}	10^{-11}	10^{-12}	10^{-13}	Distance (km)	$\chi \bar{u}/Q$ $5x10^{-10}$	10^{-10}	$5x10^{-11}$	10^{-11}	10^{-12}	10^{-13}
	H_m = 500 m							H_m = 2000 m					
0.5	1.0	1.3	1.7	2.3	2.7	3.0	0.5	0.7	1.3	1.6	1.9	2.4	2.8
1	1.1	1.4	1.9	2.5	3.0	3.4	1	0.7	1.5	1.7	2.2	2.7	3.1
2	1.2	1.6	2.4	3.1	3.7	4.2	2	0.5	1.7	2.0	2.6	3.3	3.8
4	1.2	2.0	3.1	4.3	5.2	5.9	4	0	2.1	2.6	3.5	4.5	5.3
8	0	2.1	4.5	6.5	8.1	9.4	8		2.3	3.4	5.1	6.9	8.2
10		1.5	5.0	7.6	9.5	11.0	10		1.9	3.5	5.8	8.0	9.7
20		0	5.8	11.9	15.8	18.9	20		0	0	7.9	12.8	16.2
40			0	17.4	26.4	33.1	40				4.9	19.7	27.5
80				16.4	43.3	57.5	80				0	25.9	45.5
100				0	48.2	68.4	100					24.9	52.8
	H_m = 1000 m							H_m = 3000 m					
0.5	0.7	1.0	1.6	2.0	2.5	2.9	0.5	0.3	1.2	1.4	1.9	2.3	2.7
1	0.7	1.1	1.7	2.3	2.8	3.2	1	0	1.3	1.6	2.0	2.6	3.0
2	0.5	1.2	2.0	2.9	3.5	4.0	2		1.5	1.8	2.5	3.1	3.7
4	0	1.2	2.7	3.9	4.8	5.6	4		1.7	2.3	3.3	4.3	5.1
8		0	3.5	5.8	7.4	8.8	8		1.2	2.7	4.7	6.5	7.9
10			3.7	6.7	8.7	10.3	10		0	2.6	5.2	7.5	9.3
20			0	10.0	14.2	17.5	20			0	6.5	11.9	15.4
40				12.4	23.1	30.2	40				0	17.7	25.9
80				0	34.5	51.3	80					19.7	41.9
100					37.6	60.4	100					13.8	48.2

TABLE 5-5 (Continued)

STABILITY CATEGORY IV													
Distance (km)	$\chi \bar{u}/Q$						Distance (km)	$\chi \bar{u}/Q$					
	5×10^{-9}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}		10^{-9}	5×10^{-10}	10^{-10}	10^{-11}	10^{-12}	10^{-13}
	H_m = 250 m							H_m = 1000 m					
0.5	0.5	1.3	1.9	2.3	2.7	3.1	0.5	0.7	1.0	1.5	2.1	2.5	2.8
1	0.4	1.4	2.1	2.6	3.0	3.4	1	0.7	1.1	1.7	2.2	2.7	3.1
2	0	1.6	2.5	3.1	3.7	4.1	2	0.6	1.2	1.9	2.7	3.3	3.7
4		1.9	3.3	4.3	5.1	5.8	4	0	1.2	2.5	3.6	4.4	5.1
8		2.1	4.9	6.6	7.9	9.1	8		0	3.2	5.3	6.7	7.9
10		1.7	5.5	7.6	9.3	10.7	10			3.3	6.0	7.8	9.3
20		0	7.8	12.4	15.7	18.4	20			0	8.9	12.8	15.7
40			6.0	19.4	26.7	32.5	40				10.9	20.7	27.1
80			0	26.1	44.5	57.3	80				0	30.7	46.0
100				25.9	51.8	68.5	100					33.3	54.2
	H_m = 500 m							H_m = 1500 m					
0.5	0	1.0	1.7	2.2	2.6	2.9	0.5	0.3	0.8	1.4	2.0	2.4	2.8
1		1.1	1.9	2.4	2.9	3.3	1	0.2	0.8	1.5	2.1	2.6	3.0
2		1.2	2.2	2.9	3.5	3.9	2	0	0.8	1.8	2.5	3.1	3.6
4		1.2	2.9	3.9	4.7	5.4	4		0.4	2.2	3.4	4.2	5.0
8		0	4.1	5.9	7.3	8.5	8		0	2.6	4.9	6.4	7.6
10			4.5	6.8	8.5	10.0	10			2.5	5.6	7.4	8.9
20			5.1	10.7	14.2	17.0	20			0	7.9	12.0	15.0
40			0	15.4	23.7	29.7	40				7.5	18.9	25.7
80				13.7	37.7	51.6	80				0	26.3	43.0
100				0	42.9	61.3	100					27.1	50.2

TABLE 5-5 (Continued)

STABILITY CATEGORY V

Distance (km)	$\chi \bar{u}/Q$: 5×10^{-9}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	Distance (km)	$\chi \bar{u}/Q$: 10^{-9}	5×10^{-10}	10^{-10}	10^{-11}	10^{-12}	10^{-13}
	H_m = 125 m							H_m = 500 m					
0.5	0.9	1.5	2.0	2.4	2.8	3.1	0.5	1.0	1.2	1.7	2.1	2.5	2.9
1	0.9	1.6	2.2	2.6	3.0	3.4	1	1.0	1.3	1.8	2.3	2.7	3.1
2	1.0	1.8	2.6	3.1	3.6	4.1	2	1.1	1.5	2.0	2.7	3.2	3.6
4	0.9	2.3	3.4	4.2	4.9	5.5	4	1.1	1.7	2.6	3.5	4.2	4.9
8	0	3.0	5.0	6.5	7.6	8.6	8	0	1.5	3.5	5.2	6.4	7.5
10		3.1	5.8	7.5	9.0	10.2	10		0.5	3.8	5.9	7.5	8.7
20		0	8.5	12.3	15.2	17.6	20		0	3.6	9.1	12.3	14.9
40			10.3	19.9	26.2	31.2	40			0	12.6	20.4	25.9
80			0	29.5	44.5	55.6	80				5.3	31.9	44.8
100				31.9	52.4	66.8	100				0	35.8	53.1
	H_m = 250 m							H_m = 1000 m					
0.5	0.5	1.2	1.8	2.3	2.6	3.0	0.5	0.7	1.0	1.5	2.0	2.4	2.7
1	0.5	1.3	2.0	2.5	2.9	3.2	1	0.7	1.0	1.6	2.1	2.6	2.9
2	0.2	1.5	2.3	2.9	3.4	3.8	2	0.6	1.1	1.8	2.5	3.0	3.4
4	0	1.8	3.0	3.9	4.6	5.2	4	0	1.0	2.2	3.2	3.9	4.5
8		1.7	4.3	5.8	7.0	8.0	8		0	2.7	4.6	5.9	6.9
10		1.0	4.8	6.7	8.2	9.4	10			2.7	5.2	6.8	8.1
20		0	6.3	10.7	13.7	16.2	20			0	7.5	11.0	13.7
40			0	16.3	23.2	28.5	40				8.2	17.7	23.6
80				20.2	38.1	50.0	80				0	25.4	39.9
100				17.9	44.1	59.7	100					26.9	46.7

TABLE 5-5 (Continued)

STABILITY CATEGORY VI

Distance (km)	$\chi \bar{u}/Q$ 5×10^{-9}	10^{-8}	10^{-10}	10^{-11}	10^{-12}	10^{-13}
	H_m = 125 m					
0.5	0.9	1.4	2.0	2.4	2.7	3.1
1	0.9	1.5	2.1	2.6	3.0	3.3
2	1.0	1.8	2.5	3.0	3.5	3.9
4	0.9	2.2	3.3	4.0	4.7	5.3
8	0	2.8	4.8	6.1	7.2	8.2
10		2.9	5.4	7.1	8.5	9.7
20		0	8.0	11.6	14.4	16.7
40			9.3	18.7	24.7	29.6
80			0	27.3	42.0	52.7
100				29.4	49.4	63.3
	H_m = 250 m					
0.5	0.5	1.2	1.8	2.2	2.6	2.9
1	0.5	1.3	1.9	2.4	2.8	3.2
2	0.2	1.4	2.2	2.8	3.3	3.7
4	0	1.7	2.9	3.7	4.4	4.9
8		1.6	4.0	5.5	6.6	7.6
10		0.8	4.5	6.4	7.8	9.0
20		0	5.9	10.1	13.0	15.4
40			0	15.3	22.0	27.0
80				18.3	36.0	47.5
100				15.3	41.5	56.7

Distance (km)	$\chi \bar{u}/Q$ 10^{-9}	5×10^{-10}	10^{-10}	10^{-11}	10^{-12}	10^{-13}
	H_m = 500 m					
0.5	1.0	1.2	1.6	2.1	2.5	2.8
1	1.0	1.3	1.7	2.3	2.7	3.0
2	1.1	1.4	2.0	2.6	3.1	3.5
4	1.0	1.6	2.5	3.4	4.0	4.6
8	0	1.4	3.3	4.9	6.1	7.1
10		0	3.6	5.6	7.1	8.3
20			3.2	8.6	11.7	14.2
40			0	11.7	19.3	24.7
80				0	30.1	42.7
100					33.7	50.5
	H_m = 1000 m					
0.5	0.7	1.0	1.5	2.0	2.4	2.7
1	0.7	1.0	1.5	2.1	2.5	2.9
2	0.6	1.1	1.7	2.4	2.9	3.3
4	0	1.0	2.1	3.0	3.7	4.3
8		0	2.5	4.3	5.6	6.6
10			2.5	4.9	6.5	7.7
20			0	7.1	10.5	13.1
40				7.5	16.8	22.6
80				0	23.9	38.1
100					25.1	44.7

TABLE 5-5 (Continued)

STABILITY CATEGORY VII

Distance (km)	$\chi \bar{u}/Q$ 5×10^{-9}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	Distance (km)	$\chi \bar{u}/Q$ 5×10^{-9}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}
	H_m = 75 m							H_m = 250 m					
0.5	1.1	1.6	2.0	2.4	2.8	3.1	0.5	0.5	1.2	1.8	2.2	2.6	2.9
1	1.1	1.6	2.2	2.6	3.0	3.3	1	0.5	1.3	1.9	2.3	2.7	3.0
2	1.2	1.9	2.5	3.0	3.4	3.8	2	0.3	1.4	2.1	2.7	3.1	3.5
4	1.4	2.4	3.3	4.0	4.6	5.1	4	0	1.6	2.7	3.4	4.0	4.6
8	1.1	3.2	4.8	6.1	7.1	8.0	8		1.4	3.7	5.1	6.1	7.0
10	0	3.5	5.6	7.1	8.3	9.4	10		0.2	4.1	5.9	7.2	8.3
20		3.2	8.6	11.7	14.2	16.3	20		0	5.3	9.3	12.1	14.3
40		0	11.9	19.5	24.9	29.3	40			0	14.0	20.4	25.3
80			2.9	30.5	43.0	52.6	80				16.0	33.4	44.5
100			0	34.2	51.0	63.5	100				11.8	38.4	53.1
	H_m = 125 m							H_m = 500 m					
0.5	0.9	1.4	1.9	2.3	2.7	3.0	0.5	0	1.0	1.6	2.1	2.4	2.8
1	0.9	1.5	2.0	2.5	2.9	3.2	1		1.0	1.7	2.2	2.6	2.9
2	1.0	1.7	2.3	2.9	3.3	3.7	2		1.0	1.9	2.4	2.9	3.3
4	0.9	2.0	3.0	3.7	4.3	4.9	4		1.0	2.3	3.1	3.8	4.3
8	0	2.5	4.4	5.6	6.6	7.5	8		0	3.0	4.5	5.7	6.6
10		2.6	5.0	6.5	7.8	8.9	10			3.3	5.2	6.6	7.7
20		0	7.2	10.7	13.3	15.4	20			2.6	8.0	11.0	13.3
40			8.0	17.1	22.9	27.5	40			0	10.7	18.1	23.3
80			0	24.7	38.8	48.9	80				0	28.0	40.3
100				26.1	45.5	58.8	100					31.2	47.7

TABLE 5-6

ISOPLETH WIDTHS IN KILOMETERS OF NORMALIZED DOSAGE VERSUS TRAVEL DISTANCE DOWNWIND FROM A NORMAL LAUNCH

STABILITY CATEGORY I

Distance (km)	$D\bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	$5x10^{-9}$
	H_m = 500 m					
0.5	1.0	1.4	2.0	2.2	2.6	2.7
1	1.1	1.6	2.4	2.7	3.2	3.4
2	1.0	1.9	3.2	3.6	4.4	4.7
4	0	2.2	4.6	5.3	6.7	7.2
8		0	6.9	8.4	11.0	12.0
10			7.8	9.7	13.1	14.3
20			10.6	15.1	22.4	24.8
40			0	21.0	38.3	43.6
80				5.9	63.3	75.6
100				0	73.3	89.6
	H_m = 1000 m					
0.5	0.4	1.0	1.7	2.0	2.4	2.6
1	0	1.1	2.1	2.4	3.0	3.2
2		1.0	2.7	3.2	4.1	4.4
4		0	3.8	4.6	6.2	6.8
8			5.1	6.9	10.0	11.1
10			5.4	7.9	11.8	13.1
20			0	10.6	19.7	22.5
40				0	32.1	38.5
80					48.1	63.6
100					52.3	73.7

Distance (km)	$D\bar{u}/Q$ $5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	$5x10^{-9}$
	H_m = 2000 m				
0.5	0.4	1.5	1.7	2.2	2.4
1	0	1.7	2.1	2.8	3.0
2		2.2	2.8	3.8	4.2
4		2.7	3.8	5.7	6.3
8		1.6	5.1	9.0	10.2
10		0	5.4	10.5	12.0
20			0	16.7	20.0
40				24.5	32.7
80				23.3	48.6
100				0	52.6
	H_m = 3000 m				
0.5	0	1.3	1.6	2.1	2.3
1		1.5	1.9	2.6	2.9
2		1.7	2.4	3.6	4.0
4		1.6	3.2	5.3	6.0
8		0	3.5	8.3	9.6
10			2.8	9.5	11.2
20			0	14.4	18.3
40				18.0	28.4
80				0	36.0
100					32.9

TABLE 5-6 (Continued)

STABILITY CATEGORY II												
Distance (km)	$D\bar{u}/Q$						Distance (km)	$D\bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	$5x10^{-9}$		$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	$5x10^{-9}$
	H_m = 500 m							H_m = 2000 m				
0.5	1.0	1.3	1.8	2.0	2.3	2.5	0.5	0.6	1.4	1.6	2.0	2.2
1	1.1	1.4	2.0	2.3	2.7	2.8	1	0.6	1.5	1.8	2.3	2.5
2	1.2	1.7	2.6	2.8	3.4	3.6	2	0	1.8	2.2	2.9	3.1
4	1.1	2.2	3.5	4.0	4.9	5.2	4		2.4	3.0	4.0	4.4
8	0	2.5	5.3	6.1	7.7	8.2	8		3.0	4.2	6.2	6.9
10		2.3	6.0	7.1	9.0	9.7	10		3.1	4.7	7.2	8.1
20		0	9.1	11.4	15.3	16.8	20		0	6.1	11.8	13.5
40			12.2	17.8	26.6	29.6	40			0	19.0	22.8
80			0	24.3	45.7	52.3	80				27.9	37.4
100				24.4	54.0	62.6	100				30.2	43.2
	H_m = 1000 m							H_m = 3000 m				
0.5	0.6	1.0	1.6	1.8	2.2	2.3	0.5	0	1.2	1.5	1.9	2.1
1	0.6	1.1	1.8	2.0	2.5	2.7	1		1.4	1.6	2.2	2.4
2	0	1.2	2.2	2.5	3.1	3.4	2		1.6	2.0	2.7	3.0
4		1.2	3.0	3.5	4.4	4.8	4		1.9	2.6	3.8	4.2
8		0	4.2	5.2	6.9	7.6	8		1.9	3.5	5.8	6.5
10			4.7	6.0	8.1	8.9	10		1.4	3.8	6.7	7.6
20			6.1	9.0	13.6	15.1	20		0	3.5	10.6	12.5
40			0	12.2	22.9	26.2	40			0	16.2	20.6
80				0	37.5	45.1	80				20.5	32.1
100					43.3	53.3	100				18.8	36.0

TABLE 5-6 (Continued)

STABILITY CATEGORY III

Distance (km)	$D\bar{u}/Q$: 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	$5x10^{-9}$
	H_m = 500 m					
0.5	1.0	1.3	1.8	1.9	2.3	2.4
1	1.1	1.4	2.0	2.1	2.5	2.7
2	1.2	1.7	2.4	2.6	3.1	3.3
4	1.3	2.1	3.2	3.6	4.3	4.6
8	0.2	2.6	4.8	5.4	6.7	7.2
10	0	2.7	5.5	6.3	7.9	8.5
20		0	8.5	10.2	13.4	14.6
40			12.3	16.4	23.4	25.8
80			11.5	24.3	40.6	45.9
100			0	26.3	48.3	55.2
	H_m = 1000 m					
0.5	0.7	1.0	1.6	1.7	2.1	2.2
1	0.7	1.1	1.7	1.9	2.3	2.5
2	0.6	1.2	2.1	2.3	2.9	3.1
4	0	1.3	2.7	3.1	3.9	4.2
8		0.5	3.9	4.7	6.1	6.6
10		0	4.4	5.4	7.1	7.7
20			6.2	8.3	11.9	13.1
40			5.8	12.1	20.3	22.9
80			0	11.9	33.9	39.8
100				2.5	39.6	47.4

Distance (km)	$D\bar{u}/Q$: $5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	$5x10^{-9}$
	H_m = 2000 m				
0.5	0.7	1.4	1.6	1.9	2.1
1	0.7	1.5	1.7	2.2	2.3
2	0.6	1.7	2.0	2.6	2.8
4	0	2.2	2.7	3.6	3.9
8		2.9	3.9	5.4	6.0
10		3.2	4.4	6.3	7.0
20		2.7	6.1	10.4	11.7
40		0	5.9	17.1	20.0
80			0	26.5	33.6
100				29.7	39.2
	H_m = 3000 m				
0.5	0.3	1.2	1.4	1.9	2.0
1	0.1	1.3	1.6	2.1	2.2
2	0	1.5	1.9	2.5	2.7
4		1.9	2.4	3.4	3.7
8		2.2	3.3	5.0	5.6
10		2.2	3.7	5.8	6.6
20		0	4.5	9.4	10.9
40			0	14.9	18.2
80				21.3	29.4
100				22.4	33.8

TABLE 5-6 (Continued)

STABILITY CATEGORY IV

Distance (km)	$D\bar{u}/Q$					
	5×10^{-6}	10^{-6}	5×10^{-7}	10^{-7}	10^{-8}	5×10^{-9}
	H_m = 250 m					
0.5	0.6	1.3	1.5	1.9	2.4	2.4
1	0.5	1.4	1.6	2.1	2.6	2.7
2	0.3	1.6	1.9	2.5	3.2	3.3
4	0	2.1	2.5	3.4	4.4	4.6
8		2.7	3.6	5.1	6.8	7.2
10		2.8	4.0	6.0	8.0	8.5
20		1.5	5.5	9.7	13.7	14.7
40		0	3.8	15.9	24.3	26.3
80			0	24.2	43.4	47.7
100				26.8	52.2	57.8
	H_m = 500 m					
0.5	0	1.0	1.3	1.7	2.2	2.3
1		1.1	1.4	1.9	2.4	2.6
2		1.2	1.6	2.3	2.9	3.1
4		1.4	2.0	3.0	4.0	4.3
8		1.2	2.6	4.4	6.2	6.6
10		0	2.8	5.1	7.3	7.8
20			1.7	8.0	12.4	13.4
40			0	12.1	21.7	23.8
80				14.1	37.9	42.5
100				11.2	45.2	51.2

Distance (km)	$D\bar{u}/Q$					
	10^{-6}	5×10^{-7}	10^{-7}	5×10^{-8}	10^{-8}	5×10^{-9}
	H_m = 1000 m					
0.5	0.7	1.0	1.5	1.7	2.1	2.2
1	0.7	1.1	1.7	1.9	2.3	2.4
2	0.7	1.2	2.0	2.2	2.7	2.9
4	0	1.4	2.6	2.9	3.7	3.9
8		1.2	3.7	4.4	5.6	6.0
10		0.4	4.2	5.0	6.5	7.1
20		0	6.1	7.9	11.0	12.1
40			7.0	11.9	18.9	21.2
80			0	14.2	32.0	37.1
100				11.8	37.6	44.3
	H_m = 1500 m					
0.5	0.4	0.9	1.4	1.6	2.0	2.1
1	0.3	0.9	1.5	1.8	2.2	2.3
2	0	0.9	1.8	2.1	2.6	2.8
4		0.9	2.3	2.7	3.5	3.7
8		0	3.2	4.0	5.3	5.7
10			3.6	4.5	6.1	6.7
20			4.7	6.9	10.2	11.4
40			0	9.4	17.3	19.7
80				0	28.4	34.0
100					32.8	40.2

TABLE 5-6 (Continued)

STABILITY CATEGORY V

Distance (km)	$D\bar{u}/Q$: 10^{-5}	5×10^{-6}	10^{-6}	10^{-7}	10^{-8}	5×10^{-9}
	H_m = 125 m					
0.5	0.1	1.0	1.5	2.1	2.5	2.6
1	0.7	1.1	1.7	2.2	2.7	2.8
2	0.7	1.2	1.9	2.6	3.2	3.4
4	0.3	1.4	2.5	3.6	4.4	4.6
8	0	1.3	3.6	5.5	6.8	7.2
10		0.8	4.1	6.4	8.0	8.4
20		0	6.1	10.8	14.0	14.8
40			7.3	18.5	25.1	26.8
80			0	31.5	45.9	49.4
100				37.0	55.6	60.1
	H_m = 250 m					
0.5	0	0.7	1.3	1.9	2.3	2.4
1		0.7	1.4	2.1	2.5	2.7
2		0.7	1.6	2.4	3.0	3.1
4		0.4	2.1	3.2	4.0	4.2
8		0	2.8	4.8	6.2	6.6
10			3.1	5.6	7.3	7.8
20			3.6	9.3	12.7	13.5
40			0	15.6	22.7	24.5
80				25.1	41.0	44.6
100				28.7	49.5	54.2

Distance (km)	$D\bar{u}/Q$: 10^{-6}	5×10^{-7}	10^{-7}	5×10^{-8}	10^{-8}	5×10^{-9}
	H_m = 500 m					
0.5	1.1	1.3	1.7	1.9	2.2	2.3
1	1.2	1.4	1.9	2.0	2.4	2.5
2	1.3	1.6	2.2	2.4	2.8	2.9
4	1.6	2.0	2.8	3.1	3.7	3.9
8	1.8	2.8	4.2	4.7	5.7	6.0
10	1.8	3.1	4.9	5.5	6.7	7.1
20	0	3.6	7.9	9.1	11.5	12.3
40		0	12.5	15.2	20.3	22.1
80			17.6	24.7	36.0	40.0
100			18.3	28.2	43.2	48.3
	H_m = 1000 m					
0.5	0.8	1.1	1.6	1.7	2.1	2.2
1	0.9	1.2	1.7	1.8	2.2	2.3
2	0.9	1.3	1.9	2.1	2.5	2.7
4	0.9	1.5	2.5	2.8	3.4	3.6
8	0	1.8	3.6	4.1	5.1	5.5
10		1.8	4.1	4.8	6.0	6.5
20		0	6.3	7.7	10.3	11.2
40			8.8	12.3	17.9	19.9
80			4.7	17.5	31.0	35.3
100			0	18.3	36.8	42.4

TABLE 5-6 (Continued)

STABILITY CATEGORY VI

Distance (km)	$D\bar{u}/Q$ 10^{-5}	5×10^{-6}	10^{-6}	10^{-7}	10^{-8}	5×10^{-9}
	H_m = 125 m					
0.5	0.8	1.1	1.6	2.1	2.5	2.6
1	0.8	1.1	1.7	2.2	2.7	2.8
2	0.8	1.3	1.9	2.6	3.1	3.3
4	0.7	1.5	2.5	3.5	4.2	4.4
8	0	1.6	3.6	5.3	6.5	6.9
10		1.4	4.1	6.2	7.7	8.1
20		0	6.2	10.5	13.5	14.2
40			8.1	18.2	24.4	25.9
80			0	31.2	44.6	47.9
100				36.9	54.2	58.4
	H_m = 250 m					
0.5	0.2	0.8	1.4	1.9	2.3	2.4
1	0.1	0.8	1.4	2.0	2.5	2.6
2	0	0.8	1.6	2.4	2.9	3.1
4		0.7	2.1	3.1	3.9	4.1
8		0	2.9	4.7	6.0	6.3
10			3.2	5.5	7.1	7.5
20			4.1	9.2	12.3	13.1
40			0	15.5	22.1	23.7
80				25.3	40.0	43.5
100				29.2	48.4	52.9

Distance (km)	$D\bar{u}/Q$ 5×10^{-6}	10^{-6}	5×10^{-7}	10^{-7}	10^{-8}	5×10^{-9}
	H_m = 500 m					
0.5	0.3	1.1	1.3	1.7	2.2	2.3
1	0.1	1.2	1.4	1.9	2.3	2.5
2	0	1.3	1.6	2.1	2.7	2.8
4		1.6	2.0	2.8	3.6	3.8
8		2.0	2.8	4.1	5.5	5.8
10		2.0	3.1	4.8	6.4	6.9
20		0	4.1	7.8	11.2	12.0
40			0	12.6	19.9	21.6
80				18.6	35.5	39.2
100				20.0	42.7	47.4
	H_m = 1000 m					
0.5	0	0.9	1.1	1.6	2.0	2.2
1		0.9	1.2	1.7	2.2	2.3
2		1.0	1.3	1.9	2.5	2.6
4		1.0	1.6	2.4	3.3	3.5
8		0.4	2.0	3.5	5.0	5.3
10		0	2.0	4.1	5.8	6.3
20			0	6.4	10.0	10.9
40				9.3	17.7	19.5
80				8.7	30.9	34.9
100				0	36.8	42.0

TABLE 5-6 (Continued)

STABILITY CATEGORY VII

Distance (km)	$D\bar{u}/Q$ 10^{-5}	$5x10^{-6}$	10^{-6}	10^{-7}	10^{-8}	$5x10^{-9}$	Distance (km)	$D\bar{u}/Q$ 10^{-5}	$5x10^{-6}$	10^{-6}	10^{-7}	10^{-8}	$5x10^{-9}$
	H_m = 75 m							H_m = 250 m					
0.5	1.1	1.3	1.7	2.1	2.5	2.6	0.5	0.5	0.8	1.4	1.9	2.3	2.4
1	1.1	1.4	1.8	2.3	2.7	2.8	1	0.4	0.9	1.5	2.0	2.4	2.6
2	1.2	1.5	2.1	2.7	3.1	3.3	2	0.3	0.9	1.6	2.3	2.8	2.9
4	1.4	1.9	2.7	3.5	4.2	4.4	4	0	1.0	2.0	3.0	3.7	3.9
8	1.6	2.6	4.0	5.4	6.5	6.8	8		0	2.9	4.5	5.7	6.0
10	1.5	2.8	4.6	6.3	7.7	8.0	10			3.3	5.3	6.7	7.1
20	0	3.2	7.4	10.9	13.5	14.2	20			4.5	8.9	11.8	12.5
40		0	11.6	19.3	24.7	26.1	40			3.8	15.3	21.4	22.9
80			15.9	34.3	45.8	48.7	80			0	25.7	39.0	42.2
100			16.1	41.1	55.8	59.6	100				30.0	47.3	51.4
	H_m = 125 m							H_m = 500 m					
0.5	0.9	1.1	1.6	2.0	2.4	2.5	0.5	0	0.5	1.2	1.8	2.2	2.3
1	0.9	1.2	1.7	2.2	2.6	2.7	1		0.4	1.2	1.8	2.3	2.4
2	0.9	1.3	1.9	2.5	3.0	3.1	2		0.3	1.3	2.1	2.6	2.7
4	1.0	1.6	2.4	3.3	4.0	4.1	4		0	1.6	2.7	3.4	3.6
8	0	1.9	3.5	5.0	6.1	6.4	8			2.2	4.0	5.2	5.5
10		1.9	4.1	5.9	7.2	7.6	10			2.3	4.7	6.2	6.6
20		0	6.3	10.1	12.8	13.5	20			1.8	7.7	10.8	11.6
40			9.1	17.7	23.3	24.7	40			0	12.8	19.5	21.1
80			7.5	30.8	42.9	45.9	80				19.9	35.1	38.5
100			0	36.6	52.2	56.1	100				22.2	42.3	46.7

5.3 BOX-MODEL ESTIMATES OF CONCENTRATION AND DOSAGE FOR NORMAL AND ABNORMAL LAUNCHES

The four nomograms given in Figures 5-3 through 5-6 can be used to calculate the normalized peak concentration and dosage for downwind distances exceeding 10 kilometers. In constructing the nomograms it was assumed that:

- The effective height of release and source dimensions may be neglected
- There is complete vertical mixing throughout the surface layer
- The alongwind concentration distribution and the cross-wind concentration and dosage distributions are Gaussian with standard deviations that are proportional to the downwind distance
- Wind direction shear in the mixing layer is 20 degrees over land and 10 degrees over water

Under these assumptions, the expressions for normalized concentration and dosage can be written

$$\chi/Q = \left(2\pi\, H_m\, \sigma_x\, \sigma_y\right)^{-1} \quad (5\text{-}1)$$

$$D\bar{u}/Q = \left(\sqrt{2\pi}\, H_m\, \sigma_y\right)^{-1} \quad (5\text{-}2)$$

where

Q = total amount of material released in the surface layer

H_m = depth of the mixing layer (meters)

σ_x = alongwind standard deviation (meters)

σ_y = crosswind standard deviation (meters)

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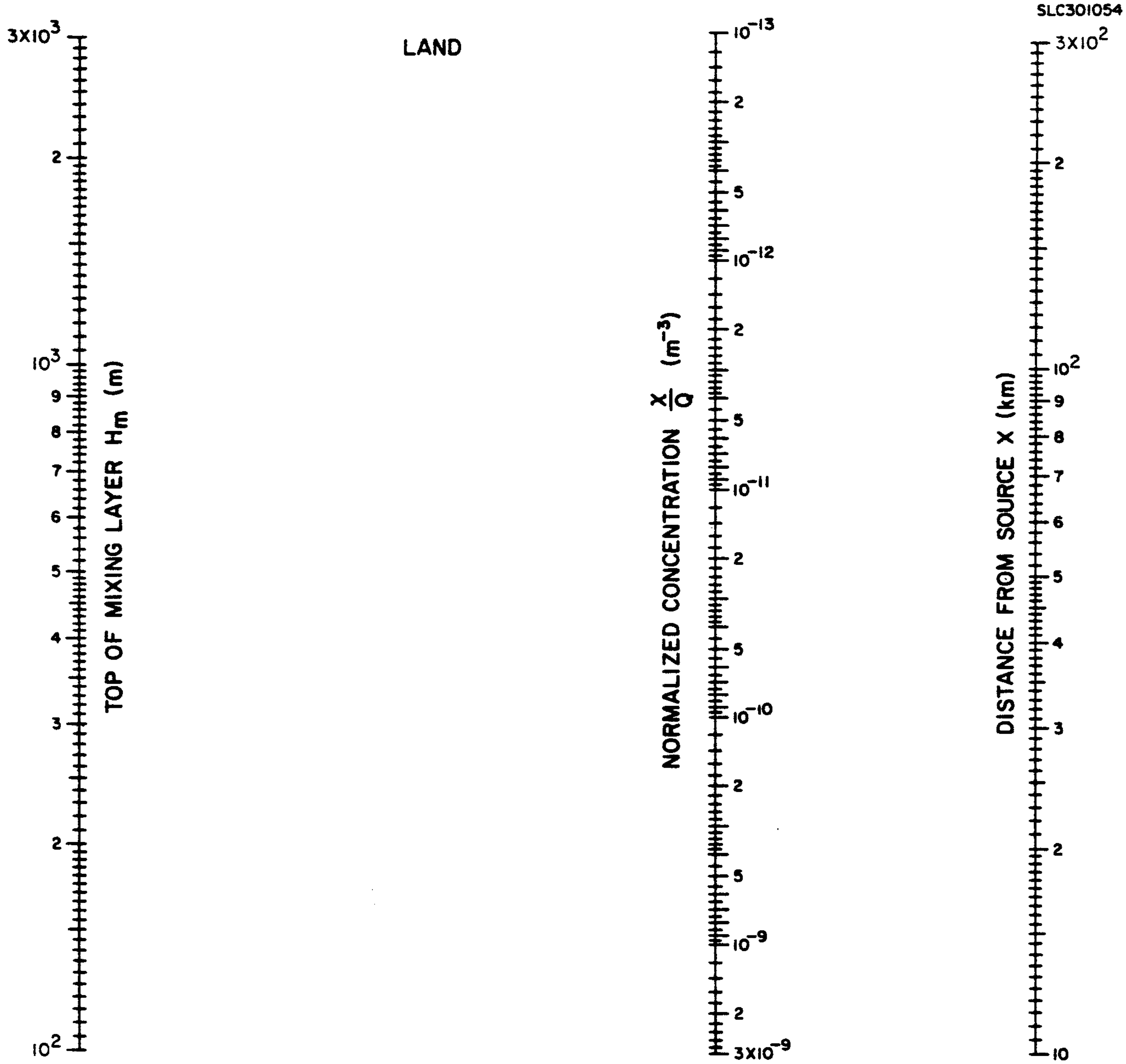

FIGURE 5-3. Nomogram for calculating normalized concentration for land trajectories at travel distances greater than 10 kilometers.

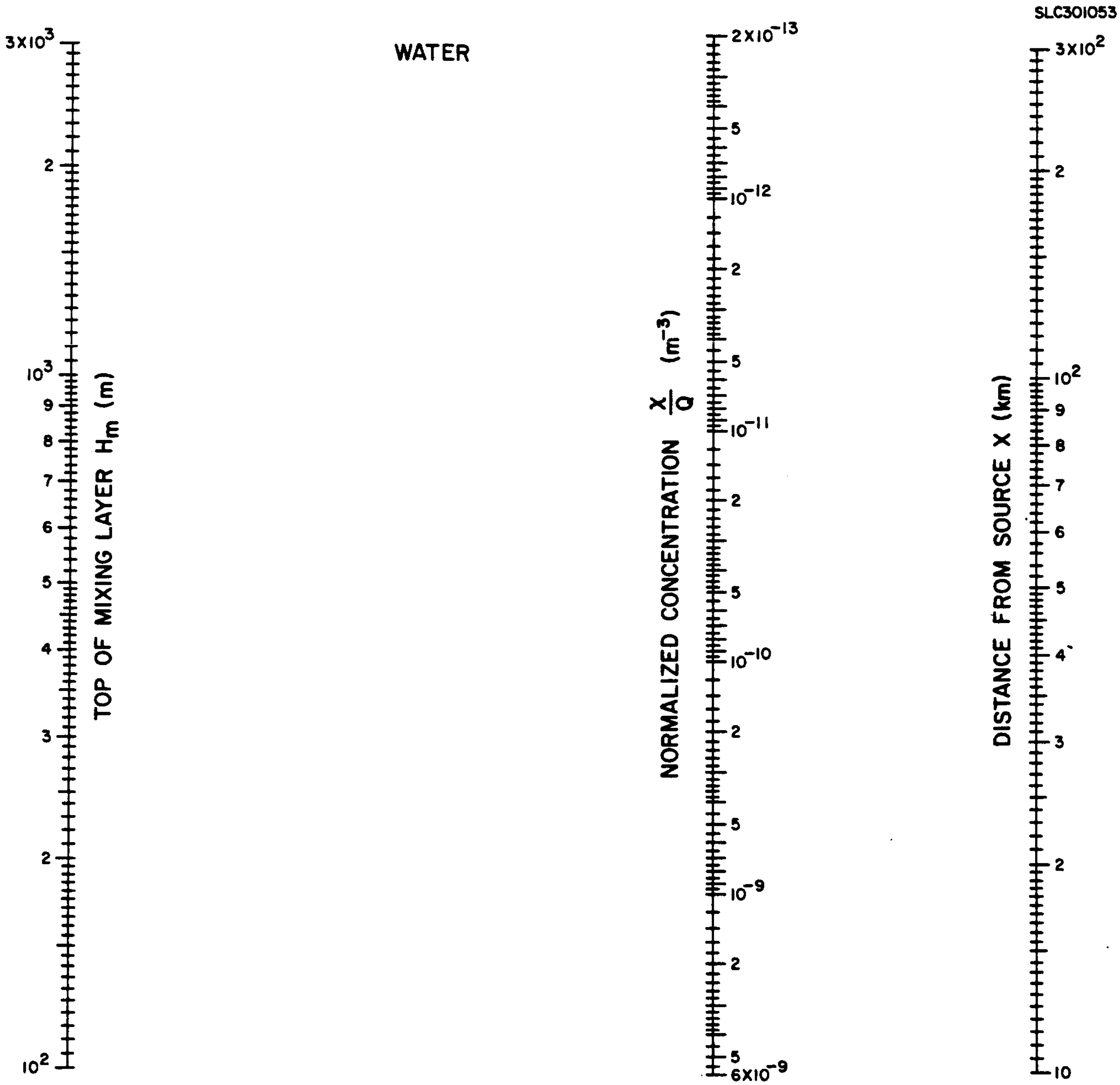

FIGURE 5-4. Nomogram for calculating normalized concentration for water trajectories at travel distances greater than 10 kilometers.

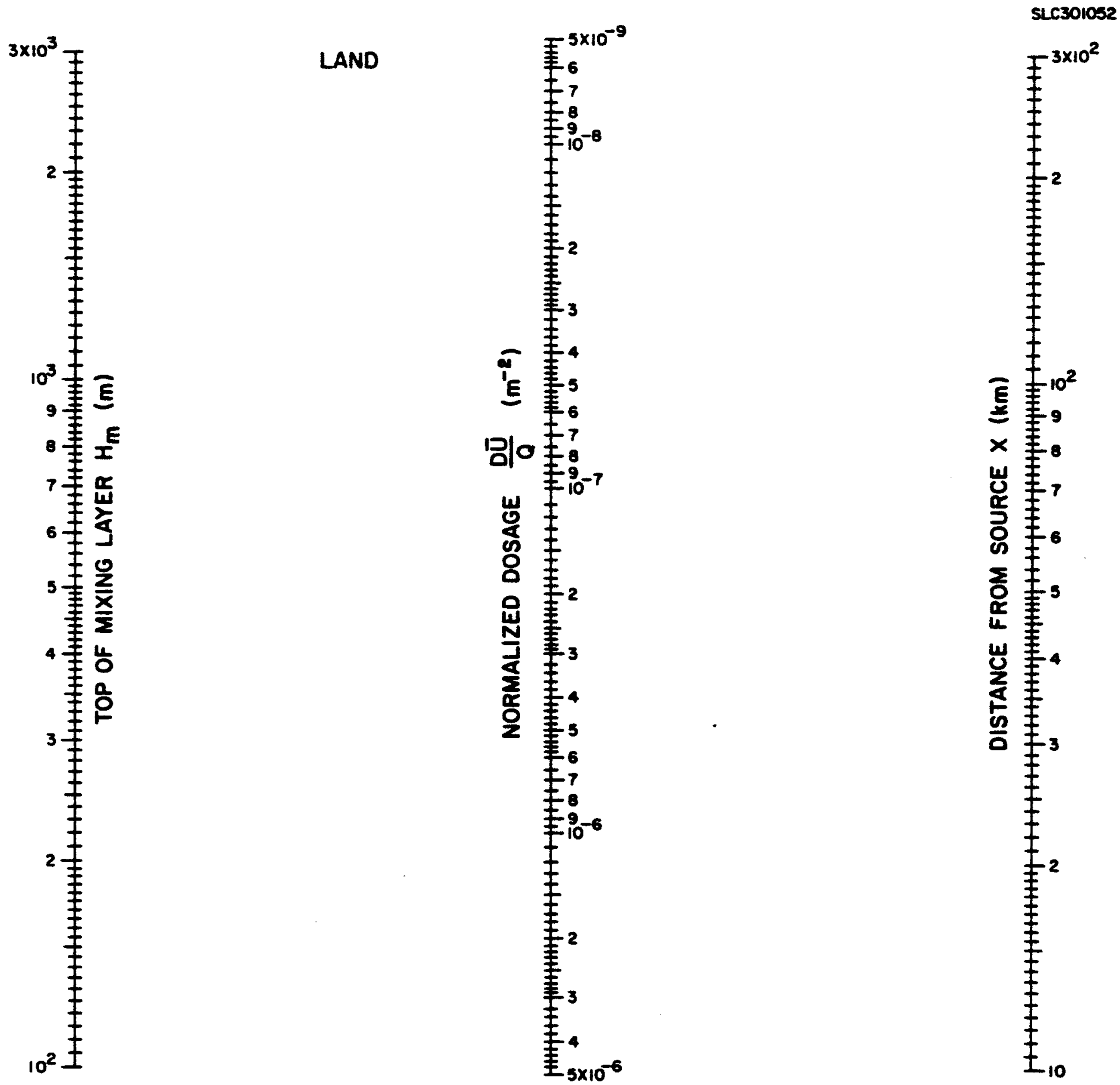

FIGURE 5-5. Nomogram for calculating normalized dosage for land trajectories at travel distances greater than 10 kilometers.

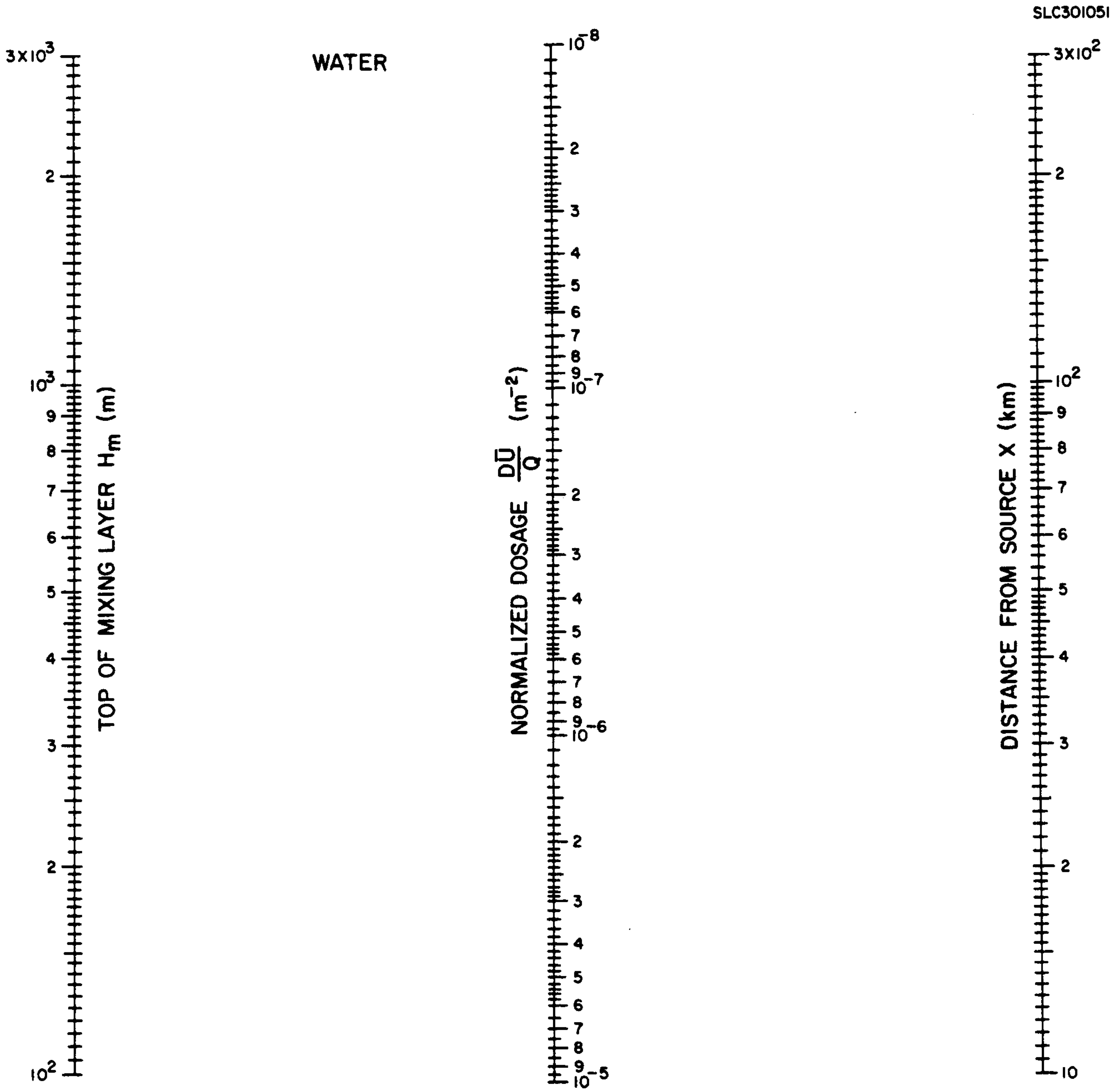

FIGURE 5-6. Nomogram for calculating normalized dosage for water trajectories at travel distances greater than 10 kilometers.

The crosswind and alongwind cloud dimensions are given by the following relationships:

Over a land surface $\sigma_x = 0.0651\ x$ $\sigma_y = 0.0811\ x$

Over a water surface $\sigma_x = 0.0651\ x$ $\sigma_y = 0.0406\ x$

where x is the downwind distance in meters. Figures 5-3 and 5-4 are used to calculate normalized concentration for land and water trajectories, respectively. Figures 5-5 and 5-6 are used to calculate normalized dosage for overland and overwater trajectories, respectively. In each case, the nomograms can also be used to calculate the distance at which the concentration or dosage drops to some specified level. Examples of the use of the nomograms are given in Figure 5-7.

5.4 CONCENTRATION FIELDS FROM COLD SPILLS AND LEAKS

Figure 5-8 shows the normalized axial ground-level (z=2m) concentration resulting from either a cold spill 50 meters in diamater or a surface leak as a function of travel distance. Separate plots are given for each of the seven stability categories, and individual curves have been drawn on each plot for several mixing depths. Differences between the concentration fields from the two release modes are significant only at distances less than 0.5 kilometers. Over these short distances, the values predicted for the cold spill are indicated by dashed lines. Estimates of actual concentration are obtained by multiplying the ordinate values by $Q/\bar{u}$, where Q is the quantity of material released per second and $\bar{u}$ is the wind speed at a height of 18 meters in meters per second.

Figure 5-9 shows similar plots of normalized axial concentration downwind from a leak at a height of 50 meters. At short travel distances, the axial concentrations at ground level (z=2m) are indicated by dashed lines and the axial concentrations at a height of 50 meters by the solid curves.

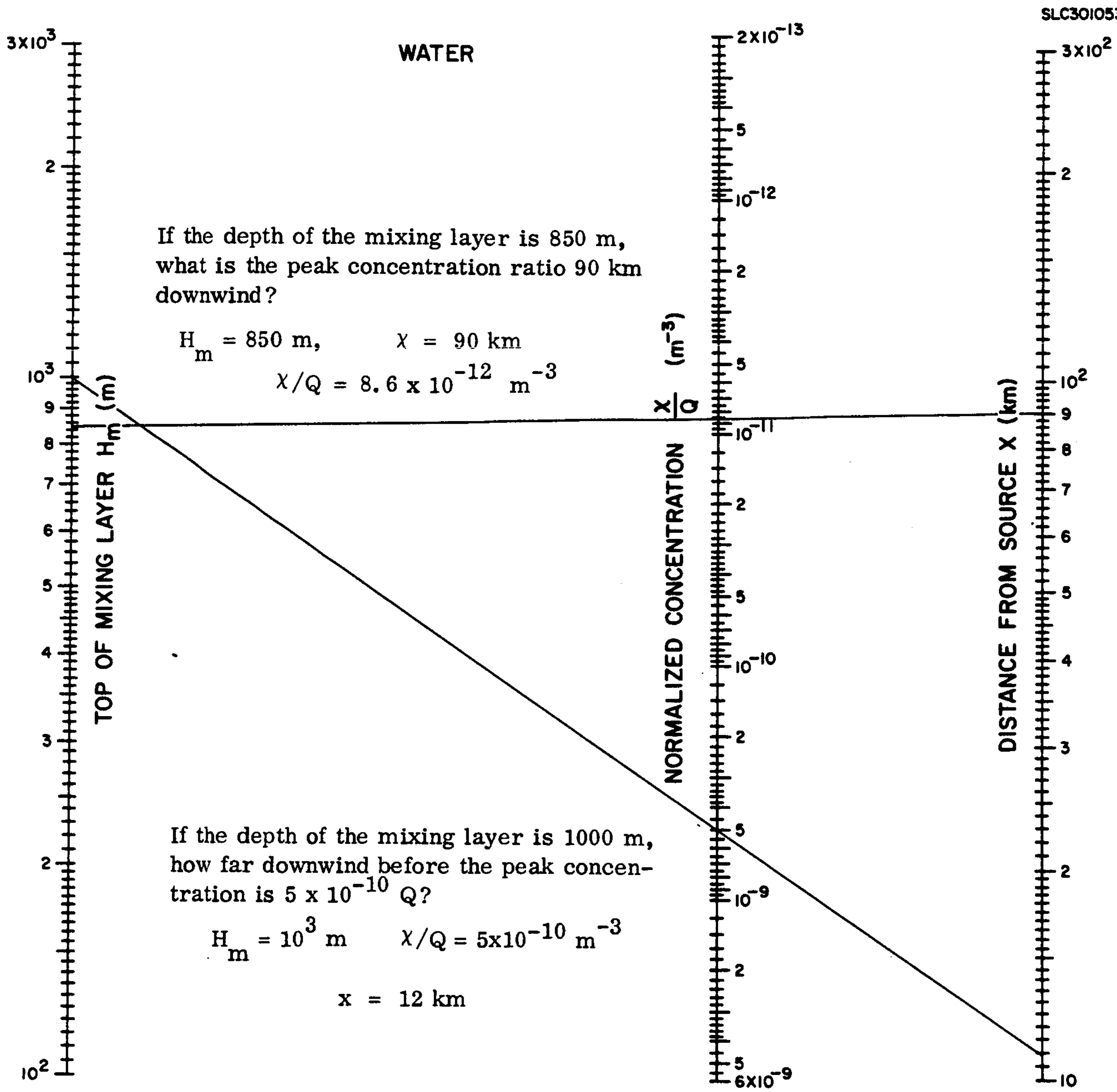

FIGURE 5-7. Two examples illustrating the use of Figure 5-4.

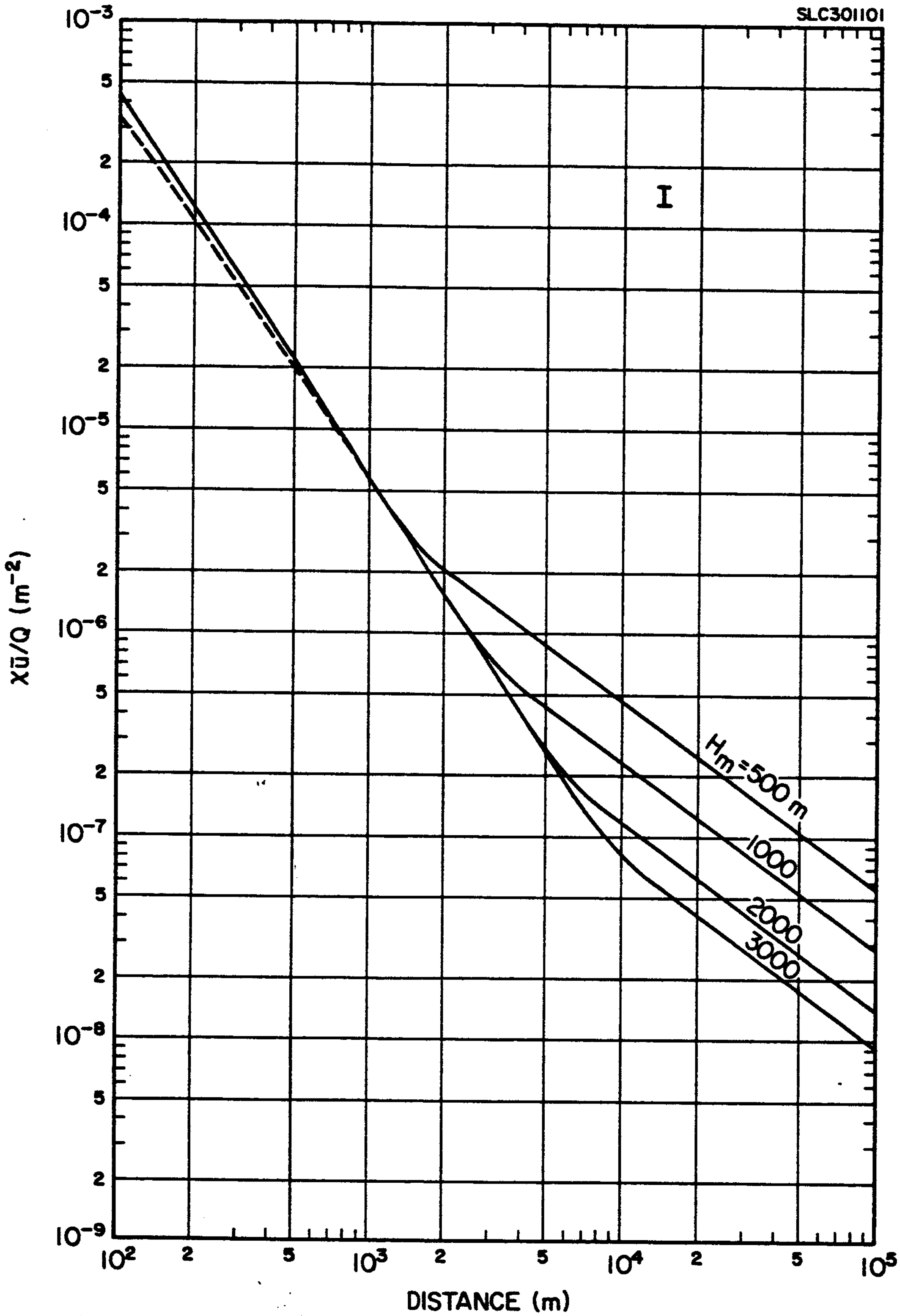

FIGURE 5-8. Normalized axial ground-level concentration versus travel distance from a surface leak or cold spill for Stability Category I. Dashed curve shows predicted values at short distances from a surface spill. H_m is depth of mixing layer.

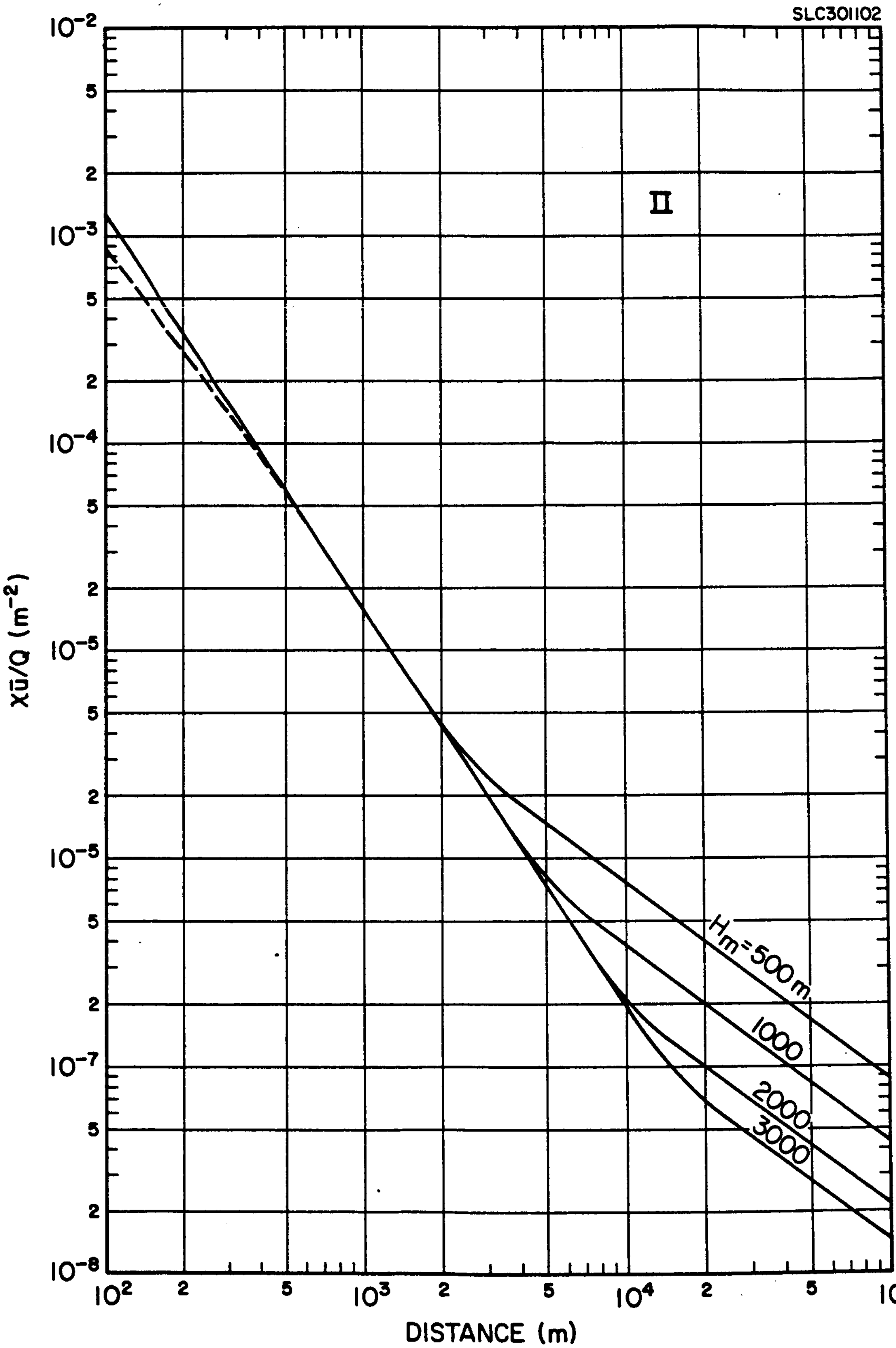

FIGURE 5-8. (Continued) Stability Category II

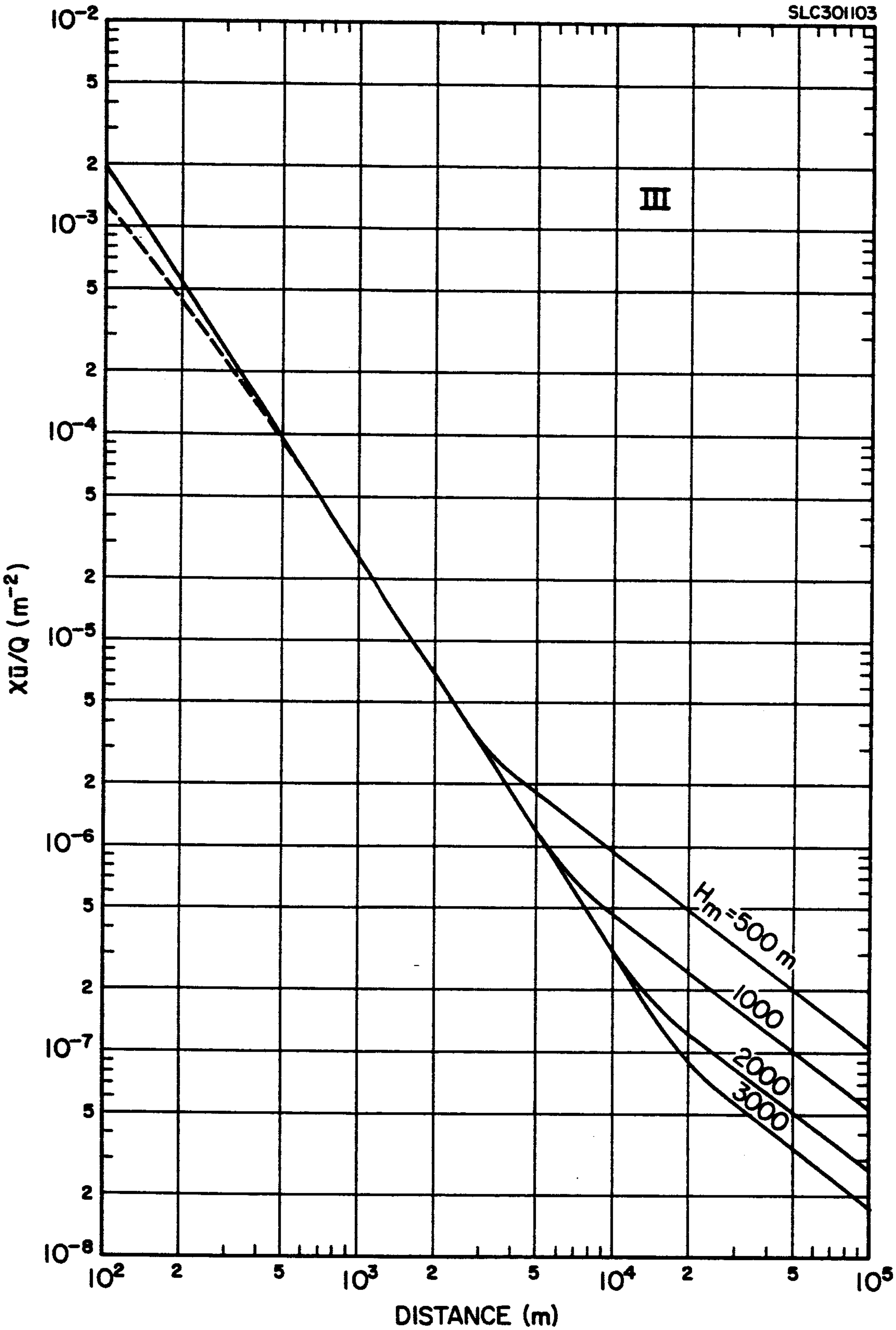

FIGURE 5-8. (Continued) Stability Category III.

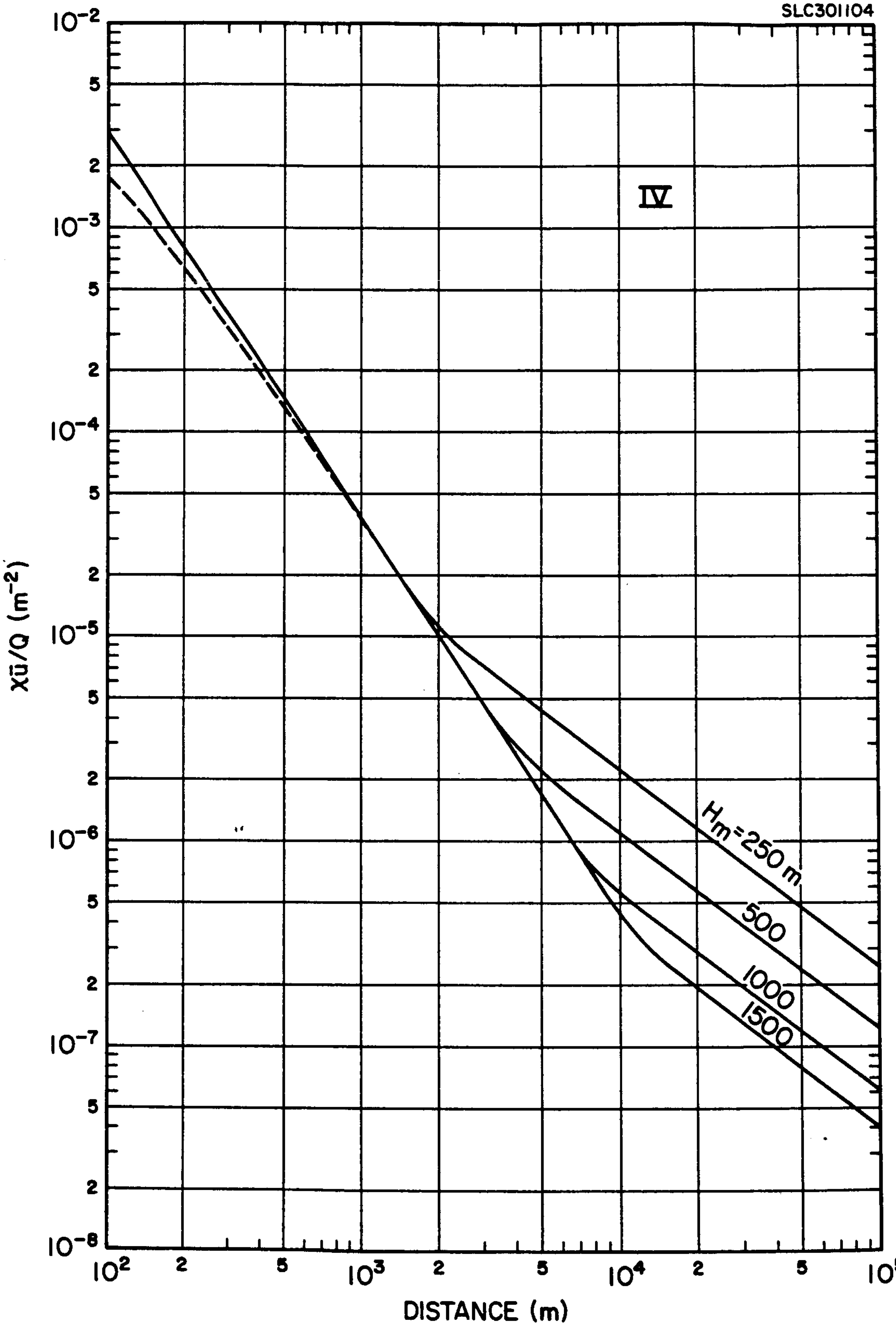

FIGURE 5-8. (Continued) Stability Category IV.

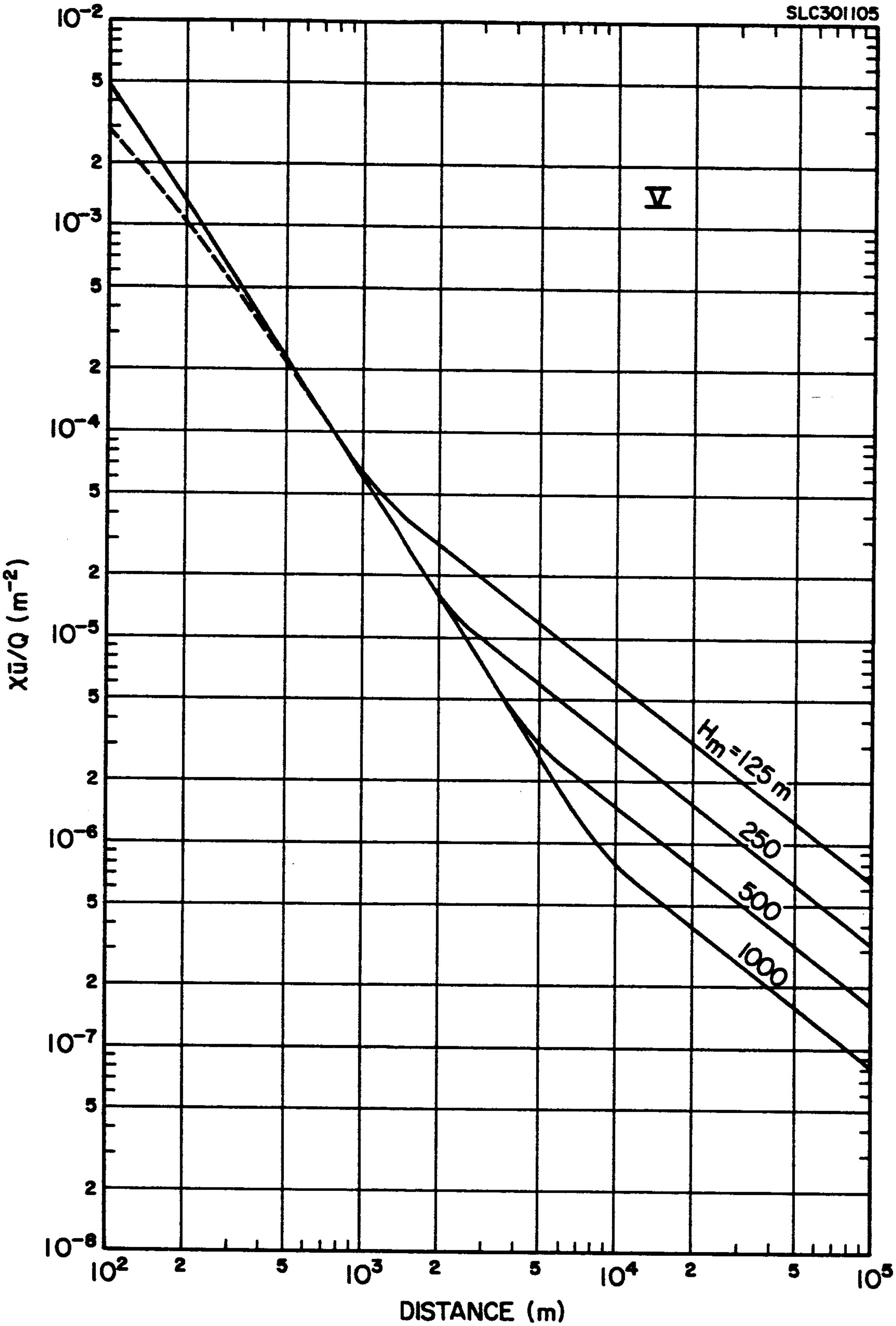

FIGURE 5-8. (Continued) Stability Category V.

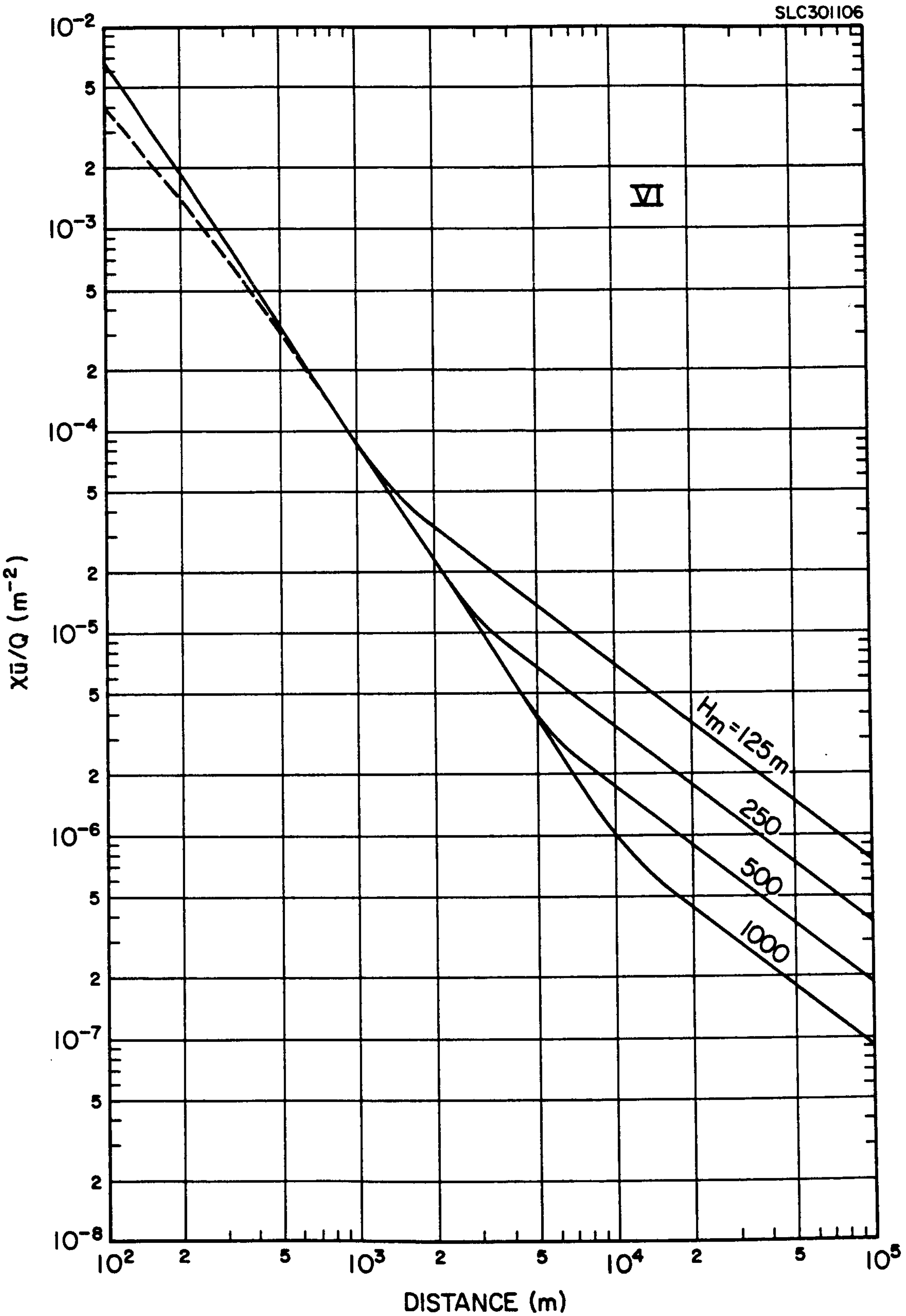

FIGURE 5-8. (Continued) Stability Category VI.

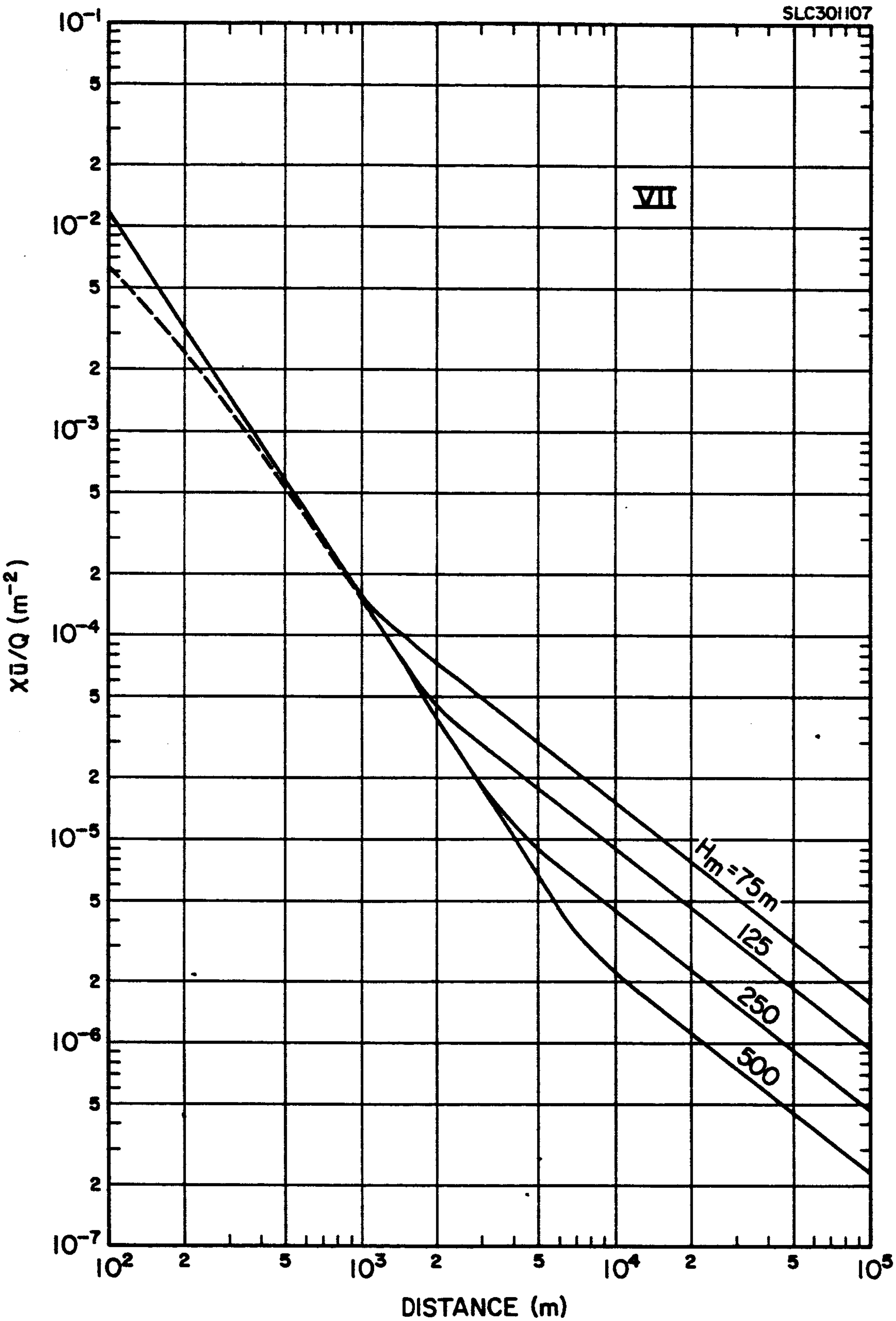

FIGURE 5-8. (Continued) Stability Category VII.

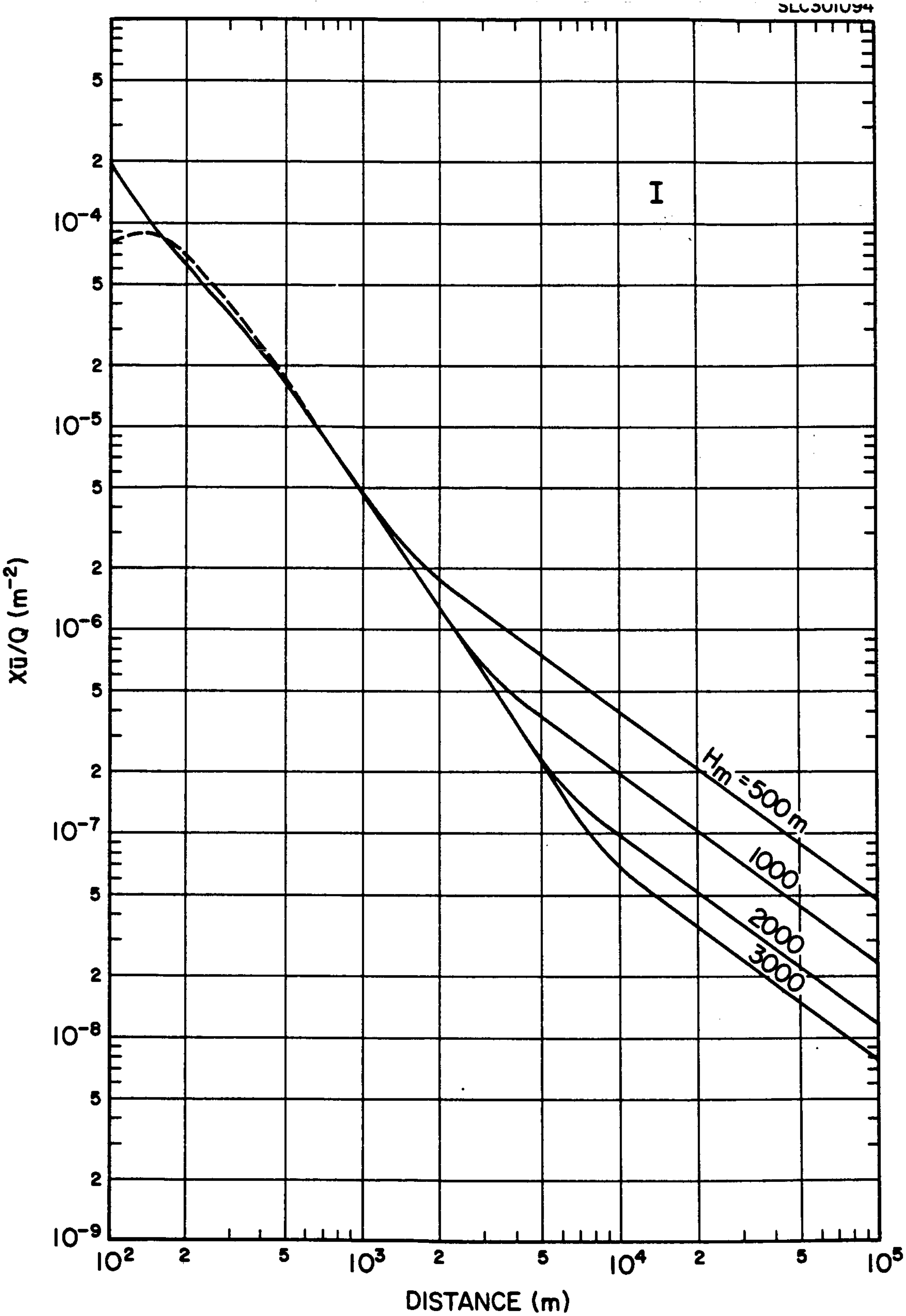

FIGURE 5-9. Normalized axial concentration versus travel distance from a leak at a height of 50 meters for Stability Category I. At short distances, solid curve shows predicted values at a height of 50 meters and the dashed curve shows predicted values at ground level. H_m is depth of mixing layer.

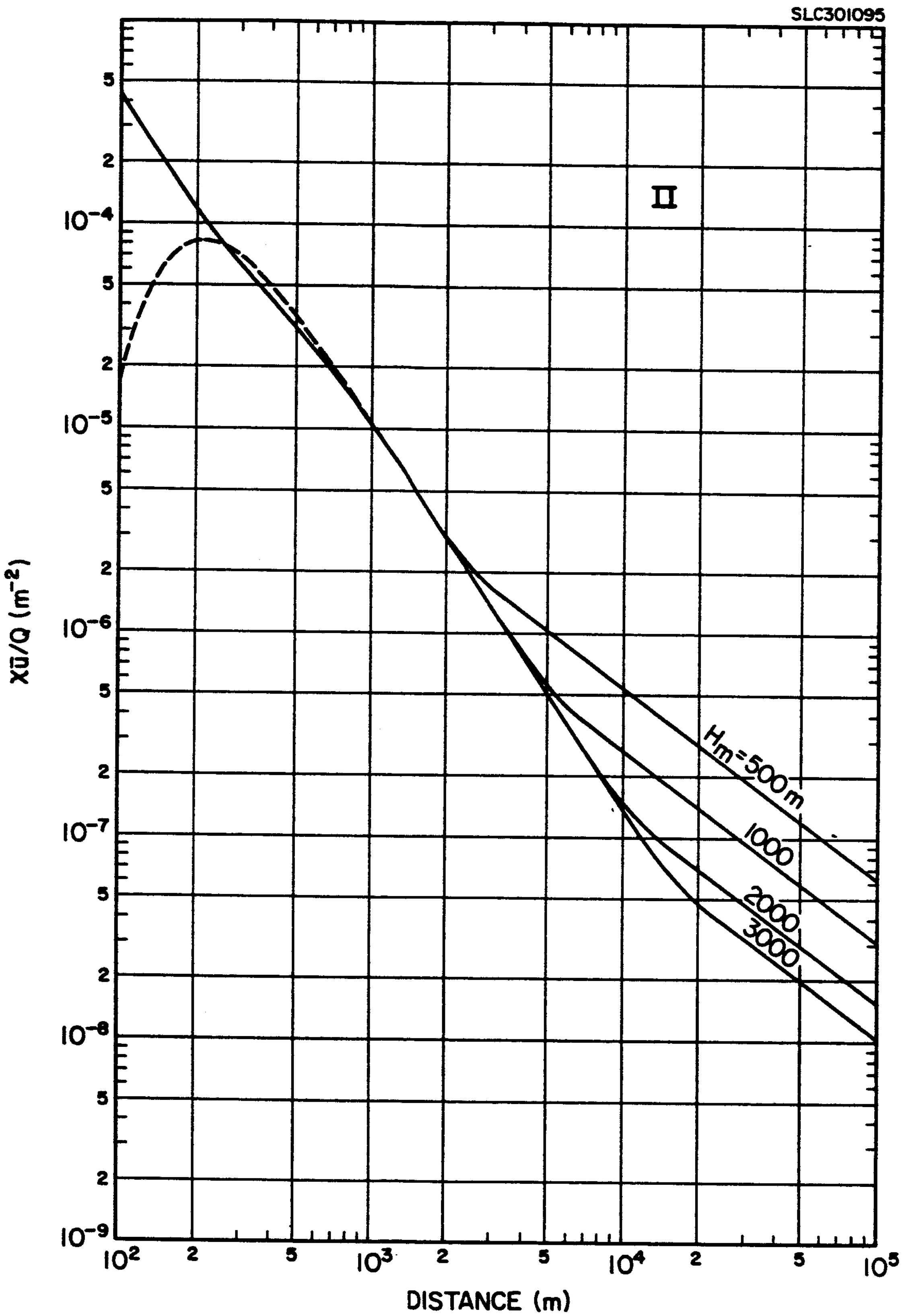

FIGURE 5-9. (Continued) Stability Category II.

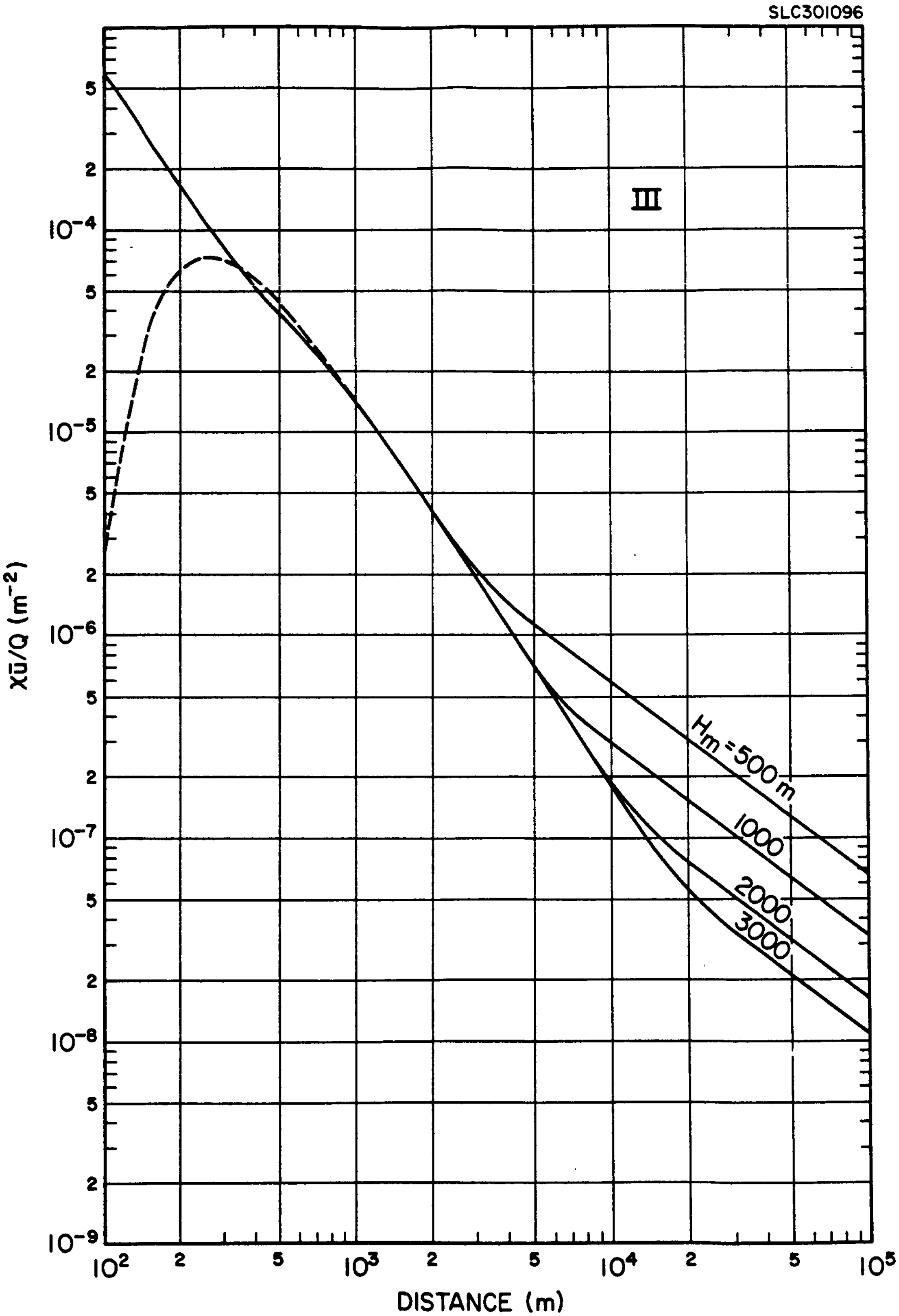

FIGURE 5-9. (Continued) Stability Category III.

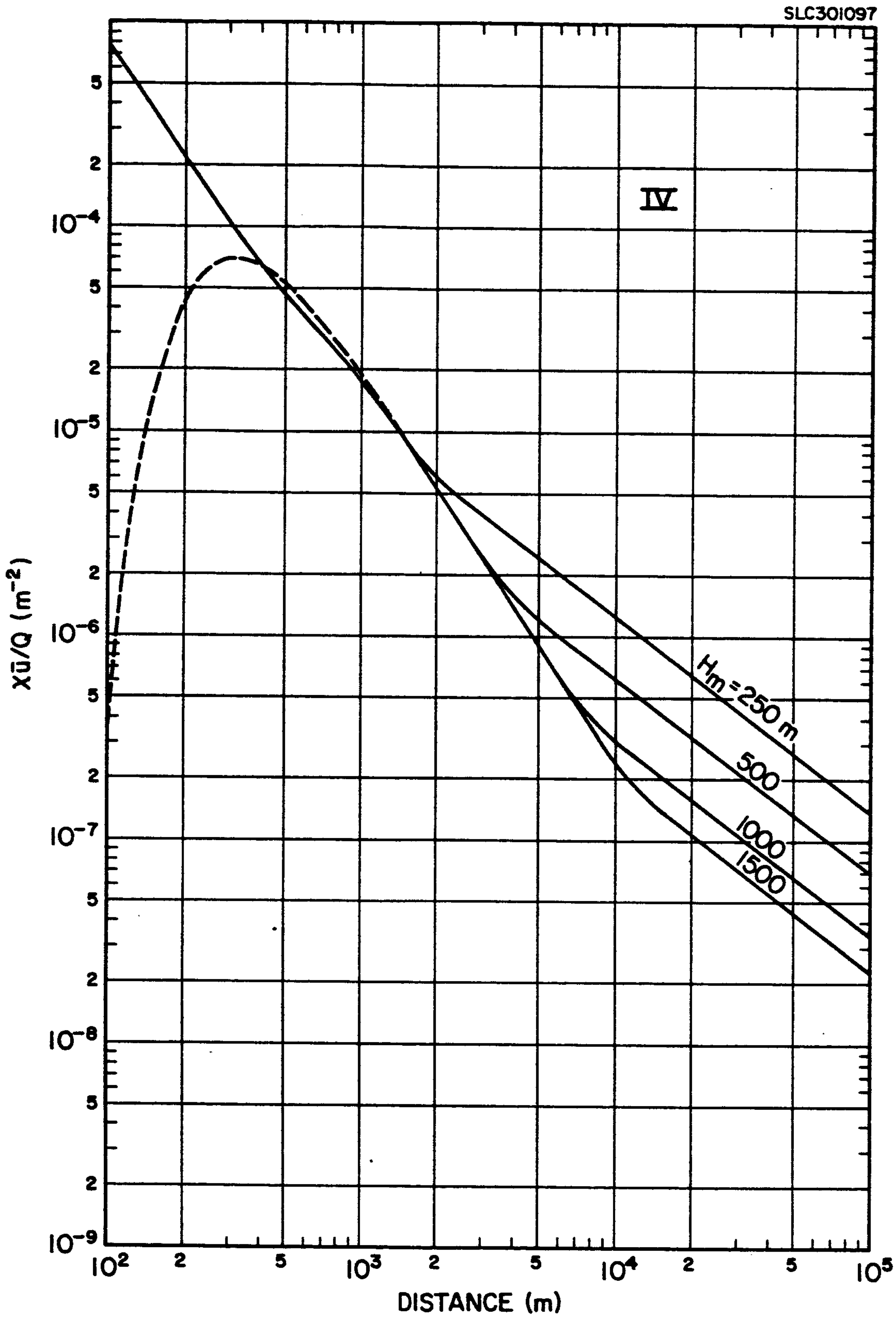

FIGURE 5-9. (Continued) Stability Category IV.

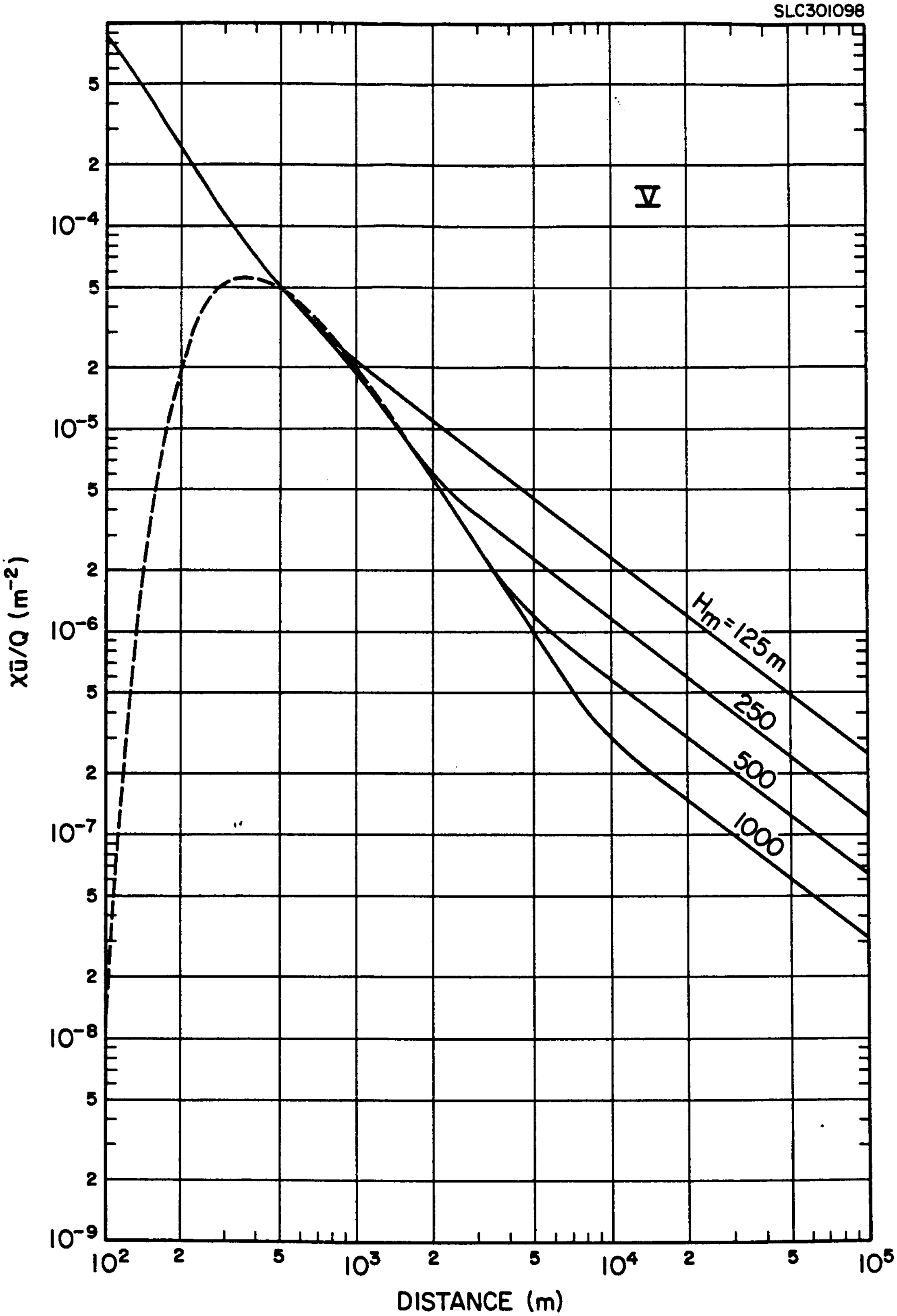

FIGURE 5-9. (Continued) Stability Category V.

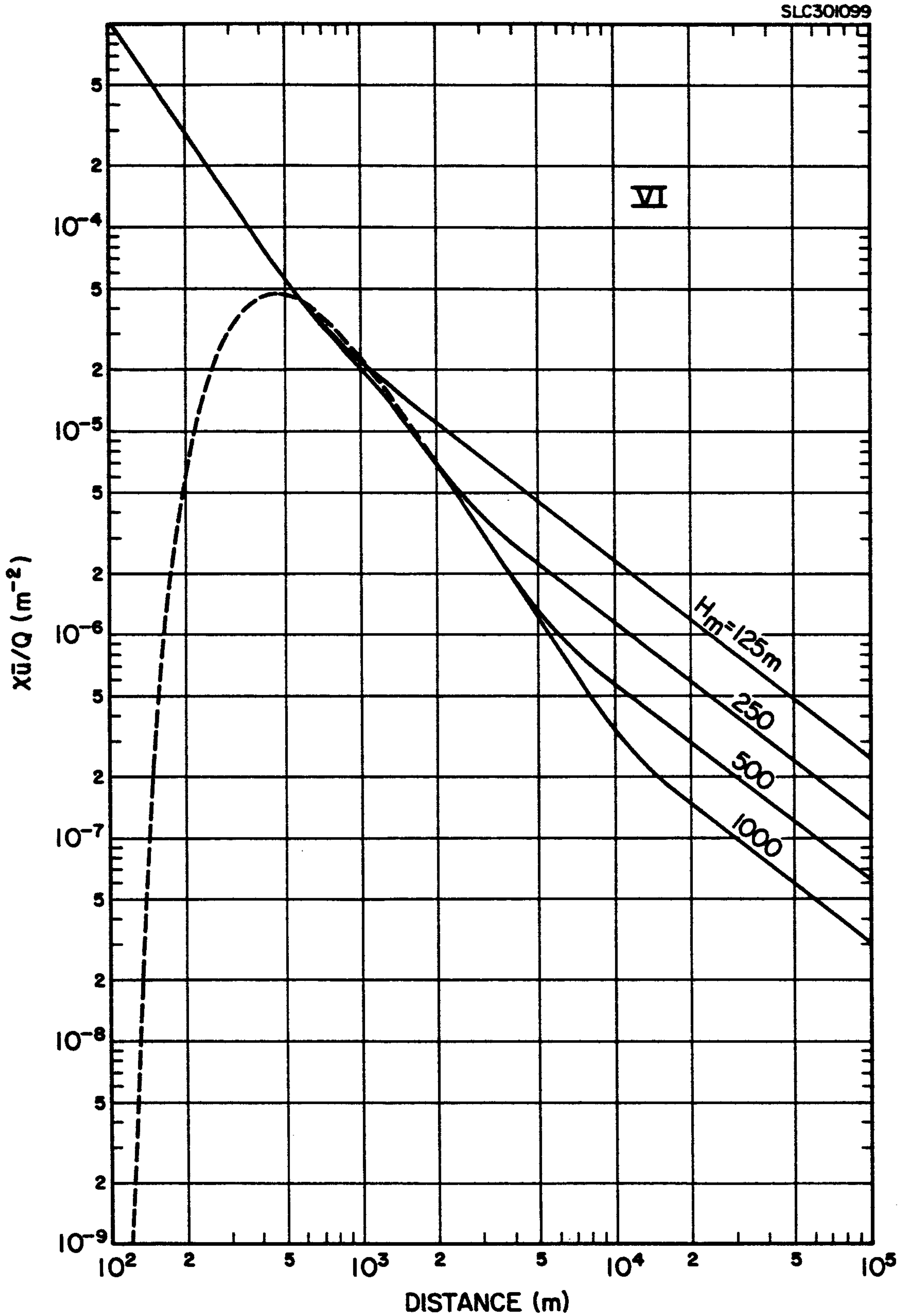

FIGURE 5-9. (Continued) Stability Category VI.

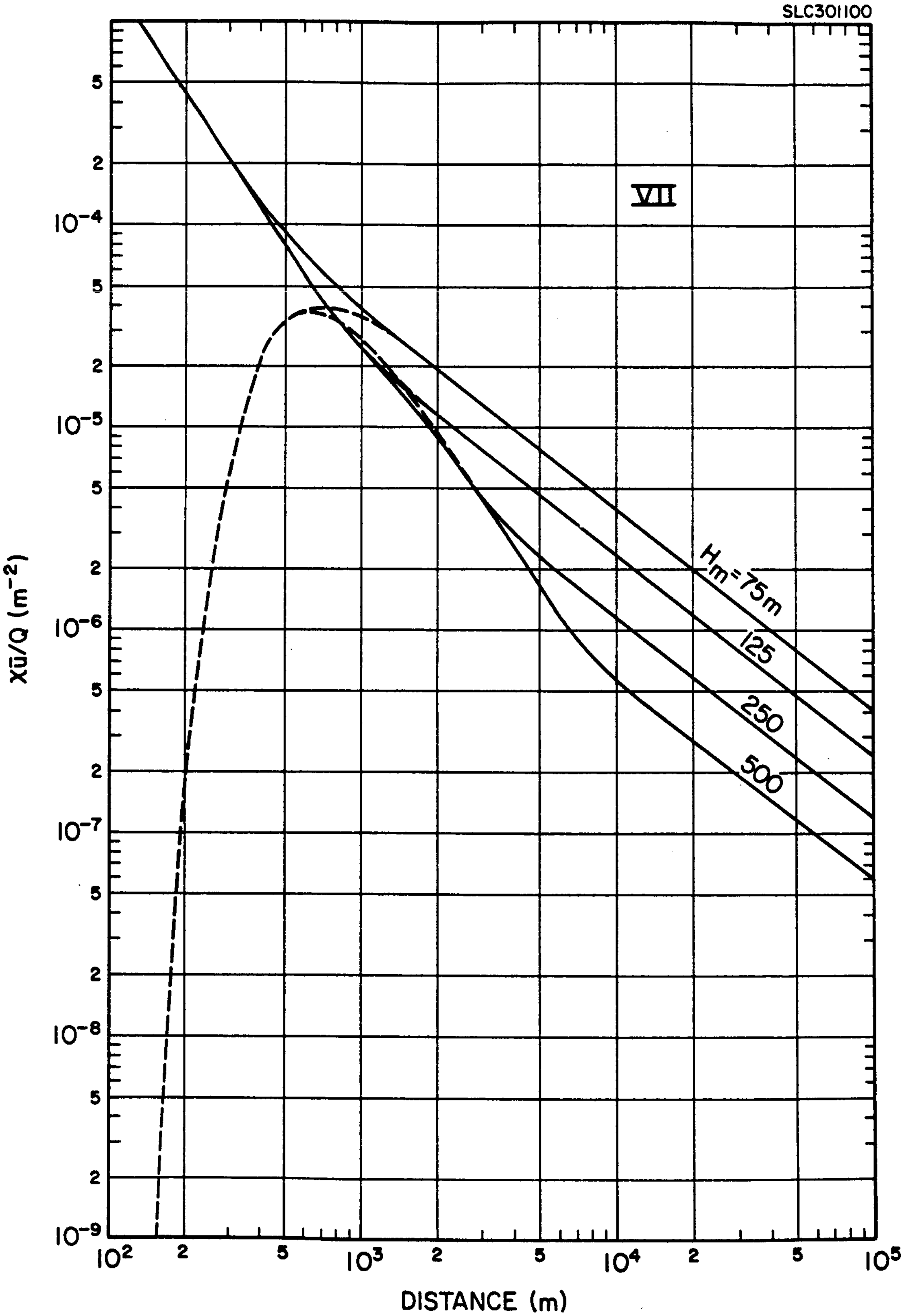

FIGURE 5-9. (Continued) Stability Category VII.

Table 5-7 gives the widths at ground level of selected normalized concentration isopleths at a number of downwind distances from either a surface spill or a surface leak. Table 5-8 gives the isopleth widths downwind from a leak at a height of 50 meters. At distances greater than 0.5 kilometers isopleth widths are not dependent on the height of release. Actual concentrations associated with each isopleth width are obtained by multiplying the column headings by $Q/\bar{u}$.

The axial concentrations and isopleth widths given in Figures 5-8 and 5-9 and Tables 5-7 and 5-8 are for a source emission or an averaging time of 10 minutes. According to Hino (1968) and others, time mean concentrations downwind from continuous elevated sources are inversely proportional to the square root of the averaging time t for values of t ranging from about 10 to 60 minutes. For $t < 10$ minutes, a minus one-fifth power-law describes the variation of ground-level concentration with time. These relationships may be used with values from Figures 5-8 and 5-9 to calculate concentrations for source emission times or averaging times different from 10 minutes. Isopleth widths from Tables 5-7 and 5-8 may be adjusted to other release times by assuming the width proportional to $t^{1/2}$ for t between 10 and 60 minutes, and proportional to $t^{1/5}$ for $t < 10$ minutes.

TABLE 5-7

ISOPLETH WIDTHS IN KILOMETERS OF NORMALIZED GROUND-LEVEL CONCENTRATION VERSUS TRAVEL DISTANCE FROM A SURFACE SPILL OR LEAK

STABILITY CATEGORY I											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 500 m						H_m = 2000 m				
0.5	0.6	0.7	0.9	0.9	1.0	0.5	0.6	0.7	0.9	0.9	1.0
1	0.9	1.1	1.4	1.5	1.7	1	0.9	1.1	1.4	1.5	1.7
2	1.1	1.5	2.2	2.4	2.9	2	0.8	1.3	2.1	2.3	2.8
4	0.6	2.1	3.6	4.1	5.1	4	0	0	2.8	3.4	4.5
8	0	1.6	5.9	6.9	8.9	8			2.7	4.6	7.2
10		0	6.7	8.1	10.7	10			2.1	5.0	8.5
20			9.7	13.0	18.4	20			0	4.7	13.8
40			10.0	19.0	31.1	40				0	21.1
80			0	20.7	51.1	80					27.0
100				15.1	59.4	100					26.0
	H_m = 1000 m						H_m = 3000 m				
0.5	0.6	0.7	0.9	0.9	1.0	0.5	0.6	0.7	0.9	0.9	1.0
1	0.9	1.1	1.4	1.5	1.7	1	0.9	1.1	1.4	1.5	1.7
2	0.8	1.3	2.1	2.3	2.8	2	0.8	1.3	2.1	2.3	2.8
4	0	0.7	3.1	3.6	4.7	4	0	0	2.8	3.4	4.5
8		0	4.5	5.8	8.1	8			1.5	4.0	6.9
10			5.0	6.7	9.6	10			0	3.8	7.9
20			4.7	9.7	16.3	20				0	12.2
40			0	9.9	26.6	40					17.1
80				0	40.9	80					13.3
100					45.8	100					0

TABLE 5-7 (Continued)

STABILITY CATEGORY II											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 500 m						H_m = 2000 m				
0.5	0.5	0.5	0.6	0.7	0.7	0.5	0.5	0.5	0.6	0.7	0.7
1	0.8	0.8	1.0	1.1	1.2	1	0.8	0.8	1.0	1.1	1.2
2	1.0	1.2	1.6	1.8	2.1	2	1.0	1.2	1.6	1.8	2.1
4	1.2	1.8	2.7	3.0	3.6	4	0.6	1.5	2.5	2.8	3.5
8	0	2.4	4.6	5.2	6.5	8	0	0	3.2	4.1	5.6
10		2.5	5.4	6.2	7.8	10			3.2	4.5	6.5
20		0	8.5	10.4	13.8	20			0.3	6.0	10.9
40			11.8	16.5	24.0	40			0	2.8	17.7
80			7.6	23.4	41.0	80				0	26.5
100			0	24.6	48.4	100					29.1
	H_m = 1000 m						H_m = 3000 m				
0.5	0.5	0.5	0.6	0.7	0.7	0.5	0.5	0.5	0.6	0.7	0.7
1	0.8	0.8	1.0	1.1	1.2	1	0.8	0.8	1.0	1.1	1.2
2	1.0	1.2	1.6	1.8	2.1	2	1.0	1.2	1.6	1.8	2.1
4	0.6	1.5	2.5	2.8	3.5	4	0.6	1.5	2.5	2.8	3.5
8	0	0	3.8	4.6	6.0	8	0	0	3.2	4.1	5.6
10			4.4	5.4	7.2	10			3.1	4.4	6.5
20			6.0	8.5	12.4	20			0	3.9	9.9
40			2.9	11.8	21.1	40				0	15.4
80			0	7.6	34.5	80					20.4
100				0	39.9	100					20.2

TABLE 5-7 (Continued)

STABILITY CATEGORY III											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 500 m						H_m = 2000 m				
0.5	0.5	0.5	0.6	0.6	0.7	0.5	0.5	0.5	0.6	0.6	0.7
1	0.7	0.8	0.9	1.0	1.1	1	0.7	0.8	0.9	1.0	1.1
2	1.0	1.2	1.5	1.6	1.9	2	1.0	1.2	1.5	1.6	1.9
4	1.3	1.7	2.5	2.7	3.3	4	1.1	1.6	2.4	2.7	3.2
8	1.1	2.5	4.2	4.8	5.8	8	0	0	3.3	4.0	5.3
10	0	2.7	5.0	5.7	7.1	10			3.5	4.5	6.1
20		0	8.1	9.6	12.6	20			2.9	6.1	10.1
40			11.9	15.7	22.2	40			0	6.1	16.8
80			12.5	23.5	38.4	80				0	26.1
100			7.3	25.7	45.6	100					29.3
	H_m = 1000 m						H_m = 3000 m				
0.5	0.5	0.5	0.6	0.6	0.7	0.5	0.5	0.5	0.6	0.6	0.7
1	0.7	0.8	0.9	1.0	1.1	1	0.7	0.8	0.9	1.0	1.1
2	1.0	1.2	1.5	1.6	1.9	2	1.0	1.2	1.5	1.6	1.9
4	1.1	1.6	2.4	2.7	3.2	4	1.1	1.6	2.4	2.7	3.2
8	0	1.1	3.6	4.2	5.4	8	0	0	3.3	4.0	5.3
10		0	4.1	5.0	6.5	10			3.5	4.5	6.1
20			6.1	8.1	11.4	20			0	4.8	9.4
40			6.1	11.9	19.7	40				0	14.8
80			0	12.5	32.8	80					21.2
100				7.2	38.3	100					22.3

TABLE 5-7 (Continued)

STABILITY CATEGORY IV

Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	5×10^{-7}	10^{-7}	5×10^{-8}	10^{-8}	Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	5×10^{-7}	10^{-7}	5×10^{-8}	10^{-8}
	H_m = 250 m						H_m = 1000 m				
0.5	0.4	0.5	0.5	0.5	0.6	0.5	0.4	0.5	0.5	0.5	0.6
1	0.7	0.7	0.9	0.9	1.0	1	0.7	0.7	0.9	0.9	1.0
2	1.0	1.2	1.4	1.5	1.8	2	1.0	1.1	1.4	1.5	1.7
4	1.6	2.0	2.5	2.8	3.2	4	1.2	1.6	2.3	2.5	3.0
8	2.5	3.2	4.5	4.9	5.8	8	0	1.5	3.5	4.0	5.1
10	2.7	3.7	5.3	5.9	7.1	10		1.0	4.0	4.7	6.1
20	2.2	5.4	9.2	10.4	12.8	20		0	6.0	7.8	10.8
40	0	4.7	15.3	18.0	23.1	40			7.1	11.9	18.8
80		0	23.5	30.0	41.3	80			0	14.3	31.8
100			26.2	34.9	49.6	100				12.1	37.3
	H_m = 500 m						H_m = 1500 m				
0.5	0.4	0.5	0.5	0.5	0.6	0.5	0.4	0.5	0.5	0.5	0.6
1	0.7	0.7	0.9	0.9	1.0	1	0.7	0.7	0.9	0.9	1.0
2	1.0	1.1	1.4	1.5	1.7	2	1.0	1.1	1.4	1.5	1.7
4	1.3	1.7	2.3	2.6	3.0	4	1.21	1.6	2.3	2.5	3.0
8	1.4	2.5	4.0	4.5	5.4	8	0	1.3	3.4	3.9	5.0
10	1.0	2.7	4.7	5.3	6.6	10		0	3.7	4.5	5.9
20	0	2.2	7.8	9.2	11.8	20			4.7	6.8	10.1
40		0	11.9	15.3	21.1	40			0	9.4	17.3
80			14.3	23.5	36.8	80				0.1	28.4
100			12.2	26.1	43.9	100					32.8

TABLE 5-7 (Continued)

STABILITY CATEGORY V

Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 125 m						H_m = 500 m				
0.5	0.4	0.4	0.5	0.5	0.6	0.5	0.4	0.4	0.5	0.5	0.6
1	0.7	0.7	0.8	0.9	1.0	1	0.7	0.7	0.8	0.9	1.0
2	1.1	1.2	1.5	1.6	1.7	2	1.0	1.1	1.4	1.5	1.7
4	1.9	2.2	2.7	2.8	3.2	4	1.4	1.7	2.3	2.5	2.9
8	3.3	3.8	4.8	5.2	5.9	8	1.8	2.6	3.9	4.4	5.3
10	3.8	4.5	5.8	6.2	7.2	10	1.8	3.0	4.7	5.3	6.4
20	5.9	7.5	10.3	11.3	13.3	20	0	3.7	7.9	9.2	11.6
40	7.4	11.7	18.1	20.2	24.5	40		0	12.7	15.6	20.9
80	0	14.9	30.9	45.6	44.8	80			17.8	25.2	37.0
100		13.7	36.4	42.5	54.2	100			18.4	28.7	44.2
	H_m = 250 m						H_m = 1000 m				
0.5	0.4	0.4	0.5	0.5	0.6	0.5	0.4	0.4	0.5	0.5	0.6
1	0.7	0.7	0.8	0.9	1.0	1	0.7	0.7	0.8	0.9	1.0
2	1.0	1.2	1.4	1.5	1.7	2	1.0	1.1	1.4	1.5	1.7
4	1.7	1.9	2.5	2.6	3.0	4	1.4	1.7	2.3	2.5	2.9
8	2.6	3.3	4.4	4.8	5.6	8	0.7	2.0	3.6	4.0	5.0
10	3.0	3.8	5.3	5.8	6.8	10	0	1.9	4.1	4.7	6.0
20	3.7	5.9	9.2	10.3	12.5	20		0	6.5	7.9	10.6
40	0	7.4	15.6	18.1	22.7	40			8.9	12.7	18.8
80		0	25.2	30.8	41.0	80			0.9	17.8	32.4
100			28.8	36.3	49.5	100			0	18.3	38.3

TABLE 5-7 (Continued)

STABILITY CATEGORY VI											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 125 m						H_m = 500 m				
0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5
1	0.7	0.7	0.8	0.8	0.9	1	0.7	0.7	0.8	0.8	0.9
2	1.1	1.2	1.4	1.5	1.7	2	1.0	1.2	1.4	1.5	1.6
4	1.9	2.1	2.6	2.7	3.1	4	1.5	1.8	2.3	2.5	2.9
8	3.3	3.7	4.7	5.0	5.7	8	1.9	2.7	3.9	4.3	5.1
10	3.8	4.5	5.7	6.1	7.0	10	2.0	3.1	4.6	5.2	6.2
20	6.1	7.5	10.2	11.1	13.0	20	0	4.1	7.9	9.1	11.4
40	8.2	12.0	18.0	20.0	24.0	40		0	13.0	15.6	20.6
80	0	16.4	31.0	35.5	44.1	80			19.0	25.6	36.7
100		16.4	36.6	42.4	53.6	100			20.3	29.5	44.1
	H_m = 250 m						H_m = 1000 m				
0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5
1	0.7	0.7	0.8	0.8	0.9	1	0.7	0.7	0.8	0.8	0.9
2	1.0	1.2	1.4	1.5	1.6	2	1.0	1.2	1.4	1.5	1.6
4	1.7	1.9	2.4	2.6	2.9	4	1.5	1.8	2.3	2.5	2.9
8	2.7	3.2	4.3	4.7	5.4	8	1.5	2.3	3.7	4.1	5.0
10	3.1	3.8	5.2	5.6	6.6	10	0.4	2.3	4.2	4.8	5.9
20	4.1	6.1	9.1	10.1	12.2	20	0	0	6.6	7.9	10.4
40	0	8.2	15.7	17.9	22.4	40			9.5	12.9	18.6
80		0	25.7	30.9	40.6	80			7.8	18.9	32.4
100			29.6	36.5	49.0	100			0	20.2	38.5

TABLE 5-7 (Continued)

STABILITY CATEGORY VII											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 75 m						H_m = 250 m				
0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5	0.5
1	0.6	0.7	0.8	0.8	0.9	1	0.6	0.7	0.8	0.8	0.9
2	1.1	1.2	1.4	1.4	1.6	2	1.0	1.1	1.3	1.4	1.5
4	2.0	2.2	2.5	2.7	3.0	4	1.6	1.9	2.3	2.4	2.8
8	3.5	3.9	4.7	5.0	5.6	8	2.7	3.2	4.1	4.4	5.2
10	4.2	4.7	5.7	6.1	6.9	10	3.1	3.8	5.0	5.4	6.3
20	7.2	8.3	10.5	11.3	13.0	20	4.6	6.2	8.9	9.8	11.7
40	11.6	14.2	19.0	20.7	24.3	40	3.7	9.1	15.5	17.6	21.6
80	16.2	23.1	34.0	37.7	45.2	80	0	7.7	26.1	30.8	39.7
100	16.7	26.3	40.8	45.6	55.2	100		0	30.4	36.6	48.1
	H_m = 125 m						H_m = 500 m				
0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5	0.5
1	0.6	0.7	0.8	0.8	0.9	1	0.6	0.7	0.8	0.8	0.9
2	1.0	1.1	1.3	1.4	1.6	2	1.0	1.1	1.3	1.4	1.5
4	1.8	2.0	2.4	2.6	2.9	4	1.6	1.8	2.2	2.4	2.7
8	3.2	3.6	4.5	4.8	5.4	8	2.1	2.7	3.8	4.1	4.9
10	3.8	4.3	5.4	5.8	6.6	10	2.3	3.1	4.5	5.0	5.9
20	6.2	7.5	9.8	10.7	12.4	20	1.8	4.5	7.8	8.9	10.9
40	9.1	12.3	17.6	19.5	23.2	40	0	3.7	13.1	15.5	20.0
80	7.9	18.2	30.9	34.9	42.9	80		0	20.3	26.1	36.1
100	0	19.5	36.7	42.0	52.3	100			22.5	30.4	43.5

TABLE 5-8

ISOPLETH WIDTHS IN KILOMETERS OF NORMALIZED CONCENTRATION VERSUS TRAVEL DISTANCE FROM A LEAK AT A HEIGHT OF 50 METERS

STABILITY CATEGORY I

Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 500 m				
0.5	0.6	0.7	0.8	0.9	1.0
1	0.8	1.0	1.3	1.4	1.6
2	0.9	1.4	2.1	2.3	2.8
4	0	1.8	3.5	4.0	5.0
8		0	5.6	6.7	8.7
10			6.4	7.8	10.4
20			8.8	12.3	17.9
40			6.2	17.3	30.1
80			0	14.6	48.9
100				0	56.5
	H_m = 1000 m				
0.5	0.6	0.7	0.8	0.9	1.0
1	0.8	1.0	1.3	1.4	1.6
2	0.6	1.2	2.0	2.2	2.7
4	0	0	2.9	3.5	4.6
8			4.2	5.6	7.9
10			4.5	6.4	9.4
20			2.2	8.8	15.7
40			0	6.2	25.4
80				0	38.1
100					42.1

Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 2000 m				
0.5	0.6	0.7	0.8	0.9	1.0
1	0.8	1.0	1.3	1.4	1.6
2	0.6	1.2	2.0	2.2	2.7
4	0	0	2.6	3.3	4.4
8			2.0	4.2	7.0
10			0	4.5	8.2
20				2.2	13.2
40				0	19.6
80					22.6
100					18.7
	H_m = 3000 m				
0.5	0.6	0.7	0.8	0.9	1.0
1	0.8	1.0	1.3	1.4	1.6
2	0.6	1.2	2.0	2.2	2.7
4	0	0	2.6	3.3	4.4
8			0	3.6	6.6
10				3.1	7.5
20				0	11.5
40					15.2
80					0
100					

TABLE 5-8 (Continued)

STABILITY CATEGORY II

Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 500 m						H_m = 2000 m				
0.5	0.4	0.5	0.6	0.6	0.7	0.5	0.4	0.5	0.6	0.6	0.7
1	0.7	0.8	0.9	1.0	1.2	1	0.7	0.8	0.9	1.0	1.2
2	0.9	1.1	1.5	1.7	2.0	2	0.9	1.1	1.5	1.7	2.0
4	0.8	1.5	2.5	2.9	3.5	4	0	1.1	2.3	2.6	3.3
8	0	1.6	4.2	4.9	6.2	8		0	2.6	3.7	5.3
10		1.1	4.9	5.8	7.5	10			2.3	3.9	6.1
20		0	7.3	9.4	13.1	20			0	4.2	10.0
40			8.6	14.3	22.6	40				0	15.7
80			0	17.3	37.8	80					21.3
100				15.1	44.2	100					21.5
	H_m = 1000 m						H_m = 3000 m				
0.5	0.4	0.5	0.6	0.6	0.7	0.5	0.4	0.5	0.6	0.6	0.7
1	0.7	0.8	0.9	1.0	1.2	1	0.7	0.8	0.9	1.0	1.2
2	0.9	1.1	1.5	1.7	2.0	2	0.9	1.1	1.5	1.7	2.0
4	0	1.1	2.3	2.7	3.3	4	0	1.1	2.3	2.6	3.3
8		0	3.3	4.2	5.7	8		0	2.6	3.6	5.3
10			3.7	4.9	6.8	10			2.1	3.8	6.0
20			4.2	7.3	11.7	20			0	0	8.9
40			0	8.5	19.4	40					13.0
80				0	30.7	80					12.9
100					34.8	100					5.2

TABLE 5-8 (Continued)

STABILITY CATEGORY III											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 500 m						H_m = 2000 m				
0.5	0.4	0.4	0.5	0.5	0.6	0.5	0.4	0.4	0.5	0.5	0.6
1	0.6	0.7	0.8	0.9	1.0	1	0.6	0.7	0.8	0.9	1.0
2	0.9	1.1	1.4	1.5	1.8	2	0.9	1.1	1.4	1.5	1.8
4	0.8	1.4	2.3	2.5	3.1	4	0.5	1.3	2.2	2.4	3.0
8	0	1.6	3.8	4.4	5.5	8	0	0	2.8	3.6	4.9
10		1.3	4.4	5.2	6.6	10			2.7	3.8	5.7
20		0	6.7	8.6	11.8	20			0	4.1	9.1
40			8.3	13.2	20.5	40				0	14.4
80			0	16.7	34.6	80					20.1
100				15.4	40.6	100					20.8
	H_m = 1000 m						H_m = 3000 m				
0.5	0.4	0.4	0.5	0.5	0.6	0.5	0.4	0.4	0.5	0.5	0.6
1	0.6	0.7	0.8	0.9	1.0	1	0.6	0.7	0.8	0.9	1.0
2	0.9	1.1	1.4	1.5	1.8	2	0.9	1.1	1.4	1.5	1.8
4	0.5	1.3	2.2	2.4	3.0	4	0.5	1.3	2.2	2.4	3.0
8	0	0	3.0	3.8	5.1	8	0	0	2.8	3.6	4.9
10			3.4	4.4	6.1	10			2.7	3.8	5.7
20			4.1	6.7	10.5	20			0	1.9	8.3
40			0	8.3	17.7	40				0	12.1
80				0	28.3	80					13.1
100					32.3	100					8.7

TABLE 5-8 (Continued)

STABILITY CATEGORY IV											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 250 m						H_m = 1000 m				
0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5	0.5
1	0.6	0.6	0.8	0.8	0.9	1	0.6	0.6	0.8	0.8	0.9
2	0.9	1.0	1.3	1.4	1.7	2	0.8	1.0	1.3	1.4	1.6
4	1.3	1.7	2.3	2.6	3.0	4	0.7	1.3	2.0	2.3	2.8
8	1.6	2.6	4.0	4.5	5.5	8	0	0	2.9	3.5	4.7
10	1.4	2.9	4.8	5.4	6.6	10			3.2	4.1	5.6
20	0	3.0	8.0	9.4	12.0	20			4.0	6.3	9.8
40		0	12.5	15.7	21.4	40			0	8.1	16.6
80			16.2	24.7	37.6	80				0	26.8
100			15.5	27.8	44.9	100					30.7
	H_m = 500 m						H_m = 1500 m				
0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5	0.5
1	0.6	0.6	0.8	0.8	0.9	1	0.6	0.6	0.8	0.8	0.9
2	0.8	1.0	1.3	1.4	1.6	2	0.8	1.0	1.3	1.4	1.6
4	0.9	1.4	2.1	2.3	2.8	4	0.7	1.3	2.0	2.3	2.8
8	0	1.6	3.5	4.0	5.1	8	0	0	2.8	3.4	4.6
10		1.4	4.1	4.8	6.1	10			2.9	3.8	5.4
20		0	6.3	8.0	10.9	20			1.5	5.1	9.0
40			8.1	12.5	19.2	40			0	3.4	14.9
80			0	16.2	32.7	80				0	22.7
100				15.4	38.4	100					25.1

TABLE 5-8 (Continued)

STABILITY CATEGORY V

Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}	Distance (km)	$\chi \bar{u}/Q$ 10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 125 m						H_m = 500 m				
0.5	0.3	0.3	0.4	0.4	0.5	0.5	0.3	0.3	0.4	0.4	0.5
1	0.6	0.6	0.7	0.8	0.9	1	0.5	0.6	0.7	0.8	0.9
2	0.9	1.1	1.3	1.4	1.6	2	0.8	1.0	1.2	1.3	1.5
4	1.6	1.8	2.4	2.6	3.0	4	0.8	1.3	2.0	2.2	2.7
8	2.4	3.1	4.2	4.6	5.5	8	0	1.4	3.2	3.8	4.7
10	2.7	3.6	5.1	5.6	6.6	10		1.2	3.8	4.5	5.7
20	2.5	5.3	8.8	9.9	12.2	20		0	5.8	7.5	10.3
40	0	5.2	14.7	17.3	22.1	40			7.2	11.6	18.0
80		0	23.0	29.1	39.7	80			0	14.4	30.7
100			25.8	33.9	47.8	100				13.0	36.1
	H_m = 250 m						H_m = 1000 m				
0.5	0.3	0.3	0.4	0.4	0.5	0.5	0.3	0.3	0.4	0.4	0.5
1	0.5	0.6	0.7	0.8	0.9	1	0.5	0.6	0.7	0.8	0.9
2	0.8	1.0	1.2	1.3	1.5	2	0.8	1.0	1.2	1.3	1.5
4	1.2	1.6	2.2	2.4	2.8	4	0.8	1.3	2.0	2.2	2.7
8	1.4	2.4	3.8	4.2	5.1	8	0	0	2.8	3.4	4.4
10	1.2	2.6	4.5	5.1	6.2	10			3.0	3.8	5.3
20	0	2.5	7.5	8.8	11.3	20			3.6	5.8	9.2
40		0	11.6	14.7	20.2	40			0	7.2	15.5
80			14.5	22.9	35.5	80				0	25.0
100			13.1	25.7	42.3	100					28.5

TABLE 5-8 (Continued)

STABILITY CATEGORY VI											
Distance (km)	$\chi \bar{u}/Q$					Distance	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 125 m						H_m = 500 m				
0.5	0.3	0.3	0.4	0.4	0.4	0.5	0.3	0.3	0.4	0.4	0.4
1	0.5	0.6	0.7	0.7	0.8	1	0.5	0.6	0.7	0.7	0.8
2	0.9	1.0	1.3	1.3	1.5	2	0.8	0.9	1.2	1.3	1.5
4	1.5	1.8	2.3	2.4	2.8	4	0.9	1.3	1.9	2.2	2.6
8	2.3	2.9	4.0	4.4	5.2	8	0	1.4	3.1	3.6	4.6
10	2.5	3.4	4.9	5.4	6.4	10		1.1	3.6	4.3	5.5
20	2.3	5.0	8.5	9.6	11.7	20		0	5.6	7.2	9.9
40	0	4.8	14.2	16.7	21.4	40			6.8	11.1	17.4
80		0	22.1	28.1	38.4	80			0	13.7	29.6
100			24.7	32.8	46.3	100				12.0	34.8
	H_m = 250 m						H_m = 1000 m				
0.5	0.3	0.3	0.4	0.4	0.4	0.5	0.3	0.3	0.4	0.4	0.4
1	0.5	0.6	0.7	0.7	0.8	1	0.5	0.6	0.7	0.7	0.8
2	0.8	0.9	1.2	1.3	1.5	2	0.8	0.9	1.2	1.3	1.5
4	1.2	1.5	2.1	2.3	2.7	4	0.9	1.3	1.9	2.2	2.6
8	1.4	2.3	3.6	4.0	4.9	8	0	0.4	2.8	3.4	4.4
10	1.1	2.5	4.3	4.9	6.0	10		0	3.0	3.8	5.1
20	0	2.3	7.2	8.4	10.8	20			3.4	5.6	8.8
40		0	11.1	14.2	19.5	40			0	6.8	15.0
80			13.7	22.0	34.3	80				0	24.1
100			12.1	24.6	40.9	100					27.4

TABLE 5-8 (Continued)

STABILITY CATEGORY VII											
Distance (km)	$\chi \bar{u}/Q$					Distance (km)	$\chi \bar{u}/Q$				
	10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}		10^{-6}	$5x10^{-7}$	10^{-7}	$5x10^{-8}$	10^{-8}
	H_m = 75 m						H_m = 250 m				
0.5	0.3	0.3	0.3	0.3	0.4	0.5	0.3	0.3	0.3	0.3	0.4
1	0.5	0.6	0.6	0.7	0.8	1	0.5	0.5	0.6	0.7	0.8
2	0.9	1.0	1.2	1.3	1.4	2	0.8	0.9	1.1	1.2	1.4
4	1.6	1.8	2.2	2.4	2.7	4	1.1	1.4	1.9	2.1	2.5
8	2.6	3.1	4.0	4.4	5.1	8	1.2	2.1	3.3	3.7	4.6
10	3.0	3.7	4.9	5.3	6.2	10	1.0	2.3	4.0	4.5	5.5
20	4.2	5.9	8.7	9.6	11.5	20	0	2.0	6.7	7.9	10.1
40	1.2	8.3	15.1	17.2	21.3	40		0	10.4	13.3	18.3
80	0	3.0	25.1	30.0	39.0	80			12.6	20.7	32.4
100		0	29.1	35.6	47.2	100			10.7	23.0	38.7
	H_m = 125 m						H_m = 500 m				
0.5	0.3	0.3	0.3	0.3	0.4	0.5	0.3	0.3	0.3	0.3	0.4
1	0.5	0.5	0.6	0.7	0.8	1	0.5	0.5	0.6	0.7	0.8
2	0.8	0.9	1.1	1.2	1.4	2	0.8	0.9	1.1	1.2	1.4
4	1.4	1.6	2.1	2.3	2.6	4	1.0	1.3	1.9	2.1	2.4
8	2.1	2.7	3.7	4.1	4.9	8	0	1.3	2.9	3.4	4.2
10	2.3	3.2	4.5	5.0	5.9	10		1.0	3.4	4.0	5.1
20	2.1	4.7	7.9	8.9	11.0	20		0	5.2	6.7	9.2
40	0	4.3	13.3	15.7	20.1	40			6.2	10.4	16.3
80		0	20.7	26.4	36.3	80			0	12.5	27.9
100			23.1	30.8	43.8	100				10.6	32.8

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APPENDIX A

USER INSTRUCTIONS FOR THE KSC MULTI-LAYER DIFFUSION MODEL PROGRAM

A.1 PROGRAM DESCRIPTION

The KSC Multi-Layer Diffusion Model Program consists of 22 subroutines, including the main driver program. The program is written in ASA FORTRAN V and should execute under most high level FORTRAN compilers when the appropriate monitor control cards are used. The program requires 33820_{10} locations of executable core. The size of the program can be reduced either by decreasing the size of common storage, or by using segmentation techniques. A diagram of the program linkage is given in Section A. 7. The program consists of five major logic sections. A block diagram of these sections is given in Figure 4-1. The subroutine linkage of each logic section is shown in Section A. 8. Sections 1 through 4 can be performed in any combination, or as a single case. Section 5 is performed as a single case and any number of cases can be processed by the program.

A. 1. 1 Logic Section 1

Section 1 calculates dosage and concentration at grid points on a three-dimensional reference coordinate system using either polar or rectangular coordinates. For rectangular coordinates, north is the positive y-axis and east is the positive x-axis. For polar coordinates, north is 0 degrees and east is 90 degrees. Options in this section include the calculation of dosage and concentration with cloud depletion by precipitation scavenging (washout) and simple time-dependent decay. Surface deposition due to precipitation scavenging can also be calculated. Provision is additionally made for calculating crosswind distances from the cloud axis to dosage or concentration isopleths of interest (cloud half-widths). This section uses subroutines READER, WASHT, TESTR, BREAK, ISO, PEAK, EL, LATER, ALONGD, VERT, SIGMA, COORD, as well as the main driver program.

Subroutine READER reads and converts most of the program input data. All program input instructions reference logical tape 5 (card reader).

Subroutine WASHT calculates ground-level patterns of deposition due to precipitation scavenging, when this option is selected.

Subroutine TESTR defines the new layer structure if the structure is changed at time t*.

Subroutine BREAK is the main calculation routine for this section and includes Models 1 through 6 as shown in Figure 4-1.

Subroutine ISO evaluates the error function ERF(X) used in calculation of Models 4 and 5.

Subroutine PEAK calculates the peak terms for dosage and concentration in Models 1, 2 and 3.

Subroutine ACH has entry points EL, LATER AND ALONGD; EL evaluates the term $L\{x_K\}$ as given by Equation (3-9); LATER evaluates the lateral term in y in Equations (3-1), (3-15) and (3-19); ALONGD calculates the alongwind term in Equation (3-7).

Subroutine VERT calculates the vertical and vertical reflection terms for Model 3 as given by Equation (3-15).

Subroutine SIGMA calculates the various standard deviations for the dosage and concentration distributions, as given by Equations (3-4), (3-8), (3-13), (3-14), (3-16), (3-23), and (3-32).

Subroutine COORD performs all coordinate transformations. The layer models are written with reference to a cloud or plume coordinate system where the x-axis is oriented along the mean wind direction, the y-axis is perpendicular to the x-axis in the crosswind direction, and the z-axis is directed vertically. The subroutine COORD relates the cloud coordinate system to the fixed reference coordinate system used to locate source and receptor locations. The fixed reference system may be in either polar or rectangular coordinates.

A.1.2 Logic Section 2

Section 2 calculates peak dosage and maximum peak concentration along the cloud axis for Models 1, 2 and 3. Options include the calculation of dosage and concentration in the presence of cloud depletion by precipitation scavenging or simple decay. This section uses subroutines CENTRL, EL, ALONGD, PEAK, VERT and SIGMA, as well as the main driver program.

Subroutine CENTRL performs the main calculations and controls all output. All program outputs reference logical tape 6 (printer). All other subroutines of this section have the same functions as described above.

A.1.3 Logic Section 3

Section 3 calculates isopleths of dosage and concentration in the horizontal plane, about the cloud alongwind axis, for Models 1, 2 and 3. Options include the calculation of dosage and concentration with cloud depletion by precipitation scavenging and decay. This section uses subroutines ISOXY, EL, ALONGD, PEAK, VERT, SIGMA, as well as the main driver program.

Subroutine ISOXY performs the main calculations for Section 3 and controls all output. The functions of all other subroutines in this section have been outlined above. Section 3 is applicable only to Models 1, 2 and 3 as defined in Figure 4-1, and the various options that can be used with these models.

A. 1. 4 Logic Section 4

Section 4 calculates isopleths of dosage and concentration in the y-z plane at selected points on the alongwind cloud axis for Models 1, 2 and 3. Options include calculations of dosage and concentration isopleths with cloud depletion by precipitation scavenging and simple decay. This section uses subroutines ISOYZ, EL, ALONGD, PEAK, VERT, SIGMA, as well as the main driver routine.

Subroutine ISOYZ performs the main calculations for Section 4 and controls the output. The functions of all other subroutines in this section have been described above.

A. 1. 5 Logic Section 5

Section 5 of the program calculates deposition on the ground due to gravitational settling. This section uses subroutines DEPOS, SGP, COORD, as well as the main driver routine.

Subroutine DEPOS assembles the necessary logic for calculating the deposition and outputs all calculations.

Subroutine SGP consists of the entry points SGP, UBARS, DEPSO and BETAK, where SGP evaluates the mathematical equations in Section 3. 8 of the main body of the report.

A.2 PROGRAM INPUT SEQUENCE

The card input information required for the computer program is listed in Table A-1. The information categories in the table are defined as follows:

CARD UNIT NO.	-	Sequence number of the card group
FORTRAN	-	Fortran Symbolic notation defining the program input
MODEL	-	Notation used in models corresponding to FORTRAN notation
UNITS	-	Dimensional units of input parameters
FORMAT	-	FORTRAN format specification
CARD COLUMNS	-	Card column number in which input information is punched
LIMITS	-	Numerical limits on input values

A.3 EXPLANATION OF PROGRAM INPUTS

A.3.1 Card Unit No. 1

The first input card, Card Unit No. 1, gives the DATE of the run and is printed at the head of the listing.

A.3.2 Card Unit No. 2

Card Unit No. 2 gives the number (NP) of times the program is to be executed. All following cards are repeated NP times.

TABLE A-1

CARD INPUT INFORMATION

CARD UNIT NO.	FORTRAN	MODEL	UNITS	FORMAT	CARD COLUMNS	LIMITS
1	DATE			2A6	1-12	
2	NP			I2	1-2	
3	IA TESTNO			A1 12A6	1 2-73	IA='A'
4	ISKIP			40I2	1-80	
5	NXS NYS NZS NDI NCI NDXR NVS NBK NVB			I3 I3 I3 I3 I3 I3 I3 I3 I3	1-3 4-6 7-9 10-12 13-15 16-18 19-21 22-24 25-27	≤ 100 ≤ 100 ≤ 21 ≤ 10 ≤ 10 ≤ 100 ≤ 20 ≤ 10 ≤ 20
6	XX(I) I=1, NXS	x_j	meters	8F10.0	1-80	
7	YY(I) I=1, NYS	y_j	meters or degrees	8F10.0	1-80	If degrees $0.0 \leq YY < 360.0$
8	Z(I) I=1, NZS	z_k	meters	8F10.0	1-80	$Z_1 > 0.0$

TABLE A-1 (Continued)

CARD UNIT NO.	FORTRAN	MODEL	UNITS	FORMAT	CARD COLUMNS	LIMITS
9	DELX(I)	x_i	meters	F10.0	1-10 21-30 41-50 61-70	
	DELY(I) I=1, NNZ (NNZ= NZS-1)	y_i	meters	F10.0	11-20 31-40 51-60 71-80	If degrees $0.0 \leq$ DELY < 360.0
10	Q(I) I=1, NNZ	Q_K	Depends on model (See Section 3)	6E12.6	1-72	
11	UBARK(I) I=1, NNZ	$\bar{u}_{TK}$	meters seconds^{-1}	8F10.0	1-80	> 0.0
12	SIGAK(I) I=1, NNZ	$\sigma_{A_{TK}}\{\tau_{oK}\}$	degrees	8F10.0	1-80	> 0.0
13	SIGYO(I) I=1, NNZ	$\sigma_{yo}\{K\}$	meters	8F10.0	1-80	
14	SIGEK(I) I=1, NNZ	$\sigma_{E_{TK}}\{\tau_{oK}\}$	degrees	8F10.0	1-80	
15	ALPHA(I) I=1, NNZ	α_K		8F10.0	1-80	
16	BETA(I) I=1, NNZ	β_K		8F10.0	1-80	
17	SIGZO(I) I=1, NNZ	$\sigma_{zo}\{K\}$	meters	8F10.0	1-80	
18	SIGXO(I) I=1, NNZ	$\sigma_{xo}\{K\}$	meters	8F10.0	1-80	

TABLE A-1 (Continued)

CARD UNIT NO.	FORTRAN	MODEL	UNITS	FORMAT	CARD COLUMNS	LIMITS
19	ZRK	Z_R	meters	F10.0	1-10	> 0.0
	SIGARK	$\sigma_{AR}\{\tau_{oK}\}$	degrees	F10.0	11-20	
	SIGERK	$\sigma_{ER}\{\tau_{oK}\}$	degrees	F10.0	21-30	
	UBARRK	$\bar{u}_R$	meters seconds^{-1}	F10.0	31-40	
	DELPHI		degrees	F10.0	41-50	≤180.0
20	THETAK(I) I=1, (NZS*2)	θ_{BK} & θ_{TK}	degrees	8F10.0	1-80	$0.0 \leq \theta_K < 360.0$
21	TAUK(I) I=1, NNZ	τ_K	seconds	8F10.0	1-80	
22	TAUOK(I) I=1, NNZ	τ_{oK}	seconds	8F0.0	1-80	
23	T(I) I=1, NNZ	t or T_K	seconds	8F10.0	1-80	
24	H(I) I=1, NNZ	H_K	meters	8F10.0	1-80	
(The A sequence of cards is read only if ISKIP(1) ≠ 2)						
25-A	IZMOD(I) I=1, NNZ		N/A	20I2	1-20	=1, 2 or 3
26-A	NPT(I) I=1, NNZ		N/A	20I2	1-20	$NNZ + \sum_{i=1}^{NNZ} NPT_i \leq 100$

TABLE A-1 (Continued)

CARD UNIT NO.	FORTRAN	MODEL	UNITS	FORMAT	CARD COLUMNS	LIMITS
27-A	DECAY	k	$seconds^{-1}$	F10.0	21-30	
	ZLIM	Z_{lim}	meters	F10.0	31-40	
	TIM1	t_1	seconds	F10.0	41-50	
	LAMBDA		$seconds^{-1}$	F10.0	51-60	
28-A	DXR(I) I=1, NDXR	x_K	meters	8F10.0	1-80	
29-A	IFLAG(I) I=1, NDXR		N/A	40I2	1-80	
30-A	DI(I) I=1, NDI	$D_K\{x_K, y_K, K\}$	grams seconds $meters^{-3}$	6E12.6	1-72	
31-A	CI(I) I=1, NCI	$\chi_K\{x_K, y_K, t_K\}$	grams $meters^{-3}$	6E12.6	1-72	
(If ISKIP(13) = 0, 32-A through 45-A are not read)						
32-A	UBARL(I) I=1, NBK	$\bar{u}_{TL}$	meters $seconds^{-1}$	8F10.0	1-80	
33-A	SIGAL(I) I=1, NBK	$\sigma_{ATL}\{\tau_{oL}\}$	degrees	8F10.0	1-80	
34-A	SIGYO(I) I=NNZ+1, NNZ+NBK	$\sigma_{yo}\{L\}$	meters	8F10.0	1-80	
35-A	SIGEL(I) I=1, NBK	$\sigma_{ETL}\{\tau_{oL}\}$	degrees	8F10.0	1-80	
36-A	ALPHA(I) I=NNZ+1, NNZ+NBK	α_L		8F10.0	1-80	

TABLE A-1 (Continued)

CARD UNIT NO.	FORTRAN	MODEL	UNITS	FORMAT	CARD COLUMNS	LIMITS
37-A	BETA(I) I=NNZ+1, NNZ+NBK	β_L		8F10.0	1-80	
38-A	SIGZO(I) I=NNZ+1, NNZ+NBK	$\sigma_{zo}\{L\}$	meters	8F10.0	1-80	
39-A	SIGXO(I) I=NNZ+1, NNZ+NBK	$\sigma_{xo}\{L\}$	meters	8F10.0	1-80	
40-A	ZRL	z_{RL}	meters	F10.0	1-10	> 0.0
	SIGARL	$\sigma_{AR}\{\tau_{oL}\}$	degrees	F10.0	11-20	
	SIGERL	$\sigma_{ER}\{\tau_{oL}\}$	degrees	F10.0	21-30	
	UBARRL	$\bar{u}_{RL}$	meters seconds^{-1}	F10.0	31-40	
41-A	THETAL(I) I=1, (NBK*2)	θ_{BL} & θ_{TL}	degrees	8F10.0	1-80	$0.0 \leq \theta'_L$ < 360.0
42-A	TAUL(I) I=1, NBK	τ_L	seconds	8F10.0	1-80	
43-A	TAUOL(I) I=1, NBK	τ_{oL}	seconds	8F10.0	1-80	
44-A	TAST(I) I=1, NBK	t*	seconds	8F10.0	1-80	
45-A	JBOT(I) JTOP(I) I=1, NBK	K K + N	N/A N/A	20I2	1-2, 5-6, 9-10----- ----37-38 3-4, 7-8, 11-12----	

TABLE A-1 (Continued)

CARD UNIT NO.	FORTRAN	MODEL	UNITS	FORMAT	CARD COLUMNS	LIMITS
(If ISKIP(1) $\neq$ 2, Card Units 25-B through 30-B are not read)						
25-B	VS(I) I=1, NVS	V_s	meters seconds^{-1}	8F10.0	1-80	$VS_i \leq 10.0$
26-B	PERC(I) I=1, NVS	f_i		8F10.0	1-80	
27-B	ACCUR	R		F10.0	1-10	
(If ISKIP(3) = 0, Card Units 28-B through 30-B are not read)						
28-B	VB(I) I=1, NVB	V_{SK}	meters seconds^{-1}	8F10.0	1-80	
29-B	PERCB(I) I=1, NVB	f_i		8F10.0	1-80	
30-B	HB	H_{SK}	meters	F10.0	1-10	

A.3.3 Card Unit No. 3

Card Unit No. 3 contains the literal A in column 1 as an indicator for the start of a new case. Also, this card contains the title (TESTNO) of the case to be executed.

A.3.4 Card Unit No. 4

Card Unit No. 4 contains the following program model and logic options (ISKIP):

a. If ISKIP(1) equals 2, the Gravitational Deposition model (Model 7 in Figure 4-1) is executed. If ISKIP(1) is not equal to 2, all other models can be executed.

b. ISKIP(2) is the coordinate system control. If ISKIP(2) equals 0, XX, YY, DELX, DELY are assumed to be in rectangular coordinates. If ISKIP(2) equals 1, they are assumed to be in polar coordinates where XX and DELX are radial distances, and YY and DELY are positive angles measured clockwise from north or 0 degrees. ISKIP(2) affects all models except those for peak dosage, peak concentration and isopleths. These routines automatically use polar coordinates (DXR, $\pi \pm \theta_K$)

c. ISKIP(3) has a dual function. For all models except gravitational deposition, ISKIP(3) controls the calculation of the lateral term in Equation (3-1). If ISKIP(3) is set to 0, the lateral term is not calculated. If ISKIP(3) is set to 1, the lateral term is calculated. In the gravitational deposition model, the occurrence of a vehicle destruct in layer NNZ is indicated by setting ISKIP(3) = 1.

d. ISKIP(4) controls the calculation of the vertical term in the dosage equation for Model 3, which is given by the exponential term in Equation (3-15); and, also, the peak dosage, maximum peak concentration, and isopleth calculations. If ISKIP(4) is set to 0, the vertical term is not calculated. If ISKIP(4) is set to 1, the vertical term is calculated.

e. ISKIP(5) controls the calculation of the vertical reflection term in Equation (3-15); and, also, the peak dosage, peak concentration, and isopleth calculations. If ISKIP(5) is set to 0, this term is not calculated. If ISKIP(5) is set to 1, the vertical reflection term is calculated.

f. ISKIP(6) controls the calculation of the alongwind term in Equation (3-7) and the isopleth calculations. If ISKIP(6) is set to 0, the alongwind term is not calculated. If ISKIP(6) is set to 1, the alongwind term is calculated.

g. ISKIP(7) controls the calculation of dosage and concentration in Models 1 through 6 shown in Figure 4-1. Also, ISKIP(7) controls the calculation of cloud half-widths. If ISKIP(7) is set to 0, dosages, concentrations, and cloud half-widths are not calculated. If ISKIP(7) is set to 1, dosage and concentration are calculated, but half-widths are not. If ISKIP(7) is set to 2, only cloud half-widths are calculated. If ISKIP(7) is set to 3, dosage, concentration and cloud half-widths are calculated.

h. ISKIP(8) controls the calculations of peak dosage and maximum peak concentration. If ISKIP(8) is set to 0, peak dosages and maximum peak concentrations are not calculated. If ISKIP(8) is set to 1, only peak dosages are calculated. If ISKIP(8) is set to 2, only maximum peak concentrations are calculated. If ISKIP(8) is set to 3, both peak dosages and maximum peak concentrations are calculated.

i. ISKIP(9) controls the calculations of dosage and concentration isopleths in the horizontal or x-y plane. If ISKIP(9) is set to 0, no horizontal isopleths are calculated. If ISKIP(9) is set to 1, only dosage isopleths at ground-level are calculated. If ISKIP(9) is set equal to 2, only dosage isopleths calculated at layer boundaries are calculated. If ISKIP(9) is set to 3, only dosage isopleths at all specified heights are calculated. If ISKIP(9) is set to 4, only concentration isopleths at ground level are calculated. If ISKIP(9) is set to 5, concentration isopleths only are calculated at all specified heights. If ISKIP(9) is set to 7, 8, or 9, both dosage and concentration isopleths are calculated, respectively, at ground level, layer boundaries, or at all specified heights.

j. ISKIP(10) controls the calculations of dosage and concentration isopleths in the vertical or y-z plane. If ISKIP(10) is set to 0, no isopleths are calculated. If ISKIP(10) is set to 1, only dosage isopleths are calculated. If ISKIP(10) is set to 2, only concentration isopleths are calculated. If ISKIP(10) is set to 3, both dosage and concentration isopleths are calculated. Vertical isopleths are calculated only at radial distances DXR at which the corresponding element in the array IFLAG is set to 1.

k. ISKIP(11) controls the calculation of dosage and concentration with simple decay. If ISKIP(11) is set to 0, the decay term is not calculated. If ISKIP(11) is set to 1, the decay term is calculated for Models 1 through 6 shown in Figure 4-1.

l. ISKIP(12) controls the calculation of the deposition due to precipitation scavenging, as well as dosage and concentration with cloud depletion by precipitation scavenging. If ISKIP(12) is set to 0, deposition is not calculated. If ISKIP(12) is set to 1, the maximum possible deposition is calculated. If ISKIP(12) is set to 2, deposition due to precipitation scavenging is calculated from Equation (3-35).

m. ISKIP(13) controls Models 5 and 6 in Figure 4-1 for changes in layer structure. If ISKIP(13) is set to 0, the layer structure is assumed not to change. If ISKIP(13) is set to 1, the layer structure is assumed to change at time t*, and the Box Model is used. If ISKIP(13) is set to 2, the Full Transition Model is used. Also, the geometry of structural change is identified by the arrays JBOT and JTOP.

ISKIP(14) through ISKIP(20) are not used at present.

A.3.5 <u>Card Unit No. 5</u>

Card Unit No. 5 contains the following input information:

- NXS - Number of x coordinates input for all calculations in Logic Sections 1 and 5 of the program (see Figure 4-1)
- NYS - Number of y coordinates input for all calculations in Logic Sections 1 and 5 of the program (see Figure 4-1)
- NZS - Number of initial layer boundaries
- NDI - Number of dosage values for which isopleths are to be calculated in the horizontal and vertical planes
- NCI - Number of concentration values for which isopleths are to be calculated in the horizontal and vertical planes
- NDXR - Number of radial distances input for all calculations in Logic Sections 2, 3 and 4 of the program
- NVS - Number of settling velocities used to calculate ground deposition for all layers except the layer in which a destruct occurs

- NBK - Number of new layers in structure-change Models 4 and 5 (see Figure 4-1)

- NVB - Number of particle settling velocities used to calculate ground deposition from vehicle destruct for layer in which the destruct occurs

A.3.6 Card Units Nos. 6 through 10

Card Units Nos. 6 through 10 contain the following information:

- XX - (Card Unit No. 6) - Receptor coordinates x_j relative to the fixed reference grid

- YY - (Card Unit No. 7) - Receptor coordinates y_j relative to the fixed reference grid

- Z - (Card Unit No. 8) - Layer boundary heights

- DELX, DELY - (Card Unit No. 9) - Coordinates of the source in the layers relative to the fixed reference grid

- Q - (Card Unit No. 10) - Source strength in the layer

A.3.7 Card Units Nos. 11 through 22

Card Units Nos. 11 through 22 apply to Models 1, 2, 3, 6 and 7 shown in Figure 4-1.

Card Units Nos. 11 through 18 contain the following information:

- UBARK - (Card Unit No. 11) - Mean wind speed at the top of the layer

- SIGAK - (Card Unit No. 12) - Standard deviation of wind azimuth angle for reference time τ_{oK} at the top of the layer

- SIGYO - (Card Unit No. 13) - Standard deviation of the crosswind concentration distribution of the source in the layer (lateral source dimension)

- SIGEK - (Card Unit No. 14) - Standard deviation of wind elevation angle at the top of the layer

- ALPHA - (Card Unit No. 15) - Lateral diffusion coefficient in the layer

- BETA - (Card Unit No. 16) - Vertical diffusion coefficient in the layer

- SIGZO - (Card Unit No. 17) - Standard deviation of the vertical concentration distribution of the source in the layer (vertical source dimension)

- SIGXO - (Card Unit No. 18) - Standard deviation of the alongwind concentration distribution of the source in the layer (alongwind source dimension)

Card Unit No. 19 contains the following information:

- ZRK - Reference height in the surface layer

- SIGARK - Standard deviation of azimuth wind angle at the reference height ZRK

- SIGERK - Standard deviation of the wind elevation angle at the reference height ZRK

- UBARRK - Mean wind speed at the reference height ZRK

- DELPHI - Angular sector, centered on alongwind cloud axis, in which concentrations and dosages are calculated

Card Units Nos. 20 through 22 contain the following information:

- THETAK - (Card Unit No. 20) - Mean wind direction at the base and top of the layer
- TAUK - (Card Unit No. 21) - Time required for cloud stabilization in the layer (source emission time)
- TAUOK - (Card Unit No. 22) - Reference time for standard deviation of wind azimuth angle SIGARK at the reference height ZRK in the surface layer

A.3.8 Card Units Nos. 23 and 24

Card Units Nos. 23 and 24 contain the following information:

- T - (Card Unit No. 23) - Time required for cloud stabilization for Models 1, 2, 3, 4, 5 and 6; residence time of vehicle in the layer for Model 7 (see Figure 4-1)
- H - (Card Unit No. 24) - Effective source height in the layer

A.3.9 Card Units Nos. 25A through 45A

If ISKIP(1) is not equal to 2 (gravitational model is not being used), Card Units Nos. 25A through 31A will be read. If ISKIP(1) is equal to 2, Card Units Nos. 25A through 45A will not be read.

The following information is contained on Card Units Nos. 25A and 26A:

- IZMOD - (Card Unit No. 25A) - Model number used in the layer (Model No. 1, 2, or 3 as shown in Figure 4-1)

- NPT - (Card Unit No. 26A) - Contains number of heights in each layer (NPT) at which concentration or dosage calculations are to be made; calculations are automatically made in the program at all layer boundary heights

Card Unit No. 27A contains the following information:

- DECAY - Decay coefficient in the concentration and dosage equations

- ZLIM - Maximum height at which precipitation occurs (must be height of the top of layer)

- TIM1 - Time after launch at which precipitation begins

- LAMBDA - Washout coefficient

Card Units Nos. 28A through 31A contain the following information:

- DXR - (Card Unit No. 28A) - Radial distances at which peak dosage, maximum peak concentration, concentration and dosage isopleths (in the x-y and y-z planes) and cloud half-widths are to be calculated

- IFLAG - (Card Unit No. 29A) - Flag used to indicate radial distances DXR at which concentration and dosage isopleths in the y-z plane are to be calculated. If IFLAG is set to 0, the corresponding radial distance DXR is ignored and no isopleths are calculated. If IFLAG is set to 1, isopleths are calculated at the corresponding radial distance DXR

- DI - (Card Unit No. 30A) - Values of the dosage for which isopleths are to be calculated

- CI - (Card Unit No. 31A) - Values of the concentration for which isopleths are to be calculated

Card Units Nos. 32A through 39A contain the following information:

(NOTE: If ISKIP(13) equals 1 or 2, indicating a change in layer structure, Card Units Nos. 32A through 45A will be read. If ISKIP(13) equals 0, Card Units Nos. 32A through 45A will not be read.)

- UBARL - (Card Unit No. 32A) - Mean wind speed at the top of new Layers L formed as a result of a change in layer structure

- SIGAL - (Card Unit No. 33A) - Standard deviation of the azimuth wind angle at the top of Layer L

- $SIGYO_L$ - (Card Unit No. 34A) - Standard deviation of lateral concentration distribution for new source in Layer L (lateral source dimension)

- SIGEL - (Card Unit No. 35A) - Standard deviation of the wind elevation angle at the top of Layer L

- $ALPHA_L$ - (Card Unit No. 36A) - Lateral diffusion coefficient in Layer L

- $BETA_L$ - (Card Unit No. 37A) - Vertical diffusion coefficient in Layer L

- $SIGZO_L$ - (Card Unit No. 38A) - Standard deviation of vertical concentration distribution for new source in Layer L (vertical source dimension)

- $SIGXO_L$ - (Card Unit No. 39A) - Standard deviation of alongwind concentration distribution for new source Layer L (alongwind source dimension)

Card Unit No. 49A contains the following information:

- ZRL - Reference height in new surface Layer L
- SIGARL - Standard deviation of wind azimuth angle at reference height ZRL if L equals 1; if L is not equal to 1, SIGARL refers to the base of first new Layer L above the surface Layer K=1
- SIGERL - Standard deviation of wind elevation angle at reference height ZRL if L equals 1; if L does not equal 1, SIGERL refers to base of first new Layer L above the surface Layer K=1
- UBARRL - Mean wind speed at reference height ZRL if L equals 1; if L is not equal to 1, UBARRL is mean wind speed at base of first new Layer L above the surface Layer K=1

Card Units Nos. 41A through 45A contain the following information:

- THETAL - (Card Unit No. 41A) - Mean wind direction at the base and top of each new layer
- TAUL - (Card Unit No. 42A) - Cloud stabilization time in the new Layer L
- TAUOL - (Card Unit No. 43A) - Reference time period for SIGARL
- TAST - (Card Unit No. 44A) - Time after launch at which change in layer structure occurs
- JBOT, JTOP - (Card Unit No. 45A) - The K number of the original layer at the base of each new layer (JBOT) and at the top of each new layer (JTOP); new layers are formed from layers existing prior to time TAST

A.3.10 Card Units Nos. 25B through 30B

Card Units Nos. 25B through 30B contain the following information required for use with Model 7 (see Figure 4-1):

(NOTE: If ISKIP(1) is not equal to 2, Model 7 is not used and Card Units Nos. 25B through 30B are not read.)

- VS - (Card Unit No. 25B) - Settling velocity assigned to each particle or droplet size category
- PERC - (Card Unit No. 26B) - Fraction of material with settling velocity V_s
- ACCUR - (Card Unit No. 27B) - Accuracy constant in line source simulation used in Model 7. A value of 0.45 for ACCUR ensures that the calculated ground deposition is within 10 percent of the deposition expected from a vertical line source; if ACCUR is set to 0.32, the calculated ground deposition is within 5 percent of the deposition expected from a vertical line source

(NOTE: If ISKIP(3) equals 1 and ISKIP(1) equals 2, a vehicle destruct is assumed to have occurred in the top K layer and Card Units Nos. 28B through 30B are read.)

- VB - (Card Unit No. 28B) - Settling velocity assigned each particle or droplet size category assigned to material from vehicle destruct in the top K layer
- PERCB - (Card Unit No. 29B) - Fraction of material with settling velocity VB
- HB - (Card Unit No. 30B) - Effective height of vehicle destruct material above the surface

A.4 ADDITIONAL REMARKS

The sequence of input cards described in Section A.3, starting with Card Unit No. 3, will be read NP times or until an end-of-file is met. The order and number of cards read depends on ISKIP(1), ISKIP(3) and ISKIP(13).

Peak dosage, maximum peak concentration, and isopleths are not calculated for Models 4, 5, 6 and 7 shown in Figure 4-1. Hence, when ISKIP(8) $\neq 0$, ISKIP(9) $\neq 0$, or ISKIP(10) $\neq 0$, all calculations refer to Models 1, 2 or 3.

Logic Sections 1 through 4 in Figure 4-1 may be processed in any combination as a multi-layer problem. Logic Section 5 in Figure 4-1 must be processed as a single multi-layer problem. Any number of problems can be processed in an execution of the computer program.

A.5 KEYPUNCH INSTRUCTIONS

The decimal in all F-type format statements can appear anywhere in the ten digit field. If the decimal is deleted, the number is right justified in the field. All I formats are right justified in the field (see Figure A-3).

A.6 OPERATOR INSTRUCTIONS

There are no special operator instructions.

A.7 LINKAGE FOR SUBROUTINES IN COMPUTER PROGRAM FOR KSC MULTI-LAYER DIFFUSION MODEL

The physical linkage for the computer program subroutines is shown in Figure A-1. Each connector represents a cummunication link between the subroutines.

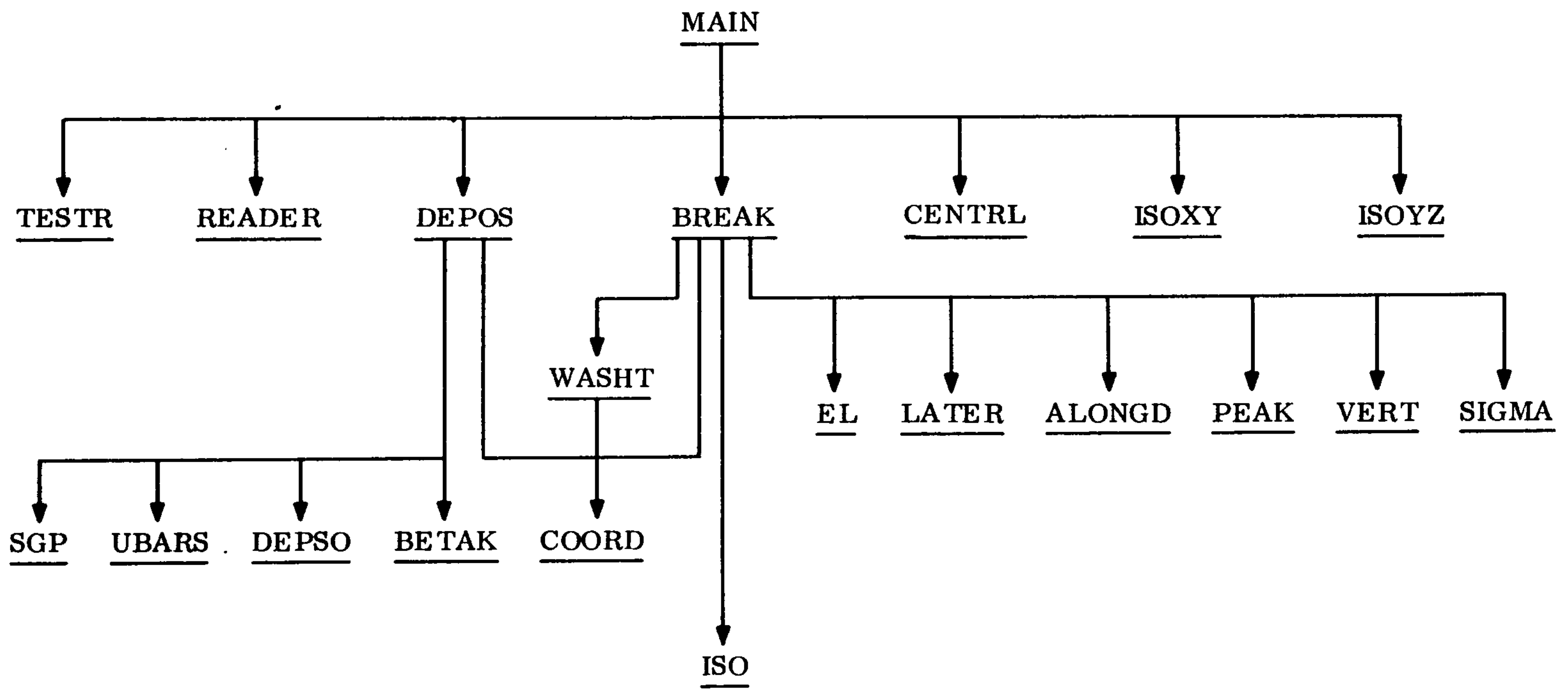


FIGURE A-1. Diagram of linkage between subroutines of computer program for KSC multi-layer diffusion model.

A.8 LINKAGE FOR SUBROUTINES IN LOGIC SECTIONS 1 THROUGH 5

The linkage for subroutines used in Logic Sections 1 through 5 of the computer program for the KSC multi-layer diffusion model is shown in Figure A-2. Each connector represents a communication link between the subroutines.

A.9 DATA FIELD CONFIGURATION

The data field configuration of each input parameter as it appears in the read sequence for the KSC multi-layer diffusion model program is shown in Figure A-3. The format symbols in the figure are defined as follows:

- A - Alphanumeric
- I - Integer
- X - Real
- E - Exponential

also, in Figure A-3, the parameter configurations are identified by the Card Unit No. and the FORTRAN name of the parameter.

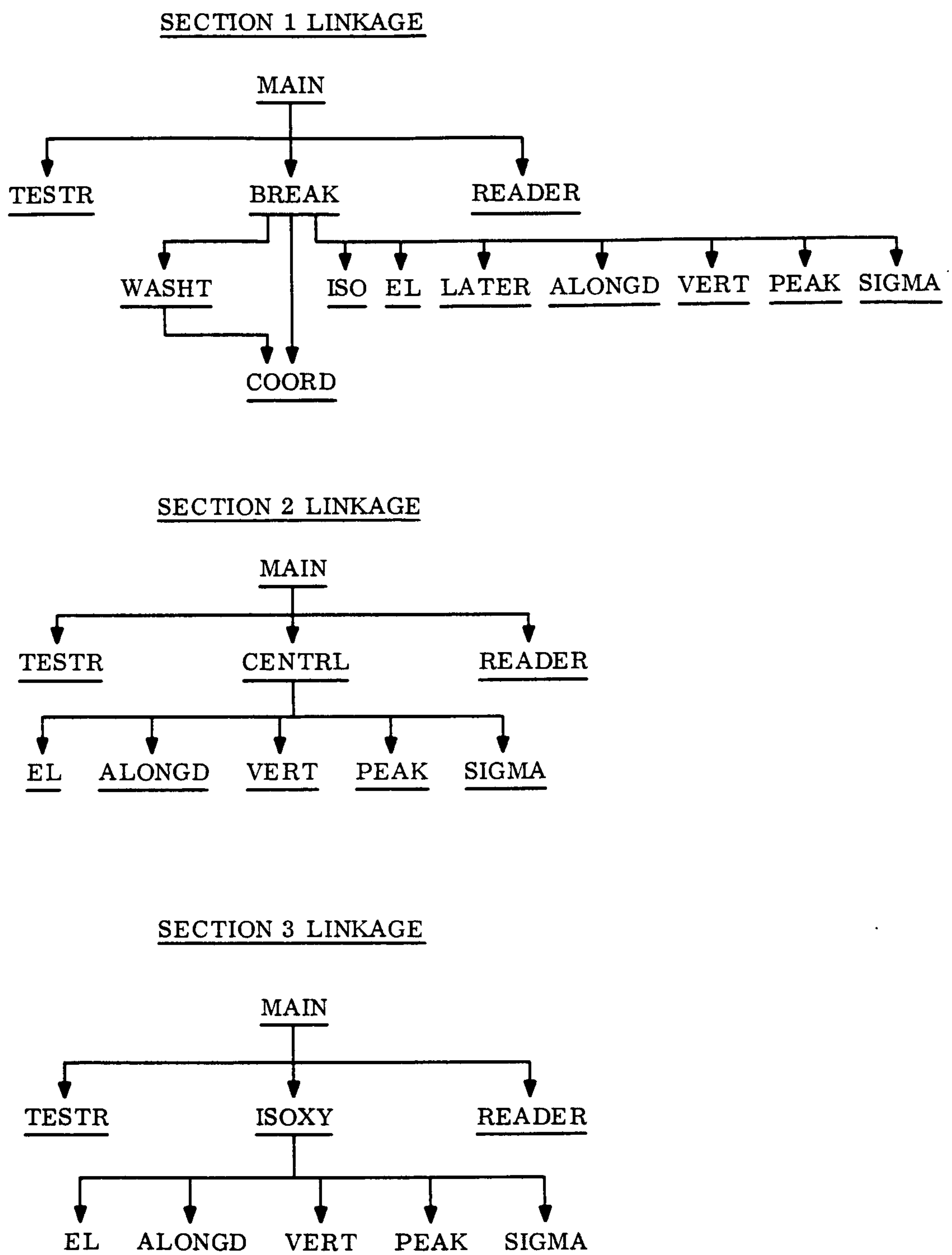
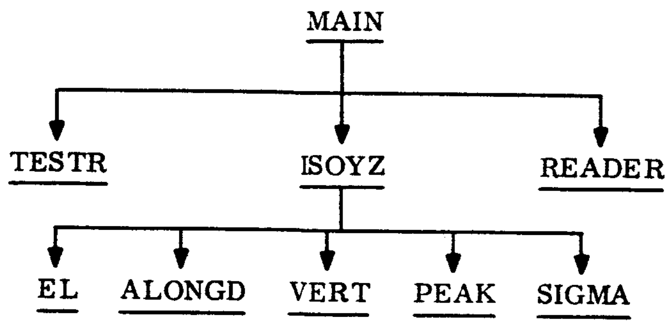


FIGURE A-2. Diagram of linkage between subroutines used in Logic Sections of computer program for KSC multi-layer diffusion model.

SECTION 4 LINKAGE



SECTION 5 LINKAGE

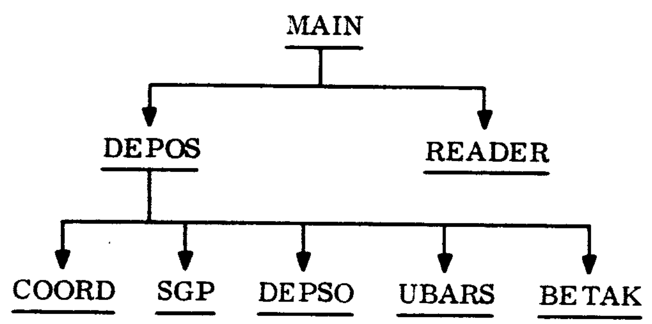


FIGURE A-2. (Continued)

FIGURE A-3. Data field configuration.

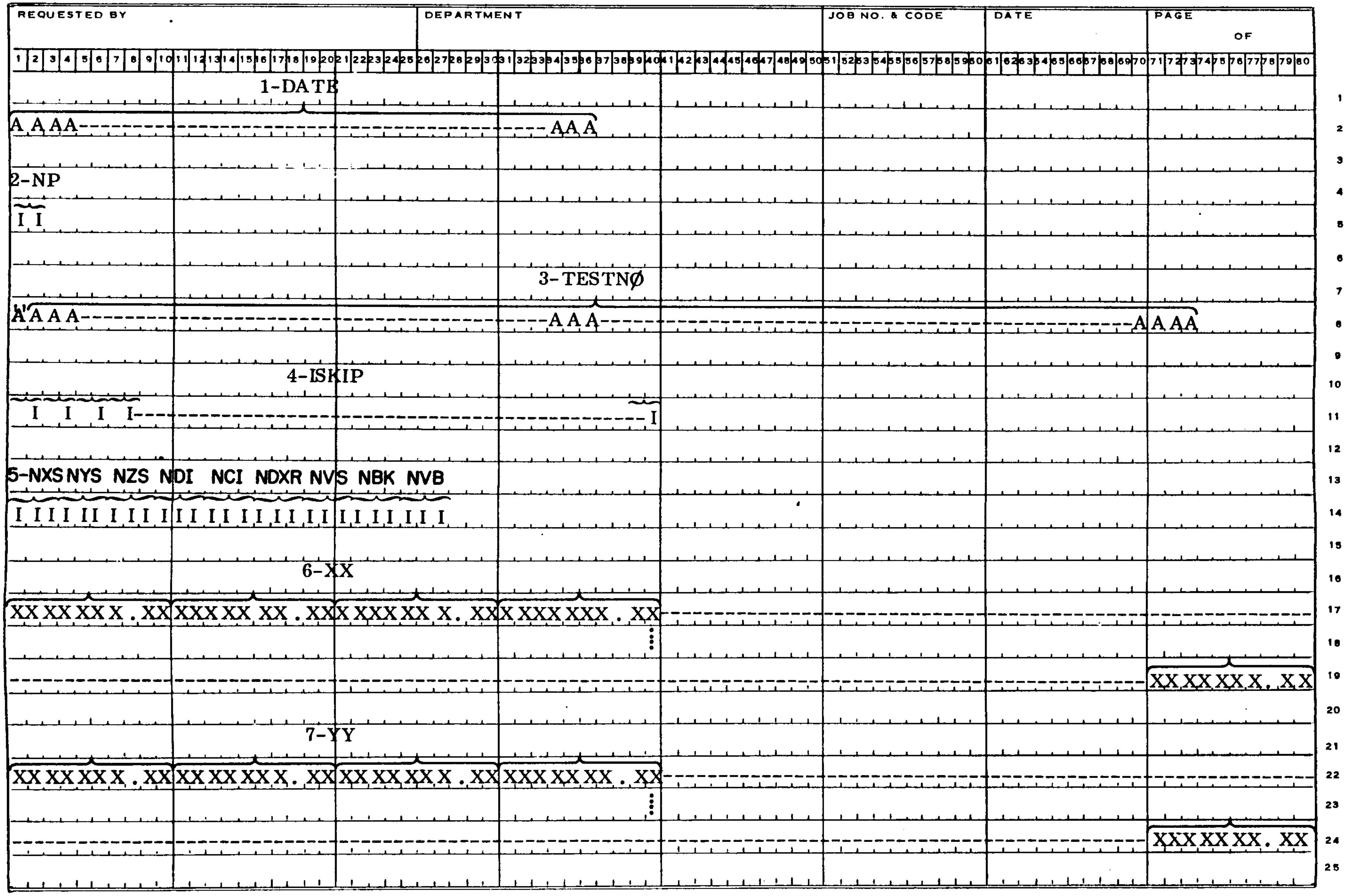


FIGURE A-3. (Continued)

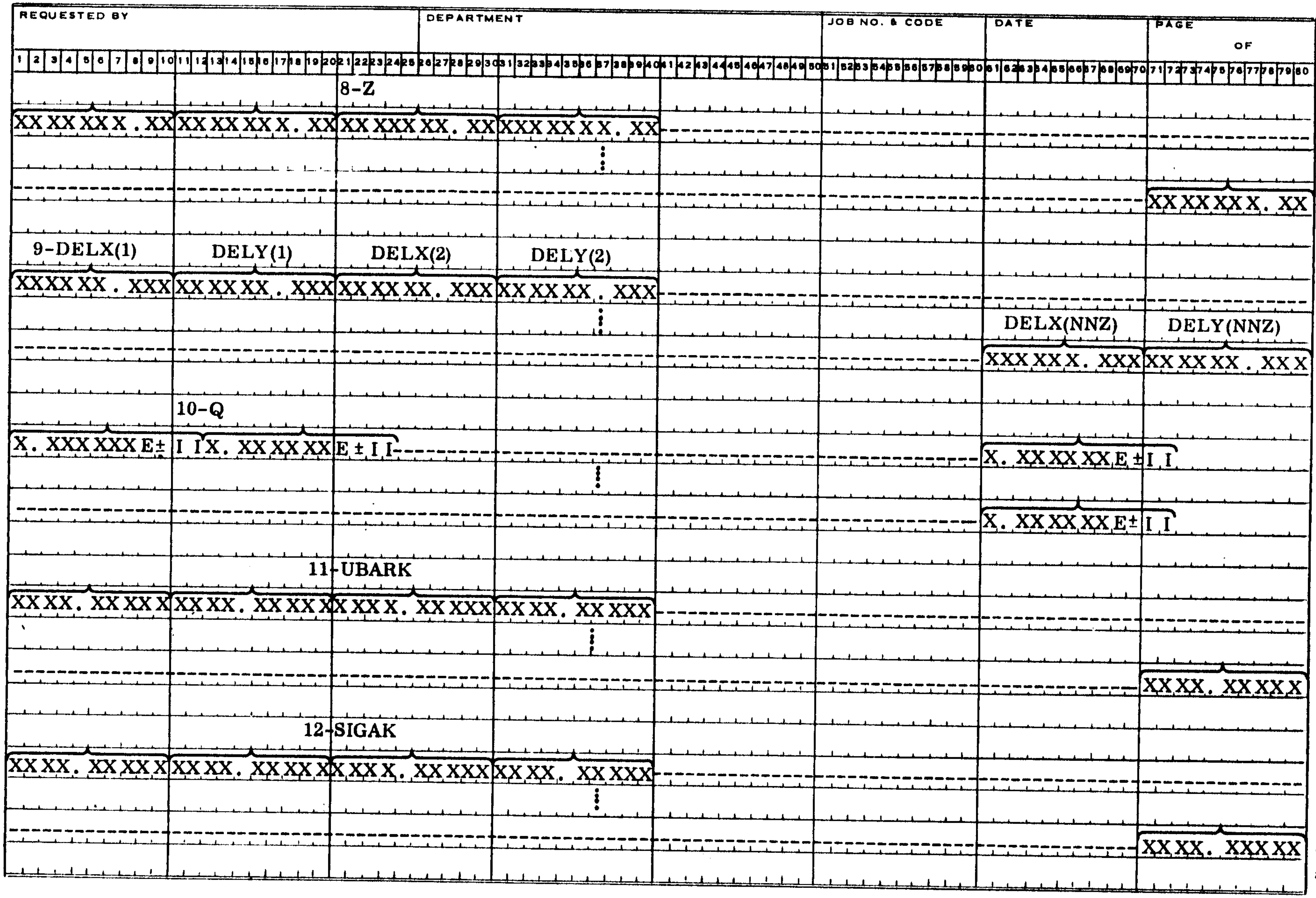


FIGURE A-3. (Continued)

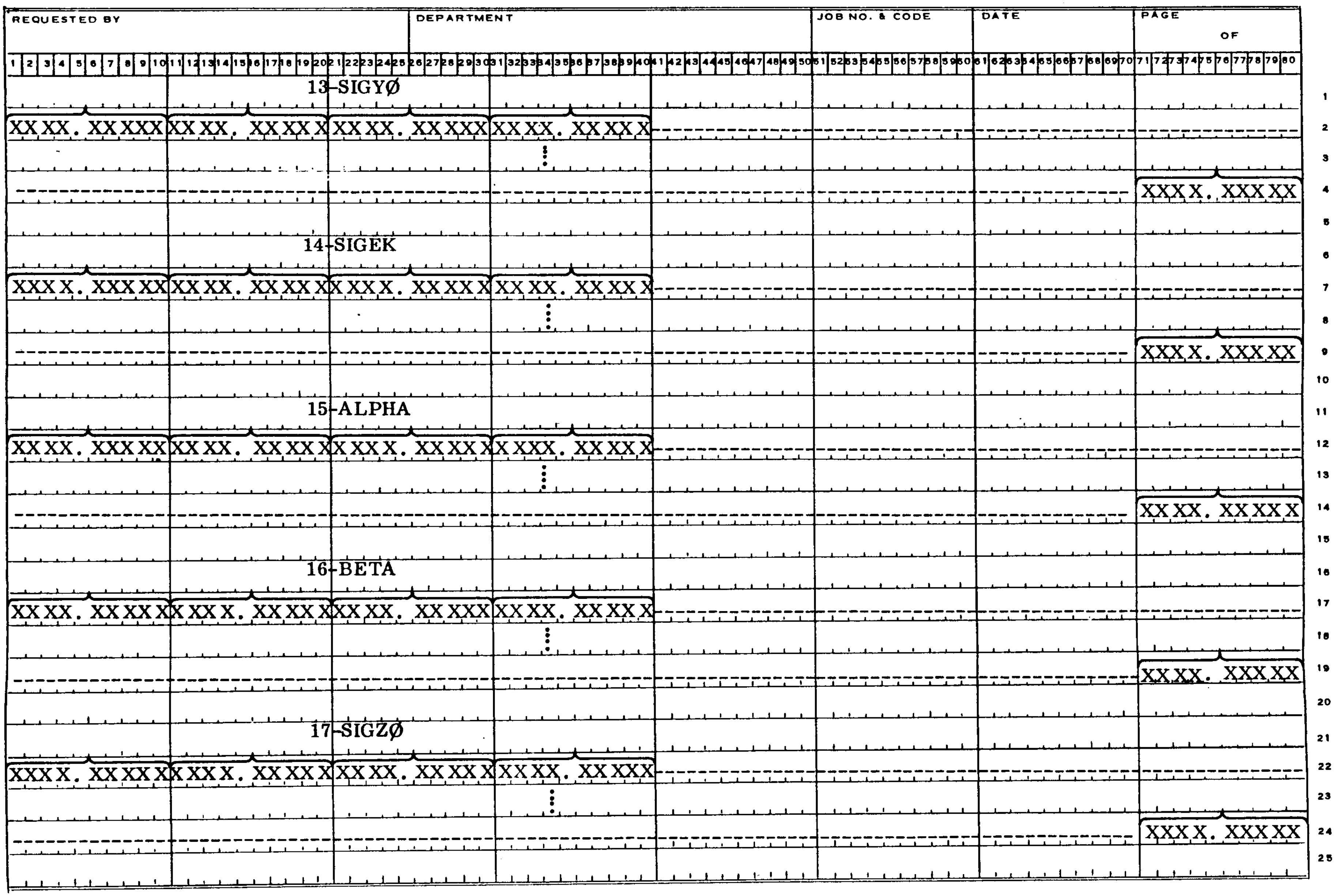


FIGURE A-3. (Continued)

	REQUESTED BY 1–10	11–20	DEPARTMENT 21–30	31–40	41–50	JOB NO. & CODE 51–60	DATE 61–70	PAGE OF 71–80
1		18-	SIGXØ					
2	XXXX. XXXXX	XXXX. XXXXX	XXXX . XXXXX	XXXX. XXXXX				
3				⋮				
4								XXXX. XXXXX
5								
6	19-ZRK	SIGARK	SIGERK	UBARRK	DELPHI			
7	XXXXXX. XXX	XXXX. XXXXX	XXXX . XXXXX	XXXX. XXXXX	XXXX . XXXXX			
8								
9		20-	THETAK					
10	XXXX. XXXXX	XXXX. XXXXX	XXXX . XXXXX	XXXX. XXXXX				
11				⋮				
12								XXXX. XXXXX
13								
14		21-	TAUK					
15	XXXXXX . XXX	XXXXXX . XXX	XXXXXX. XXX	XXXXXX . XXX				
16				⋮				
17								XXXXXX. XXX
18		22-	TAUØK					
19	XXXXXX . XXX	XXXXXX. XXX	XXXXXX. XXX	XXXXXX. XXX				
20				⋮				
21								XXXXXX. XXX
22		23-	T					
23	XXXXXX. XXX	XXXXXX. XXX	XXXXXX . XXX	XXXXXX . XXX				
24				⋮				
25								XXXXXX . XXX

FIGURE A-3. (Continued)

REQUESTED BY	DEPARTMENT	JOB NO. & CODE	DATE	PAGE OF

```
                    24-H
XXXXXX.XXX XXXXXX.XXX XXXXXX.XXX XXXXXX.XXX ----------------------------------------
                                      :
----------------------------------------------------------------------- XXXXXX.XXX

              25A-IZMØD
I I I I I ----------------------------------- I

              26A-NPT
I I I I I I I I I I ------------------------- I I

27A-DECAY     ZLIM        TIM1       LAMBDA
XXXX.XXXXX XXXXXX.XXX XXXXXX.XXX XXXX.XXXXX

              28A-DXR
XXXXXX.XXX XXXXXX.XXX XXXXXX.XXX XXXXXX.XXX ----------------------------------------
                                      :
----------------------------------------------------------------------- XXXXXX.XXX

              29A-IFLAG
I I I I I I I I I I --------------------------------------------------------------
                                      :
------------------------------------------------------------------------------- I
```

FIGURE A-3. (Continued)

REQUESTED BY | DEPARTMENT | JOB NO. & CODE | DATE | PAGE OF

```
30A-DI
X.XXXXXXE±II X.XXXXXXE±II X.XXXXXXE±II ------------------------------ X.XXXXXXE±II
      ⋮
-------------------------------------------------------------------- X.XXXXXXE±II

31A-CI
X.XXXXXXE±II X.XXXXXXE±II X.XXXXXXE±II ------------------------------ X.XXXXXXE±II
      ⋮
-------------------------------------------------------------------- X.XXXXXXE±II

32A-UBARL
XXXX.XXXXX XXXX.XXXXX XXXX.XXXXX XXXX.XXXXX --------------------------------
      ⋮
-------------------------------------------------------------------- XXXX.XXXXX

33A-SIGAL
XXXX.XXXXX XXXX.XXXXX XXXX.XXXXX XXXX.XXXXX --------------------------------
      ⋮
-------------------------------------------------------------------- XXXX.XXXXX

34A-SIGYØL
XXXX.XXXXX XXXX.XXXXX XXXX.XXXXX XXXX.XXXXX --------------------------------
      ⋮
-------------------------------------------------------------------- XXXX.XXXXX
```

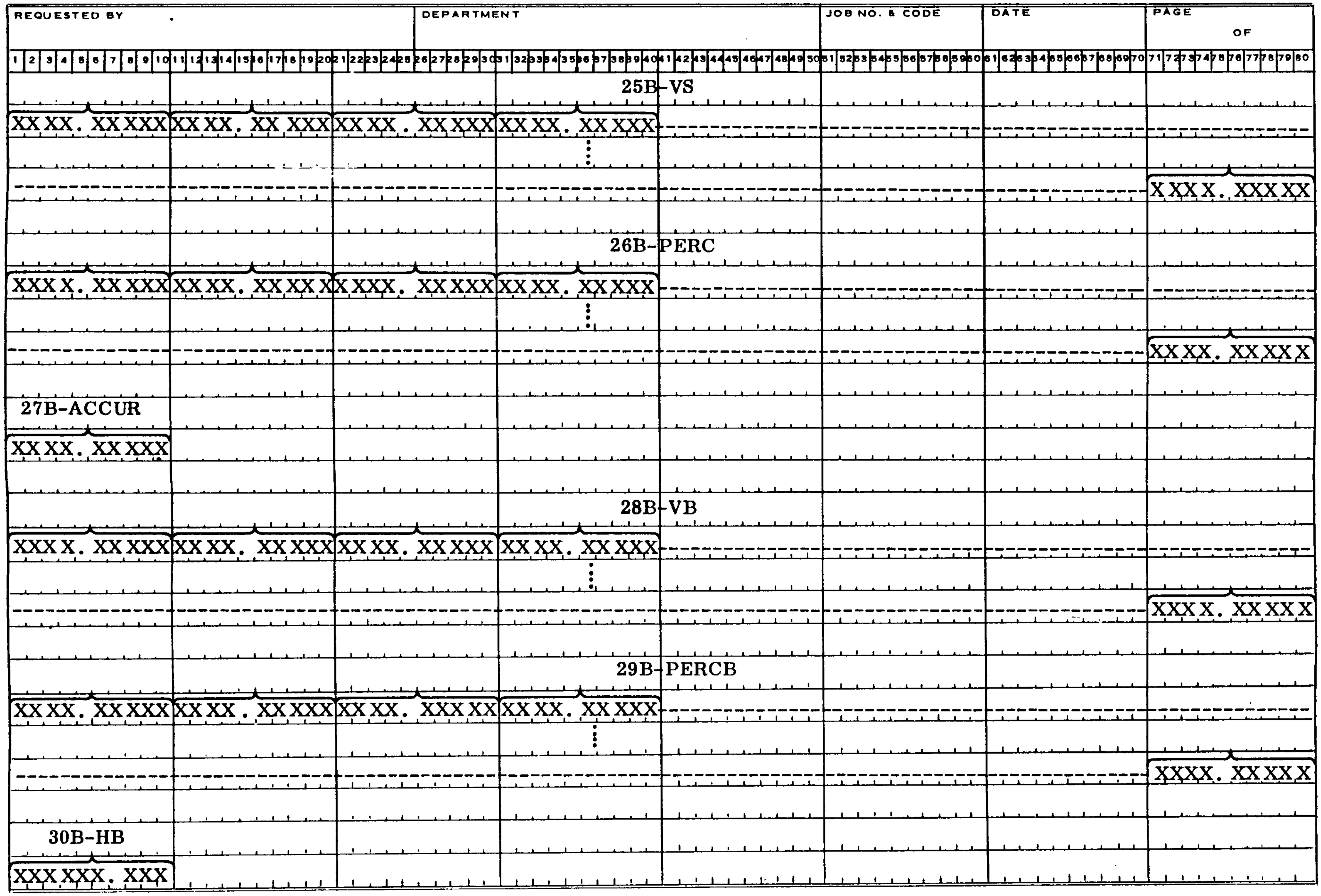
FIGURE A-3. (Continued)

REQUESTED BY		DEPARTMENT			JOB NO. & CODE	DATE	PAGE OF
1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
			35A	-SIGEL			
XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX				
			⋮				
							XXXX. XXXXX
			36A	-ALPHA$_L$			
XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX				
			⋮				
							XXXX. XXXXX
			37A	-BETA$_L$			
XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX				
			⋮				
							XXXX. XXXXX
			38A	-SIGZØ$_L$			
XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX				
			⋮				
							XXXX. XXXXX
			39A	-SIGXØ$_L$			
XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX				
			⋮				
							XXXX. XXXXX

FIGURE A-3. (Continued)

REQUESTED BY		DEPARTMENT			JOB NO. & CODE	DATE	PAGE OF	
	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	40A-ZRL	SIGARL	SIGERL	UBARRL				
2	XXXXXX. XXX	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX				
3								
4				41A-	THETAL			
5	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX	XXXX. XXXXX				
6				⋮				
7								XXXX. XXXXX
8								
9				42A-	TAUL			
10	XXXXXX. XXX	XXXXXX. XXX	XXXXXX. XXX	XXXXXX. XXX				
11				⋮				
12								XXXXXX. XXX
13								
14				43A-	TAUØL			
15	XXXXXX. XXX	XXXXXX. XXX	XXXXXX. XXX	XXXXXX. XXX				
16				⋮				
17								XXXXXX. XXX
18								
19				44A-	TAST			
20	XXXXXX. XXX	XXXXXX. XXX	XXXXXX. XXX	XXXXXX. XXX				
21				⋮				
22								XXXXXX. XXX
23–24	JBOT(1) JTOP(1) JBOT(2) JTOP(2) JBOT(3)	JTOP(3)		45A JBOT(NBK) JTOP(NBK)				
25	I I I I I	I		I I				

FIGURE A-3. (Continued)



APPENDIX B

Appendix B contains a complete listing of the present configuration of the computer program for the KSC Multi-Layer Diffusion Model. The program is written in FORTRAN V and has been assembled and executed on a UNIVAC 1108 computer under the EXEC II Monitor.

aI FOR MODEL
UNIVAC 1108 FORTRAN V LEVEL 2206 0018 F5010P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:34:49

MAIN PROGRAM

STORAGE USED (BLOCK, NAME, LENGTH)

0001	*CODE	001613
0000	*DATA	001127
0002	*BLANK	000000
0003	PARAMT	033754
0004	PARAMS	025577

EXTERNAL REFERENCES (BLOCK, NAME)

0005	READER
0006	DEPOS
0007	TESTR
0010	BREAK
0011	SIGMA
0012	CENTRL
0013	ISOXY
0014	ISOYZ
0015	NRDU$
0016	NI01$
0017	NI02$
0020	NWDU$
0021	SQRT
0022	NEXP6$
0023	NSTOP$

STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001		000751	100L	0001		000006	115G	0001		000020	123G	0001		000040	134G	0001		000054	143G
0001		000070	152G	0001		000122	173G	0001		000062	2L	0001		000140	202G	0001		000150	206G
0001		000171	215G	0001		000201	221G	0001		000264	247G	0001		000403	302G	0001		001024	405L
0001		001115	410L	0001		001123	420L	0001		001127	430L	0001		001271	440L	0001		000247	5L
0001		000764	517G	0001		001146	520L	0001		000772	522G	0001		001366	522L	0001		001401	524L
0001		001427	525L	0001		001502	527L	0001		001536	528L	0001		001567	535L	0001		001673	540L
0001		001072	546G	0001		001577	560L	0001		001133	574G	0001		001603	580L	0001		001300	600L
0001		001212	620G	0001		001231	625G	0001		001250	633G	0001		001333	657G	0001		001343	663G
0001		000307	76L	0001		001603	700L	0001		001550	727G	0001		001607	777L	0001		000321	80L
0000		000015	800F	0000		000016	801G	0000		000017	802F	0000		000020	806F	0000		000025	807F
0001		000343	82L	0001		000355	84L	0001		000364	90L	0000		000027	900F	0000		000035	901F
0000		000045	902F	0000		000050	903F	0000		000056	904F	0000		000063	905F	0000		000205	906F
0000		000216	907F	0000		000223	908F	0000		000260	909F	0000		000272	910F	0000		000335	911F
0000		000350	912F	0000		000363	913F	0000		000374	914F	0000		000447	915F	0000		000463	916F
0000		000504	917F	0000		000510	918F	0000		000617	919F	0001		000477	92L	0000		000623	920F
0000		000721	921F	0000		000776	922F	0000		001032	923F	0000		001067	924F	0001		000534	93L
0001		000546	94L	0001		000631	96L	0001		000656	97L	0001		000726	98L	0004	R	000216	ACCUR
0003	R	007102	ALONG	0003	R	000226	ALPHA	0004	R	001023	ALPHAK	0004	R	001170	ANG	0003	R	000264	BETA
0004	R	000657	BETAUK	0003	R	007774	CI	0003	R	001522	CON	0004	R	000342	DATE	0004	R	000000	DECAY

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0004 R 025246 DELPHI   0003 R 000454 DELTHP   0003 R 001010 DELU     0003 R 000606 DELX     0003 R 000644 DELY
0004 R 000345 DEP      0004 R 001335 DEPN     0003 R 007762 DI       0000 R 000004 DIFF     0003 R 001356 DOS
0004 R 000273 DTHK     0003 R 007246 DXR      0004 R 000126 ERFX     0003 R 000036 H        0004 R 000267 HB
0003 I 010014 I        0000 I 000004 IA       0003 I 010050 IBUT     0000 I 000002 IERR     0003 I 007436 IFLAG
0004 I 000344 II       0003 I 010036 ILK      0003 I 000000 ISKIP    0003 I 007602 ITAG     0003 I 010047 ITOP
0003 I 000740 IZMOD    0000 I 000000 IS       0003 I 010015 J        0004 I 000114 JBOT     0004 I 000041 JP
0004 I 000134 JTOP     0000 I 000003 JXJ      0000 I 000005 K        0003 I 010016 KK       0000 I 000010 KTK
0003 R 010012 L        0003 R 010110 LAMBDA   0003 R 006426 LAT      0004 I 000322 LB1      0004 I 000326 LB2
0004 I 000332 LB3      0004 I 000336 LB4      0000 I 000011 LSP      0000 I 000007 M        0004 R 000272 MP3R
0000 I 000012 N        0003 I 010035 NBK      0003 I 010093 NCI      0003 I 010042 NLI      0003 I 010044 NDXR
0003 I 010046 NNZ      0000 I 000001 NP       0003 I 000764 NPT      0004 I 000321 NVB      0004 I 000320 NVS
0004 I 001334 NXCI     0003 I 010037 NXS      0003 I 010040 NYS      0003 I 010041 NZS      0003 R 006262 PEAKC
0003 R 001464 PEAKD    0004 R 000172 PERC     0004 R 000293 PERCB    0003 R 002342 PLT      0004 R 000270 PPAR
0003 R 000132 Q        0004 R 000271 QPVR     0003 R 010045 RAD      0003 R 033560 SIGAK    0004 R 000013 SIGAL
0004 R 025122 SIGAN    0003 R 000360 SIGAP    0003 R 033631 SIGARK   0004 R 000040 SIGARL   0003 R 033604 SIGEK
0004 R 000025 SIGEL    0004 R 024754 SIGENK   0003 R 000550 SIGEP    0003 R 033632 SIGERK   0004 R 000042 SIGERL
0003 R 010010 SIGX     0003 R 010107 SIGXNK   0003 R 000416 SIGXO    0003 R 010007 SIGY     0004 R 024755 SIGYNK
0003 R 000322 SIGYO    0003 R 010006 SIGZ     0003 R 000512 SIGZO    0004 R 001167 SQBAR    0003 R 010011 SQR2P
0003 R 010017 STD1     0003 R 010020 STD2     0003 R 010021 STC3     0003 R 007412 T        0003 R 010023 TAST
0003 R 033704 TAUK     0004 R 000070 TAUL     0003 R 033730 TAUDK    0004 R 000102 TAUDL    0003 I 007746 TESTNO
0003 R 010013 T        0003 R 000702 THETA    0003 R 033634 THETAK   0004 R 000044 THETAL   0003 R 010111 TIM1
0003 R 010112 TIM2     0003 R 010022 TRD      0003 R 000170 UBAR     0003 R 033634 UBARK    0004 R 000001 UBARL
0004 R 000513 UBARN    0003 R 033633 ULARK    0004 R 000043 UBARRL   0004 R 025267 UBARZK   0004 R 025433 UBARZL
0004 R 000217 VB       0003 R 006572 VER      0003 R 006736 VREF     0004 R 000146 VS       0003 R 010114 WASHOU
0003 R 010061 XAST     0004 R 000512 XBARX    0003 R 001212 XR       0003 R 002032 XX       0000 R 000013 Y
0004 R 000346 YBARY    0000 R 000014 YS       0003 R 002176 YY       0003 R 000074 Z        0003 R 010113 ZLIM
0003 R 033630 ZRK      0004 R 000037 ZRL      0003 R 001046 ZZL
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00100    1*   C              ********** MULTILAYER DIFFUSION MODEL **********         MAIN  20
00100    2*   C                                                                       MAIN  30
00100    3*   C                                                                       MAIN  40
00100    4*   C                                                                       MAIN  50
00100    5*   C                                                                       MAIN  60
00100    6*   C     ISKIP= PROGRAM CONTROL OPTIONS                                    MAIN  70
00100    7*   C     H     = EFFECTIVE RELEASE HEIGHT IN LAYER (METERS)                MAIN  80
00100    8*   C     Z     = BOUNDARY HEIGHTS OF LAYERS (METERS)                       MAIN  90
00100    9*   C     Q     = SOURCE STRENGTH IN LAYER (MASS/HEIGHT)                    MAIN 100
00100   10*   C     UBAR = CALCULATED TRANSPORT SPEED IN LAYER                        MAIN 110
00100   11*   C     ALPHA = LATERAL POWER LAW EXPANSION COEFFICIENT                   MAIN 120
00100   12*   C     BETA  = VERTICAL POWER LAW EXPANSION COEFFICIENT                  MAIN 130
00100   13*   C     SIGYO = STANDARD DEVIATION OF THE LATERAL SOURCE DIMENSION (METER)MAIN 140
00100   14*   C     SIGAP = CALCULATED LATERAL DIFFUSION COEFFICIENT IN LAYER         MAIN 150
00100   15*   C     SIGXO = STANDARD DEVIATION OF THE ALONG WIND SOURCE DIMENSION     MAIN 160
00100   16*   C             (METERS)                                                  MAIN 170
00100   17*   C     DELTHP = CALCULATED WIND DIRECTION SHEAR IN LAYER                 MAIN 180
00100   18*   C     SIGZO  = STANDARD DEVIATION OF THE VERTICAL SOURCE DIMENSION      MAIN 190
00100   19*   C             (METERS)                                                  MAIN 200
00100   20*   C     SIGEP = CALCULATED VERTICAL DIFFUSION COEFFICIENT                 MAIN 210
00100   21*   C     DELX = X COORDINATE OF SOURCE IN LAYER RELATIVE TO ORIGIN OF FIXEDMAIN 220
00100   22*   C           GRID SYSTEM (METERS , RECTANGULAR OR POLAR)                 MAIN 230
00100   23*   C     DELY = Y COORDINATE OF SOURCE IN LAYER RELATIVE TO ORIGIN OF FIXEDMAIN 240
00100   24*   C           GRID SYSTEM (METERS,DEGREES**RECTANGULAR,POLAR)             MAIN 250
00100   25*   C     THETA = CALCULATED MEAN WIND DIRECTION IN LAYER                   MAIN 260
00100   26*   C     IZMOD = MODEL NO TO USE IN LAYER (1,2 OR 3)                       MAIN 270
00100   27*   C     NPT   = NUMBER OF CALCULATION HEIGHTS ZZL DESIRED IN LAYER        MAIN 280
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00100  C   DELU   = CALCULATED WIND SPEED SHEAR                                 MAIN 290
00100  C   ZZL    = CALCULATION HEIGHTS IN LAYER                                MAIN 300
00100  C   AR     = CLOUD HALF WIDTHS                                           MAIN 310
00100  C   DOS    = CALCULATED VALUE OF DOSAGE                                  MAIN 320
00100  C   CON    = CALCULATED VALUE OF CONCENTRATION                           MAIN 330
00100  C   PEAKD = PART OF DOSAGE EQUATION                                      MAIN 340
00100  C   XX     = X COORDINATE OF RECEPTOR RELATIVE TO FIXED GRID SYSTEM      MAIN 350
00100  C  (POSITIVE X AXIS EAST 90 DEGREES, METERS, RECTANGULAR OR POLAR)      MAIN 360
00100  C   YY     = Y COORDINATE OF RECEPTOR RELATIVE TO FIXED GRID SYSTEM      MAIN 370
00100  C   (POSITIVE Y AXIS NORTH 0 DEGREES, METERS OR DEGREES, RECTANGULAR OMAIN 380
00100  C   POLAR)                                                               MAIN 390
00100  C   PLT  = CALCULATED VALUES OF DOSAGE AND CONCENTRATION ISOPLETHS       MAIN 400
00100  C   LAT    = LATERAL TERM OF DOSAGE EQUATION                             MAIN 410
00100  C   VER    = VERTICAL TERM OF DOSAGE EQUATION                            MAIN 420
00100  C   VREF   = REFLECTION TERM OF DOSAGE EQUATION                          MAIN 430
00100  C   ALONGW = ALONG WIND TERM OF CONCENTRATION EQUATION                   MAIN 440
00100  C   DXR = RADIAL DISTANCES FOR MAXIMUM PEAK DOSAGE AND CONCENTRATION     MAIN 450
00100  C         AND ISOPLETH AND CLOUD HALF-WIDTH CALCULATIONS                 MAIN 460
00100  C   T     = TIME AFTER CLOUD STABILIZATION EXCEPT IN GRAVITATIONAL       MAIN 470
00100  C          DEPOSITION MODEL SOURCE EMISSION TIME IN LAYER (SECONDS)      MAIN 480
00100  C   IFLAG = FLAG TO INDICATE AT WHICH DISTANCES DXR VERTICAL ISOPLETHSMAIN 490
00100  C           ARE TO BE CALCULATED                                         MAIN 500
00100  C   ITAG   = FLAG TO INDICATE WHICH RECEPTOR COORDINATES ARE OUTSIDE     MAIN 510
00100  C           OF CALCULATION SECTOR DELPHI                                 MAIN 520
00100  C   TESTNO = CASE TITLE                                                  MAIN 530
00100  C    DI = DOSAGE ISOPLETH VALUES OF INTEREST                             MAIN 540
00100  C    CI  = CONCENTRATION ISOPLETH VALUES OF INTEREST                     MAIN 550
00100  C   SIGZ = CALCULATED STANDARD DEVIATION OF THE VERTICAL DOSAGE          MAIN 560
00100  C          DISTRIBUTION                                                  MAIN 570
00100  C   SIGY = CALCULATED STANDARD DEVIATION OF THE LATERAL DOSAGE           MAIN 580
00100  C          DISTRIBUTION                                                  MAIN 590
00100  C   SIGX = CALCULATED STANDARD DEVIATION OF THE ALONG WIND DOSAGE        MAIN 600
00100  C          DISTRIBUTION                                                  MAIN 610
00100  C   SQR2P =  SQUARE ROOT TWO PI                                          MAIN 620
00100  C   L      = LENGTH OF CLOUD IN ALONG WIND DIRECTION                     MAIN 630
00100  C   TH = THETA*PI/180                                                    MAIN 640
00100  C   I      = INDEX OF X COORDINATES                                      MAIN 650
00100  C   J      = INDEX OF Y COORDINATES                                      MAIN 660
00100  C   KK     = INDEX OF LAYERS                                             MAIN 670
00100  C   K = INDEX OVER CALCULATION HEIGHTS ZZL                               MAIN 680
00100  C   STO1   = TEMP STORAGE                                                MAIN 690
00100  C   STO2   = TEMP STORAGE                                                MAIN 700
00100  C   STO3   = TEMP STORAGE                                                MAIN 710
00100  C   TRD = HALF CALCULATION SECTOR DELPHI                                 MAIN 720
00100  C   TAST   = TIME OF LAYER STRUCTURE CHANGE (SECONDS)                    MAIN 730
00100  C   NBK = NO OF DISTINCT GROUPS OF LAYERS THAT FORM INTO ONE AT TIME     MAIN 740
00100  C          TAST.                                                         MAIN 750
00100  C   ILK   = INDEX OF NEW LAYERS AFTER TIME TAST                          MAIN 760
00100  C   NXS   = NO OF X COORDINATES                                          MAIN 770
00100  C   NYS   = NO OF Y COORDINATES                                          MAIN 780
00100  C   NZS   = NO OF LAYER BOUNDARIES                                       MAIN 790
00100  C   NDI   = NO OF DOSAGE ISOPLETHS                                       MAIN 800
00100  C   NCI   = NO OF CONCENTRATION ISOPLETHS                                MAIN 810
00100  C   NDXR = NO OF RADIAL DISTANCES DXR ALONG CLOUD AXIS                   MAIN 820
00100  C   RAD   = PI/180                                                       MAIN 830
00100  C   NNZ   = NZS-1 NO OF LAYERS                                           MAIN 840
00100  C   ITOP   = TOP OF NEW LAYER AFTER TAST IN TERMS OF OLD LAYER STRUCTURMAIN 850
00100  C   IBOT   = BOTTOM OF NEW LAYER AFTER TAST IN TERMS OF OLD LAYER        MAIN 860
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00100  C        STRUCTURE (ITOP AND IBOT INDEXES)                              MAIN 870
00100  C     XAST  = CALCULATE DISTANCE TO TAST                                MAIN 880
00100  C     SIGXNK = SIGX OF NEW LAYER STRUCTURE                              MAIN 890
00100  C     LAMBDA = WASHOUT COEFFICIENT                                      MAIN 900
00100  C     TIM1 = TIME OF START OF RAIN (SECONDS)                            MAIN 910
00100  C     TIM2  = TIME RAIN STOPS (SECONDS)                                 MAIN 920
00100  C     ZLIM  = MAXIMUM HEIGHT OF WASHOUT                                 MAIN 930
00100  C     WASHOU = CALCULATE WASHOUT AT GROUND                              MAIN 940
00100  C     UBARK = WIND SPEED AT TOP OF LAYER (METERS/SEC)                   MAIN 950
00100  C     SIGAK = SIGAP AT TOP OF LAYER (DEGREES)                           MAIN 960
00100  C     SIGEK = SIGEP AT TOP OF LAYER (DEGREES)                           MAIN 970
00100  C     ZRK = REFERENCE HEIGHT IN SURFACE LAYER (METERS)                  MAIN 980
00100  C     SIGARK = SIGAP AT ZRK (DEGREES)                                   MAIN 990
00100  C     SIGERK = SIGEP AT ZRK (DEGREES)                                   MAIN1000
00100  C     UBARRK = WIND SPEED AT ZRK (METERS/SEC)                           MAIN1010
00100  C     THETAK = WIND DIRECTION AT LAYER BOUNDARIES (DEGREES)             MAIN1020
00100  C     TAUK  = TIME IN SECONDS REQUIRED FOR LATERAL CLOUD STABILIZATION  MAIN1030
00100  C     TAUOK = SAMPLING PERIOD IN SECONDS AT THE TOP OF THE LAYER        MAIN1040
00100  C     DECAY = DECAY COEFFICIENT IN DOSAGE EQUATION                      MAIN1050
00100  C     UBARL = WIND SPEED AT TOP OF NEW LAYER AFTER TAST (METERS/SEC)    MAIN1060
00100  C     SIGAL = SIGAP AT TOP OF NEW LAYER AFTER TAST (DEGREES)            MAIN1070
00100  C     SIGEL = SIGEP AT TOP OF NEW LAYER AFTER TAST (DEGREES)            MAIN1080
00100  C     ZRL = REFERENCE HEIGHT IN SURFACE LAYER OF NEW STRUCTURE (METERS) MAIN1090
00100  C     SIGARL = SIGAP AT ZRL IF FIRST LAYER INCLUDES OLD SURFACE LAYER   MAIN1100
00100  C              ELSE EQUALS SIGAP AT BOTTOM OF FIRST NEW LAYER (DEGREES) MAIN1110
00100  C     SIGERL = SIGAP AT ZRL IF FIRST LAYER INCLUDES OLD SURFACE LAYER   MAIN1120
00100  C              ELSE EQUALS SIGEP AT BOTTOM OF FIRST NEW LAYER (DEGREES) MAIN1130
00100  C     UBARRL = WIND SPEED AT ZRL IF FIRST LAYER INCLUDES OLD SURFACE    MAIN1140
00100  C              LAYER ELSE EQUALS WIND SPEED AT BOTTOM OF FIRST NEW      MAIN1150
00100  C              LAYER (METERS/SEC)                                       MAIN1160
00100  C     THETAL = WIND DIRECTION AT BOUNDARIES OF NEW LAYER STRUCTURE (DEGRMAIN1170
00100  C     TAUL  = TIME IN SECONDS FOR LATERAL CLOUD STABILIZATION IN NEW    MAIN1180
00100  C              LAYER STRUCTURE                                          MAIN1190
00100  C     TAUOL = TIME IN SECONDS OF SAMPLING PERIOD AT TOP OF NEW LAYER    MAIN1200
00100  C     JBOT  = INPUT LAYER NUMBER OF BOTTOM OF NEW LAYER STRUCTURE       MAIN1210
00100  C              RELATIVE TO OLD                                          MAIN1220
00100  C     JTOP  = INPUT LAYER NUMBER OF TOP OF NEW LAYER STRUCTURE          MAIN1230
00100  C              RELATIVE TO OLD                                          MAIN1240
00100  C     VS    = SETTLING VELOCITY IN GRAVITATIONAL DEPOSITION MODEL       MAIN1250
00100  C     PERC  = FREQUENCY OF VS                                           MAIN1260
00100  C     ACCUR = DESIRED ACCURACY COEFFICIENT (.45) INSURES THAT GROUND    MAIN1270
00100  C              DEPOSITION FROM NXCI POINT SOURCES IN THE LAYER VARIES   MAIN1280
00100  C              LESS THAN TEN PERCENT FROM DEPOSITION EXPECTED FROM A    MAIN1290
00100  C              VERTICAL LINE SOURCE IN THE LAYER. FOR (.32) REDUCED TO  MAIN1300
00100  C              FIVE PERCENT                                             MAIN1310
00100  C     VB    = SETTLING VELOCITIES FROM A BURST OR DESTRUCT IN LAYER NNZ MAIN1320
00100  C     PERCB = FREQUENCY OF VB                                           MAIN1330
00100  C     HB    = HEIGHT OF BURST (METERS)                                  MAIN1340
00100  C     PPWR  = CALCULATED WIND SPEED POWER LAW EXPONENT                  MAIN1350
00100  C     QPWR  = CALCULATED SIGEP POWER LAW EXPONENT                       MAIN1360
00100  C     MPWR  = CALCULATED SIGAP POWER LAW EXPONENT                       MAIN1370
00100  C     DTHK  = WIND ANGLE SHEAR                                          MAIN1380
00100  C     NVS   = NUMBER OF SETTLING VELOCITIES VS                          MAIN1390
00100  C     NVB   = NUMBER OF SETTLING VELOCITIES VB                          MAIN1400
00100  C     LB1   = PRINTED INFORMATION =LB2,LB3,LB4                          MAIN1410
00100  C     DATE  = RUN DATE                                                  MAIN1420
00100  C     II    = INDEX ON VS AND VB                                        MAIN1430
00100  C     DEP   = TEMP STORAGE                                              MAIN1440
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00100   C     YBARY = CALCULATED COORDINATE OF POINT ON CLOUD AXIS OF VS AT
00100   C             INTERSECTION WITH GROUND  (DEPOSITION)
00100   C     XBARX = CALCULATED COORDINATE OF POINT ON CLOUD AXIS OF VS AT
00100   C             INTERSECTION WITH GROUND  (DEPOSITION)
00100   C     UBARNK = CALCULATED WIND SPEED  (DEPOSITION)
00100   C     BETANK = CALCULATED BETA   (DEPOSITION)
00100   C     ALPHNK = CALCULATED ALPHA  (DEPOSITION)
00100   C     SQBAR  = TEMP STORAGE
00100   C     ANG    =  ANGLE  TO POINT XBARX,YBARY  (DEPOSITION)
00100   C     NXCI   = NUMBER OF POINT SOURCES IN LAYER  (DEPOSITION)
00100   C     DEPN   = CALCULATED VALUE OF GRAVITATIONAL DEPOSITION
00100   C     SIGYNK = SIGY OF NEW LAYER STRUCTURE IN CALCULATION OF DOSAGE AND
00100   C              CONCENTRATION
00100   C     SIGENK = CALCULATED SIGEP (DEPOSITION)
00100   C     SIGANK = CALCULATED SIGAP (DEPOSITION)
00100   C
00100   C
00100   C     NOTE ALL REFERENCES TO GROUND REFER TO SOME SLIGHT DISTANCE ABOVE
00100   C     THE GROUND AS A STARTING PLANE FOR ALL MODELS
00100   C
00100   C
00101         COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),
00101        1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),
00101        2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),
00101        3ZZL(100),XR(100),DOS(100),CON(100),PEAKD(100),XX(100),YY(100),
00101        4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100),
00101        5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,
00101        6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRD,TAST(10),NBK,ILK,
00101        7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),
00101        8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHDU(100,100),UBARK(20),SIGAK(20),
00101        9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20),
00103         COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,
00103        1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),
00103        2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,
00103        3PPYR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,
00103        4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,
00103        5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),
00103        6DELPHI,UBARZK(100),UBARZL(100)
00104         REAL MPWR,L,LAT,LAMBDA
00105         INTEGER TESTNO
00106         DATA LB1/24HX IS RADIAL DISTANCE    /,LB2/24HY IS ANGLE IN DEGREES
00106        1   /,LB3/24HY IS LATERAL DISTANCE   /,LB4/24HX IS LINEAR DISTANCE
00106        2   /
00106   C               *** INPUT SECTION ***
00113         READ (5,800) (DATE(I),I=1,2)
00121         WRITE (6,900) (DATE(I),I=1,2)
00127         READ (5,802) NP
00132         IERR = 0
00132   C                    EXECUTE PROGRAM NP TIMES
00133         DO 700 JXJ=1,NP
00136         IF (IERR .EQ. 1) GO TO 2
00140         READ (5,807) IA,(TESTNO(I),I=1,12)
00147       2 CONTINUE
00150         READ (5,801) (ISKIP(I),I=1,30)
00156         READ (5,802) NXS,NYS,NZS,NDI,NCI,NDXR,NVS,NBK,NVB
00171         WRITE (6,901) (TESTNO(I),I=1,12)
00177         IF (ISKIP(2) .EQ. 0) WRITE (6,902) LB4,LB3
00212         IF (ISKIP(2) .EQ. 1) WRITE (6,902) LB1,LB2
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      NNZ = NZS-1
      SQR2P = SQRT(6.2831853072)
      RAD = 3.1415926536/180.0
      IERR = 0
C                       READ MODEL PARAMETERS
      CALL READER(IERR,NP,JXJ)
      IF (IERR .EQ. 1) GO TO 700
      IF (IERR .EQ. 2) GO TO 777
      IF (ISKIP(1) .NE. 2) GO TO 5
C                EXECUTE GRAVITATIONAL DEPOSITION MODEL
      CALL DEPOS(NP)
      GO TO 700
    5 CONTINUE
      IF (DELPHI .GT. 180.0) DELPHI = 180.0
C
C     CALCULATE HEIGHTS ZZL(K) AND WIND SPEED UBARZK(KK) AT ZZL(K).
      K = 0
      DO 90 KK=1,NNZ
      DIFF = (Z(KK+1)-Z(KK))/FLOAT(NPT(KK)+1)
      M = 1
      K = K+1
      ZZL(K) = Z(KK)
      GO TO 80
   70 K = K+1
      ZZL(K) = ZZL(K-1)+DIFF
      M = M+1
   80 CONTINUE
      IF (KK .EQ. 1) GO TO 82
      UBARZK(K) = UBARK(KK-1)+((UBARK(KK)-UBARK(KK-1))/(Z(KK+1)-Z(KK)))*
     1(ZZL(K)-Z(KK))
      GO TO 84
   82 UBARZK(K) = UBARRK*(ZZL(K)/ZRK)**PPWR
   84 CONTINUE
      IF (M .GE. NPT(KK)+1) GO TO 90
      GO TO 70
   90 CONTINUE
       KTK = K
      TRD = .5*DELPHI*RAD
      K = 0
      ILK = 1
      DO 600 KK=1,NNZ
      TH = RAD*THETA(KK)
C               *** LIST INPUT PARAMETERS ***
      LSP = KK*2-1
      WRITE (6,903) KK
      WRITE (6,904)
      IF (KK .NE. 1) GO TO 92
      WRITE (6,905) Q(KK),ZRK,UBARRK,SIGARK,TAUOK(KK),TAUK(KK),SIGAK(KK)
     1,ALPHA(KK),SIGYO(KK),Z(KK),UBARK(KK),THETAK(LSP),THETAK(LSP+1),
     2SIGERK,SIGEK(KK),BETA(KK),SIGZO(KK),T(KK),H(KK),DELX(KK),DELY(KK),
     3DELPHI,IZMOD(KK),TIM1,ZLIM,LAMBDA,SIGXO(KK)
      GO TO 93
   92 CONTINUE
      WRITE (6,918) Q(KK),TAUOK(KK),TAUK(KK),SIGAK(KK),ALPHA(KK),SIGYO(K
     1K),Z(KK),UBARK(KK),THETAK(LSP),THETAK(LSP+1),SIGEK(KK),BETA(KK),
     2SIGZO(KK),T(KK),H(KK),DELX(KK),DELY(KK),DELPHI,IZMOD(KK),TIM1,
     3ZLIM,LAMBDA,SIGXO(KK)
   93 IF (KK .NE. NNZ) GO TO 94
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      WRITE (6,919) Z(KK+1)
   94 CONTINUE
      IF (ISKIP(13) .EQ. 0.OR.KK .NE. JBOT(ILK)) GO TO 97
      IF (JBOT(1) .NE. KK) GO TO 96
      LSP = ILK*2-1
      WRITE (6,920) ZRL,UBARRL,SIGARL,TAUDL(ILK),TAUL(ILK),SIGAL(ILK),
     1ALPHA(NNZ+ILK),SIGYO(NNZ+ILK),UBARL(ILK),THETAL(LSP),THETAL(LSP+1)
     2,SIGERL,SIGEL(ILK),BETA(NNZ+ILK),SIGZO(NNZ+ILK),SIGXO(NNZ+ILK)
      GO TO 97
   96 CONTINUE
      WRITE (6,921) TAUDL(ILK),TAUL(ILK),SIGAL(ILK),ALPHA(NNZ+ILK),
     1SIGYO(NNZ+ILK),UBARL(ILK),THETAL(LSP),THETAL(LSP+1),SIGEL(ILK),
     2BETA(NNZ+ILK),SIGZO(NNZ+ILK),SIGXO(NNZ+ILK)
   97 CONTINUE
      WRITE (6,922) UBAP(KK),THETA(KK),DELTHP(KK),DELU(KK),SIGAP(KK),
     1SIGEP(KK)
      IF (ISKIP(13) .EQ. 0.OR.KK .NE. JBOT(ILK)) GO TO 98
      WRITE (6,923) UBAR(NNZ+ILK),THETA(NNZ+ILK),DELTHP(NNZ+ILK),
     1DELU(NNZ+ILK),SIGAP(NNZ+ILK),SIGEP(NNZ+ILK)
   98 CONTINUE
       CALL TESTR(KTK)
      WRITE (6,917)
      IF (ISKIP(7) .EQ. 0.OR.ISKIP(7) .EQ. 2) GO TO 600
C               *** GENERAL GRID PATTERN CALCULATION SECTION ***
      M = 0
  100 M = M+1
      K = K+1
      DO 520 I=1,NXS
      DO 310 J=1,NYS
      N = 1
      CALL BREAK(K,N,XX(I),YY(J))
  310 CONTINUE
C               *****OUTPUT SECTION *****
      IF (I .NE. 1) GO TO 405
      WRITE (6,906) ZZL(K)
  405 WRITE (6,907) XX(I)
      IF (ISKIP(11) .EQ. 1) WRITE (6,924)
      IF (ISKIP(13) .NE. 0.AND. KK .GE. IBOT.AND.KK .LE. ITOP) GO TO 430
      DO 420 J=1,NYS
      IF (ITAG(J) .EQ. 9) GO TO 410
      WRITE (6,908) YY(J),DDS(J),PEAKC(J),CON(J),VER(J),VREF(J),ALONGW(J
     1),LAT(J)
      GO TO 420
  410 WRITE (6,909) YY(J)
  420 ITAG(J) = 0
      GO TO 520
  430 DO 433 J=1,NYS
      WRITE (6,911) YY(J),DDS(J),CON(J)
  433 CONTINUE
  520 CONTINUE
      WRITE (6,917)
      IF (ISKIP(12) .EQ. 0) GO TO 440
      IF (KK .NE. NNZ. OR.M-1 .LT. NPT(KK)) GO TO 440
      WRITE (6,913)
      DO 435 I=1,NXS
      WRITE (6,916) XX(I),(YY(J),WASHOU(I,J),J=1,NYS)
      DO 435 J=1,NYS
      WASHOU(I,J) = 0.0
```

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00636   435 CONTINUE                                                            MAIN3280
00641       WRITE (6,917)                                                       MAIN3290
00643   440 CONTINUE                                                            MAIN3300
00643 C                                                                         MAIN3330
00644       IF (M-1 .GE.  NPT(KK)) GO TO 600                                    MAIN3340
00646       GO TO 100                                                           MAIN3350
00647   600 CONTINUE                                                            MAIN3360
00647 C     ***** CALCULATE CLOUD HALF WIDTHS *****                             MAIN3370
00651       IF (ISKIP(7) .NE. 2.AND.ISKIP(7) .NE. 3) GO TO 535                  MAIN3380
00653       WRITE (6,914)                                                       MAIN3390
00655       ILK = 1                                                             MAIN3400
00656       DO 530 KK=1,NNZ                                                     MAIN3410
00661       CALL TESTR(KTK)                                                     MAIN3420
00662       DO 525 I=1,NDXR                                                     MAIN3430
00665       IF (ISKIP(13) .NE. 0.AND. KK .GE. IBOT.AND.KK .LE. ITOP) GO TO 524MAIN3440
00667   522 CALL SIGMA(DXR(I),0,0)                                              MAIN3450
00670       XR(I) = SIGY*2.15                                                   MAIN3460
00671       GO TO 525                                                           MAIN3470
00672   524 IF (DXR(I) .LT. XAST(KK)) GO TO 522                                 MAIN3480
00674       CALL SIGMA(XAST(KK),0,0)                                            MAIN3490
00675       CALL SIGMA(DXR(I),KK,0)                                             MAIN3500
00676       XR(I) = SIGYNK*2.15                                                 MAIN3510
00677   525 CONTINUE                                                            MAIN3520
00701       IF (THETA(KK) .LT. 180.0) Y = THETA(KK)+180.0                       MAIN3530
00703       IF (THETA(KK) .GE. 180.0) Y = THETA(KK)-180.0                       MAIN3540
00705       WRITE (6,903) KK                                                    MAIN3550
00710       IF (ISKIP(13) .NE. 0.AND. KK .GE. IBOT.AND.KK .LE. ITOP) GO TO 527MAIN3560
00712       GO TO 528                                                           MAIN3570
00713   527 IF (THETA(NNZ+ILK-1) .GE. 180.0) YS = THETA(NNZ+ILK-1)-180.0        MAIN3580
00715       IF (THETA(NNZ+ILK-1) .LT. 180.0) YS = THETA(NNZ+ILK-1)+180.0        MAIN3590
00717       WRITE (6,912) YS,XAST(KK)                                           MAIN3600
00723   528 CONTINUE                                                            MAIN3610
00724       WRITE (6,915) Y,(DXR(I),XR(I),I=1,NDXR)                             MAIN3620
00734   530 CONTINUE                                                            MAIN3630
00736       WRITE (6,917)                                                       MAIN3640
00740   535 CONTINUE                                                            MAIN3650
00740 C     ****CALCULATE CENTER LINE CONCENTRATION AND-OR DOSAGE ****          MAIN3660
00741       IF (ISKIP(8) .EQ. 0) GO TO 540                                      MAIN3670
00743       CALL CENTRL                                                         MAIN3680
00744   540 CONTINUE                                                            MAIN3690
00744 C                  ***** ISOPLETH SECTION *****                           MAIN3700
00744 C     **** CALCULATE ISOPLETHS X,Y PLANE ****                             MAIN3710
00745       IF (ISKIP(9) .EQ. 0) GO TO 560                                      MAIN3720
00747       CALL ISOXY                                                          MAIN3730
00750   560 CONTINUE                                                            MAIN3740
00750 C     **** CALCULATE ISOPLETHS Y,Z PLANE ****                             MAIN3750
00751       IF (ISKIP(10) .EQ. 0) GO TO 580                                     MAIN3760
00753       CALL ISOYZ                                                          MAIN3770
00754   580 CONTINUE                                                            MAIN3780
00754 C     **** LOOP FOR NEXT TEST *****                                       MAIN3790
00755   700 CONTINUE                                                            MAIN3800
00757   777 CONTINUE                                                            MAIN3810
00760   800 FORMAT (6A6)                                                        MAIN3820
00761   801 FORMAT (40I2)                                                       MAIN3830
00762   802 FORMAT (10I3)                                                       MAIN3840
00763   806 FORMAT (2F6.2,4F10.0,2F6.2/8I4,5I6)                                 MAIN3850
00764   807 FORMAT (A1,12A6)                                                    MAIN3860
00765   900 FORMAT (18H1  ***** RUN DATE ,2A6,6H *****)                         MAIN3870
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00766   901 FORMAT (1H1,17X,18H***** THE TEST IS ,12A6,6H *****///)                 MAIN3880
00767   902 FORMAT (41X,4A6,2H, ,4A6)                                               MAIN3890
00770   903 FORMAT (1H0,55X,11H***** LAYER,I2,6H *****)                             MAIN3900
00771   904 FORMAT (1H0,57X,16H** INPUT DATA **)                                    MAIN3910
00772   905 FORMAT (1H0,3H Q=,E12.6,6H, ZRK=,F10.4,9H, UBARRK=,F10.5,9H, SIGARMAIN3920
00772      1K=,F10.5,8H, TAUOK=,F10.5,7H, TAUK=,F10.5/1X,14H SIGAK AT TOP=,F10MAIN3930
00772      2.5,8H, ALPHA=,F10.5,8H, SIGYO=,F10.5,4H, Z=,F10.3,15H, UBARK AT TOMAIN3940
00772      3P=,F10.5,19H, THETAK AT BOTTOM=,F10.5/   16H  THETAK AT TOP=,F10.5MAIN3950
00772      4,9H, SIGERK=,F10.5,15H, SIGEK AT TOP=,F10.5,7H, BETA=,F10.5,8H, SIMAIN3960
00772      5GZO=,F10.5,4H, T=,F10.4/   4H  H=,F10.4,7H, DELX=,F10.5,7H, DELY=,MAIN3970
00772      6F10.5,9H, DELPHI=,F10.5,8H, MODEL=,I3,7H, TIM1=,F10.4,7H, ZLIM=,F1MAIN3980
00772      70.3/ 9H  LAMBDA=,F10.5,8H, SIGXO=,F10.5)                               MAIN3990
00773   906 FORMAT (1H0,48X,25H** CALCULATION HEIGHT Z =,F9.3,3H **)               MAIN4000
00774   907 FORMAT (1H0,57X,4H* X=,F10.2,2H *)                                     MAIN4010
00775   908 FORMAT (8H **** Y=,F10.2,9H, DOSAGE=,E14.8,11H, PEAK CON=,E14.8,16MAIN4020
00775      1H, CONCENTRATION=,E14.8,11H, VERTICAL=,E14.8/18X,13H  REFLECTION=,MAIN4030
00775      2E14.8,13H, ALONG WIND=,E14.8,10H, LATERAL=,E14.8)                       MAIN4040
00776   909 FORMAT (8H **** Y=,F10.2,38H, RECEPTOR OUTSIDE OF SECTOR DELTA PHIMAIN4050
00776      1)                                                                      MAIN4060
00777   910 FORMAT (1H ,46HMET PARAMETERS FOR NEW LAYER ** SIGMA A PRIME=,F9.5MAIN4070
00777      1,16H, SIGMA E PRIME=,F9.5,8H, ALPHA=,F8.5,7H, BETA=,F8.5/1H ,18HDEMAIN4080
00777      2LTA THETA PRIME=,F8.3,7H, UBAR=,F8.3,8H, THETA=,F8.3,5H, T=,F9.3,MAIN4090
00777      39H, MODEL =,I3)                                                       MAIN4100
01000   911 FORMAT (8H **** Y=,F10.2,9H, DOSAGE=,E14.8,16H, CONCENTRATION=,E14MAIN4110
01000      1.8)                                                                    MAIN4120
01001   912 FORMAT (1H ,19HNOTE, Y CHANGES TO ,F7.2,22H DEGREES AT X DISTANCE,MAIN4130
01001      1F10.2)                                                                 MAIN4140
01002   913 FORMAT (1H0,47X,36H*** WASHOUT DEPOSITION AT GROUND ***)                MAIN4150
01003   914 FORMAT (1H0,54H---------------------------------------------------MAIN4160
01003      1---,23H** CLOUD HALF WIDTHS **,52H----------------------------------MAIN4170
01003      2=------------------/9X,101HCHW IS LATERAL DISTANCE FROM CLOUD CENMAIN4180
01003      3TER LINE, R IS RADIAL DISTANCE, Y IS ANGLE TO CLOUD CENTER LINE)  MAIN4190
01004   915 FORMAT (1H ,55X,2HY=,F10.2,8H DEGREES/(10X,4(5H** R=,F10.2,6H, CHMAIN4200
01004      1=,F10.2)))                                                             MAIN4210
01005   916 FORMAT (1H ,05H** X=,F10.2,3(4H, Y=,F10.2,10H, WASHOUT=E14.8)/(18 MAIN4220
01005      1X,3(2HY=,F10.2,10H, WASHOUT=,E14.8,2H, )))                            MAIN4230
01006   917 FORMAT (12X,18(6H------)/)                                             MAIN4240
01007   918 FORMAT (1H0,3H Q=,E12.6,8H, TAUOK=,F10.5,7H, TAUK=,F10.5,15H, SIGAMAIN4250
01007      1K AT TOP=,F10.5,8H, ALPHA=,F10.5,8H, SIGYO=,F10.5/        1X,3H ZMAIN4260
01007      2=,F10.3,15H, UBARK AT TOP=,F10.5,19H, THETAK AT BOTTOM=,F10.5,16H,MAIN4270
01007      3 THETAK AT TOP=,F10.5,15H, SIGEK AT TOP=,F10.5/1X,6H BETA=,F10.5,8HMAIN4280
01007      4H, SIGZO=,F10.5,4H, T=,F10.4,4H, H=,F10.3,7H, DELX=,F10.5,7H, DELYMAIN4290
01007      5=,F10.5,9H, DELPHI=,F10.5/ 8H  MODEL=,I3,7H, TIM1=,F10.4,7H, ZLIM=MAIN4300
01007      6,F10.3,9H, LAMBDA=,F10.5,8H, SIGXO=,F10.5)                             MAIN4310
01010   919 FORMAT (1X,10H Z AT TOP=,F10.4)                                        MAIN4320
01011   920 FORMAT (1H0,37HINPUT DATA FOR LAYER CHANGE ***  ZRL=,F10.4,9H, UBAMAIN4330
01011      1RRL=,F10.5,9H, SIGARL=,F10.5,8H, TAUOL=,F10.5,7H, TAUL=,F10.5/1X,1MAIN4340
01011      24H SIGAL AT TOP=,F10.5,10H, ALPHA L=,F10.5,10H, SIGYO L=,F10.5,15HMAIN4350
01011      3, UBARL AT TOP=,F10.5,19H, THETAL AT BOTTOM=,F10.5/1X,15H THETAL AMAIN4360
01011      4T TOP=,F10.5,9H, SIGERL=,F10.5,15H, SIGEL AT TOP=,F10.5,9H, BETA LMAIN4370
01011      5=,F10.5,10H, SIGZO L=,F10.5,10H, SIGXO L=,F10.5)                       MAIN4380
01012   921 FORMAT (1H0,7H TAUOL=,F10.5,7H, TAUL=,F10.5,15H, SIGAL AT TOP=,F10MAIN4390
01012      1.5,10H, ALPHA L=,F10.5,10H, SIGYO L=,F10.5,15H, UBARL AT TOP=,F10.MAIN4400
01012      25/1X,18H THETAL AT BOTTOM=,F10.5,16H, THETAL AT TOP=,F10.5,15H, SIMAIN4410
01012      3GEL AT TOP=,F10.5,9H, BETA L=,F10.5,10H, SIGZO L=,F10.5/1X,9H SIGXMAIN4420
01012      40 L=,F10.5)                                                            MAIN4430
01013   922 FORMAT (1H0,56HCALCULATED INPUT PARAMETERS FOR MODELS 1,2,3 **** UMAIN4440
01013      1BAR =,F10.5,9H, THETA =,F10.5,10H, DELTHP =,F10.5,8H, DELU =,F10.5MAIN4450
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01013   4340*        2/1X,C9H, SIGAP =,F10.5,9H, SIGEP =,F10.5)                MAIN4460
01014   4350*     923 FORMAT (1H0,63HCALCULATED INPUT PARAMETERS FOR LAYER CHANGE MODELSMAIN4470
01014   4360*        1 ***** UBAR =,F10.5,9H, THETA =,F10.5,10H, DELTHP =,F10.5/1X,9H  GEMAIN4480
01014   4370*        2LU =,F10.5,9H, SIGAP =,F10.5,9H, SIGEP =,F10.5)          MAIN4490
01015   4380*     924 FORMAT (41X,49H* DECAY IS INCLUDED IN DOSAGE AND CONCENTRATION *) MAIN4500
01016   4390*          STOP                                                    MAIN4510
01017   4400*          END                                                     MAIN4520

     END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
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@I FOR BREAK
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:34:53

   SUBROUTINE BREAK      ENTRY POINT 001035

   STORAGE USED (BLOCK, NAME, LENGTH)

         0001    *CODE    001076
         0000    *DATA    000057
         0002    *BLANK   000000
         0003    PARAMT   033754
         0004    PARAMS   025577

   EXTERNAL REFERENCES (BLOCK, NAME)

         0005    COORD
         0006    EL
         0007    SIGMA
         0010    PEAK
         0011    VERT
         0012    LATER
         0013    ALONGD
         0014    ISO
         0015    WASHT
         0016    EXP
         0017    NERR3S

   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001     000051 125L       0001     000166 127L       0001     000214 135L       0001     000235 140L       0001     000353 150L
    0001     000242 1526       0001     000451 160L       0001     000454 165L       0001     000552 175L       0001     000613 180L
    0001     000624 185L       0001     000745 195L       0001     000762 200L       0001     000444 2176       0001     000545 2446
    0001     000764 310L       0001     001017 340L       0000 R 000007 AB         0004 R 000216 ACCUR      0003 R 007102 ALONGW
    0003 R 000226 ALPHA      0004 R 001023 ALPHNK     0004 R 001170 ANG        0000 R 000003 ASP        0003 R 000264 BETA
    0004 R 000457 BETANK     0003 R 007774 CI         0003 R 001522 CON        0004 R 000342 DATE       0004 R 000000 DECAY
    0004 R 025264 DELPHI     0003 R 000454 DELTHP     0003 R 001010 DELU       0003 R 000606 DELX       0003 R 000644 DELY
    0004 R 000345 DEP        0004 R 001335 DEPN       0003 R 007762 DI         0003 R 001356 DOS        0004 R 000273 DTHK
    0003 R 007246 DXR        0004 R 000126 ERFX       0003 R 000036 H          0004 R 000267 H8         0003 I 010014 I
    0003 I 010050 IBOT       0000 I 000011 IC1        0000 I 000016 IC2        0000 I 000012 IC3        0003 I 007436 IFLAG
    0004 I 000344 II         0003 I 010036 ILK        0000 I 000006 IS         0003 I 000000 ISKIP      0000 I 000005 ISWS
    0003 I 007602 ITAG       0003 I 010047 ITOP       0003 I 000740 IZMOD      0003 I 010015 J          0004 I 000114 JBOT
    0004 I 000041 JF         0004 I 000134 JTOP       0003 I 010016 KK         0003 R 010012 L          0003 R 010110 LAMBDA
    0003 R 006426 LAT        0004 I 000322 LB1        0004 I 000326 LB2        0004 I 000332 LB3        0004 I 000336 LB4
    0000 I 000010 M          0004 R 000272 MPWR       0000 I 000015 MS         0003 I 010035 NBK        0003 I 010043 NCI
    0003 I 010042 NDI        0003 I 010044 NDXR       0000 I 000000 NF         0003 I 010046 NNZ        0003 I 000764 NPT
    0004 I 000321 NVB        0004 I 000320 NVS        0004 I 001334 NXCI       0003 I 010037 NXS        0003 I 010040 NYS
    0003 I 010041 NZS        0003 R 006262 PEAKC      0003 R 001666 PEAKD      0004 R 000172 PERC       0004 R 000243 PERCB
    0003 R 002342 PLT        0004 R 000270 PPWR       0003 R 000132 Q          0004 R 000271 QPWR       0003 R 010045 RAD
    0003 R 033540 SIGAK      0004 R 000013 SIGAL      0004 R 025122 SIGANK     0003 R 000360 SIGAP      0003 R 033631 SIGARK
    0004 R 000040 SIGARL     0003 R 033604 SIGEK      0004 R 000025 SIGEL      0004 R 024756 SIGENK     0003 R 000550 SIGEP
    0003 R 033632 SIGERK     0004 R 000042 SIGERL     0003 R 010010 SIGX       0003 R 010107 SIGXNK     0003 R 000416 SIGXO
    0003 R 010007 SIGY       0004 R 024755 SIGYNK     0003 R 000322 SIGYO      0003 R 010006 SIGZ       0003 R 000512 SIGZO
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0004 R 001117 SUBAR    0003 R 010011 SUB2P    0003 R 010017 STO1    0003 R 010020 STO2    0003 R 010021 STO3
0000 R 010013 S1       0000 R 010014 S2       0003 R 007412 T       0003 R 010023 TAST    0003 R 033704 TAUK
0004 R 000070 TAUL     0003 R 033730 TAUOK    0004 R 000162 TAUOL   0003 I 007746 TESTNO  0003 R 010013 TH
0003 R 000702 THETA    0003 R 033634 THETAK   0004 R 000044 THETAL  0003 R 010111 TIM1    0003 R 010112 TIM2
0003 R 010022 TRD      0003 R 000176 VEAF     0003 R 033534 UBARK   0004 R 000001 UBARL   0004 R 000513 UBARNK
0003 R 033633 UBARRK   0004 R 000040 UBARRL   0004 R 025267 UBARZK  0004 R 025433 UBARZL  0004 R 000217 VB
0003 R 006572 VER      0003 R 004736 VREF     0004 R 000196 VS      0003 R 010114 WASHOU  0000 R 000001 X
0003 R 010051 XAST     0004 R 000512 XBARK    0003 R 001212 XR      0000 R 000004 XS      0003 R 002032 XX
0000 R 000002 Y        0004 R 000346 YBARY    0003 R 002176 YY      0003 R 000074 Z       0003 R 010113 ZLIM
0003 R 033630 ZRK      0004 R 000037 ZRL      0003 R 001046 ZZL
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00101          SUBROUTINE BREAK(K,N,X?,YO)                                   BREK  20
00103          COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30), BREK  30
00103         1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),  BREK  40
00103         2SIGEP(30),?EL?(30),?EL?(30),THETA(30),I?(20),?PY(20),UELL(30), BREK  50
00103         3ZZL(100),XR(100),DOS(100),CON(100),PEAK?(100),XY(100),Y?(100), BREK  60
00103         4FLT(2,100,10),PEAKD(100),LAT(100),VER(100),VREF(100),ALONG?(100), BREK  70
00103         5???(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),CI(10),CI(10),SIGZ,BREK  80
00103         6SIGY,SIGX,SUB2P,L,THOI,??K,STO1,STO2,STO3,TRD,TAST(10),NBK,ILK, BREK  90
00103         7,XS,YS, ZS,?DI,?CI,?DXR,RAD,??Z,ITOP,IBOT,XAST(30),          BREK 100
00103         8SIGX?K,LAMBDA,TIM1,TIM2,ZLIM,WASHO?(100,100),UBARK(20),SIGAK(20), BREK 110
00103         9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20), BREK 120
00104          COMMON/ARA?S/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF, BREK 130
00104         1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),WFLT(10),ERFX(6), BREK 140
00104         2,TOP(10),VS(20),PERC(20),ACCUM,VB(20),PERC3(20),MB,PP R,WP?R, BREK 150
00104         3?P R,CTH?(21),?VS,?VB,?(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP, BREK 160
00104         4YBARY(100),XBARK,UBAR?(100),BETANK(100),ALPHNK(100),SOBAR,    BREK 170
00104         5ANG(100),?XCI,?FP?(100,100),SIGYNK,SIGENK(100),SIGANK(100),   BREK 180
00104         6DELPHI,UBARZK(100),??ZL(100)                                  BREK 190
00105          REAL ?P R,L,LAT,LA?E?                                         BREK 200
00106          INTEGER TESTNO                                                BREK 210
00106   C      *** THIS SUBROUTINE CALCULATES DOSAGE,CONCENTRATION AND WASHOUT **BREK 220
00106   C      *** ON A GENERAL GRID WITHIN THE SECTOR DELPHI.               BREK 230
00107          NF = 1                                                        BREK 240
00107   C      DETERMINE LOCATION OF RECEPTOR RELATIVE TO SOURCE AND WIND    BREK 250
00107   C      DIRECTION                                                     BREK 260
00110          CALL COORD(N,KK,X,Y,XO,YO,ASP,YS,1)                           BREK 270
00111          DOS(J) = 0.0                                                  BREK 280
00112          CON(J) = 0.0                                                  BREK 290
00113          ISW5 = 0                                                      BREK 300
00114          IF (ISKIP(13) .NE. 0.AND.IBOT .LE. KK.AND.KK .LE. ITOP) GO TO 135 BREK 310
00116          IS = 1                                                        BREK 320
00117          IF (N .EQ. 9) GO TO 310                                       BREK 330
00117   C                          CALCULATION OF MODELS 1,2,3               BREK 340
00121      125 CALL EL(X,C)                                                  BREK 350
00122          CALL SIGMA(X,0,C)                                             BREK 360
00123          CALL PEAK(NF,Y)                                               BREK 370
00124          CALL VERT(K,NF)                                               BREK 380
00125          CALL LATER(Y)                                                 BREK 390
00126          PERC(1) = SIGY                                                BREK 400
00127          PERC(3) = SIGX                                                BREK 410
00130          DOS(J) = PEAKD(J)*LAT(J)*(VER(J)+VREF(J))*EXP(-DECAY*X/UBAR(KK)) BREK 420
00131          IF (ISKIP(12) .GE. 2.OR.TIM1 .GE. (X/UBAR(KK))) GO TO 127     BREK 430
00133          IF (Z(KK) .GT. ZLIM) GO TO 127                                BREK 440
00135          AR = EXP(-LAMBDA*((X/UBAR(KK))-TIM1))                         BREK 450
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      DOS(J) = DOS(J)*AF                                              BREK 460
  127 CONTINUE                                                        BREK 470
      CALL ALONGD(X,T(KK))                                            BREK 480
       PEAKC(J) = DOS(J)*UBARZK(K)/(SQR2P*SIGX)                       BREK 490
      CON(J) = PEAKC(J)*ALONG (J)                                     BREK 500
  130 IF (IS .EQ. 1) GO TO 310                                        BREK 510
      GO TO 140                                                       BREK 520
  135 IS = 0                                                          BREK 530
      IF (X .LE. XAST(KK).AND.N .NE. 9) GO TO 125                     BREK 540
C        CALCULATION OF BOX MODEL OR FULL TRANSITION MODEL   140 - 200BREK 550
  140 DO 200 M=IBOT,ITOP                                              BREK 560
      IS 5 = 1                                                        BREK 570
      N = NF                                                          BREK 580
      CALL COORD(N,M,X,Y,XO,YO,ASP,XS,2)                              BREK 590
      IF (N .EQ. 9) GO TO 200                                         BREK 600
      CALL EL(XAST(M),M)                                              BREK 610
      CALL SIGMA(XAST(M),O,M)                                         BREK 620
      CALL EL(X,-1)                                                   BREK 630
      CALL SIGMA(X,M,O)                                               BREK 640
      IF (M .EQ. KK) PERC(2) = SIGYNK                                 BREK 650
      STO2 = 1.0                                                      BREK 660
      IF (ISKIP(13) .EQ. 1.OR.IZMOD(M) .EQ. 3) GO TO 180              BREK 670
      STO1 = 1.414214*SIGZ                                            BREK 680
      STO2 = 0.0                                                      BREK 690
      IF (SIGZ - 0.0) 148,175,148                                     BREK 700
  148 IC1 = -1                                                        BREK 710
      IC3 = 0                                                         BREK 720
      S1 = -1.0                                                       BREK 730
  150 S1 = S1+1.0                                                     BREK 740
      S2 = 2.0*S1*(Z(ITOP+1)-Z(IBOT))                                 BREK 750
      ERFX(3) = (S2+2.0*Z(IBOT)-Z(M)-ZZL(K))/STO1                     BREK 760
      IF (ERFX(3) .GT. 3.0) IC3 = IC3+1                               BREK 770
      IF (IC3 .GE. 2) GO TO 160                                       BREK 780
      ERFX(1) = (S2-Z(M)+ZZL(K))/STO1                                 BREK 790
      ERFX(2) = (S2+Z(M+1)-ZZL(K))/STO1                               BREK 800
      ERFX(4) = (S2-2.0*Z(IBOT)+Z(M+1)+ZZL(K))/STO1                   BREK 810
      CALL ISO(1,4)                                                   BREK 820
      IC1 = IC1 + 1                                                   BREK 830
      DO 155 MS=1,4                                                   BREK 840
  155 STO2 = STO2+ERFX(MS)                                            BREK 850
      GO TO 150                                                       BREK 860
  160 S1 = 0.0                                                        BREK 870
      IC2 = 0                                                         BREK 880
      IC3 = 0                                                         BREK 890
  165 S1 = S1+1.0                                                     BREK 900
      S2 = 2.0*S1*(Z(ITOP+1)-Z(IBOT))                                 BREK 910
      ERFX(4) = (-S2-2.0*Z(IBOT)+Z(M+1)+ZZL(K))/STO1                  BREK 920
      IF (-3.0 .GT. ERFX(4)) IC3 = IC3+1                              BREK 930
      IF (IC3 .GE. 2) GO TO 175                                       BREK 940
      ERFX(1) = (-S2-Z(M)+ZZL(K))/STO1                                BREK 950
      ERFX(2) = (-S2+Z(M+1)-ZZL(K))/STO1                              BREK 960
      ERFX(3) = (-S2+2.0*Z(IBOT)-Z(M)-ZZL(K))/STO1                    BREK 970
      CALL ISO(1,4)                                                   BREK 980
      IC2 = IC2+1                                                     BREK 990
      DO 170 MS=1,4                                                   BREK1000
  170 STO2 = STO2+ERFX(MS)                                            BREK1010
      GO TO 165                                                       BREK1020
  175 STO3 = 1.0                                                      BREK1030
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```
00252   103*         IF (IC1 .EQ. IC2) GO TO 185                                       BREK1040
00254   104*         IF (IC1 .GT. IC2) STO2 = STO2-4.0*FLOAT(IC1-IC2)                  BREK1050
00256   105*         IF (IC1 .LT. IC2) STO2 = STO2+4.0*FLOAT(IC2-IC1)                  BREK1060
00260   106*         GO TO 185                                                         BREK1070
00261   107*     180 STO3 = 2.0*(Z(M+1)-Z(M))/(Z(ITOP+1)-Z(IBOT))                      BREK1080
00262   108*     185 CONTINUE                                                          BREK1090
00263   109*         XBARX = EXP(-.5*(Y/SIGYNK)**2)                                    BREK1100
00264   110*         YBARY(1) = 1.0                                                    BREK1105
00265   111*         IF (ISKIP(6) .EQ. 0) GO TO 190                                    BREK1106
00267   112*         YBARY(1) = EXP(-0.5*((Y-UBAR(NNZ+ILK-1)*(T(M)-TAST(ILK-1)))/SIGXNKBREK1110
00267   113*        1)**2)                                                             BREK1120
00270   114*     190  S1 = ((G(M)*STO3)/(2.0*SQR2P*UBARZL(K)*SIGYNK))*XBARX*STO2*      BREK1130
00270   115*        1 EXP(-DECAY*X/UBAR(NNZ+ILK-1))                                    BREK1140
00271   116*         IF (ISKIP(12) .NE. 2.OR.TIM1 .GE. X/UBAR(NNZ+ILK-1)+TAST(ILK-1))  BREK1150
00271   117*        1GO TO 195                                                         BREK1160
00273   118*         IF (Z(M) .GT. ZLI ) GO TO 195                                     BREK1170
00275   119*         S1 = S1*EXP(-LAMBDA*(X/UBAR(NNZ+ILK-1)+TAST(ILK-1)-TIM1))         BREK1180
00276   120*     195 CONTINUE                                                          BREK1190
00277   121*          S2 = (S1*UBARZL(K)/(SQR2P*SIGXNK))*YBARY(1)                      BREK1200
00300   122*         DOS(J) = DOS(J)+S1                                                BREK1210
00301   123*         CON(J) = CON(J)+S2                                                BREK1220
00302   124*     200 CONTINUE                                                          BREK1230
00304   125*     310 CONTINUE                                                          BREK1240
00304   126*    C               ** CALCULATE WASHOUT **                                BREK1250
00305   127*         IF (ISKIP(12) .EQ. 0) GO TO 340                                   BREK1260
00307   128*         IF (Z(KK)-ZZL(K)) 340,315,340                                     BREK1270
00312   129*     315 IF (Z(KK) .GT. ZLIM) GO TO 340                                    BREK1280
00314   130*          CALL WASHT(X,Y,ISW5,XC,YO,H,K)                                   BREK1290
00315   131*     340 CONTINUE                                                          BREK1300
00316   132*         RETURN                                                            BREK1310
00317   133*         END                                                               BREK1320
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END OF UNIVAC 1108 FORTRAN V COMPILATION.   0 *DIAGNOSTIC* MESSAGE(S)

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FI FOR DEPOS
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 FS01PP
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:34:56

   SUBROUTINE DEPOS      ENTRY POINT 001014

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    001034
        0000    *DATA    000450
        0002    *BLANK   000000
        0003    FARAIT   033754
        0004    PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME)

        0005    SGP
        0006    UBARS
        0007    BETAK
        0010    COORD
        0011    DEPSO
        0012    NWDUS
        0013    NI02S
        0014    NI01S
        0015    NEXP6S
        0016    SQRT
        0017    SIN
        0020    COS
        0021    EXP
        0022    NERR3S


  STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001     000014 112G      0001     000211 12L       0001     000157 210G      0001     000200 223G      0001     000251 244G
   0001     000257 251G      0001     000301 262G      0001     000323 273G      0001     000367 313G      0001     000500 340G
   0001     000346 35L       0001     000556 353G      0001     000570 356G      0001     000622 365G      0001     000361 40L
   0001     000730 414G      0001     000737 421G      0001     000753 431G      0001     000754 434G      0001     000363 45L
   0001     000467 50L       0001     000474 55L       0001     000066 7L        0001     000675 70L       0001     000677 71L
   0001     000116 8L        0000     000021 8C1F      0000     000023 8C2F      0000     000024 8C3F      0001     000131 9L
   0000     000031 900F      0000     000144 901F      0000     000167 902F      0000     000210 903F      0000     000226 904F
   0000     000232 905F      0000     000243 906F      0000     000342 907F      0000     000346 908F      0004 R   000216 ACCUR
   0003 R   007102 ALONG     0003 R   000226 ALPHA     0004 R   001023 ALPHNK    0004 R   001170 ANG       0000 R   000016 ASP
   0003 R   000264 BETA      0004 R   000657 BETANK    0003 R   007774 CI        0003 R   001522 CON       0004 R   000342 DATE
   0004 R   000030 DECAY     0004 R   025266 DELPHI    0003 R   000454 DELTMP    0003 R   001010 DELU      0003 R   000606 DELX
   0003 R   000644 DELY      0004 R   000345 DEP       0004 R   001335 DEPN      0000 R   000012 DHK       0003 R   007762 DI
   0003 R   001356 DOS       0004 R   000273 DTHK      0003 R   007246 DXP       0004 R   000126 ERFX      0003 R   000036 H
   0004 R   000267 HR        0003 I   010014 I         0003 I   010050 IBOT      0003 I   007436 IFLAG     0004 I   000344 II
   0003 I   010036 ILK       0003 I   000000 ISKIP     0003 I   007602 ITAG      0003 I   010047 ITOP      0000 I   000013 IZ
   0003 I   000740 IZMOD     0003 I   010015 J         0004 I   000114 JBOT      0004 I   000041 JF        0004 I   000134 JTOP
   0003 I   010016 KK        0003 R   010012 L         0003 R   010110 LAMBDA    0003 R   006424 LAT       0004 I   000322 LB1
   0004 I   000326 LB2       0004 I   000332 LB3       0004 I   000336 LB4       0000 I   000000 LS        0000 I   000003 M
   0004 R   000272 MPYR      0000 I   000002 N         0003 I   010035 NDK       0003 I   010043 NCI       0003 I   010042 NDI
   0003 I   010044 NDXR      0003 I   010046 NZ        0003 I   000764 NPT       0000 I   000004 NTAD      0000 I   000006 NTAK
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0000 I 000005 NTAP      0000 I 000007 NTAR      0004 I 000321 NVB       0004 I 000320 NVS       0004 I 001334 NXCI
0003 I 010037 NYS       0003 I 010040 NYS       0003 I 010041 NZS       0003 R 006262 PEAKC     0003 R 001666 PEAKO
0004 R 000172 PERC      0004 R 000243 PERCB     0000 R 000020 PHI       0003 R 002342 PLT       0004 R 000270 PPAR
0003 R 000132 Q         0004 R 000271 QPWR      0003 R 010045 RAD       0000 R 000010 S         0003 R 033560 SIGAK
0004 R 000013 SIGAL     0004 R 025122 SIGAM     0003 R 000360 SIGAP     0003 R 033631 SIGARK    0004 R 000040 SIGARL
0003 R 033604 SIGEK     0004 R 000025 SIGEL     0004 R 024756 SIGENK    0003 R 000550 SIGEP     0003 R 033632 SIGERK
0004 R 000042 SIGERL    0003 R 010010 SIGX      0003 R 010107 SIGKNK    0003 R 000416 SIGXD     0003 R 010007 SIGY
0004 R 024765 SIGYNK    0003 R 000322 SIGYD     0003 R 010006 SIGZ      0003 R 000512 SIGZD     0004 R 001167 SQBAR
0003 R 010011 SQR2P     0003 R 010017 STD1      0003 R 010020 STD2      0003 R 010021 STD3      0003 R 007412 T
0003 R 010023 TAST      0003 R 033704 TAUK      0004 R 000070 TAUL      0003 R 033730 TAUOK     0004 R 000102 TAUOL
0003 I 007746 TESTNO    0003 R 010013 TH        0000 R 000001 THET      0003 R 000702 THETA     0003 R 033634 THETAK
0004 R 000044 THETAL    0003 R 010111 TIM1      0003 R 010112 TIM2      0003 R 010022 TRD       0003 R 000170 UBAR
0003 R 033534 UBARK     0004 R 000001 UBARL     0004 R 000513 UBARNK    0003 R 033633 UBARRK    0004 R 000093 UBARRL
0004 R 025247 UBARZK    0004 R 025433 UBARZL    0000 R 000011 UBMK      0004 R 000217 VB        0003 R 006572 VER
0003 R 006736 VREF      0004 R 000146 VS        0003 R 010114 WASHOU    0000 R 000014 X         0003 R 010051 XAST
0004 R 000512 XBARX     0003 R 001212 XR        0000 R 000017 XS        0003 R 002032 XX        0000 R 000015 Y
0004 R 000346 YBARY     0003 R 002176 YY        0003 R 000074 Z         0003 R 010113 ZLIM      0003 R 033630 ZRK
0004 R 000037 ZRL       0003 R 001046 ZZL
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00101           SUBROUTINE DEPCS(HP)                                              DEPO  20
00103           COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),     DEPO  30
00103          1BETA(30),SIGYO(30),SIGAP(30),SIGXD(30),CELTHP(30),SIGZO(30),     DEPO  40
00103          2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOC(20),NPT(20),DELU(30), DEPO  50
00103          3ZZL(100),XR(100),DOS(100),CON(100),PEAKO(100),XX(100),YY(100),   DEPO  60
00103          4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALPNG(100), DEPO  70
00103          5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,DEPO  80
00103          6SIGY,SIGX,SQR2P,L,TH,I,J,K,STD1,STD2,STD3,TRD,TAST(10),NBK,ILK,  DEPO  90
00103          7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IPCT,XAST(30),            DEPO 100
00103          8SIGKNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20),DEPO 110
00103          9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20), DEPO 120
00104           COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,  DEPO 130
00104          1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),    DEPO 140
00104          2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PP.R,QPWR,    DEPO 150
00104          3HP.R,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP, DEPO 160
00104          4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,     DEPO 170
00104          5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),     DEPO 180
00104          6DELPHI,UBARZK(100),UBARZL(100)                                   DEPO 190
00104     C     **** THIS SUBROUTINE CALCULATES GRAVITATIONAL DEPOSITION AT GROUNDDEPO 200
00104     C                                                                      DEPO 210
00104     C                                                                      DEPO 220
00105           REAL HPWR,L,LAT,LAMBDA                                           DEPO 240
00106           INTEGER TESTNO                                                   DEPO 250
00106     C                                                                      DEPO 320
00107           WRITE (6,905)                                                    DEPO 330
00111           DO 10 I=1,NNZ                                                    DEPO 340
00114           LS = I*2-1                                                       DEPO 350
00114     C                    LIST INPUT PARAMETERS                             DEPO 360
00115           IF (I .GT. 1) GO TO 7                                            DEPO 370
00117           WRITE (6,900)  I,UBARRK,SIGARK,SIGERK,ZRK,UBARK(I),Q(I),SIGAK(I), DEPO 380
00117          1SIGEK(I),DELX(I),DELY(I),SIGYO(I),SIGZO(I),ALPHA(I),BETA(I),     DEPO 390
00117          2THETAK(LS),THETAK(LS+1),TAUK(I),TAUOK(I),T(I),DELPHI,Z(I)        DEPO 400
00147           GO TO 8                                                          DEPO 410
00150         7 CONTINUE                                                         DEPO 420
00151           WRITE (6,904) I,UBARK(I),Q(I),SIGAK(I),SIGEK(I),DELX(I),DELY(I), DEPO 430
00151          1SIGYO(I),SIGZO(I),ALPHA(I),BETA(I),THETAK(LS),THETAK(LS+1),TAUK(I)DEPO 440
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00151          2,TAUCK(I),T(I),DELPHI,Z(I)                               DEPO 450
00175        6 IF (I .LT. NNZ) GO TO 9                                   DEPO 460
00177          WRITE (6,907) Z(I+1)                                      DEPO 470
00202        9 SIGAK(I) = SIGAK(I)*(TAUK(I)/TAUOK(I))**(1.0/5.0)         DEPO 480
00203       10 CONTINUE                                                  DEPO 490
00205          SIGARK = SIGARK*(TAUK(I)/TAUOK(I))**(1.0/5.0)             DEPO 500
00206          WRITE (6,901) (I,VS(I),I,PERC(I),I=1,NVS)                 DEPO 510
00217          IF (ISKIP(3) .EQ. 0) GO TO 12                             DEPO 520
00221          WRITE (6,908) (I,VB(I),I,PERCB(I),I=1,NVB)                DEPO 530
00232       12 CONTINUE                                                  DEPO 540
00233          THETA(I) = THETAK(I)                                      DEPO 550
00234          TH = THETA(I)*RAD                                         DEPO 560
00235          TRD = .5*DELPHI*RAD                                       DEPO 570
00236          IF (THETA(I) .LT. 180.0) THET = (THETA(I)+180.0)*RAD      DEPO 580
00240          IF (THETA(I) .GE. 180.0) THET = (THETA(I)-180.0)*RAD      DEPO 590
00242          DTHK(1) = 0.0                                             DEPO 600
00243          DO 20 N=2,NZS                                             DEPO 610
00246       20 DTHK(N) = DTHK(N-1)+DELTHP(N-1)                           DEPO 620
00250          DO 25 N=2,NZS                                             DEPO 630
00253       25 DTHK(N) = DTHK(N)*RAD                                     DEPO 640
00255          M = ISKIP(2)+1                                            DEPO 650
00256          NTAD = 1                                                  DEPO 660
00257          IF (ISKIP(3) .EQ. 1) NTAD = 2                             DEPO 670
00261          DO 73 JF=1,NTAD                                           DEPO 680
00264          NTAP = NVS                                                DEPO 690
00265          IF (JF .EQ. 2) NTAP = NVB                                 DEPO 700
00267          DO 73 II=1,NTAP                                           DEPO 710
00272          IF (JF .EQ. 2.OR.VS(II) .LE. 10.0) GO TO 35               DEPO 720
00274          WRITE (6,903) VS(II)                                      DEPO 730
00277          RETURN                                                    DEPO 740
00300       35 CONTINUE                                                  DEPO 750
00301          NTAK = 1                                                  DEPO 760
00302          NTAR = NNZ                                                DEPO 770
00303          IF (ISKIP(3) .EQ. 0) GO TO 45                             DEPO 780
00305          IF (JF .EQ. 2) GO TO 40                                   DEPO 790
00307          NTAR = NTAR-1                                             DEPO 800
00310          GO TO 45                                                  DEPO 810
00311       40 NTAK = NNZ                                                DEPO 820
00312       45 DO 72 KK=NTAK,NTAR                                        DEPO 830
00315          IF (JF .EQ. 2) GO TO 50                                   DEPO 840
00317          S = ((Z(KK+1)-Z(KK))/3.0)+Z(KK)                           DEPO 850
00320          CALL SGP(S,KK,SIGENK(I),I)                                DEPO 860
00321          CALL UBARS(S,KK,I,UBHK)                                   DEPO 870
00322          DHK = ACCUR*SIGENK(I)*SQBAR*SQRT(1.0+VS(II))/UBHK)        DEPO 880
00323          IF (DHK .LT. 10.0) DHK = 10.0                             DEPO 890
00325          S = (Z(KK+1)-Z(KK))/DHK                                   DEPO 900
00326          NXCI = S+1.0                                              DEPO 910
00327          IF (NXCI .LT. 3) NXCI = 3                                 DEPO 920
00331          DHK = (Z(KK+1)-Z(KK))/FLOAT(NXCI)                         DEPO 930
00332          STO1 = Z(KK)                                              DEPO 940
00333          GO TO 55                                                  DEPO 950
00334       50 NXCI = 1                                                  DEPO 960
00335          STO1 = 0.0                                                DEPO 970
00336          DHK = HB                                                  DEPO 980
00337       55 DO 95 IZ=1,NXCI                                           DEPO 990
00342          STO1 = STO1+DHK                                           DEPO1000
00343          ZZL(IZ) = STO1                                            DEPO1010
00344          CALL SGP(ZZL(IZ),KK,SIGENK(IZ),I)                         DEPO1020
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00345        CALL SGP(ZZL(IZ),KK,SIGARK(IZ),2)                          DEP01030
00346        CALL UBARS(ZZL(IZ),KK,IZ,LGMK)                             DEP01040
00347        CALL BETAK(ZZL(IZ),KK,IZ)                                  DEP01050
00350     95 CONTINUE                                                   DEP01060
00352        DO 71 I=1,NXS                                              DEP01070
00355        DO 71 J=1,NYS                                              DEP01080
00360        N = 1                                                      DEP01090
00361        CALL COORD(N,KK,X,Y,XX(I),YY(J),ASP,XS,1)                  DEP01100
00362        IF (N .EQ. 9) GO TO 71                                     DEP01110
00364        DO 70 IZ=1,NXCI                                            DEP01120
00367        PHI = ABS(ASP-(THET+ANG(IZ)))                              DEP01130
00370        IF (PHI .GT. 3.1415926536) PHI = 6.2831853072-PHI          DEP01140
00372        Y =XS*SIN(PHI)                                             DEP01150
00373        X =XS*COS(PHI)                                             DEP01160
00374        IF (X .LT. 0.0) GO TO 70                                   DEP01170
00376        CALL DEPSD(X,KK,IZ)                                        DEP01180
00377        DEP = DEP*EXP(-.5*(Y/SIGYNK)**2)                           DEP01190
00400        DEPN(I,J) = DEPN(I,J)+DEP                                  DEP01200
00401     70 CONTINUE                                                   DEP01210
00403     71 CONTINUE                                                   DEP01220
00406     72 CONTINUE                                                   DEP01230
00410     73 CONTINUE                                                   DEP01240
00413        DO 75 I=1,NXS                                              DEP01250
00416        WRITE (6,902) XX(I),(YY(J),DEPN(I,J),J=1,NYS)              DEP01260
00424     75 CONTINUE                                                   DEP01270
00426                                                                   DEP01430
00430        DO 90 I=1,NXS                                              DEP01440
00433        DO 90 J=1,NYS                                              DEP01450
00436        DEPN(I,J) = 0.0                                            DEP01460
00437     90 CONTINUE                                                   DEP01470
00442        WRITE (6,904)                                              DEP01480
00444        RETURN                                                     DEP01490
00445    801 FORMAT (8F10.5)                                            DEP01500
00446    802 FORMAT (40I2)                                              DEP01510
00447    803 FORMAT (2F6.2,4F10.0,2F6.2/8I4,5I4)                        DEP01520
00450    900 FORMAT (1H0,22H*** INPUT DATA LAYER ,I3,4H ***/1X,9H UBAR RK=,F10.DEP01530
00450       15,9H, SIGARK=,F10.5,9H, SIGERK=,F10.5,6H, ZRK=,F10.5,15H, UBARK ATDEP01540
00450       2 TOP=,F10.5,5H, Q =,E12.6/1X,14H SIGAK AT TOP=,F10.5,15H, SIGEK ATDEP01550
00450       3 TOP=,F10.5,7H, DELX=,F10.5,7H, DELY=,F10.5,8H, SIGYO=,F10.5,8H, SDEP01560
00450       4IGZO=,F10.5/1X,7H ALPHA=,F10.5,7H, BETA=,F10.5,19H, THETAK AT BOTTDEP01570
00450       5OM=,F10.5,16H, THETAK AT TOP=,F10.5,7H, TAUK=,F10.5,8H, TAUCK=,F10DEP01580
00450       6.5/   4H  T=,F10.4,9H, DELPHI=,F10.5,14H, Z AT BOTTOM=,F10.4)    DEP01590
00451    901 FORMAT (1H0,3(3HVS(,I2,2H)=,F10.5,7H, PERC(,I2,2H)=,F10.5,2H, )/(1DEP01600
00451       1X,3(3HVS(,I2,2H)=,F10.5,7H, PERC(,I2,2H)=,F10.5,2H, )))          DEP01610
00452    902 FORMAT (1H0,6X,3H X=,F10.2,3(5H **Y=,F10.2,6H, DEP=,E14.8,1H )/(20DEP01620
00452       1X,3(5H **Y=,F10.2,6H, DEP=,E14.8,1H )))                         DEP01630
00453    903 FORMAT (1H0,67H******* ERROR ****** VS HAS EXCEEDED MAXIMUM ALLOWABDEP01640
00453       1LE VALUE 10, VS=,F9.4)                                           DEP01650
00454    904 FORMAT (12X,18(6H------)/)                                       DEP01660
00455    905 FORMAT (1H1,48X,36H****** GRAVITATIONAL DEPOSITION *****)        DEP01670
00456    906 FORMAT (1H0,22H*** INPUT DATA LAYER ,I3,4H ***/1X,14H UBARK AT TOPDEP01680
00456       1=,F10.5,5H, Q =,E12.6,15H, SIGAK AT TOP=,F10.5,15H, SIGEK AT TOP=,DEP01690
00456       2F10.5,7H, DELX=,F10.5,7H, DELY=,F10.5/1X,7H SIGYO=,F10.5,8H, SIGZODEP01700
00456       3=,F10.5,8H, ALPHA=,F10.5,7H, BETA=,F10.5,19H, THETAK AT BOTTOM=,F1DEP01710
00456       40.5,16H, THETAK AT TOP=,F10.5/   7H  TAUK=,F10.5,8H, TAUDK=,F10.5,DEP01720
00456       54H, T=,F10.4,9H, DELPHI=,F10.5,14H, Z AT BOTTOM=,F10.4)          DEP01730
00457    907 FORMAT (1X,10H Z AT TOP=,F10.4)                                  DEP01740
00460    908 FORMAT (1X,19HHEIGHT OF BURST HP=,F10.4,3HVP(,I2,2H)=,F10.5,8H, PEDEP01750
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00460   153*     1RCB(,I2,2H)=,F10.5,2H, /(1X,3(3HVR(,I2,2H)=,F10.5,8X, PERCB(,I2,2HDEP01760
00460   154*     2)=,F10.5,2H, )))                                              DEP01770
00461   155*      END                                                           DEP01780

      END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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```
@I FOR CENTRL
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F5C1PP
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17134158

   SUBROUTINE CENTRL      ENTRY POINT 000323

   STORAGE USED (BLOCK, NAME, LENGTH)

         0001    *CODE    000334
         0000    *DATA    000156
         0002    *BLANK   000000
         0003    PARAMT   033754
         0004    PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME)

         0005    EL
         0006    SIGMA
         0007    PEAK
         0010    VERT
         0011    NWDU$
         0012    NI02$
         0013    EXP
         0014    NI01$
         0015    NERR3$


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001    000014 1136     0001    000236 120L     0001    000056 1276     0001    000266 130L     0001    000231 1656
 0001    000043 20L      0001    000261 2016     0001    000275 400L     0001    000154 80L      0000    000003 900F
 0000    000026 901F     0000    000035 902F     0000    000044 903F     0000    000061 904F     0000    000077 905F
 0000    000103 906F     0000    000115 907F     0004 R  000216 ACCUR    0003 R  007102 ALONG    0003 R  000226 ALPHA
 0004 R  001023 ALPHNK   0004 R  001170 ANG      0003 R  000264 BETA     0004 R  000657 BETANK   0003 R  007774 CI
 0003 R  001522 CON      0004 R  000342 DATE     0004 R  000000 DECAY    0004 R  025266 DELPHI   0003 R  000484 DELTMP
 0003 R  001010 DELU     0003 R  000606 DELX     0003 R  000644 DELY     0004 R  000345 DEP      0004 R  001335 DEPN
 0003 R  007762 DI       0003 R  001356 DOS      0004 R  000273 DTHK     0003 R  007246 DXR      0004 R  000126 ERFX
 0003 R  000036 H        0004 R  000267 HB       0003 I  010014 I        0003 I  010050 IBOT     0003 I  007436 IFLAG
 0004 I  000344 II       0003 I  010036 ILK      0003 I  000000 ISKIP    0003 I  007602 ITAG     0003 I  010047 ITOP
 0003 I  000740 I7MOD    0003 I  010015 J        0004 I  000114 JBOT     0004 I  000041 JF       0004 I  000134 JTOP
 0000 I  000000 K        0003 I  010016 KK       0003 R  010012 L        0003 R  010110 LAMBDA   0003 R  006426 LAT
 0004 I  000322 LB1      0004 I  000326 LB2      0004 I  000332 LB3      0004 I  000336 LB4      0000 I  000001 M
 0004 R  000272 MPEK     0003 I  010035 N3K      0003 I  010043 NCI      0003 I  010042 NCI      0003 I  010044 NOXR
 0003 I  010046 NNZ      0003 I  000764 NST      0004 I  000321 NVB      0004 I  000320 NXS      0004 I  001334 NXCI
 0003 I  010037 NXS      0003 I  010040 NXS      0003 I  010041 NZS      0003 R  006262 PEAKC    0003 R  001666 PEAKD
 0004 R  000172 PERC     0004 R  000243 PERCP    0003 R  002342 PLT      0004 R  000270 PPWR     0003 R  000132 Q
 0004 R  000271 QPER     0003 R  010045 RAD      0003 R  033560 SIGA     0004 R  000013 SIGAL    0004 R  025122 SIGANK
 0003 R  000360 SIGAP    0003 R  033631 SIGARK   0004 R  000040 SIGARL   0003 R  033604 SIGEK    0004 R  000025 SIGEL
 0004 R  024756 SIGEKK   0003 R  000550 SIGEP    0003 R  033632 SIGERK   0004 R  000042 SIGERL   0003 R  010010 SIGX
 0003 R  010107 SIGANK   0003 R  000416 SIGXO    0003 R  010007 SIGY     0004 R  024755 SIGYNK   0003 R  000322 SIGYO
 0003 R  010006 SIGZ     0003 R  000612 SIGZP    0004 R  001167 SUBAR    0003 R  010011 SUR2P    0003 R  010017 STO1
 0003 R  010020 STC2     0003 R  010021 STC3     0003 R  007412 T        0003 R  010023 TAST     0003 R  033704 TAUK
 0004 R  000070 TAUL     0003 R  033730 TAUTH    0004 R  000102 TAUO     0003 I  007746 TESTNO   0003 R  010013 TH
 0003 R  000702 THETA    0003 R  033624 THETAK   0004 R  000044 THETAL   0003 R  010111 TIM1     0003 R  010112 TIM2
```

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0003 R 010022 T.D      0003 R 000170 ...     0003 R 033534 UBARK   0004 R 000001 UBARL   0004 R 000513 UBARNK
0003 R 033633 UBARR.   0004 R 000043 UBARRL  0004 R 025267 UBARZK  0004 R 025433 UBARZL  0004 R 000217 VB
0003 R 006572 VER      0003 R 006736 VREF    0004 R 000146 VS      0003 R 010119 XASHOU  0003 R 010051 XAST
0004 R 000512 XBARX    0003 R 001212 XR      0003 R 002032 XX      0004 R 000346 YBARY   0000 R 000002 YO
0003 R 002176 YY       0003 R 000074 Z       0003 R 010113 ZLIM    0003 R 033630 ZRK     0004 R 000037 ZRL
0003 R 001046 ZZL

00101          SUBROUTINE CENTRL
00103          COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),
00103         1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),
00103         2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),
00103         3ZZL(100),XR(100),DOS(100),CON(100),PEAKD(100),XX(100),YY(100),
00103         4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONG(100),
00103         5CXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,
00103         6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRD,TAST(10),NBK,ILK,
00103         7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),
00103         8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,XASHOU(100,100),UBARK(20),SIGAK(20),
00103         9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20),
00104          COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,
00104         1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),
00104         2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,
00104         3MPAR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,
00104         4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,
00104         5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),
00104         6DELPHI,UBARZK(100),UBARZL(100)
00105          INTEGER TESTNO
00106          REAL MP,R,L,LAT,LAMBDA
00106 C    **** THIS SUBROUTINE CALCULATES PEAK DOSAGE AND PEAK CONCENTRATION
00106 C    **** AT RADIAL DISTANCES DXR ALONG THE CLOUD AXIS.
00106 C    **** CONTROLS THE PLOTTING OF PEAK DOSAGE AND PEAK CONCENTRATION
00106 C    **** VS. DXR.
00107          WRITE (6,907)
00111          K = 0
00112          DO 400 KK=1,NNZ
00115          TH = RAD*THETA(KK)
00116          J = 1
00117          M = 0
00120          IF (THETA(KK) .LT. 180.0) YO = THETA(KK)+180.0
00122          IF (THETA(KK) .GE. 180.0) YO = THETA(KK)-180.0
00124       2  M = M+1
00125          K = K+1
00126          DO 100 I=1,NDXR
00126 C                  ***** CALCULATION SECTION *****
00131          CALL EL(DXR(I),0)
00132          CALL SIGMA(DXR(I),0,0)
00133          CALL PEAK(2,K)
00134          CALL VERT(K,2)
00135          DOS(I) = STO1*(STO2+STO3)*EXP(-DECAY*DXR(I)/UBAR(KK))
00136          IF (ISKIP(12) .NE. 2.OR.TIM1 .GE. DXR(I)/UBAR(KK)) GO TO 80
00140          IF (Z(KK) .GT. ZLIM) GO TO 80
00142          DOS(I) = DOS(I)*EXP(-LAMBDA*(DXR(I)/UBAR(KK)-TIM1))
00143       80 CONTINUE
00144          CON(I) = DOS(I)*UBARZK(K)/(SQR2P*SIGX)
00145      100 CONTINUE
00145 C               *** SOLUTION OUTPUT SECTION ***
```

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00147          WRITE (6,900) KK,ZZL(K)                                           CNTL 500
00153          IF (ISKIP(11) .EQ. 1) WRITE (6,906)                               CNTL 510
00156          IF (ISKIP(8) .EQ. 2) GO TO 120                                    CNTL 520
00160          WRITE (6,903) YO                                                  CNTL 530
00163          WRITE (6,901) (DXR(I),DOS(I),I=1,NDXR)                            CNTL 540
00172      120 IF (ISKIP(8) .EQ. 1) GO TO 130                                    CNTL 550
00174          WRITE (6,904) YO                                                  CNTL 560
00177          WRITE (6,902) (DXR(I),CON(I),I=1,NDXR)                            CNTL 570
00206      130 CONTINUE                                                          CNTL 580
00206    C                                                                       CNTL 670
00207      380 IF (M=1 .GE. NPT(KK)) GO TO 400                                   CNTL 680
00211          GO TO 20                                                          CNTL 690
00212      400 CONTINUE                                                          CNTL 700
00214          WRITE (6,905)                                                     CNTL 710
00216          RETURN                                                            CNTL 720
00217      900 FORMAT (1HO,08(3H---),53H** MAX PEAK CONCENTRATION AND,OR PEAK DOSCNTL 730
00217         1AGE IN LAYER,I3,11H AT HEIGHT ,F10.2,3H **,8(3H---))              CNTL 740
00220      901 FORMAT (3(8X,5H **R=,F10.2,7H,  DOS=,E14.8))                      CNTL 750
00221      902 FORMAT (3(8X,5H **R=,F10.2,7H,  CON=,E14.8))                      CNTL 760
00222      903 FORMAT (34X,27H** DOSAGE, CLOUD AXIS IS AT,F8.3,30H DEGREES RELATICNTL 770
00222         1VE TO SOURCE **)                                                  CNTL 780
00223      904 FORMAT (30X,34H** CONCENTRATION, CLOUD AXIS IS AT,F8.3,30H DEGREESCNTL 790
00223         1 RELATIVE TO SOURCE **)                                           CNTL 800
00224      905 FORMAT (12X,18(6H------)/)                                        CNTL 810
00225      906 FORMAT (41X,49H* DECAY IS INCLUDED IN DOSAGE AND CONCENTRATION *) CNTL 820
00226      907 FORMAT (1H1,40X,50H**** MAXIMUM PEAK DOSAGE AND/OR CONCENTRATION *CNTL 830
00226         1***///)                                                           CNTL 840
00227          END                                                               CNTL 850

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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@I FOR ISOXY
UNIVAC 1108 FORTRAN V LEVEL   2226 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:00

   SUBROUTINE ISOXY      ENTRY POINT 000607

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000625
        0000    *DATA    000215
        0002    *BLANK   000000
        0003    PARAMT   033754
        0004    PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME)

        0005    EL
        0006    SIGMA
        0007    PEAK
        0010    VERT
        0011    ALONGD
        0012    ALOG
        0013    MADUS
        0014    NIO2S
        0015    EXP
        0016    SQRT
        0017    NIO1S
        0020    NERR3S


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001   000025 116G      0001   000070 134G      0001   000101 143G      0001   000133 160G      0001   000060 20L
   0001   000304 203G      0001   000352 220G      0001   000455 244G      0001   000464 251G      0001   000524 264G
   0001   000533 271G      0001   000121 50L       0001   000335 530L      0001   000377 535L      0001   000400 536L
   0001   000403 540L      0001   000476 570L      0001   000545 590L      0001   000126 60L       0001   000234 62L
   0001   000545 620L      0001   000554 630L      0001   000331 65L       0001   000332 66L       0000   000005 907F
   0000   000013 908F      0000   000021 909F      0000   000046 910F      0000   000062 911F      0000   000071 912F
   0000   000075 913F      0000   000116 919F      0000   000133 920F      0004 R 000216 ACCUR     0012 R 000000 ALOG
   0003 R 007102 ALONG     0003 R 000226 ALPHA     0004 R 001023 ALPHAK    0004 R 001170 ANG       0000 R 000004 B
   0003 R 000264 BETA      0004 R 000657 BETANK    0003 R 007774 CI        0003 R 001522 CUN       0004 R 000342 DATE
   0004 R 000000 DECAY     0004 R 025266 DELPHI    0003 R 000454 DELTHP    0003 R 001010 DELU      0003 R 000606 DELX
   0003 R 000644 DELY      0004 R 000345 DEP       0004 R 001335 DEPN      0003 R 007762 DI        0003 R 001356 DOS
   0004 R 000273 DTHK      0003 R 007246 DXR       0004 R 000126 ERFX      0003 R 000036 H         0004 R 000267 HB
   0003 I 010014 I         0003 I 010050 IBOT      0003 I 007936 IFLAG     0004 I 000344 II        0003 I 010036 ILK
   0003 I 000000 ISKIP     0003 I 007602 ITAG      0003 I 010047 ITOP      0003 I 000740 IZMOD     0003 I 010015 J
   0004 I 000114 JBOT      0004 I 000041 JF        0004 I 000134 JTOP      0000 I 000000 K         0003 I 010016 KK
   0003 R 010012 L         0003 R 010110 LAMBDA    0003 R 006426 LAT       0004 I 000322 LB1       0004 I 000326 LB2
   0004 I 000332 LB3       0004 I 000336 LB4       0000 I 000001 M         0004 R 000272 MPHR      0000 I 000003 N
   0003 I 010035 NBK       0003 I 010043 NCI       0003 I 010042 NCI       0003 I 010044 NDXR      0003 I 010046 NNZ
   0003 I 000764 NPT       0004 I 000321 NVB       0004 I 000320 NVS       0004 I 001334 NXCI      0003 I 010037 NXS
   0003 I 010040 NYS       0003 I 010041 NZS       0003 R 006262 PEAKC     0003 R 001666 PEAKD     0004 R 000172 PERC
   0004 R 000243 PERCB     0003 R 002342 PLT       0004 R 000270 PPAR      0003 R 000132 Q         0004 R 000271 QPAR
   0003 R 010045 RAD       0000 R 000002 S         0003 R 033560 SIGAK     0004 R 000013 SIGAL     0004 R 026122 SIGANK
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0003 R 000360 SIGAP     0002 R 033631 SIGARK    0004 R 000040 SIGARL    0003 R 033604 SIGEK     0004 R 000025 SIGEL
0004 R 024756 SIGENK    0003 R 000550 SIGEP     0003 R 033632 SIGERK    0004 R 000042 SIGERL    0003 R 010010 SIGX
0003 R 010107 SIGXNK    0003 R 000416 SIGXC     0003 R 010007 SIGY      0004 R 024755 SIGYNK    0003 R 000322 SIGYO
0003 R 010006 SIGZ      0003 R 000512 SIGZO     0004 R 001167 SQBAR     0003 R 010011 SQR2P     0003 R 010017 STD1
0003 R 010020 STD2      0003 R 010021 STD3      0003 R 007412 T         0003 R 010023 TAST      0003 R 033704 TAUK
0004 R 000070 TAUL      0003 R 033730 TAUOK     0004 R 000102 TAUOL     0003 I 007746 TESTNO    0003 R 010013 TH
0003 R 000702 THETA     0003 R 033634 THETAK    0004 R 000044 THETAL    0003 R 010111 TIM1      0003 R 010112 TIM2
0003 R 010022 TRD       0003 R 000170 UBAR      0003 R 033534 UBARK     0004 R 000001 UBARL     0004 R 000513 UBARNK
0003 R 033633 UBARRK    0004 R 000043 UBARRL    0004 R 025267 UBARZK    0004 R 025433 UBARZL    0004 R 000217 VB
0003 R 006572 VER       0003 R 006736 VREF      0004 R 000146 VS        0003 R 010114 WASHOU    0003 R 010051 XAST
0004 R 000512 XBARX     0003 R 001212 XR        0003 R 002032 XX        0004 R 000346 YBARY     0003 R 002176 YY
0003 R 000074 Z         0003 R 010113 ZLIM      0003 R 033630 ZRK       0004 R 000037 ZRL       0003 R 001046 ZZL
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00101      1*            SUBROUTINE ISOXY                                                        ISXY  20
00103      2*            COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),           ISXY  30
00103      3*           1BETA(30),SIGYO(30),SIGAP(30),SIGXC(30),DELTHP(30),SIGZO(30),            ISXY  40
00103      4*           2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),       ISXY  50
00103      5*           3ZZL(100),XR(100),DCS(100),CON(100),PEAKD(100),XX(100),YY(100),          ISXY  60
00103      6*           4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100),       ISXY  70
00103      7*           5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,      ISXY  80
00103      8*           6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STD1,STD2,STD3,TRD,TASY(10),NBK,ILK,        ISXY  90
00103      9*           7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),                    ISXY 100
00103     10*           8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20),       ISXY 110
00103     11*           9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20),       ISXY 120
00104     12*            COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,        ISXY 130
00104     13*           1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),UROT(10),ERFX(6),           ISXY 140
00104     14*           2UTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,           ISXY 150
00104     15*           3HPWR,DTHK(2),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,        ISXY 160
00104     16*           4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,             ISXY 170
00104     17*           5ANG(100),NYC1,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),             ISXY 180
00104     18*           6DELPHI,UBARZK(100),UBARZL(100)                                          ISXY 190
00105     19*            INTEGER TESTNO                                                          ISXY 200
00106     20*            REAL HPWR,L,LAT,LAMBDA                                                  ISXY 210
00106     21*      C     **** THIS SUBROUTINE CALCULATES DOSAGE AND CONCENTRATION ISOPLETHSISXY 220
00106     22*      C     **** IN THE X,Y PLANE AROUND THE CLOUD AXIS. THE ISOPLETH PRODUCEDISXY 230
00106     23*      C     **** IS THE LATERAL DISTANCE FROM THE CLOUD AXIS. ISKIP(9)              ISXY 240
00106     24*      C     **** CONTROLS AT WHICH HEIGHTS ISOPLETHS ARE CALCULATED)                ISXY 250
00107     25*            WRITE (6,909)                                                           ISXY 260
00111     26*            IF (ISKIP(11) .EQ. 1) WRITE (6,913)                                     ISXY 270
00114     27*            K = 0                                                                   ISXY 280
00115     28*            DO 630 KK=1,NNZ                                                         ISXY 290
00120     29*            TH = RAD*THETA(KK)                                                      ISXY 300
00121     30*            M = 0                                                                   ISXY 310
00122     31*            IF (THETA(KK) .GE. 180.0) S = THETA(KK)-180.0                           ISXY 320
00124     32*            IF (THETA(KK) .LT. 180.0) S = THETA(KK)+180.0                           ISXY 330
00126     33*            WRITE (6,910) S                                                         ISXY 340
00131     34*         20 M = M+1                                                                 ISXY 350
00132     35*            K = K+1                                                                 ISXY 360
00133     36*            DO 30 N=3,9,3                                                           ISXY 370
00136     37*            IF (ISKIP(9) .EQ. N) GO TO 60                                           ISXY 380
00140     38*         30 CONTINUE                                                                ISXY 390
00142     39*            DO 40 N=2,8,3                                                           ISXY 400
00145     40*            IF (ISKIP(9) .EQ. N) GO TO 50                                           ISXY 410
00147     41*         40 CONTINUE                                                                ISXY 420
00151     42*            IF (M .GT. 1) RETURN                                                    ISXY 430
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00153          GO TO 60                                                        ISXY 440
00154       50 IF (Z(KK)-ZZL(K)) 620,60,620                                    ISXY 450
00156     C                    CALCULATION SECTION                             ISXY 460
00157       60 DO 540 I=1,NDXR                                                 ISXY 470
00162          J = 1                                                           ISXY 480
00163          CALL EL(DXR(I),0)                                               ISXY 490
00164          CALL SIGMA(DXR(I),0,0)                                          ISXY 500
00165          CALL PEAK(2,K)                                                  ISXY 510
00166          CALL VERT(K,2)                                                  ISXY 520
00167          DOS(I) = STO1*(STO2+STO3)*EXP(-DECAY*DXR(I)/UBAR(KK))           ISXY 530
00170          IF (ISKIP(12) .NE. 2.OR.TIMI .GE. DXR(I)/UBAR(KK)) GO TO 62     ISXY 540
00172          IF (Z(KK) .GT. ZLIM) GO TO 62                                   ISXY 550
00174          DOS(I) = DOS(I)*EXP(-LAMBDA*(DXR(I)/UBAR(KK)-TIMI))             ISXY 560
00175       62 CONTINUE                                                        ISXY 570
00176          CALL ALONGD(DXR(I),T(KK))                                       ISXY 580
00177          CON(I) = DOS(I)*UBARZK(K)/(SQR2P*SISX)*ALONGW(J)                ISXY 590
00200          IF (ISKIP(9) .LE. 6.AND.ISKIP(9) .GE. 4) GO TO 530              ISXY 600
00202          DO 66 J=1,NDI                                                   ISXY 610
00205          B = DOS(I)/DI(J)                                                ISXY 620
00206          IF (B .LE. 1.0) GO TO 65                                        ISXY 630
00210          PLT(1,I,J) = SQRT(2.0*SIGY**2*ALOG(B))                          ISXY 640
00211          GO TO 66                                                        ISXY 650
00212       65 PLT(1,I,J) = 0.0                                                ISXY 660
00213       66 CONTINUE                                                        ISXY 670
00215      530 IF (ISKIP(9) .LE. 3) GO TO 540                                  ISXY 680
00217          DO 536 J=1,NCI                                                  ISXY 690
00222          B = CON(I)/CI(J)                                                ISXY 700
00223          IF (B .LE. 1.0) GO TO 535                                       ISXY 710
00225          PLT(2,I,J) = SQRT(2.0*SIGY**2*ALOG(B))                          ISXY 720
00226          GO TO 536                                                       ISXY 730
00227      535 PLT(2,I,J) = 0.0                                                ISXY 740
00230      536 CONTINUE                                                        ISXY 750
00232      540 CONTINUE                                                        ISXY 760
00234          WRITE (6,907) ZZL(K)                                            ISXY 770
00237          IF (ISKIP(9) .LE. 6.AND.ISKIP(9) .GE. 4) GO TO 570              ISXY 780
00237     C                    *****WRITE ISOPLETHS *****                      ISXY 790
00241          WRITE (6,908)                                                   ISXY 800
00243          DO 560 I=1,NDXR                                                 ISXY 810
00246      560 WRITE (6,919)  DXR(I),(DI(J),PLT(1,I,J),J=1,NDI)                ISXY 820
00257      570 IF (ISKIP(9) .LE. 3) GO TO 590                                  ISXY 830
00261          WRITE (6,911)                                                   ISXY 840
00263          DO 580 I=1,NDXR                                                 ISXY 850
00266      580 WRITE (6,920)  DXR(I),(CI(J),PLT(2,I,J),J=1,NCI)                ISXY 860
00277      590 CONTINUE                                                        ISXY 870
00277     C                                                                    ISXY 950
00300      620 IF (M-1 .GE. MPT(KK)) GO TO 630                                 ISXY 960
00302          GO TO 23                                                        ISXY 970
00303      630 CONTINUE                                                        ISXY 980
00305          WRITE (6,912)                                                   ISXY 990
00307          RETURN                                                          ISXY1000
00310      907 FORMAT (1H ,54X,10H* HEIGHT =,F10.2,2H *)                       ISXY1010
00311      908 FORMAT (1H ,54X,20H* DOSAGE ISOPLETHS *).                       ISXY1020
00312      909 FORMAT (1H1,37X,56H***** ISOPLETHS HORIZONTAL PLANE AROUND CLOUD AISXY1030
00312         1XIS *****/45X,43H** Y IS LATERAL DISTANCE FROM CLOUD AXIS **///) ISXY1040
00313      910 FORMAT (30X,23H** ANGLE TO CLOUD AXIS=,F8.3,30H DEGREES RELATIVE TISXY1050
00313         1O SOURCE **)                                                    ISXY1060
00314      911 FORMAT (1H ,53X,27H* CONCENTRATION ISOPLETHS *)                 ISXY1070
00315      912 FORMAT (12X,18(6H------)/)                                      ISXY1080
```

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00316   101*      913 FORMAT (22X,89H0 THE DECAY TERM HAS BEEN INCLUDED IN DOSAGE AND COISXY1090
00316   102*         1NCENTRATION IN CALCULATING ISOPLETHS *)                         ISXY1100
00317   103*      919 FORMAT (1H ,56X,16HRACIAL DISTANCE R=,F10.2/(9X,3(10H * DOSAGE=,E1ISXY1110
00317   104*         14.8,4H, Y=,F10.2)))                                              ISXY1120
00320   105*      920 FORMAT (1H ,56X,18HRADIAL DISTANCE R=,F10.2/(3(16H *CONCENTRATION=ISXY1130
00320   106*         1,E14.8,4H, Y=,F10.2)))                                           ISXY1140
00321   107*          END                                                              ISXY1150

      END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
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@I FOR ISOYZ
UNIVAC 1108 FORTRAN V LEVEL   2206 C018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:01

   SUBROUTINE ISOYZ      ENTRY POINT 005506

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000521
        0000    *DATA    000204
        0002    *BLANK   000000
        0003    PARAMT   033754
        0004    PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME)

        0005    EL
        0006    SIGMA
        0007    PEAK
        0010    VERT
        0011    ALONGD
        0012    ALOG
        0013    NWDU$
        0014    NIO2$
        0015    EXP
        0016    SQRT
        0017    NIO1$
        0020    NERR3$


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001     000024 115G      0001     000036 124G      0001     000224 156G      0001     000271 173G      0001     000060 20L
   0001     000166 22L       0001     000367 223G      0001     000376 230G      0001     000251 24L       0001     000435 243G
   0001     000444 250G      0001     000252 26L       0001     000255 40L       0001     000316 42L       0001     000317 44L
   0001     000322 620L      0001     000331 670L      0001     000410 680L      0001     000456 690L      0001     000456 710L
   0000     000005 915F      0000     000031 916F      0000     000035 917F      0000     000044 918F      0000     000066 919F
   0000     000073 920F      0000     000077 921F      0000     000120 925F      0004 R 000216 ACCUR      0012 R 000000 ALOG
   0003 R 007102 ALONG       0003 R 000226 ALPHA      0004 R 001023 ALPHNK     0004 R 001170 ANG        0000 R 000003 B
   0003 R 000264 BETA        0004 R 000657 BETANK     0003 R 007774 CI         0003 R 001522 CON        0004 R 000342 DATE
   0004 R 000000 DECAY       0004 R 025266 DELPHI     0003 R 000454 DELTHP     0003 R 001010 DELU       0003 R 000606 DELX
   0003 R 000644 DELY        0004 R 000345 DEP        0004 R 001335 DEPN       0003 R 007762 DI         0003 R 001356 DOS
   0004 R 000273 DTHK        0003 R 007246 EXR        0004 R 000126 ERFX       0003 R 000036 H          0004 R 000267 HB
   0003 I 010014 I           0003 I 010050 IOUT       0003 I 007436 IFLAG      0004 I 000344 II         0003 I 010036 ILK
   0003 I 000000 ISKIP       0003 I 007602 ITAG       0003 I 010047 ITOP       0003 I 000740 IZMOD      0003 I 010015 J
   0004 I 010114 JAPT        0004 I 000041 JF         0004 I 000134 JTOP       0000 I 000000 K          0003 I 010016 KK
   0003 R 010012 L           0003 R 010110 LAMBDA     0003 R 006426 LAT        0004 I 000322 LB1        0004 I 000326 LB2
   0004 I 000332 LB3         0004 I 000336 LB4        0000 I 000002 M          0004 R 000272 MPAR       0000 I 000004 N
   0003 I 010035 NBK         0003 I 010043 NCI        0003 I 010042 NDI        0003 I 010044 NLXR       0003 I 010046 NNZ
   0003 I 000764 NPT         0004 I 000321 NVB        0004 I 000320 NVS        0004 I 001334 NXCI       0003 I 010037 NXS
   0003 I 010040 NYS         0003 I 010041 NZS        0003 R 006262 PEAKC      0003 R 001666 PEAKD      0004 R 000172 PERC
   0004 R 000243 PERCE       0003 R 002342 PLT        0004 R 000270 PPAR       0003 R 000132 Q          0004 R 000271 QPAR
   0003 R 010045 RAD         0000 R 000001 S          0003 R 033560 SIGAK      0004 R 000013 SIGAL      0004 R 025122 SIGANK
   0003 R 000360 SIGAP       0003 R 033631 SIGARK     0004 R 000040 SIGARL     0003 R 033604 SIGEK      0004 R 000025 SIGEL
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0004 R 024756 SIGENK     0003 R 010551 SIGEP      0003 R 033632 SIGERK     0004 R 000042 SIGERL     0003 R 010010 SIGX
0003 R 010107 SIGXNK     0003 R 000416 SIGXO      0003 R 010007 SIGY       0004 R 024755 SIGYNK     0003 R 000322 SIGYO
0003 R 010006 SIGZ       0003 R 000512 SIGZO      0004 R 001167 SQBAR      0003 R 010011 SWR2P      0003 R 010017 STD1
0003 R 010020 STD2       0003 R 010021 STD3       0003 R 007412 T          0003 R 010023 TAST       0003 R 033704 TAUK
0004 R 000070 TALL       0003 R 033730 TAUOK      0004 R 000102 TAUOL      0003 I 007746 TESTNO     0003 R 010013 TH
0003 R 000702 THETA      0003 R 033634 THETAK     0004 R 000044 THETAL     0003 R 010111 TIM1       0003 R 010112 TIM2
0003 R 010022 TRD        0003 R 000170 UBAR       0003 R 033534 UBARK      0004 R 000001 UBARL      0004 R 000513 UBARNK
0003 R 033633 UBARRK     0004 R 000043 UBARRL     0004 R 026267 UBARZK     0004 R 025433 UBARZL     0004 R 000217 VB
0003 R 006572 VER        0003 R 006736 VREF       0004 R 000146 VS         0003 R 010114 XASHOU     0003 R 010051 XAST
0004 R 000512 XBARK      0003 R 001212 XP         0003 R 002032 XX         0004 R 000346 YBARY      0003 R 002176 YY
0003 R 000074 Z          0003 R 010113 ZLIM       0003 R 033630 ZRK        0004 R 000037 ZRL        0003 R 001096 ZZL
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00101        SUBROUTINE ISOYZ                                                        ISYZ  20
00103        COMMON/PARAMT/ISKIP(30),H(30),Z(30),W(30),UBAR(30),ALPHA(30),           ISYZ  30
00103       1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),            ISYZ  40
00103       2SIGEP(30),DELX(30),DELY(30),THETA(30),IZRCD(20),NPT(20),DELU(30),       ISYZ  50
00103       3ZZL(100),XP(100),DCS(100),CON(100),PEAKP(100),XX(100),YY(100),          ISYZ  60
00103       4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONG(100),        ISYZ  70
00103       5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,      ISYZ  80
00103       6SIGY,SIGX,SWR2P,L,TIM1,JJKK,STD1,STD2,STD3,TRD,TAST(10),NBK,ILK,        ISYZ  90
00103       7NXS,NYS,NZS,NDI,NCI,LOYR,RAD,NNZ,ITOP,IOUT,XAST(30),                    ISYZ 100
00103       8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,XASHOU(100,100),UBARK(20),SIGAK(20),       ISYZ 110
00103       9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20),       ISYZ 120
00104        COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,        ISYZ 130
00104       1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),           ISYZ 140
00104       2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPR,WPR,             ISYZ 150
00104       3MPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,       ISYZ 160
00104       4YBARY(100),XBARK,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,             ISYZ 170
00104       5ANG(100),NKCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGAKY(100),             ISYZ 180
00104       6DELPHI,UBARZK(100),UBARZL(100)                                          ISYZ 190
00105        INTEGER TESTNO                                                          ISYZ 200
00106        REAL MPWR,L,LAT,LAMBDA                                                  ISYZ 210
00106 C      **** THIS SUBROUTINE CALCULATES DOSAGE AND CONCENTRATION ISOPLETHS      ISYZ 220
00106 C      **** IN THE Y,Z PLANE AROUND THE CLOUD AXIS. THE ISOPLETH PRODUCED      ISYZ 230
00106 C      **** IS THE LATERAL DISTANCE FROM THE CLOUD AXIS. THE ARRAY IFLAG       ISYZ 240
00106 C      **** CONTROLS AT WHICH DISTANCES DXR ISOPLETHS WILL BE                  ISYZ 250
00106 C      **** CALCULATED                                                         ISYZ 260
00107        WRITE (6,915)                                                           ISYZ 270
00111        IF (ISKIP(11) .EQ. 1) WRITE (6,921)                                     ISYZ 280
00111 C                         CALCULATION SECTION                                  ISYZ 290
00114        DO 710 I=1,NDXR                                                         ISYZ 300
00117        IF (IFLAG(I) .EQ. 0) GO TO 710                                          ISYZ 310
00121        K = 0                                                                   ISYZ 320
00122        S = 0.0                                                                 ISYZ 330
00123        DO 670 KK=1,NNZ                                                         ISYZ 340
00126        M = 0                                                                   ISYZ 350
00127        IF (THETA(KK) .GE. 180.0) S = THETA(KK)-180.0                           ISYZ 360
00131        IF (THETA(KK) .LT. 180.0) S = THETA(KK)+180.0                           ISYZ 370
00133     20 M = M+1                                                                 ISYZ 380
00134        K = K+1                                                                 ISYZ 390
00135        J = 1                                                                   ISYZ 400
00136        CALL EL(DXR(I),0)                                                       ISYZ 410
00137        CALL SIGMA(DXR(I),0,0)                                                  ISYZ 420
00140        CALL PEAK(2,K)                                                          ISYZ 430
00141        CALL VERT(K,2)                                                          ISYZ 440
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00142        DOS(I) = ST01*(ST02+ST03)*EXP(-DECAY*DXR(I)/UBAR(KK))              ISYZ 450
00143        IF (ISKIP(12) .NE. 2.OR.T1P1 .GE. DXR(I)/UBAR(KK)) GO TO 22        ISYZ 460
00145        IF (Z(KK) .GT. ZLIM) GO TO 22                                      ISYZ 470
00147        DOS(I) = DOS(I)*EXP(-LAMBDA*(DXR(I)/UBAR(KK)-T1P1))                ISYZ 480
00150     22 CONTINUE                                                           ISYZ 490
00151        CALL ALONCD(DXR(I),T(KK))                                          ISYZ 500
00152        CON(I) = DOS(I)*UBARZK(K)/(SQR2P*SIGX)*ALOPGN(J)                   ISYZ 510
00153        IF (ISKIP(10) .EQ. 2) GO TO 40                                     ISYZ 520
00155        DO 26 J=1,NCI                                                      ISYZ 530
00160        B = DOS(I)/CI(J)                                                   ISYZ 540
00161        IF (B .LE. 1.0) GO TO 24                                           ISYZ 550
00163        PLT(1,K,J) = SQRT(2.0*SIGY**2*ALOG(B))                             ISYZ 560
00164        GO TO 26                                                           ISYZ 570
00165     24 PLT(1,K,J) = 0.0                                                   ISYZ 580
00166     26 CONTINUE                                                           ISYZ 590
00170     40 IF (ISKIP(10) .EQ. 1) GO TO 620                                    ISYZ 600
00172        DO 44 J=1,NCI                                                      ISYZ 610
00175        B = CON(I)/CI(J)                                                   ISYZ 620
00176        IF (B .LE. 1.0) GO TO 42                                           ISYZ 630
00200        PLT(2,K,J) = SQRT(2.0*SIGY**2*ALOG(B))                             ISYZ 640
00201        GO TO 44                                                           ISYZ 650
00202     42 PLT(2,K,J) = 0.0                                                   ISYZ 660
00203     44 CONTINUE                                                           ISYZ 670
00205    620 CONTINUE                                                           ISYZ 680
00206        IF (M-1 .GE. NPT(KK)) GO TO 670                                    ISYZ 690
00210        GO TO 20                                                           ISYZ 700
00211    670 CONTINUE                                                           ISYZ 710
00211  C                         OUTPUT SECTION                                 ISYZ 720
00213        WRITE (6,917) DXR(I)                                               ISYZ 730
00216        IF (ISKIP(10) .EQ. 2) GO TO 680                                    ISYZ 740
00220        WRITE (6,916)                                                      ISYZ 750
00222        DO 675 M=1,K                                                       ISYZ 760
00225    675 WRITE (6,918) ZZL(M),(DI(J),PLT(1,M,J),J=1,NDI)                    ISYZ 770
00236    680 IF (ISKIP(10) .EQ. 1) GO TO 690                                    ISYZ 780
00240        WRITE (6,919)                                                      ISYZ 790
00242        DO 685 M=1,K                                                       ISYZ 800
00245    685 WRITE (6,925) ZZL(M),(CI(J),PLT(2,M,J),J=1,NCI)                    ISYZ 810
00256    690 CONTINUE                                                           ISYZ 820
00256  C                                                                        ISYZ 890
00257    710 CONTINUE                                                           ISYZ 900
00261        WRITE (6,920)                                                      ISYZ 910
00263        RETURN                                                             ISYZ 920
00264    915 FORMAT (1H1,38X,54H***** ISOPLETHS VERTICAL PLANE AROUND CLOUD AXIISYZ 930
00264       1S *****/40X,42H* Y  IS LATERAL DISTANCE FROM CLOUD AXIS *///)      ISYZ 940
00265    916 FORMAT (60X,12H** DOSAGE **)                                       ISYZ 950
00266    917 FORMAT (56X,21H** RADIAL DISTANCE R=,F10.2,3H **)                  ISYZ 960
00267    918 FORMAT (10H HEIGHT Z=,F10.2,2(11H, * DOSAGE=,E14.6,5H, YW=,F10.2)/ISYZ 970
00267       1(20X,2(11H, * DOSAGE=,E14.6,5H, YW=,F10.2)))                       ISYZ 980
00270    919 FORMAT (57X,19H** CONCENTRATION **)                                ISYZ 990
00271    920 FORMAT (12X,18(6H------)/)                                         ISYZ1000
00272    921 FORMAT (22X,89H* THE DECAY TERM HAS BEEN INCLUDED IN DOSAGE AND COISYZ1010
00272       INCENTRATION IN CALCULATING ISOPLETHS *)                            ISYZ1020
00273    925 FORMAT (10H HEIGHT Z=,F10.2,2(18H, * CONCENTRATION=,E14.8,5H, YW=,ISYZ1030
00273       1F10.2)/(20X,2(18H, * CONCENTRATION=,E14.8,5H, YW=,F10.2)))         ISYZ1040
00274        END                                                                ISYZ1050
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END OF UNIVAC 1108 FORTRAN V COMPILATION.   0 *DIAGNOSTIC* MESSAGE(S)

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@I FOR WASHT
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:03 .

   SUBROUTINE WASHT      ENTRY POINT 000333

   STORAGE USED (BLOCK, NAME, LENGTH)

         0001    *CODE    000374
         0000    *DATA    000053
         0002    *BLANK   000000
         0003    PARAMT   033754
         0004    PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME,

         0005    COORD
         0006    NWDUS
         0007    NIO2S
         0010    EXP
         0011    NERR3S


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001     000065 10L        0001     000101 15L        0001     000124 20L        0001     000152 35L        0001     000027 5L
    0001     000171 80L        0001     000174 60L        0001     000213 64L        0001     000236 66L        0001     000041 9L
    0000     000011 920F       0000 R 000001 A           0004 R 000216 ACCUR      0003 R 007102 ALONGX     0003 R 000226 ALPHA
    0004 R 001023 ALPHNK     0004 R 001170 ANG         0000 R 000007 ASP        0000 R 000002 B          0003 R 000264 BETA
    0004 R 000657 BETANK     0000 R 000003 C           0003 R 007774 CI         0003 R 001522 CON        0000 R 000004 D
    0004 R 000342 DATE       0004 R 000000 DECAY       0004 R 025266 DELPHI     0003 R 000454 DELTHP     0003 R 001010 DELU
    0003 R 000606 DELX       0003 R 000644 DELY        0004 R 000345 DEP        0004 R 001335 DEPN       0003 R 007762 DI
    0003 R 001356 DOF        0004 R 000273 DTHK        0003 R 007246 DXR        0000 R 000005 E          0004 R 000126 ERFX
    0000 R 000006 G          0003 R 000036 H           0004 R 000267 HB         0003 I 010014 I          0003 I 010050 IBOT
    0003 I 007436 IFLAG      0004 I 000344 II          0003 I 010036 ILK        0003 I 000000 ISKIP      0000 I 000000 ISW6
    0003 I 007602 ITAG       0003 I 010047 ITOP        0003 I 000740 IZMOD      0003 I 010015 J          0004 I 000114 JBOT
    0004 I 000041 JF         0004 I 000134 JTOP        0003 I 010016 KK         0003 R 010012 L          0003 R 010110 LAMBDA
    0003 R 006426 LAT        0004 I 000322 LB1         0004 I 000326 LB2        0004 I 000332 LB3        0004 I 000336 LB4
    0004 R 000272 MPWR       0003 I 010035 NHK         0003 I 010043 NCI        0003 I 010042 NDI        0003 I 010044 NDXR
    0003 I 010046 NNZ        0003 I 000764 NPT         0004 I 000321 NVB        0004 I 000320 NVS        0004 I 001334 NXCI
    0003 I 010037 NXS        0003 I 010040 NYS         0003 I 010041 NZS        0003 R 006262 PEAKC      0003 R 001666 PEAKO
    0004 R 000172 PERC       0004 R 000243 PERCB       0003 R 002342 PLT        0004 R 000270 PPAR       0003 R 000132 Q
    0004 R 000271 QPWR       0003 R 010045 RAD         0003 R 033560 SIGAK      0004 R 000013 SIGAL      0004 R 025122 SIGANK
    0003 R 000360 SIGAP      0003 R 033631 SIGARK      0004 R 000040 SIGARL     0003 R 033604 SIGEK      0004 R 000025 SIGEL
    0004 R 024756 SIGENK     0003 R 000550 SIGEP       0003 R 033632 SIGERK     0004 R 000042 SIGERL     0003 R 010010 SIGX
    0003 R 010107 SIGXNK     0003 R 000416 SIGXO       0003 R 010007 SIGY       0004 R 024755 SIGYNK     0003 R 000322 SIGYO
    0003 R 010006 SIGZ       0003 R 000512 SIGZO       0004 R 001167 SMBAR      0003 R 010011 SNR2P      0003 R 010017 STO1
    0003 R 010020 STO2       0003 R 010021 STO3        0003 R 007412 T          0003 R 010023 TAST       0003 R 033704 TAUK
    0004 R 000070 TAUL       0003 R 033730 TAUOK       0004 R 000102 TAUUL      0003 I 007746 TESTNO     0003 R 010013 TH
    0003 R 000702 THETA      0003 R 033634 THETAK      0004 R 000044 THETAL     0003 R 010111 TIM1       0003 R 010112 TIM2
    0003 R 010022 TRD        0003 R 000170 UBAR        0003 R 033534 UBARK      0004 R 000001 UBARL      0004 R 000513 UBARNK
    0003 R 033633 UBARRK     0004 R 000043 UBARRL      0004 R 025267 UBARZK     0004 R 025433 UBARZL     0004 R 000217 VB
    0003 R 006572 VEN        0003 R 006736 VREF        0004 R 000146 VS         0003 R 010114 WASHOU     0003 R 010051 XAST
    0004 R 000512 XBARX      0003 R 001212 XR          0000 R 000010 XS         0003 R 002032 XA         0004 R 000346 YBARY
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      0003 R 002176 YY          0003 F 000074 Z          0003 R 010113 ZLIM        0003 R 033630 ZRK          0004 R 000037 ZRL
      0003 R 001046 ZZL

00101          SUBROUTINE WASHT(X,Y,ISW5,XO,YO,N,K)                                    WASH  20
00103          COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),           WASH  30
00103         1BETA(30),SIGYO(30),SIGAP(30),SIGYO(30),DELTHP(30),SIGZO(30),            WASH  40
00103         2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),       WASH  50
00103         3ZZL(100),XR(100),DOS(100),CON(100),PEAKD(100),XX(100),YY(100),          WASH  60
00103         4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONG(100),        WASH  70
00103         5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,      WASH  80
00103         6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRD,TAST(10),NBK,ILK,        WASH  90
00103         7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),                    WASH 100
00103         8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20),       WASH 110
00103         9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20),       WASH 120
00104          COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,        WASH 130
00104         1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),           WASH 140
00104         2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),MB,PPWR,QP6R,           WASH 150
00104         3HPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,       WASH 160
00104         4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,             WASH 170
00104         5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),             WASH 180
00104         6DELPHI,UBARZK(100),UBARZL(100)                                          WASH 190
00105          REAL HPWR,L,LAT,LAMBDA                                                  WASH 200
00106          INTEGER TESTNO                                                          WASH 210
00106          THIS SUBROUTINE CALCULATES WASHOUT DEPOSITION FOR ALL MODELS .          WASH 220
00107          ISW6 = 0                                                                WASH 230
00110          IF (ISKIP(13) .NE. 0.AND.IBOT .LE. KK.AND.KK .LE. ITOP) GO TO 60        WASH 240
00112          IF (N .EQ. 9) GO TO 50                                                  WASH 250
00114        5 IF (TIM1 .LT. X/UBAR(KK)) GO TO 9                                       WASH 260
00116          GO TO 50                                                                WASH 270
00117        9 IF (TIM1 .LT. (X-2.15*PERC(3))/UBAR(KK)) GO TO 10                       WASH 280
00121          WRITE (6,920) XX(I),YY(J)                                               WASH 290
00125       10 A = UBAR(KK)                                                            WASH 300
00126          SIGY = PERC(1)                                                          WASH 310
00127          B = SIGY                                                                WASH 320
00130          C = 1.0                                                                 WASH 330
00131          D = 1.0                                                                 WASH 340
00132          E = 1.0                                                                 WASH 350
00133          G = TIM1                                                                WASH 360
00134       15 CONTINUE                                                                WASH 370
00135          IF (IZMOD(KK) .EQ. 3.AND.ISKIP(13) .NE. 2) GO TO 20                     WASH 380
00137          D = Z(KK+1)-Z(KK)                                                       WASH 390
00140       20 E = EXP(-.5*(Y/B)**2)                                                   WASH 400
00141          IF (ISKIP(12) .NE. 2) GO TO 35                                          WASH 410
00143          C = EXP(-LAMBDA*(X/A-G))                                                WASH 420
00144       35 CONTINUE                                                                WASH 430
00145          WASHOU(I,J) = WASHOU(I,J)+(LAMBDA*Q(KK)/(SQR2P*A*B))*C*D*E              WASH 440
00146       50 CONTINUE                                                                WASH 450
00147          RETURN                                                                  WASH 460
00150       60 IF (ISW5 .EQ. 0) GO TO 64                                               WASH 470
00152          N = 1                                                                   WASH 480
00153          CALL COORD(N,KK,X,Y,XO,YO,ASP,X5,1)                                     WASH 490
00154       64 IF (X .GT. XAST(KK).OR.N .EQ. 9) GO TO 66                               WASH 500
00156          SIGY = PERC(1)                                                          WASH 510
00157          GO TO 5                                                                 WASH 520
00160       66 N = 1                                                                   WASH 530
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00161        CALL COORD(N,KK,X,Y,XO,YO,ASP,X5,2)                                  WASH 540
00162     70 IF (N .EQ. 9) GO TO 50                                               WASH 550
00164        IF (X/UBAR(NNZ+ILK-1)+TAST(ILK-1) .LE. TIMI) GO TO 50                WASH 560
00166        ISW6 = 1                                                             WASH 570
00167        SIGYNK = PERC(2)                                                     WASH 580
00170        A = UBAR(NNZ+ILK-1)                                                  WASH 590
00171        B = SIGYNK                                                           WASH 600
00172        C = 1.0                                                              WASH 610
00173        D = 1.0                                                              WASH 620
00174        E = 1.0                                                              WASH 630
00175        IF (ISKIP(12) .EQ. 1) GO TO 15                                       WASH 640
00177        G = TIMI-TAST(ILK-1)                                                 WASH 650
00200        GO TO 15                                                             WASH 660
00201    920 FORMAT (1H0,29H *** WASHOUT DEPOSITION AT X=,F10.3,4H, Y=,F10.3,26HWASH 670
00201       1H MAY BE OVER ESTIMATED ***)                                         WASH 680
00202        END                                                                  WASH 690

END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
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```
@I FOR TESTR
UNIVAC 1108 FORTRAN V LEVEL   2216 C018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:05

   SUBROUTINE TESTR      ENTRY POINT 000210

   STORAGE USED (BLOCK, NAME, LENGTH)

         0001    *CODE    000224
         0000    *DATA    000030
         0002    *BLANK   000000
         0003    PARAMT   033754
         0004    PARAMS   025577

   EXTERNAL REFERENCES (BLOCK, NAME)

         0005    NEXP6$
         0006    NERP3$

   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000172 100L     0001   000025 116G     0001   000043 131G     0001   000034 61L      0001   000045 80L
 0001   000123 82L      0001   000126 84L      0001   000131 86L      0001   000146 88L      0001   000155 90L
 0004 R 000216 ACCUR    0003 R 007102 ALONGW   0003 R 000226 ALPHA    0004 R 001023 ALPHNK   0004 R 001170 ANG
 0003 R 000264 BETA     0004 R 000657 BETANK   0003 R 007774 CI       0003 R 001522 CON      0004 R 000342 DATE
 0004 R 000000 DECAY    0004 R 025266 DELPHI   0003 R 000454 DELTHP   0003 R 001010 DELU     0003 R 000606 DELX
 0003 R 000644 DELY     0004 R 000345 DFF      0004 R 001335 DEPN     0003 R 007762 DI       0003 R 001356 DOS
 0004 R 000273 DTHK     0003 R 007246 DXR      0004 R 000126 ERFX     0003 R 000036 H        0004 R 000267 HB
 0003 I 010014 I        0003 I 010050 IBOT     0003 I 007436 IFLAG    0004 I 000344 II       0003 I 010036 ILK
 0003 I 000000 ISKIP    0003 I 007602 ITAG     0003 I 010047 ITOP     0003 I 000740 IZMOD    0003 I 010015 J
 0004 I 000114 JBOT     0004 I 000041 JF       0004 I 000134 JTOP     0000 I 000001 KF       0003 I 010016 KK
 0000 I 000000 KS       0003 R 010012 L        0003 R 010110 LAMBDA   0003 R 006426 LAT      0004 I 000322 LB1
 0004 I 000026 LB2      0004 I 000337 LB3      0004 I 000336 LB4      0000 I 000003 M        0000 I 000002 MM
 0004 R 000272 MPWR     0003 I 010035 NHK      0003 I 010043 NCI      0003 I 010042 NOI      0003 I 010044 NDXR
 0003 I 010046 NNZ      0003 I 000764 NPT      0004 I 000321 NVB      0004 I 000320 NVS      0004 I 001334 NXCI
 0003 I 010037 NXS      0003 I 010040 NYS      0003 I 010041 NZS      0003 R 006262 PEAKC    0003 R 001666 PEAKD
 0004 R 000172 PERC     0004 R 000243 PERCB    0003 R 002342 PLT      0004 R 000270 PPWR     0003 R 000132 Q
 0004 R 000271 QPWR     0003 R 010045 RAC      0003 R 033560 SIGAK    0004 R 000013 SIGAL    0004 R 025122 SIGANK
 0003 R 000360 SIGAP    0003 R 033631 SIGARK   0004 R 000040 SIGARL   0003 R 033604 SIGEK    0004 R 000025 SIGEL
 0004 R 024756 SIGENK   0003 R 000550 SIGEP    0003 R 033632 SIGERK   0004 R 000042 SIGERL   0003 R 010010 SIGX
 0003 R 010107 SIGXNK   0003 R 000416 SIGXO    0003 R 010007 SIGY     0004 R 024765 SIGYNK   0003 R 000322 SIGYO
 0003 R 010006 SIGZ     0003 R 000512 SIGZO    0004 R 001167 SQBAR    0003 R 010011 SQR2P    0003 R 010017 STO1
 0003 R 010020 STO2     0003 R 010021 STO3     0003 R 007412 T        0003 R 010023 TAST     0003 R 033704 TAUK
 0004 R 000070 TAUL     0003 R 033730 TAUOK    0004 R 000102 TAUOL    0003 I 007746 TESTNO   0003 R 010013 TH
 0003 R 000702 THETA    0003 R 033634 THETAK   0004 R 000044 THETAL   0003 R 010111 TIM1     0003 R 010112 TIM2
 0003 R 010022 TRD      0003 R 000170 UBAR     0003 R 033534 UBARK    0004 R 000001 UBARL    0004 R 000513 UBARNK
 0003 R 033633 UBARRK   0004 R 000043 UBARRL   0004 R 025267 UBARZK   0004 R 025433 UBARZL   0000 R 000004 UBZ1
 0004 R 000217 VB       0003 R 006572 VES      0003 R 006736 VREF     0004 R 000146 VS       0003 R 010114 WASHOU
 0003 R 010051 XAST     0004 R 000512 XBARX    0003 R 001212 XR       0003 R 002032 XX       0004 R 000346 YBARY
 0003 R 002175 YY       0003 R 000074 Z        0003 R 010113 ZLIM     0003 R 033630 ZRK      0004 R 000037 ZRL
 0003 R 001046 ZZL
```

```
00101         SUBROUTINE TESTR(KTK)
00103         COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),
00103        1BETA(30),SIGYD(30),SIGAP(30),SIGXD(30),CELTHP(30),SIGZO(30),
00103        2SIGEF(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),
00103        3ZZL(100),XR(100),DDS(100),CON(100),PEAKD(100),XX(100),YY(100),
00103        4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONG(100),
00103        5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,
00103        6SIGY,SIGX,SQR2P,L,THEI,JKK,STC1,STC2,STC3,TRD,TAST(10),NBK,ILK,
00103        7NXS,NYS,NZS,NCI,NCI,NDXP,PAC,NNZ,ITOP,IBOT,XAST(30),
00103        8SIGXKK,LAMBDA,TIM1,TIM2,ZLIM,NASHO(100,100),UBARK(20),SIGAK(20),
00103        9SISEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUDK(20),
00104         COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,
00104        1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUDL(10),JBOT(10),ERFX(6),
00104        2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,
00104        3NPWP,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,
00104        4YBARY(100),XBARX,UBARKK(100),BETANK(100),ALPHNK(100),SQBAR,
00104        5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),
00104        6DELPHI,UBARZK(100),UBARZL(100)
00105         INTEGER TESTNO
00106         REAL MPKR,L,LAT,LAMBDA
00106   C     THIS SUBROUTINE DETERMINES THE STRUCTURAL CHANGE IN LAYERS FOR
00106   C     BOX MODEL AND FULL TRANSITION MODEL. ALSO, WIND SPEED AT HEIGHT
00106   C     ZZL(K) (UBARZL(K)) IN THE NEW LAYER IS CALCULATED.
00107         IF (ISKIP(13) .EQ. 0) GO TO 100
00111         IF (KK .NE. JBOT(ILK)) GO TO 61
00113         IBOT = KK
00114         ITOP = JTOP(ILK)
00115         DO 60 J=IBOT,ITOP
0012C      60 XAST(J) = UBAR(J)*TAST(ILK)
00122         ILK = ILK+1
00123      61 CONTINUE
00124         IF (KTK .EQ. 0) GO TO 100
00126         KS = 0
00127         KF = 1
00130         DO 95 MM=1,NNZ
00133         M = 0
00134      80 M = M+1
00135         KS = KS+1
00136         IF (MM .LT. JBOT(KF).OR.MM .GT. JTOP(KF)) GO TO 88
00140         IF (KF .GT. 1) GO TO 84
00142         IF (JBOT(1) .GT. 1) GO TO 82
00144         UBARZL(KS) = UBARRL*(ZZL(KS)/ZRL)**QPWR
00145         GO TO 88
00146      82 UBZH = UBARRL
00147         GO TO 86
00150      84 UBZH = UBARL(KF-1)
00151      86 UBARZL(KS) = UBZH+((UBARL(KF)-UBZH)/(Z(MM+1)-Z(M)))*(ZZL(KS)-Z(M))
00152      88 IF (M-1 .GE. NPT(MM)) GO TO 90
00154         GO TO 80
00155      90 IF (MM .EQ. JTOP(KF)) KF = KF+1
00157      95 CONTINUE
00161         KTK = 0
00162     100 CONTINUE
00163         RETURN
00164         END
```

END OF UNIVAC 1108 FORTRAN V COMPILATION. 0 *DIAGNOSTIC* MESSAGE(S)

```
@I FOR ACH
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 FSC1RP
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:06

   SUBROUTINE ACH        ENTRY POINT 000201

              EL         ENTRY POINT 000204

              LATER      ENTRY POINT 000215


              ALONGD     ENTRY POINT 000222

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE   000231
        0000    *DATA   000023
        0002    *BLANK  000000
        0003    PARAMT  033754
        0004    PARAMS  025677


   EXTERNAL REFERENCES (BLOCK, NAME)

        0005    EXP
        0006    NERR3S


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001     000032 23L       0001     000051 24L       0001     000066 25L       0001     000103 30L       0001     000117 40L
    0001     000163 50L       0004 R 000216 ACCUR     0003 R 007102 ALONG     0003 R 000226 ALPHA     0004 R 001023 ALPHNK
    0004 R 001170 ANG       0003 R 000264 BETA      0004 R 000667 BETANK    0003 R 007774 CI        0003 R 001622 CON
    0004 R 000342 DATE      0004 R 000000 DECAY     0004 R 025266 DELPHI    0003 R 000454 DELTHP    0003 R 001010 DELU
    0003 R 000606 DELX      0003 R 000644 DELY      0004 R 000345 DEP       0004 R 001335 DEPN      0003 R 007762 DI
    0003 R 001366 DOS       0004 R 003273 DTHK      0003 R 007246 DXR       0004 R 000126 ERFX      0003 R 000036 H
    0004 R 000267 HB        0003 I 010014 I         0003 I 010050 IBOT      0003 I 007436 IFLAG     0004 I 000344 II
    0003 I 010036 ILK       0003 I 000000 ISKIP     0003 I 007602 ITAG      0003 I 010047 ITOP      0003 I 000740 IZMOD
    0003 I 010015 J         0004 I 000114 JBOT      0004 I 000041 JF        0004 I 000134 JTOP      0003 I 010016 KK
    0003 R 010012 L         0003 R 010113 LAMBDA    0003 R 006426 LAT       0004 I 000322 LBI       0004 I 000326 LB2
    0004 I 000332 LB3       0004 I 000336 LB4       0004 R 000272 MPHR      0003 I 010035 NBK       0003 I 010043 NCI
    0003 I 010042 NDI       0003 I 010044 NDXR      0003 I 010046 NHZ       0003 I 000764 NPT       0004 I 000321 NVB
    0004 I 000320 NVS       0004 I 001334 NXCI      0003 I 010037 NXS       0003 I 010040 NYS       0003 I 010041 NZS
    0003 R 006262 PEAKC     0003 R 001666 PEAKD     0004 R 000172 PERC      0004 R 000243 PERCB     0003 R 002342 PLT
    0004 R 000270 PPHR      0003 R 000132 Q         0004 R 000271 QPHR      0003 R 010045 RAD       0003 R 033560 SIGAK
    0004 R 000013 SIGAL     0004 R 025122 SIGAPK    0003 R 000360 SIGAP     0003 R 033631 SIGARK    0004 R 000040 SIGARL
    0003 R 033604 SIGEK     0004 R 000025 SIGEL     0004 R 024756 SIGENK    0003 R 000550 SIGEP     0003 R 033632 SIGERK
    0004 R 000042 SIGERL    0003 R 010010 SIGX      0003 R 010107 SIGXNK    0003 R 000416 SIGXD     0003 R 010007 SIGY
    0004 R 024755 SIGYNK    0003 R 000322 SIGYD     0003 R 010006 SIGZ      0003 R 000512 SIGZD     0004 R 001147 SGBAR
    0003 R 010011 SQR2P     0003 R 010017 STO1      0003 R 010020 STO2      0003 R 010021 STO3      0003 R 007412 T
    0003 R 010023 TAST      0003 R 033704 TAUK      0004 R 000070 TAUL      0003 R 033730 TAUOK     0004 R 000102 TAUOL
    0003 I 007746 TESTNC    0003 R 010013 TH        0003 R 000702 THETA     0003 R 033634 THETAK    0004 R 000044 THETAL
    0003 R 010111 TIM1      0003 R 010112 TIM2      0003 R 010022 TRD       0000 R 000000 TS        0003 R 000170 UBAR
    0003 R 033534 UBARK     0004 R 000001 UBARL     0004 R 000513 UBARNK    0003 R 033633 UBARRK    0004 R 000043 UBARRL
    0004 R 025267 UBARZK    0004 R 025433 UBARZL    0004 R 000217 VB        0003 R 006572 VER       0003 R 006736 VREF
    0004 R 000146 VS        0003 R 010114 WASHOU    0003 R 010051 XAST      0004 R 000512 XMARK     0003 R 001212 XR
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 0003 R 002032 XX        0004 R 000346 YBARY     0003 R 002176 YY        0003 R 000074 Z         0003 R 010113 ZLIN
 0003 R 033630 Z^K       0004 R 000037 ZRL       0003 R 001046 ZZL

00101          SUBROUTINE ACH
00103          COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),
00103         1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),
00103         2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),
00103         3ZZL(100),XR(100),COS(100),CON(100),PEAKO(100),XX(100),YY(100),
00103         4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100),
00103         5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNC(12),DI(10),CI(10),SIGZ,
00103         6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRO,TAST(10),MBK,ILK,
00103         7NXS,NYS,NZS,NDI,NCI,NDXR,R/N,NNZ,ITOP,IHOT,XAST(30),
00103         8SIEXNK,LAMBDA,TIM1,TIM2,ZLIN,WASHOU(100,100),UBARK(20),SIGAK(20),
00103         9SIGEK(20),ZRK,SIGARK,SIGERK,UBARKK,THETAK(40),TAUK(20),TAUDK(20),
00104          COMMON/PARAMS/CECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,
00104         1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),UBOT(10),ERFA(6),
00104         2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),MB,PP,R,PWR,
00104         3MPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,
00104         4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,
00104         5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),
00104         6DELPHI,UBARZK(100),UBARZL(100)
00105          INTEGER TESTNC
00106          REAL MP R,L,LAT,LAMBDA
00106    C     **** THIS SUBROUTINE CALCULATES L     .
00106    C     **** LATERAL TERM OF OPTION AND ALONG WIND TERM ON OPTION.
00107       20 RETURN
00110          ENTRY EL(X,M)
00112          IF (M .GT. 0) GO TO 24
00114          IF (M .LT. 0) GO TO 23
00116          L = 0.28*ABS(DELU(KK))/UBAR(KK)*X
00117          IF (DELU(KK) .LT. 0.0) L = 0.0
00121          GO TO 25
00122       23 L = 0.28*ABS(DELU(NNZ+ILK-1))/UBAR(NNZ+ILK-1)*X
00123          IF (DELU(NNZ+ILK-1) .LT. 0.0) L = 0.0
00125          GO TO 25
00126       24 L = 0.28*ABS(DELU(M))/UBAR(M)*X
00127          IF (DELU(M) .LT. 0.0) L = 0.0
00131       25 CONTINUE
00132          RETURN
00133          ENTRY LATER(Y)
00135          IF (ISKIP(3) .EQ. 1) GO TO 30
00137          LAT(J) = 1.0
00140          GO TO 40
00141       30 LAT(J) = EXP(-Y**2/(2.0*SIGY**2))
00142       40 RETURN
00143          ENTRY ALONGD(X,TT)
00145          ALONGW(J) = 1.0
00146          IF (ISKIP(6) .EQ. 2) GO TO 50
00150          TS = TT
00151          IF (ISKIP(6) .EQ. 0) TS = X/UBAR(KK)
00153          ALONGW(J) = EXP(-(X-UBAR(KK)*TS)**2/(2.0*SIGX**2))
00154       50 RETURN
00155          END

END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
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```
@I FOR VERT
UNIVAC 1108 FORTRAN V LEVEL   220A 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:07

   SUBROUTINE VERT        ENTRY POINT 000231

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000241
        0000    *DATA    000030
        0002    *BLANK   000000
        0003    PARAMT   033754
        0004    PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME)

        0005    NERR2S
        0006    EXP
        0007    NERR3S


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000054 10L      0001   000066 20L      0001   000067 30L      0001   000077 40L      0001   000017 5L
 0001   000200 50L      0001   000202 60L      0001   000212 70L      0001   000216 80L      0004 R 000216 ACCUR
 0003 R 007102 ALONG    0003 R 000226 ALPHA    0004 R 001023 ALPHNK   0004 R 001170 ANG      0003 R 000264 BETA
 0004 R 000657 BETANK   0003 R 007774 CI       0003 R 001522 CON      0004 R 000342 DATE     0004 R 000000 DECAY
 0004 R 025266 DELPHI   0003 R 000454 DELTHP   0003 R 001010 DELJ     0003 R 000606 DELX     0003 R 000644 DELY
 0004 R 000345 DEP      0004 R 001335 DEPN     0003 R 007762 DI       0003 R 001356 DOS      0004 R 000273 DTHK
 0003 R 007246 DXR      0004 R 000126 ERFX     0003 R 000036 H        0004 R 000267 HW       0003 I 010014 I
 0003 I 010050 IBOT     0003 I 007436 IFLAG    0004 I 000344 II       0003 I 010036 ILK      0003 I 000000 ISKIP
 0003 I 007602 ITAG     0003 I 010047 ITOP     0003 I 000745 IZHDN    0003 I 010015 J        0004 I 000114 JBOT
 0004 I 000041 JF       0004 I 000134 JTUP     0003 I 010016 KK       0003 R 010012 L        0003 R 010110 LAMBDA
 0003 R 006426 LAT      0004 I 000322 LB1      0004 I 000326 LB2      0004 I 000332 LB3      0004 I 000336 LB4
 0004 R 000272 MPWR     0000 I 000000 N        0003 I 010035 NBK      0003 I 010043 NCI      0003 I 010042 NOI
 0003 I 010044 NDXR     0003 I 010046 NNZ      0003 I 000764 NPT      0004 I 000321 NVB      0004 I 000320 NVS
 0004 I 001334 NXCI     0003 I 010037 NAS      0003 I 010040 NYS      0003 I 010041 NZS      0003 R 006262 PEAKC
 0003 R 001666 PEAKD    0004 R 000172 PERC     0004 R 000243 PERCB    0003 R 002342 PLT      0004 R 000270 PPWR
 0003 R 000132 Q        0004 R 000271 QPWR     0003 R 010045 RAD      0003 R 033560 SIGAK    0004 R 000013 SIGAL
 0004 R 025122 SIGANK   0003 R 000360 SIGAP    0003 R 033631 SIGARK   0004 R 000040 SIGARL   0003 R 033604 SIGEK
 0004 R 000025 SIGEL    0004 R 024756 SIGENK   0003 R 000550 SIGEP    0003 R 033632 SIGERK   0004 R 000042 SIGERL
 0003 R 010010 SIGX     0003 R 010107 SIGXNK   0003 R 000416 SIGXD    0003 R 010007 SIGY     0004 R 024755 SIGYNK
 0003 R 000322 SIGYD    0003 R 010006 SIGZ     0003 R 000512 SIGZU    0004 R 001167 SQBAR    0003 R 010011 SQR2P
 0003 R 010017 STD1     0003 R 010020 STD2     0003 R 010021 STD3     0003 R 007412 T        0003 R 010023 TAST
 0003 R 033704 TAUK     0004 R 000070 TAUL     0003 R 033730 TAUOK    0004 R 000102 TAUDL    0003 I 007746 TESTNO
 0003 R 010013 TH       0003 R 000702 THETA    0003 R 033634 THETAK   0004 R 000044 THETAL   0000 R 000001 TI
 0003 R 010111 TIM1     0003 R 010112 TIM2     0000 R 000003 TLIM     0000 R 000002 TR       0003 R 010022 TRD
 0003 R 000170 UBAR     0003 R 033534 UBARK    0004 R 000001 UBARL    0004 R 000513 UBARNK   0003 R 033633 UBARRK
 0004 R 000043 UBARRL   0004 R 025267 UBARZK   0004 R 025433 UBARZL   0004 R 000217 VB       0003 R 006572 VER
 0003 R 006736 VREF     0004 R 000146 VS       0003 R 010114 VASHOU   0003 R 010051 XAST     0004 R 000512 XBARX
 0003 R 001212 XR       0003 R 002032 XX       0004 R 000346 YBARY    0003 R 002176 YY       0003 R 000074 Z
 0003 R 010113 ZLIM     0003 R 033630 ZRK      0004 R 000037 ZRL      0003 R 001046 ZZL
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```
00101        SUBROUTINE VERT(K,NN)                                              VERT  20
00103        COMMON/PARAMT/ISKIP(30),H(30),Z(30),I(30),UBAR(30),ALPHA(30),      VERT  30
00103       1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),       VERT  40
00103       2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),  VERT  50
00103       3ZZL(100),XR(100),DOS(100),CON(100),PEAKD(100),XX(100),YY(100),     VERT  60
00103       4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100),  VERT  70
00103       5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ, VERT  80
00103       6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRD,TAST(10),NBK,ILK,   VERT  90
00103       7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),               VERT 100
00103       8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20),  VERT 110
00103       9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20),  VERT 120
00104        COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,   VERT 130
00104       1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),J3OT(10),ERFX(6),      VERT 140
00104       2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PP.R,WPXR,      VERT 150
00104       3MPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,  VERT 160
00104       4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,        VERT 170
00104       5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGA K(100),        VERT 180
00104       6DELPHI,UBARZK(100),UBARZL(100)                                     VERT 190
00105        INTEGER TESTNO                                                     VERT 200
00106        REAL MP R,L,LAT,LAMBDA                                             VERT 210
00106        ***** THIS SUBROUTINE CALCULATES VERTICAL AND VERTICAL REFLECTIONVERT 220
00107        STC2 = 0.0                                                         VERT 230
00110        N = IZMOD(KK)                                                      VERT 240
00111        GO TO (50,50,5),N                                                  VERT 250
00112      5 IF (ISKIP(4) .EQ. 0) GO TO 10                                      VERT 260
00114        STO2= EXP(-(H(KK)-ZZL(K))**2/(2.0*SIGZ**2))+EXP(-(H(KK)-(2.0*Z(KK)VERT 270
00114       1)+ZZL(K))**2/(2.0*SIGZ**2))                                        VERT 280
00115     10 STO3 = 0.0                                                         VERT 290
00116        IF (ISKIP(5) .EQ. 1) GO TO 20                                      VERT 300
00120        IF (ISKIP(4) .EQ. 0) STO3 = 1.0                                    VERT 310
00122        GO TO 60                                                           VERT 320
00123     20 TI = 0.0                                                           VERT 330
00124     30 TI = TI+1.0                                                        VERT 340
00125        IF (SIGZ-0.0) 40,35,40                                             VERT 350
00130     35 STO3 = 0.0                                                         VERT 360
00131        GO TO 60                                                           VERT 370
00132     40 CONTINUE                                                           VERT 380
00133        TR = 2.0*TI*(Z(KK+1)-Z(KK))                                        VERT 390
00134        TLIM = ((-(TR-H(KK)+(2.0*Z(KK))-ZZL(K))**2)/(2.0*SIGZ**2))         VERT 400
00135        IF (-10.0 .GT. TLIM) GO TO 60                                      VERT 410
00137        STO3 = STO3+EXP(TLIM)+EXP((-(TR-H(KK)+ZZL(K))**2)/(2.0*SIGZ**2))   VERT 420
00137       1+EXP((-(TR+H(KK)-ZZL(K))**2)/(2.0*SIGZ**2))                        VERT 430
00137       2+EXP((-(TR+H(KK)-(2.0*Z(KK))+ZZL(K))**2)/(2.0*SIGZ**2))            VERT 440
00140        GO TO 30                                                           VERT 450
00141     50 STO3 = 1.0                                                         VERT 460
00142     60 GO TO (70,80),NN                                                   VERT 470
00143     70 VER(J) = STC2                                                      VERT 480
00144        VREF(J) = STO3                                                     VERT 490
00145     80 RETURN                                                             VERT 500
00146        END                                                                VERT 510

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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```
SI FOR PEAK
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:08

   SUBROUTINE PEAK       ENTRY POINT 000060

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001   *CODE    000067
        0000   *DATA    000014
        0002   *BLANK   000000
        0003   PARAMT   033754
        0004   PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME)

        0005   NERR2S
        0006   NERR3S


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000016 10L      0001   000025 20L      0001   000034 25L      0001   000044 30L      0001   000046 40L
    0004 R 000216 ACCUR    0003 R 007102 ALONGW   0003 R 000226 ALPHA    0004 R 001023 ALPHNK   0004 R 001170 ANG
    0003 R 000264 BETA     0004 R 000657 BETANK   0003 R 007774 CI       0003 R 001522 CON      0004 R 000342 DATE
    0004 R 000000 DECAY    0004 R 025266 DELPHI   0003 R 000454 DELTHP   0003 R 001010 DELU     0003 R 000606 DELX
    0003 R 000644 DELY     0004 R 000345 DEP      0004 R 001335 DEPN     0003 R 007762 DI       0003 R 001386 DOS
    0004 R 000273 DTHK     0003 R 007246 DXR      0004 R 000126 ENFX     0003 R 000036 H        0004 R 000267 HB
    0003 I 010014 I        0003 I 010050 IBOT     0003 I 007436 IFLAG    0004 I 000344 II       0003 I 010036 ILK
    0003 I 000000 ISKIP    0003 I 007402 ITAG     0003 I 010047 ITOP     0003 I 000740 IZMOD    0003 I 010015 J
    0004 I 000114 JBOT     0004 I 000041 JF       0004 I 000134 JTOP     0003 I 010016 KK       0003 R 010012 L
    0003 R 010110 LAMBDA   0003 R 006426 LAT      0004 I 000322 LB1      0004 I 000326 LB2      0004 I 000332 LB3
    0004 I 000336 LB4      0000 I 000000 M        0004 R 000272 MPWR     0003 I 010035 NBK      0003 I 010043 NC1
    0003 I 010042 ND1      0003 I 010044 NDXR     0003 I 010046 NNZ      0003 I 000764 NPT      0004 I 000321 NVB
    0004 I 000320 NVS      0004 I 001334 NXC1     0003 I 010037 NXS      0003 I 010040 NYS      0003 I 010041 NZS
    0003 R 006262 PEAKC    0003 R 001666 PEAKD    0004 R 000172 PERC     0004 R 000243 PERCB    0003 R 002342 PLT
    0004 R 000270 PPWR     0003 R 000132 Q        0004 R 000271 QPWR     0003 R 010045 RAD      0003 R 033560 SIGAK
    0004 R 000013 SIGAL    0004 R 025122 SIGANK   0003 R 000360 SIGAP    0003 R 033631 SIGARK   0004 R 000040 SIGARL
    0003 R 033604 SIGEK    0004 R 000025 SIGFL    0004 R 024756 SIGENK   0003 R 000550 SIGEP    0003 R 033632 SIGERK
    0004 R 000042 SIGERL   0003 R 010010 SIGX     0003 R 010107 SIGXNK   0003 R 000416 SIGXO    0003 R 010007 SIGY
    0004 R 024755 SIGYNK   0003 R 000322 SIGYO    0003 R 010006 SIGZ     0003 R 000512 SIGZO    0004 R 001167 SQBAR
    0003 R 010011 S*R2P    0003 R 010017 STO1     0003 R 010020 STO2     0003 R 010021 STO3     0003 R 007412 T
    0003 R 010023 TAST     0003 R 033704 TAUK     0004 R 000070 TAUL     0003 R 033730 TAUOK    0004 R 000102 TAUOL
    0003 I 007746 TESTNO   0003 R 010013 TH       0003 R 000702 THETA    0003 R 033634 THETAK   0004 R 000044 THETAL
    0003 R 010111 TIM1     0003 R 010112 TIM2     0003 R 010022 TRD      0003 R 000170 UBAR     0003 R 033534 UBARK
    0004 R 000001 UBARL    0004 R 000513 UBARNK   0003 R 033633 UBARRK   0004 R 000043 UBARRL   0004 R 025267 UBARZK
    0004 R 025433 UBARZL   0004 R 000217 VR       0003 R 006572 VER      0003 R 006736 VREF     0004 R 000146 VS
    0003 R 010114 WASHOU   0003 R 010051 XAST     0004 R 000512 XBARX    0003 R 001212 XR       0003 R 002032 XX
    0004 R 000346 YHARY    0003 R 002176 YY       0003 R 000074 Z        0003 R 010113 ZLIM     0003 R 033630 ZRK
    0004 R 000037 ZRL      0003 R 001046 ZZL
```

```
 0101      SUBROUTINE PEAK(NN,K)                                              PEAK  20
00103      COMMON/PARAMT/ISWIF(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),     PEAK  30
 0103     1BETA(30),SIGMU(30),SIGAP(30),SIGXE(30),DELTHP(30),SIGZU(30),      PEAK  40
00103     2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30), PEAK  50
00103     3ZZL(100),XR(100),DOS(100),CUN(100),PEAKD(100),XX(100),YY(100),    PEAK  60
00103     4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100), PEAK  70
00103     5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,PEAK  80
00103     6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRD,TAST(10),NBK,ILK,  PEAK  90
00103     7NXS,NYS,NZS,MCI,NCI,MDXP,RAD,NMZ,ITOP,IBOT,XAST(30),              PEAK 100
00103     8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20), PEAK 110
00103     9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUCK(20), PEAK 120
00104      COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,  PEAK 130
00104     1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),     PEAK 140
00104     2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,     PEAK 150
00104     3HPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP, PEAK 160
00104     4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,       PEAK 170
00104     5ANG(100),NYCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),       PEAK 180
00104     6DELPHI,UBARZK(100),UBARZL(100)                                    PEAK 190
00105      INTEGER TESTNO                                                     PEAK 200
00106      REAL MPWR,L,LAT,LAMBDA                                             PEAK 210
00106       ***** THIS SUBROUTINE CALCULATES THE PEAK TERM *****             PEAK 220
00107      M = IZMOD(KK)                                                      PEAK 230
00110      GO TO (10,10,20),M                                                 PEAK 240
00111   10 STO1 = Q(KK)/(SQR2P*SIGY*UBARZK(K))                                PEAK 250
00112      GO TO 25                                                           PEAK 260
00113   20 STO1 = Q(KK)/(6.2831853072*SIGY*SIGZ*UBARZK(K))                    PEAK 270
00114   25 GO TO (30,40),NN                                                   PEAK 280
00115   30 PEAKD(J) = STO1                                                    PEAK 290
00116   40 RETURN                                                             PEAK 300
00117      END                                                                PEAK 310

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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```
@I FOR SIGMA
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:09

   SUBROUTINE SIGMA       ENTRY POINT 000311

   STORAGE USED (BLOCK, NAME, LENGTH)

         0001   *CODE    000326
         0000   *DATA    000027
         0002   *BLANK   000000
         0003   PARAMT   033754
         0004   PARAMS   025577

   EXTERNAL REFERENCES (BLOCK, NAME)

         0005   NEXP6$
         0006   NERR2$
         0007   SQRT
         0010   COS
         0011   SIN
         0012   NERR3$

   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001   000052 10L      0001   000060 20L      0001   000146 30L      0001   000007 4L       0001   000153 40L
 0001   000014 6L       0001   000300 60L      0001   000020 8L       0004 R 000214 ACCUR    0003 R 007102 ALONGW
 0003 R 000226 ALPHA    0000 R 000001 ALPHAP   0004 R 001023 ALPHNK   0004 R 001170 ANG      0003 R 000264 BETA
 0004 R 000467 BETANK   0000 R 000002 BETAP    0003 R 007774 CI       0003 R 001522 CON      0004 R 000342 DATE
 0004 R 000000 DECAY    0004 R 025266 DELPHI   0003 R 000454 DELTHP   0003 R 001010 DELU     0003 R 000606 DELX
 0003 R 000644 DELY     0004 R 000345 DEP      0004 R 001335 DEPN     0003 R 007762 DI       0003 R 001356 DOS
 0004 R 000273 DTHK     0003 R 007246 DXR      0004 R 000126 ERFX     0003 R 000036 H        0004 R 000267 HB
 0003 I 010014 I        0003 I 010050 IBOT     0003 I 007436 IFLAG    0004 I 000344 II       0003 I 010036 ILK
 0000 I 000000 ISAVE    0003 I 000000 ISKIP    0003 I 007602 ITAG     0003 I 010047 ITOP     0003 I 000740 IZMOD
 0003 I 010015 J        0004 I 000114 JBOT     0004 I 000041 JF       0004 I 000134 JTOP     0003 I 010016 KK
 0003 R 010012 L        0003 R 010110 LAMBDA   0003 R 006426 LAT      0004 I 000322 LB1      0004 I 000326 LB2
 0004 I 000332 LB3      0004 I 000336 LB4      0004 R 000272 MPYR     0000 I 000004 N        0003 I 010035 NBK
 0003 I 010043 NCI      0003 I 010042 NCI      0003 I 010044 NDXR     0003 I 010046 NNZ      0003 I 000744 NPT
 0004 I 000321 NVB      0004 I 000320 NVS      0004 I 001334 NXCI     0003 I 010037 NXS      0003 I 010040 NYS
 0003 I 010041 NZS      0003 R 006262 PEAKC    0003 R 001666 PEAKD    0004 R 000172 PERC     0004 R 000243 PERCB
 0003 R 002342 PLT      0004 R 000270 PPHR     0003 R 000132 Q        0004 R 000271 QPWR     0003 R 010045 RAD
 0003 R 033540 SIGAK    0004 R 000013 SIGAL    0004 R 025122 SIGANK   0003 R 000360 SIGAP    0003 R 033631 SIGARK
 0004 R 000040 SIGARL   0003 R 033604 SIGEK    0004 R 000025 SIGEL    0004 R 024756 SIGENK   0003 R 000550 SIGEP
 0003 R 033632 SIGERK   0004 R 000042 SIGERL   0003 R 010010 SIGX     0003 R 010107 SIGXNK   0003 R 000416 SIGXO
 0003 R 010007 SIGY     0004 R 024755 SIGYNK   0003 R 000322 SIGYO    0003 R 010006 SIGZ     0003 R 000512 SIGZO
 0004 R 001167 SSBAR    0003 R 010011 SQR2P    0003 R 010017 STO1     0003 R 010020 STO2     0003 R 010021 STO3
 0003 R 007412 T        0003 R 010023 TAST     0003 R 033704 TAUK     0004 R 000070 TAUL     0003 R 033730 TAUOK
 0004 R 000102 TAUOL    0003 I 007746 TESTNG   0003 R 010013 TM       0003 R 000702 THETA    0003 R 033634 THETAK
 0004 R 000044 THETAL   0003 R 010111 TIM1     0003 R 010112 TIM2     0003 R 010022 TRD      0000 R 000005 T1
 0000 R 000006 T2       0003 R 000170 UBAR     0003 R 033534 UBARK    0004 R 000001 UBARL    0004 R 000513 UBARNK
 0003 R 033633 UBARNK   0004 R 000043 UBARRL   0004 R 025267 UBAR2K   0004 R 025433 UBARZL   0004 R 000217 VB
 0003 R 006572 VER      0003 R 006736 VREF     0004 R 000146 VS       0003 R 010114 WASHOU   0003 R 010051 XAST
 0004 R 000512 XBARX    0003 R 001212 X4       0003 R 002032 XX       0000 R 000003 XY       0000 R 000007 XZ
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0004 R 000346 YBARY     0003 R 002176 YY     0003 R 000074 Z     0003 R 010113 ZLIM     0003 R 033630 ZRK
0004 R 000037 ZRL       0003 R 001046 ZZL

00101    1*        SUBROUTINE SIGMA(X,M,MM)                                            SIGM  20
00103    2*        COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),       SIGM  30
00103    3*       1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),        SIGM  40
00103    4*       2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),   SIGM  50
00103    5*       3ZZL(100),XR(100),DOS(100),CON(100),PEAKP(100),XX(100),YY(100),      SIGM  60
00103    6*       4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100),   SIGM  70
00103    7*       5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,SIGM  80
00103    8*       6SIGY,SIGX,SQRZP,L,TH,I,J,KK,STD1,STD2,STD3,TRD,TAST(10),NBK,ILK,    SIGM  90
00103    9*       7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),                SIGM 100
00103   10*       8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20),   SIGM 110
00103   11*       9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUDK(20),   SIGM 120
00104   12*        COMPCH/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,    SIGM 130
00104   13*       1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUDL(10),JBCT(10),ERFX(6),       SIGM 140
00104   14*       2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,       SIGM 150
00104   15*       3MPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,   SIGM 160
00104   16*       4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,         SIGM 170
00104   17*       5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),         SIGM 180
00104   18*       6DELPHI,UBARZK(100),UBARZL(100)                                      SIGM 190
00105   19*        INTEGER TESTNO                                                      SIGM 200
00106   20*        REAL MPWR,L,LAT,LAMBDA                                              SIGM 210
00106   21*         ***** THIS SUBROUTINE CALCULATES THE STANDARD DEVIATIONS OF X,Y,ZSIGM 220
00107   22*        IF (MM .GT. 0) GO TO 4                                              SIGM 230
00111   23*        GO TO 6                                                             SIGM 240
00112   24*      4 ISAVE = KK                                                          SIGM 250
00113   25*        KK = MM                                                             SIGM 260
00114   26*        GO TO 8                                                             SIGM 270
00115   27*      6 IF (M .GT. 0) GO TO 40                                              SIGM 280
00117   28*      8 CONTINUE                                                            SIGM 290
00120   29*        ALPHAP = 1.0/ALPHA(KK)                                              SIGM 300
00121   30*        BETAP = 1.0/BETA(KK)                                                SIGM 310
00122   31*        XY = (SIGYO(KK)/SIGAP(KK))**ALPHAP                                  SIGM 320
00123   32*        N = IZMOD(KK)                                                       SIGM 330
00124   33*        GO TO (20,10,20),N                                                  SIGM 340
00125   34*     10 SIGY = SIGYO(KK)                                                    SIGM 350
00126   35*        SIGX = SIGXO(KK)                                                    SIGM 360
00127   36*        GO TO 30                                                            SIGM 370
00130   37*     20 T1 = SIGAP(KK)*(X+XY)**ALPHA(KK)                                    SIGM 380
00131   38*        T2 = (ABS(DELTHP(KK))*RAD*X/4.3)**2                                 SIGM 390
00132   39*        SIGY = SQRT(T1**2+T2)                                               SIGM 400
00133   40*        SIGX = SQRT((L/4.3)**2+SIGXO(KK)**2)                                SIGM 410
00134   41*        XZ = (SIGZO(KK)/SIGEP(KK))**BETAP                                   SIGM 420
00135   42*        SIGZ = SIGEP(KK)*(X+XZ)**BETA(KK)                                   SIGM 430
00136   43*     30 IF (MM .EQ. 0) GO TO 60                                             SIGM 440
00140   44*        KK = ISAVE                                                          SIGM 450
00141   45*        GO TO 60                                                            SIGM 460
00142   46*     40 SIGYNK = SQRT((SIGX*SIN((THETA(M)-THETA(NNZ+ILK-1))*RAD))**2+(SIGYSIGM 470
00142   47*       1*COS((THETA(M)-THETA(NNZ+ILK-1))*RAD))**2)                          SIGM 480
00143   48*        SQBAR = (SIGYNK/SIGAP(NNZ+ILK-1))**(1.0/ALPHA(NNZ+ILK-1))           SIGM 490
00144   49*        SIGYNK = SQRT((SIGAP(NNZ+ILK-1)*(X+SQBAR)**ALPHA(NNZ+ILK-1))**2+    SIGM 500
00144   50*       1((ABS(DELTHP(NNZ+ILK-1))*RAD/4.3)*X)**2)                            SIGM 510
00145   51*        SIGZ = SIGEP(NNZ+ILK-1)*X**BETA(NNZ+ILK-1)                          SIGM 520
00146   52*        SQBAR = SQRT((SIGX*COS((THETA(M)-THETA(NNZ+ILK-1))*RAD))**2+(SIGY*SIGM 530
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      1SIN((THETA(M)-THETA(NNZ+ILK-1))*RAD))**2)                         SIGM 540
       SIGXNK = SQRT((L/4.3)**2+SOBAR**2)                                SIGM 550
   60 CONTINUE                                                           SIGM 560
       RETURN                                                            SIGM 570
       END                                                               SIGM 580

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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```
@I FOR ISO
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:10

   SUBROUTINE ISO        ENTRY POINT 000121

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000130
        0000    *DATA    000064
        0002    *BLANK   000000
        0003    PARAMT   033759
        0004    PARAMS   025677


   EXTERNAL REFERENCES (BLOCK, NAME)

        0005    NERR3S


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000021 1176     0004 R 000216 ACCUR    0003 R 007102 ALONGW   0003 R 000226 ALPHA    0004 R 001023 ALPHNK
    0004 R 001170 ANG      0000 D 000010 A1C      0000 D 000012 A11      0000 D 000000 A6       0000 D 000002 A7
    0000 D 000004 A8       0000 D 000006 A9       0003 R 000264 BETA     0004 R C00657 BETANK   0003 R 007774 CI
    0003 R 001522 CON      0004 R 000342 DATE     0004 R 000000 DECAY    0004 R 025266 DELPHI   0003 R 000454 DELTHP
    0003 R 001010 DELU     0003 R 000606 DELX     0003 R 000644 DELY     0004 R 000345 DEP      0004 R 001338 DEPN
    0003 R 007762 DI       0003 R 001356 DOS      0004 R 000273 DTHK     0000 D 000014 DTX      0003 R 007246 DXR
    0004 R 000126 ERFX     0003 R 000036 H        0004 R 000267 HB       0003 I 010014 I        0003 I 010050 IBOT
    0003 I 007436 IFLAG    0004 I 000344 II       0003 I 010036 ILK      0000 I 000017 IV       0003 I 000000 ISKIP
    0003 I 007602 ITAG     0003 I 010047 ITOP     0003 I 000740 IZMOD    0003 I 010015 J        0004 I 000114 JBOT
    0004 I 000041 JF       0004 I 000134 JTOP     0003 I 010016 KK       0003 R 010012 L        0003 R 010110 LAMBDA
    0003 R 006426 LAT      0004 I 000322 LB1      0004 I 000326 LB2      0004 I 000332 LB3      0004 I 000336 LB4
    0000 I 000016 M        0004 R 000272 MPWR     0003 I 010035 NBK      0003 I 010043 NCI      0003 I 010042 NDI
    0003 I 010044 NOXR     0003 I 010046 NNZ      0003 I 000764 NPT      0004 I 000321 NVB      0004 I 000320 NVS
    0004 I 001334 NXCI     0003 I 010037 NXS      0003 I 010040 NYS      0003 I 010041 NZS      0003 R 006262 PEAKC
    0003 R 001466 PEAKD    0004 R 000172 PERC     0004 R 000243 PERCB    0003 R 002342 PLT      0004 R 000270 PPWR
    0003 R 000132 Q        0004 R 000271 QPWR     0003 R 010045 RAD      0003 R 033560 SIGAK    0004 R 000013 SIGAL
    0004 R 025122 SIGANK   0003 R 000360 SIGAP    0003 R 033631 SIGARK   0004 R 000040 SIGARL   0003 R 033604 SIGEK
    0004 R 000025 SIGEL    0004 R 024756 SIGENK   0003 R 000550 SIGEP    0003 R 033632 SIGERK   0004 R 000042 SIGERL
    0003 R 010010 SIGX     0003 R 010107 SIGXNK   0003 R 000416 SIGXO    0003 R 010007 SIGY     0004 R 024755 SIGYNK
    0003 R 000322 SIGYO    0003 R 010006 SIGZ     0003 R 000512 SIGZO    0004 R 001167 SGBAR    0003 R 010011 SQR2P
    0003 R 010017 STO1     0003 R 010020 STO2     0003 R 010021 STO3     0003 R 007412 T        0003 R 010023 TAST
    0003 R 033704 TAUK     0004 R 000070 TAUL     0003 R 033730 TAUOK    0004 R 000102 TAUOL    0003 I 007746 TESTNO
    0003 R 010013 TH       0003 R 000702 THETA    0003 R 033634 THETAK   0004 R 000044 THETAL   0003 R 010111 TIMI
    0003 R 010112 TIMZ     0003 R 010022 TRC      0003 R 000170 UBAR     0003 R 033534 UBARK    0004 R 000001 UBARL
    0004 R 000513 UBARNK   0003 R 033633 UBARRK   0004 R 000043 UBARRL   0004 R 025267 UBARZK   0004 R 025433 UBARZL
    0004 R 000217 VB       0003 R 006572 VER      0003 R 006736 VREF     0004 R 000146 VS       0003 R 010114 WASHOU
    0003 R 010051 XAST     0004 R 000512 XBARK    0003 R 001212 XR       0003 R 002032 XX       0004 R 000346 YBARY
    0003 R 002176 YY       0003 R 000074 Z        0003 R 010113 ZLIM     0003 R 033630 ZRK      0004 R 000037 ZRL
    0003 R 001046 ZZL
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00101        SUBROUTINE ISO(NR,MT)                                              ISO   20
00103        COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAP(30),ALPHA(30),      ISO   30
00103       1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZO(30),       ISO   40
00103       2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),  ISO   50
00103       3ZZL(100),XR(100),DOS(100),CON(100),PEAKD(100),XX(100),YY(100),     ISO   60
00103       4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100),  ISO   70
00103       5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ, ISO   80
00103       6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRO,TAST(10),MBK,ILK,   ISO   90
00103       7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NN2,ITOP,IBOT,XAST(30),               ISO  100
00103       8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20),  ISO  110
00103       9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUDK(20),  ISO  120
00104        COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,   ISO  130
00104       1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUDL(10),JBOT(10),ERFX(6),      ISO  140
00104       2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,      ISO  150
00104       3MP(R,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,  ISO  160
00104       4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,        ISO  170
00104       5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),        ISO  180
00104       6DELPHI,UBARZK(100),UBARZL(100)                                     ISO  190
00105        INTEGER TESTNO                                                     ISO  200
00106        REAL MPWR,L,LAT,LAMBDA                                             ISO  210
00107        DOUBLE PRECISION A6,A7,A8,A9,A10,A11,DTX
00107 C      THIS SUBROUTINE EVALUATES ERF(X)                                   ISO  220
00110        A6 = .0705230784D0                                                 ISO  230
00111        A7 = .0422820123D0                                                 ISO  240
00112        A8 = .0092705272D0                                                 ISO  250
00113        A9 = .0001520143D0                                                 ISO  260
00114        A10 = .0002765672D0                                                ISO  270
00115        A11 = .0000430638D0                                                ISO  280
00116        DO 10 M=NR,MT                                                      ISO  290
00121        IN = 0                                                             ISO  300
00122        IF (ERFX(M) .LT. 0.0) IN = 1                                       ISO  310
00124        ERFX(M) = ABS(ERFX(M))                                             ISO  320
00125        DTX = 1.0D0+A6*ERFX(M)+A7*ERFX(M)**2+A8*ERFX(M)**3+A9*ERFX(M)**4+  ISO  330
00125       1A10*ERFX(M)**5+A11*ERFX(M)**6                                      ISO  340
00126        ERFX(M) = 1.0D0-(1.0D0/DTX**16)                                    ISO  350
00127        IF (IN .EQ. 1) ERFX(M) = -ERFX(M)                                  ISO  360
00131     10 CONTINUE                                                           ISO  370
00133        RETURN                                                             ISO  380
00134        END                                                                ISO  390

END OF UNIVAC 1108 FORTRAN V COMPILATION.    0 *DIAGNOSTIC* MESSAGE(S)
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@I FOR COORD
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F5018P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:11

   SUBROUTINE COORD      ENTRY POINT 000635

   STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000710
        0000    *DATA    000043
        0002    *BLANK   000000
        0003    PARAMT   033754
        0004    PARAMS   025577

   EXTERNAL REFERENCES (BLOCK, NAME)

        0005    SQRT
        0006    ACOS
        0007    COS
        0010    SIN
        0011    NERR3$

   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001   000350 100L      0001   000457 110L      0001   000465 120L      0001   000477 130L      0001   000511
   0001   000523 150L      0001   000563 180L      0001   000612 182L      0001   000617 185L      0001   000621
   0001   000032 20L       0001   000105 23L       0001   000141 26L       0001   000151 40L       0001   000163
   0001   000277 81L       0001   000314 82L       0001   000321 85L       0001   000333 90L       0001   000336
   0004 R 000216 ACCUR     0003 R 007102 ALONGW    0000 R 000006 ALP       0003 R 000226 ALPHA     0004 R 001023
   0004 R 001170 ANG       0000 R 000010 B         0003 R 000264 BETA      0004 R 000657 BETANK    0003 R 007774
   0003 R 001522 CON       0004 R 000342 DATE      0004 R 000000 DECAY     0000 R 000011 DEL       0004 R 026246
   0003 R 000454 DELTHP    0003 R 001010 DELU      0003 R 000606 DELX      0003 R 000644 DELY      0004 R 000345
   0004 R 001335 DEPN      0003 R 007762 DI        0003 R 001356 DGS       0004 R 000273 DTHK      0000 R 000004
   0000 R 000007 DXP       0003 R 007246 DXR       0000 R 000005 DY        0004 R 000126 ERFX      0003 R 000036
   0004 R 000267 H0        0003 I 010014 I         0003 I 010050 IBOT      0003 I 007436 IFLAG     0004 I 000344
   0003 I 010036 ILK       0003 I 000000 ISKIP     0003 I 007602 ITAG      0003 I 010047 ITOP      0003 I 000740
   0003 I 010015 J         0004 I 000114 JBOT      0004 I 000041 JF        0004 I 000134 JTOP      0003 I 010016
   0003 R 010012 L         0003 R 010110 LAMBDA    0003 R 006426 LAT       0004 I 000322 LB1       0004 I 000326
   0004 I 000332 LB3       0004 I 000336 LB4       0004 R 000272 MPWR      0003 I 010035 NBK       0003 I 010043
   0003 I 010042 NC1       0003 I 010044 NCXR      0003 I 010046 NNZ       0003 I 000764 NPT       0004 I 000321
   0004 I 000320 NVS       0004 I 001334 NXCI      0003 I 010037 NXS       0003 I 010040 NYS       0003 I 010041
   0003 R 006262 PEAKC     0003 R 001666 PEAKD     0004 R 000172 PERC      0004 R 000243 PERCB     0000 R 000015
   0003 R 002342 PLT       0004 R 000270 PPWR      0003 R 000132 Q         0004 R 000271 QPWR      0003 R 010045
   0000 R 000012 S         0003 R 033560 SIGAK     0004 R 000013 SIGAL     0004 R 025122 SIGANK    0003 R 000360
   0003 R 033631 SIGARK    0004 R 000040 SIGARL    0003 R 033604 SIGEK     0004 R 000025 SIGEL     0004 R 024756
   0003 R 000550 SIGEP     0003 R 033632 SIGERK    0004 R 000042 SIGERL    0003 R 010010 SIGX      0003 R 010107
   0003 R 000416 SIGXO     0003 R 010007 SIGY      0004 R 024755 SIGYNK    0003 R 000322 SIGYO     0003 R 010006
   0003 R 000512 SIGZO     0004 R 001167 SGBAR     0003 R 010011 SGR2P     0003 R 010017 STO1      0003 R 010020
   0003 R 010021 STO3      0003 R 007412 T         0003 R 010023 TAST      0003 R 033704 TAUK      0004 R 000070
   0003 R 033730 TAUOK     0004 R 000102 TAUOL     0003 I 007746 TESTNO    0003 R 010013 TH        0003 R 000702
   0003 R 033634 THETAK    0004 R 000044 THETAL    0000 R 000001 THP       0000 R 000000 THPL      0003 R 010111
   0003 R 010112 TIN2      0003 R 010022 TRD       0000 R 000014 T1        0003 R 000170 UBAR      0003 R 033534
   0004 R 000001 USARL     0004 R 000513 UBARNK    0003 R 033633 UBARRK    0004 R 000043 UBARRL    0004 R 025267
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0004 R 025433 UBARZL    0004 R 000217 VB      0003 R 006572 VER     0003 R 006736 VREF    0004 R 000146 VS
0003 R 010114 WASHOU    0003 R 010051 XAST    0004 R 000512 XBARX   0000 R 000013 XCI     0003 R 001212 XR
0003 R 002032 XX        0000 R 000002 XI      0004 R 000346 YBARY   0003 R 002176 YY      0000 R 000003 YI
0003 R 000074 Z         0003 R 010113 ZLIM    0003 R 033630 ZRK     0004 R 000037 ZRL     0003 R 001046 ZZL

00101          SUBROUTINE COORD(N,M,X,Y,XO,YO,ASP,XS,ICK)                           CORD  20
00103           COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),        CORD  30
00103          1BETA(30),SIGYO(30),SIGAP(30),SIGXO(30),DELTHP(30),SIGZ0(30),        CORD  40
00103          2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30),   CORD  50
00103          3ZZL(100),XR(100),DOS(100),CON(100),PEAKD(100),XX(100),YY(100),      CORD  60
00103          4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONG (100),   CORD  70
00103          5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),C(10),SIGZ,CORD  80
00103          6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRD,TAST(10),NBK,ILY,    CORD  90
00103          7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),                CORD 100
00103          8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20),   CORD 110
00103          9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUDK(20),   CORD 120
00104           COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,    CORD 130
00104          1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUDL(10),JBCT(10),ERFX(6),       CORD 140
00104          2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,QPWR,       CORD 150
00104          3HPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP,   CORD 160
00104          4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SOBAR,         CORD 170
00104          5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),         CORD 180
00104          6DELPHI,UBARZK(100),UBARZL(100)                                     CORD 190
00105           INTEGER TESTNO                                                     CORD 200
00106           REAL HPWR,L,LAT,LAMBDA                                             CORD 210
00106    C       *****THIS SUBROUTINE TRANSLATES AND ROTATES THE FIXED INPUT *****CORD 220
00106    C       ***** COORDINATES RELATIVE TO A SYSTEM WITH POSITIVE X AXIS  ****CORD 230
00106    C       ***** ALONG THE WIND DIRECTION THETA. IT ALSO DETERMINES IF  ****CORD 240
00106    C       ***** THE RECEPTOR COORDINATES LY WITHIN AN ANGLE OF ONE-   *****CORD 250
00106    C       *****  HALF DELPHI FROM THETA                                    CORD 260
00107           IF (ICK .NE. 2) GO TO 20                                           CORD 270
00111           IF (THETA(NNZ+ILK-1) .GE. 180.0) THPL =(THETA(NNZ+ILK-1)-180.0)*   CORD 280
00111          1RAD                                                                CORD 290
00113           IF (THETA(NNZ+ILK-1) .LT. 180.0) THPL =(THETA(NNZ+ILK-1)+180.0)*   CORD 300
00113          1RAD                                                                CORD 310
00115       20 IF (THETA(M) .GE. 180.0) THP = (THETA(M)-180.0)*RAD                 CORD 320
00117          IF (THETA(M) .LT. 180.0) THP = (THETA(M)+180.0)*RAD                 CORD 330
00121          IF (ISKIP(2) .EQ. 1) GO TO 40                                       CORD 340
00123          XI = SQRT(XO**2+YO**2)                                              CORD 350
00124          YI = ACOS(YO/XI)                                                    CORD 360
00125          IF (XI -0.0) 23,22,23                                               CORD 370
00130       22 YI = 0.0                                                            CORD 380
00131       23 IF (XO .LT. 0.0) YI = 6.2831853072-YI                               CORD 390
00133          DX = SQRT(DELX(M)**2+DELY(M)**2)                                    CORD 400
00134          DY = ACOS(DELY(M)/DX)                                               CORD 410
00135          IF (DX - 0.0) 26,25,26                                              CORD 420
00140       25 DY = 0.0                                                            CORD 430
00141       26 IF (DELX(M) .LT. 0.0) DY = 6.2831853072-DY                          CORD 440
00143          GO TO 60                                                            CORD 450
00144       40 XI = XO                                                             CORD 460
00145          YI = YO*RAD                                                         CORD 470
00146          DX = DELX(M)                                                        CORD 480
00147          DY = DELY(M)*RAD                                                    CORD 490
00150       60 IF (ICK .NE. 2) GO TO 100                                           CORD 500
00152          IF (TH-DY) 70,100,70                                                CORD 510
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00155          70 IF (THP-DY) 80,100,80                                          CORD 520
00160          80 ALP = ABS(TH-DY)                                               CORD 530
00161             IF (ALP .GT. 3.1415926536) ALP = 6.2831853072-ALP              CORD 540
00163             DXP = SQRT(XAST(M)**2+DY**2-2.0*XAST(M)*DX*COS(ALP))           CORD 550
00164             B = (DXP**2+XAST(M)**2-DX**2)/(2.0*DXP*XAST(M))                CORD 560
00165             IF (B .GT. 1.0) B = 1.0                                        CORD 570
00167             IF (B .LT. -1.0) B = -1.0                                      CORD 580
00171             DEL = ACOS(B)                                                  CORD 590
00172             DX = DXP                                                       CORD 600
00173             IF (DXP-0.0) 81,,81                                            CORD 610
00176             DY = 0.0                                                       CORD 620
00177             GO TO 100                                                      CORD 630
00200          81 CONTINUE                                                       CORD 640
00201             IF (ABS(TH-DY) .GT. 3.1415926536) GO TO 82                     CORD 650
00203             IF (TH-DY) 85,90,95                                            CORD 660
00206          82 IF (TH-DY) 95,90,85                                            CORD 670
00211          85 DY = THP-DEL                                                   CORD 680
00212             IF (DY .LT. 0.0) DY = 6.2831853072+DY                          CORD 690
00214             GO TO 100                                                      CORD 700
00215          90 DY = THP                                                       CORD 710
00216             GO TO 100                                                      CORD 720
00217          95 DY = THP+DEL                                                   CORD 730
00220             IF (DY .GE. 6.2831853072) DY = DY-6.2831853072                 CORD 740
00222         100 S = ABS(Y1-DY)                                                 CORD 750
00223             IF (S .GT. 3.1415926536) S = 6.2831853072-S                    CORD 760
00225             XS = SQRT(X1**2+DX**2-2.0*X1*DX*COS(S))                        CORD 770
00226             B = (X1**2+XS**2-DX**2)/(2.0*X1*XS)                            CORD 780
00227             IF (B .GT. 1.0) B = 1.0                                        CORD 790
00231             IF (B .LT. -1.0) B = -1.0                                      CORD 800
00233             XCI = ACOS(B)                                                  CORD 810
00234             IF (ABS(Y1-DY) .GT. 3.1415926536) GO TO 110                    CORD 820
00236             IF (Y1-DY) 130,120,140                                         CORD 830
00241         110 IF (Y1-DY) 140,120,130                                         CORD 840
00244         120 ASP = Y1                                                       CORD 850
00245             IF (XCI .GE. 3.0)       ASP = ASP+3.1415926536                 CORD 860
00247             GO TO 150                                                      CORD 870
00250         130 ASP = Y1-XCI                                                   CORD 880
00251             IF (ASP .LT. 0.0) ASP = 6.2831853072+ASP                       CORD 890
00253             GO TO 150                                                      CORD 900
00254         140 ASP = Y1+XCI                                                   CORD 910
00255             IF (ASP .GE. 6.2831853072) ASP = ASP-6.2831853072              CORD 920
00257         150 CONTINUE                                                       CORD 930
00260             T1 = THP                                                       CORD 940
00261             IF (ICK .EQ. 2) T1 = THPL                                      CORD 950
00263         170 PHI = ABS(ASP-T1)                                              CORD 960
00264             IF (PHI .GT. 3.1415926536) PHI = 6.2831853072-PHI              CORD 970
00266             IF (PHI .LE. TRD) GO TO 180                                    CORD 980
00270             N = 9                                                          CORD 990
00271             ITAG(J) = 9                                                    CORD1000
00272             X = XS                                                         CORD1010
00273             RETURN                                                         CORD1020
00274         180 X = XS*COS(PHI)                                                CORD1030
00275             Y = XS*SIN(PHI)                                                CORD1040
00276             IF (ABS(ASP-T1) .GT. 3.1415926536) GO TO 182                   CORD1050
00300             IF (ASP-T1) 185,190,190                                        CORD1060
00303         182 IF (ASP-T1) 190,190,185                                        CORD1070
00306         185 Y = -Y                                                         CORD1080
00307         190 CONTINUE                                                       CORD1090
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00310   109*        ITAG(J) = 0                                  CORD1100
00311   110*        RETURN                                       CORD1110
00312   111*        END                                          CORD1120

     END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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QI FOR SGP
UNIVAC 1108 FORTRAN V LEVEL   2206 C018 FSC18P
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:13

   SUBROUTINE SGP       ENTRY POINT 001071

          UBARS         ENTRY POINT 001151

          DEPSO         ENTRY POINT 001231

          BETAK         ENTRY POINT 001265

   STORAGE USED (BLOCK, NAME, LENGTH)

         0001    *CODE    001341
         0000    *DATA    000063
         0002    *BLANK   000000
         0003    PARAMT   033754
         0004    PARAMS   025577

   EXTERNAL REFERENCES (BLOCK, NAME)

         0005    NEXP6S
         0006    SIN
         0007    COS
         0010    ATAN
         0011    SQRT
         0012    EXP
         0013    NERR3S

   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000053 10L       0001   000042 125G      0001   000240 1736      0001   000057 20L       0001   001000 2726
    0001   000070 30L       0001   000107 35L       0001   000117 40L       0001   000142 42L       0001   000020 5L
    0001   000312 50L       0001   000376 52L       0001   000427 54L       0001   000475 56L       0001   000501 60L
    0001   000573 65L       0001   001031 90L       0001   001037 95L       0004 R 000216 ACCUR     0003 R 007102 ALONGW
    0003 R 000226 ALPHA     0004 R 001023 ALPHNX    0004 R 001170 ANG       0003 R 000264 BETA      0004 R 000657 BETANK
    0003 R 007774 CI        0003 R 001522 CON       0004 R 000342 DATE      0004 R 000000 DECAY     0004 R 025266 DELPHI
    0003 R 000454 DELTHP    0003 R 001010 DELU      0003 R 000606 DELX      0003 R 000644 DELY      0004 R 000345 DEP
    0004 R 001335 DEPN      0003 R 007762 DI        0003 R 001356 DOS       0004 R 000273 DTHK      0003 R 007246 DXR
    0004 R 000126 ERFX      0003 R 000036 H         0004 R 000267 HB        0000 R 000002 HHNK      0000 R 000003 HHRK
    0003 I 010014 I         0003 I 010050 IEOT      0003 I 007436 IFLAG     0004 I 000344 II        0003 I 010036 ILK
    0003 I 000000 ISKIP     0003 I 007602 ITAG      0003 I 010047 ITOP      0003 I 000740 IZMOD     0003 I 010015 J
    0004 I 000114 JBOT      0004 I 000041 JF        0004 I 000134 JTOP      0003 I 010016 KK        0003 R 010012 L
    0003 R 010110 LAMBDA    0003 R 006426 LAT       0004 I 000322 LB1       0004 I 000326 LB2       0004 I 000332 LB3
    0004 I 000336 LB4       0000 I 000005 M         0000 I 000001 MN        0004 R 000272 MP*R      0003 I 010035 NBK
    0003 I 010043 NCI       0003 I 010042 NDI       0003 I 010044 NDXR      0003 I 010046 NNZ       0003 I 000764 NPT
    0004 I 000321 NVB       0004 I 000320 NVS       0004 I 001334 NXCI      0003 I 010037 NXS       0003 I 010040 NYS
    0003 I 010041 NZS       0003 R 006262 PEAKC     0003 R 001666 PEAKO     0004 R 000172 PERC      0004 R 000243 PERCB
    0000 R 000015 PERK      0003 R 002342 PLT       0004 R 000270 PPWR      0000 R 000010 PWR       0003 R 000132 Q
    0004 R 000271 QPWR      0003 R 010045 RAD       0000 R 000000 S         0000 R 000006 SG1       0000 R 000007 SG2
    0000 R 000004 SG3       0003 R 033560 SIGAK     0004 R 000013 SIGAL     0004 R 025122 SIGANK    0003 R 000360 SIGAP
    0003 R 033631 SIGARK    0004 R 000040 SIGARL    0003 R 033604 SIGEK     0004 R 000025 SIGEL     0004 R 024756 SIGENK
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0003 R 000550 SIGEP     0003 R 033632 SIGERK    0004 R 000042 SIGERL    0003 R 010010 SIGX      0003 R 010107 SIGXNK
0003 R 000416 SIGXD     0003 R 010007 SIGY      0004 R 024755 SIGYNK    0003 R 000322 SIGYO     0003 R 010006 SIGZ
0003 R 000512 SIGZD     0004 R 001167 SQBAR     0003 R 010011 SQR2P     0003 R 010017 STO1      0003 R 010020 STO2
0003 R 010021 STO3      0000 R 000012 S1        0000 R 000013 S2        0000 R 000016 S3        0003 R 007412 T
0003 R 010023 TAST      0003 R 033724 TAUK      0004 R 000070 TAUL      0003 R 033730 TAUOK     0004 R 000102 TAUOL
0003 I 007746 TESTNO    0003 R 010013 TH        0003 R 000702 THETA     0003 R 033634 THETAK    0004 R 000044 THETAL
0003 R 010111 TIM1      0003 R 010112 TIM2      0003 R 010022 TRO       0003 R 000170 UBAR      0003 R 033534 UBARK
0004 R 000001 UBARL     0004 R 000513 UBARNK    0003 R 033633 UBARRK    0004 R 000043 UBARRL    0004 R 026267 UBARZK
0004 R 025433 UBARZL    0004 R 000217 VH        0003 R 006572 VER       0003 R 006736 VREF      0004 R 000146 VS
0000 R 000011 VV        0003 R 010114 WASHOU    0003 R 010051 XAST      0004 R 000512 XBARK     0000 R 000020 XJNK
0000 R 000017 XKNK      0003 R 001212 XR        0003 R 002032 XX        0000 R 000014 XXX       0000 R 000021 XY
0004 R 000346 YBARY     0003 R 002176 YY        0003 R 000074 Z         0003 R 010113 ZLIM      0003 R 033430 ZRK
0004 R 000037 ZRL       0003 R 001046 ZZL
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00101     1*         SUBROUTINE SGP(ZH,N,SIG,IN)                                        SGP   20
00103     2*         COMMON/PARAMT/ISKIP(30),H(30),Z(30),Q(30),UBAR(30),ALPHA(30),     SGP   30
00103     3*        1BETA(30),SIGYO(30),SIGAP(30),SIGXD(30),DELTHP(30),SIGZO(30),      SGP   40
00103     4*        2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30), SGP   50
00103     5*        3ZZL(100),XR(100),DOS(100),CON(100),PEAKO(100),XX(100),YY(100),    SGP   60
00103     6*        4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGW(100), SGP   70
00103     7*        5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,SGP   80
00103     8*        6SIGY,SIGX,SQR2P,L,TH,I,J,KK,STO1,STO2,STO3,TRO,TAST(10),NBK,ILK,  SGP   90
00103     9*        7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),             SGP  100
00103    10*        8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHOU(100,100),UBARK(20),SIGAK(20), SGP  110
00103    11*        9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20), SGP  120
00104    12*         COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF,  SGP  130
00104    13*        1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),     SGP  140
00104    14*        2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWH,QPWR,     SGP  150
00104    15*        3HPWR,DTHK(21),NVS,NVB,LB1(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEF, SGP  160
00104    16*        4YBARY(100),XBARK,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,       SGP  170
00104    17*        5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),       SGP  180
00104    18*        6DELPHI,UBARZK(100),UBARZL(100)                                    SGP  190
00105    19*         INTEGER TESTNO                                                     SGP  200
00106    20*         REAL HPWR,L,LAT,LAMBDA                                             SGP  210
00106    21*  C      SUBROUTINE SGP CALCULATES SIGENK AND SIGANK WITH OR WITHOUT        SGP  220
00106    22*  C      DESTRUCT IN THE LAYER.                                             SGP  230
00107    23*         S = 0.0                                                            SGP  240
00110    24*         MN = N-1                                                           SGP  250
00111    25*         HHNK = ZH                                                          SGP  260
00112    26*         HHRK = 1.0                                                         SGP  270
00113    27*         IF (IN .EQ. 1) GO TO 5                                             SGP  280
00115    28*         HHRK = ZH                                                          SGP  290
00116    29*         HHNK = Z(N+1)                                                      SGP  300
00117    30*       5 SG3 = SIGERK                                                       SGP  310
00120    31*         IF (IN .EQ. 2) SG3 = SIGARK                                        SGP  320
00122    32*         IF (N .LE. 2) GO TO 30                                             SGP  330
00124    33*         DO 25 M=2,MN                                                       SGP  340
00127    34*         IF (IN .EQ. 2) GO TO 10                                            SGP  350
00131    35*         SG1 = SIGEK(M)                                                     SGP  360
00132    36*         SG2 = SIGEK(M-1)                                                   SGP  370
00133    37*         GO TO 20                                                           SGP  380
00134    38*      10 SG1 = SIGAK(M)                                                     SGP  390
00135    39*         SG2 = SIGAK(M-1)                                                   SGP  400
00136    40*      20 S = S+(SG1 +SG2)*(Z(M+1)-Z(M))/2.0                                 SGP  410
00137    41*      25 CONTINUE                                                           SGP  420
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00141   42*     30 IF (IN .EQ. 2) GO TO 35                                              SGP  430
00143   43*        SG1 = SIGEK(N)                                                       SGP  440
00144   44*        SG2 = SIGEK(N-1)                                                     SGP  450
00145   45*        PWR = QPWR+1.0                                                       SGP  460
00146   46*        GO TO 40                                                             SGP  470
00147   47*     35 SG1 = SIGAK(N)                                                       SGP  480
00150   48*        SG2 = SIGAK(N-1)                                                     SGP  490
00151   49*        PWR = MPWR+1.0                                                       SGP  500
00152   50*     40 IF (N .EQ. 1) GO TO 42                                               SGP  510
00154   51*        S = S+(ZH-Z(N))*(((SG1-SG2)/(Z(N+1)-Z(N)))*(ZH-Z(N))+SG2)/2.0        SGP  520
00155   52*     42 SIG = (S+(SG3*(HHNK**PWR-ZRK**PWR)/(PWR*(HHNK-ZRK)*ZRK**(PWR-1.0     SGP  530
00155   53*       1))))*(RAD/HHRK)                                                      SGP  540
00156   54*        RETURN                                                               SGP  550
00157   55*        ENTRY UBARS(ZH,N,IZ,UBHK)                                            SGP  560
00157   56*   C    SUBROUTINE UBARS CALCULATES UBARNK, X NK, Y NK, CAP THETA (ANG)      SGP  570
00161   57*        XBARX = 0.0                                                          SGP  580
00162   58*        YBARY(IZ) = 0.0                                                      SGP  590
00163   59*        VV = VS(II)                                                          SGP  600
00164   60*        PWR = PPWR+1.0                                                       SGP  610
00165   61*        IF (JF .EQ. 2) VV =-VB(II)                                           SGP  620
00167   62*        IF (N .EQ. 1) GO TO 50                                               SGP  630
00171   63*        MN = N-1                                                             SGP  640
00172   64*        DO 45 M=1,MN                                                         SGP  650
00175   65*        S1 = SIN(DTHK(M+1))-SIN(DTHK(M))                                     SGP  660
00176   66*        S2 = COS(DTHK(M+1))-COS(DTHK(M))                                     SGP  670
00177   67*        S = UBAR(M)/(VV*(DTHK(M+1)-DTHK(M))/(Z(M+1)-Z(M)))                   SGP  680
00200   68*        XBARX = XBARX+(S1*S)                                                 SGP  690
00201   69*        YBARY(IZ) = YBARY(IZ)+(S2*(-S))                                      SGP  700
00202   70*     45 CONTINUE                                                             SGP  710
00204   71*     50 S = ((DTHK(N+1)-DTHK(N))/(Z(N+1)-Z(N)))*(ZH-Z(N))+DTHK(N)            SGP  720
00205   72*        S1 = SIN(S)-SIN(DTHK(N))                                             SGP  730
00206   73*        S2 = COS(S)-COS(DTHK(N))                                             SGP  740
00207   74*        IF (N .EQ. 1) GO TO 52                                               SGP  750
00211   75*        UBHK = ((UBARK(N)-UBARK(N-1))/(Z(N+1)-Z(N)))*((ZH-Z(N))/2.0)+        SGP  760
00211   76*       1(UBARK(N-1)/2.0)                                                     SGP  770
00212   77*        GO TO 54                                                             SGP  780
00213   78*     52 UBHK = (UBARRK*(ZH**PWR-ZRK**PWR))/(PWR*(ZH-ZRK)*ZRK**(PWR-1.0))     SGP  790
00214   79*     54 S = UBHK/(VV*(DTHK(N+1)-DTHK(N))/(Z(N+1)-Z(N)))                      SGP  800
00215   80*        XBARX = XBARX+(S1*S)                                                 SGP  810
00216   81*        YBARY(IZ) = YBARY(IZ)+(S2*(-S))                                      SGP  820
00217   82*        ANG(IZ) = ATAN(YBARY(IZ)/XBARX)                                      SGP  830
00220   83*        IF (XBARX .GE. 0.0) GO TO 60                                         SGP  840
00222   84*        IF (YBARY(IZ) .GE. 0.0) GO TO 56                                     SGP  850
00224   85*        ANG(IZ) = ANG(IZ)-3.1415926536                                       SGP  860
00225   86*        GO TO 60                                                             SGP  870
00226   87*     56 ANG(IZ) = ANG(IZ)+3.1415926536                                       SGP  880
00227   88*     60 SQBAR = SQRT(XBARX**2+YBARY(IZ)**2)                                  SGP  890
00230   89*        UBARNK(IZ) = SQBAR*VV/ZH                                             SGP  900
00231   90*        RETURN                                                               SGP  910
00232   91*        ENTRY DEPSO(X,N,IZ)                                                  SGP  920
00232   92*   C    SUBROUTINE DEPSO CALCULATES ALL OF THE DEPOSITION EQUATION EXCEPT    SGP  930
00232   93*   C    THE LATERAL TERM                                                     SGP  940
00234   94*        ZH = ZZL(IZ)                                                         SGP  950
00235   95*        VV = VS(II)                                                          SGP  960
00236   96*        XXX = X                                                              SGP  970
00237   97*        PERK = PERC(II)                                                      SGP  980
00240   98*        IF (JF .EQ. 1) GO TO 65                                              SGP  990
00242   99*        ZH = HB                                                              SGP 1000
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00243          VV = VB(II)                                                     SGP 1010
00244          XXX = X+(SIGZO(N)/SIGENK(IZ))**(1.0/BETANK(IZ))                 SGP 1020
00245          PERK = PERCB(II)                                                SGP 1030
00246          T(N) = 1.0                                                      SGP 1040
00247       65 S3 = VV*XXX/UBARNK(IZ)                                          SGP 1050
00250          S2 = SIGENK(IZ)*XXX**BETANK(IZ)                                 SGP 1060
00251          S1 = EXP(-0.5*((S3-ZH)/S2)**2)                                  SGP 1070
00252          S2 = EXP(-0.5*((ZH-(2.0*Z(N+1))-S3)/S2)**2)                     SGP 1080
00253          XKNK = SIGENK(IZ)*XXX**(BETANK(IZ)+1.0)                         SGP 1090
00254          XJNK = (((1.0-BETANK(IZ))*S3+BETANK(IZ)*ZH)/XKNK)*S1            SGP 1100
00255          XKNK = ((2.0*BETANK(IZ)*Z(N+1)-BETANK(IZ)*ZH-(1.0-BETANK(IZ))*S3)/SGP 1110
00255         1XKNK)*S2                                                        SGP 1120
00256          XY = (SIGYO(N)/SIGANK(IZ))**(1.0/ALPHNK(IZ))                    SGP 1130
00257          SIGYNK = SQRT((SIGANK(IZ)*(X+XY)**ALPHNK(IZ))**2+(SIGENK(IZ)*XXX**SGP 1140
00257         1BETANK(IZ)*YBARY(IZ)/ZH)**2)                                    SGP 1150
00260          DEP = (Q(N)*PERK*T(N)/(6.283185307*SIGYNK*FLOAT(NXC1)))*(XJNK+  SGP 1160
00260         1XKNK)                                                           SGP 1170
00261          RETURN                                                          SGP 1180
00262          ENTRY BETAK(ZH,N,IZ)                                            SGP 1190
00262    C     SUBROUTINE BETAK CALCULATES  BETA NK AND ALPHA NK               SGP 1200
00264          S1 = 0.0                                                        SGP 1210
00265          S2 = 0.0                                                        SGP 1220
00266          IF (N .EQ. 1) GO TO 90                                          SGP 1230
00270          MN = N-1                                                        SGP 1240
00271          DO 70 M=1,MN                                                    SGP 1250
00274          S1 = S1+BETA(M)*(Z(M+1)-Z(M))                                   SGP 1260
00275          S2 = S2+ALPHA(M)*(Z(M+1)-Z(M))                                  SGP 1270
00276       70 CONTINUE                                                        SGP 1280
00300          BETANK(IZ) = (S1+BETA(N)*(ZH-Z(N)))/ZH                          SGP 1290
00301          ALPHNK(IZ) = (S2+ALPHA(N)*(ZH-Z(N)))/ZH                         SGP 1300
00302          GO TO 95                                                        SGP 1310
00303       90 BETANK(IZ) = BETA(N)                                            SGP 1320
00304          ALPHNK(IZ) = ALPHA(N)                                           SGP 1330
00305       95 CONTINUE                                                        SGP 1340
00306          RETURN                                                          SGP 1350
00307          END                                                             SGP 1360

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
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@I FOR READER
UNIVAC 1108 FORTRAN V LEVEL   2206 0018 F501BP
THIS COMPILATION WAS DONE ON 12 DEC 69 AT 17:35:16

   SUBROUTINE READER     ENTRY POINT 002544

   STORAGE USED (BLOCK, NAME, LENGTH)

         0001    *CODE    002577
         0000    *DATA    000136
         0002    *BLANK   000000
         0003    PARAMT   033754
         0004    PARAMS   025577


   EXTERNAL REFERENCES (BLOCK, NAME)

         0005    ALOG
         0006    NWDUS
         0007    NIO2S
         0010    NRDUS
         0011    NIO1S
         0012    NEXP6S
         0013    NERR3S


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000113 10L      0001     001522 1006G    0001     001615 1023G    0001     001715 1040G    0001     001725 1045G
 0001     002016 1066G    0001     002144 1116G    0001     002262 1136G    0001     002274 1143G    0001     002367 1164G
 0001     000132 12L      0001     002503 1205G    0001     000151 14L      0001     001544 155L     0001     000170 16L
 0001     001650 165L     0001     001766 178L     0001     002066 192L     0001     002127 193L     0001     002134 197L
 0001     000017 2L       0001     000207 20L      0001     002173 205L     0001     002233 210L     0001     002241 215L
 0001     002335 228L     0001     002415 240L     0001     002465 242L     0001     002473 243L     0001     000221 246G
 0001     000212 25L      0001     002521 250L     0001     002524 260L     0001     000324 266G     0001     000336 274G
 0001     000267 30L      0001     000350 302G     0001     000362 310G     0001     000375 317G     0001     000407 325G
 0001     000421 333G     0001     000433 341G     0001     000445 347G     0001     000457 355G     0001     000471 363G
 0001     000503 371G     0001     000515 377G     0001     000036 4L       0001     000546 415G     0001     000560 423G
 0001     000572 431G     0001     000604 437G     0001     000616 445G     0001     000624 452G     0001     000712 476G
 0001     001331 50L      0001     000724 504G     0001     000747 520G     0001     000761 526G     0001     000773 534G
 0001     001005 542G     0001     001021 552G     0001     001033 560G     0001     001057 570G     0001     001071 574G
 0001     000055 6L       0001     001425 60L      0001     001104 604G     0001     001117 612G     0001     001436 62L
 0001     001132 620G     0001     001145 626G     0001     001175 643G     0001     001462 65L      0001     001207 651G
 0001     001221 657G     0001     001233 665G     0001     001245 673G     0001     001254 701G     0001     001345 725G
 0001     001357 733G     0001     001401 746G     0001     001413 754G     0001     000074 8L       0000     000030 800F
 0000     000032 801F     0000     000034 802F     0000     000035 803F     0000     000037 900F     0000     000053 901F
 0004 R 000216 ACCUR      0005 R 000000 ALOG      0003 R 007102 ALONG     0003 R 000226 ALPHA     0004 R 001023 ALPHNK
 0004 R 001170 ANG        0003 R 000264 BETA      0004 R 000657 BETANK    0003 R 007774 CI        0003 R 001522 CON
 0004 R 000342 DATE       0004 R 000000 DECAY     0004 R 025266 DELPHI    0003 R 000454 DELTHP    0003 R 001010 DELU
 0003 R 000606 DELX       0003 R 000644 DELY      0004 R 000345 DEP       0004 R 001335 DEPN      0003 R 007762 DI
 0003 R 001356 DOS        0004 R 000273 DTHK      0003 R 007246 DXR       0004 R 000126 ERFX      0003 R 000036 H
 0004 R 000267 HB         0003 I 010014 I         0000 I 000020 IA        0003 I 010050 IBOT      0003 I 007436 IFLAG
 0004 I 000344 II         0003 I 010036 ILK       0000 I 000012 IRD       0003 I 000000 ISKIP     0003 I 007602 ITAG
 0003 I 010047 ITOP       0000 I 000000 IWD       0003 I 000740 IZMOD     0003 I 010015 J         0000 I 000017 JA
 0004 I 000114 JBOT       0004 I 000041 JF        0004 I 000134 JTOP      0003 I 010016 KK        0003 R 010012 L
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0003 R 010110 LAMBDA     0003 R C06426 LAT        0004 I 000322 LB1        0004 I 000326 LB2        0004 I 000332 LB3
0004 I 000336 LB4        0000 I 000027 M          0004 R 000272 MPWR       0003 I 010035 NBK        0003 I 010043 NCI
0003 I 010042 NCI        0003 I 010044 NDXR       0003 I 010046 NNZ        0003 I 000764 NPT        0000 I 000022 NTAK
0000 I 000023 NTAP       0000 I 000021 NTAR       0004 I 000321 NVB        0004 I 000323 NVS        0004 I 001334 NXCI
0003 I 010037 NXS        0003 I 010040 NYS        0003 I 010041 NZS        0000 R 000026 P          0003 R 006262 PEAKC
0003 R 001666 PEAKD      0004 R 000172 PERC       0004 R 000243 PERCB      0003 R 002342 PLT        0004 R 000270 PPWR
0003 R 000132 Q          0004 R 000271 QPWR       0003 R 010045 RAD        0000 R 000024 S          0003 R 033560 SIGAK
0004 R 000013 SIGAL      0004 R 025122 SIGANK     0003 R 000360 SIGAP      0003 R 033631 SIGARK     0004 R 000040 SIGARL
0003 R 033604 SIGEK      0004 R 000025 SIGEL      0004 R 024756 SIGENK     0003 R 000550 SIGEP      0003 R 033632 SIGERK
0004 R 000042 SIGERL     0003 R 010010 SIGX       0003 R 010107 SIGXNK     0003 R 000416 SIGXD      0003 R 010007 SIGY
0004 R 024755 SIGYNK     0003 R 000322 SIGYD      0003 R 010006 SIGZ       0003 R 000512 SIGZD      0004 R 001147 SQBAR
0003 R 010011 SQR2P      0003 R 010017 STO1       0003 R 010020 STO2       0003 R 010021 STO3       0000 R 000025 S1
0003 R 007412 T          0003 R 010023 TAST       0003 R 033704 TAUK       0004 R 000070 TAUL       0003 R 033730 TAUOK
0004 R 000102 TAUOL      0003 I 007746 TESTNO     0003 R 010013 TH         0003 R 000702 THETA      0003 R 033634 THETAK
0004 R 000044 THETAL     0003 R 010111 TIM1       0003 R 010112 TIM2       0003 R 010022 TRD        0003 R 000170 UBAR
0003 R 033534 UBARK      0004 R 000001 UBARL      0004 R 000513 UBARNK     0003 R 033633 UBARRK     0004 R 000043 UBARRL
0004 R 025267 UBARZK     0004 R 025433 UBARZL     0004 R 000217 VB         0003 R 006572 VER        0003 R 006736 VREF
0004 R 000146 VS         0003 R 010114 WASHDU     0003 R 010051 XAST       0004 R 000512 XBARX      0003 R 001212 XR
0003 R 002032 XX         0004 R 000346 YBARY      0003 R 002176 YY         0003 R 000074 Z          0003 R 010113 ZLIM
0003 R 033630 ZRK        0004 R 000037 ZRL        0003 R 001046 ZZL
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00101          SUBROUTINE READER(IERR,NP,JKJ)                                  READ  10
00103          COMMON/PARAMT/ISKIP(30),H(30),Z(30),W(30),UBAR(30),ALPHA(30),   READ  20
00103         1BETA(30),SIGYD(30),SIGAP(30),SIGXD(30),DELTHP(30),SIGZD(30),    READ  30
00103         2SIGEP(30),DELX(30),DELY(30),THETA(30),IZMOD(20),NPT(20),DELU(30), READ  40
00103         3ZZL(100),XR(100),DOS(100),CON(100),PEAKD(100),XX(100),YY(100),  READ  50
00103         4PLT(2,100,10),PEAKC(100),LAT(100),VER(100),VREF(100),ALONGA(100), READ  60
00103         5DXR(100),T(20),IFLAG(100),ITAG(100),TESTNO(12),DI(10),CI(10),SIGZ,READ  70
00103         6SIGY,SIGX,SQR2P,L,TH,I,JJKK,STO1,STO2,STO3,TRD,TAST(10),NBK,ILK, READ  80
00103         7NXS,NYS,NZS,NDI,NCI,NDXR,RAD,NNZ,ITOP,IBOT,XAST(30),            READ  90
00103         8SIGXNK,LAMBDA,TIM1,TIM2,ZLIM,WASHDU(100,100),UBARK(20),SIGAK(20), READ 100
00103         9SIGEK(20),ZRK,SIGARK,SIGERK,UBARRK,THETAK(40),TAUK(20),TAUOK(20), READ 110
00104          COMMON/PARAMS/DECAY,UBARL(10),SIGAL(10),SIGEL(10),ZRL,SIGARL,JF, READ 120
00104         1SIGERL,UBARRL,THETAL(20),TAUL(10),TAUOL(10),JBOT(10),ERFX(6),   READ 130
00104         2JTOP(10),VS(20),PERC(20),ACCUR,VB(20),PERCB(20),HB,PPWR,WPWR,   READ 140
00104         3MPWR,DTHK(21),NVS,NVB,LPI(4),LB2(4),LB3(4),LB4(4),DATE(2),II,DEP, READ 150
00104         4YBARY(100),XBARX,UBARNK(100),BETANK(100),ALPHNK(100),SQBAR,     READ 160
00104         5ANG(100),NXCI,DEPN(100,100),SIGYNK,SIGENK(100),SIGANK(100),     READ 170
00104         6DELPHI,UBARZK(100),UBARZL(100)                                  READ 180
00105          DIMENSION IWD(10),IRD(5)                                        READ 190
00106          DATA IWD(1)/4H NXS/,IWD(2)/4H NYS/,IWD(3)/4H NZS/,IWD(4)/4H NDI/, READ 200
00106         1IWD(5)/4H NCI/,IWD(6)/4HNDXR/,IWD(7)/4H NVS/,IWD(8)/4H NBK/,    READ 210
00106         2IWD(9)/4H NVB/,IRD(1)/3H100/,IRD(2)/3H 20/,IRD(3)/3H 21/,IRD(4) READ 220
00106         3/3H 1C/                                                         READ 230
00124          INTEGER TESTNO                                                  READ 240
00125          REAL MPWR,L,LAT,LAMBDA                                          READ 250
00126          DATA JA/1HA/                                                    READ 260
00126    C     THIS SUBROUTINE READS ALL MODEL AND PROGRAM PARAMETERS AND CHECKS READ 270
00126    CC     TO MAKE SURE CRITICAL LIMITS ARE NOT EXCEEDED. ALSO, CALCULATED READ 280
00126    C     MODEL PARAMETERS ARE DETERMINED HERE.                           READ 290
00130          IF (NXS .LE. 100) GO TO 2                                       READ 300
00132          WRITE (6,900) IWD(1),NXS,IRD(1)                                 READ 310
00137          IERR = 1                                                        READ 320
00140        2 IF (NYS .LE. 100) GO TO 4                                       READ 330
00142          WRITE (6,900) IWD(2),NYS,IRD(1)                                 READ 340
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00147          IERR = 1                                         READ 350
00150        4 IF (NZS .LE. 21) GO TO 6                         READ 360
00152          WRITE (6,900) IWD(3),NZS,IRD(3)                  READ 370
00157          IERR = 1                                         READ 380
00160        6 IF (NDI .LE. 10) GO TO 8                         READ 390
00162          WRITE (6,900) IWD(4),NDI,IRD(4)                  READ 400
00167          IERR = 1                                         READ 410
00170        8 IF (NCI .LE. 10) GO TO 10                        READ 420
00172          WRITE (6,900) IWD(5),NCI,IRD(4)                  READ 430
00177          IERR = 1                                         READ 440
00200       10 IF (NDXR .LE. 100) GO TO 12                      READ 450
00202          WRITE (6,900) IWD(6),NDXR,IRD(1)                 READ 460
00207          IERR = 1                                         READ 470
00210       12 IF (NVS .LE. 20) GO TO 14                        READ 480
00212          WRITE (6,900) IWD(7),NVS,IRD(2)                  READ 490
00217          IERR = 1                                         READ 500
00220       14 IF (NBK .LE. 10) GO TO 16                        READ 510
00222          WRITE (6,900) IWD(8),NBK,IRD(4)                  READ 520
00227          IERR = 1                                         READ 530
00230       16 IF (NVB .LE. 20) GO TO 20                        READ 540
00232          WRITE (6,900) IWD(9),NVB,IRD(2)                  READ 550
00237          IERR = 1                                         READ 560
00240       20 J = 0                                            READ 570
00241          IF (IERR .EQ. 0) GO TO 30                        READ 580
00243       25 READ (5,803) IA,(TESTNO(I),I=1,12)               READ 590
00252          J = J+1                                          READ 600
00253          IF (IA .EQ. JA) RETURN                           READ 610
00255          IF (J .LT. 102.AND.NP .GT. JXJ) GO TO 25         READ 620
00257          WRITE (6,901)                                    READ 630
00261          IERR = 2                                         READ 640
00262          RETURN                                           READ 650
00263       30 CONTINUE                                         READ 660
00264          READ (5,800) (XX(I),I=1,NXS)                     READ 670
00272          READ (5,800) (YY(I),I=1,NYS)                     READ 680
00300          READ (5,800) (Z(I),I=1,NZS)                      READ 690
00306          READ (5,800) (DELX(I),DELY(I),I=1,NNZ)           READ 700
00316          READ (5,801) (Q(I),I=1,NNZ)                      READ 710
00323          READ (5,800) (UBARK(I),I=1,NNZ)                  READ 720
00331          READ (5,800) (SIGAK(I),I=1,NNZ)                  READ 730
00337          READ (5,800) (SIGYO(I),I=1,NNZ)                  READ 740
00345          READ (5,800) (SIGEK(I),I=1,NNZ)                  READ 750
00353          READ (5,800) (ALPHA(I),I=1,NNZ)                  READ 760
00361          READ (5,800) (BETA(I),I=1,NNZ)                   READ 770
00367          READ (5,800) (SIGZO(I),I=1,NNZ)                  READ 780
00375          READ (5,800) (SIGXO(I),I=1,NNZ)                  READ 790
00403          READ (5,800) ZRK,SIGARK,SIGERK,UBARRK,DELPHI     READ 800
00412          NTAR = NNZ*2                                     READ 810
00413          READ (5,800) (THETAK(I),I=1,NTAR)                READ 820
00421          READ (5,800) (TAUK(I),I=1,NNZ)                   READ 830
00427          READ (5,800) (TAUOK(I),I=1,NNZ)                  READ 840
00435          READ (5,800) (T(I),I=1,NNZ)                      READ 850
00443          READ (5,800) (H(I),I=1,NNZ)                      READ 860
00451          DO 34 I=1,NNZ                                    READ 870
00454          IF (SIGAK(I) .LT. .5) SIGAK(I) = .5              READ 880
00456          IF (SIGEK(I) .LT. .1) SIGEK(I) = .1              READ 890
00460          IF (UBARK(I) .LT. .1) UBARK(I) = .1              READ 900
00462       34 CONTINUE                                         READ 910
00464          IF (SIGARK .LT. .5) SIGARK = .5                  READ 920
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00466         IF (SIGERK .LT. .1) SIGERK = .1                                  READ 930
00470         IF (UBARRK .LT. .1) UBARRK = .1                                  READ 940
00472         IF (ISKIP(1) .EQ. 2) GO TO 50                                    READ 950
00474         READ (5,802) (IZMOD(I),I=1,NNZ)                                  READ 960
00502         READ (5,802) (NPT(I),I=1,NNZ)                                    READ 970
00510         READ (5,800) DECAY,ZLIM,TIM1,LAMBDA                              READ 980
00516         READ (5,800) (CXR(I),I=1,NDXR)                                   READ 990
00524         READ (5,802) (IFLAG(I),I=1,NDXR)                                 READ1000
00532         READ (5,801) (DI(I),I=1,NDI)                                     READ1010
00540         READ (5,801) (CI(I),I=1,NCI)                                     READ1020
00546         IF (ISKIP(13) .EQ. 0) GO TO 40                                   READ1030
00550         READ (5,800) (UBARL(I),I=1,NBK)                                  READ1040
00556         READ (5,800) (SIGAL(I),I=1,NBK)                                  READ1050
00564         NTAK = NNZ+1                                                     READ1060
00565         NTAP = NNZ+NBK                                                   READ1070
00566         READ (5,800) (SIGYO(I),I=NTAK,NTAP)                              READ1080
00574         READ (5,800) (SIGEL(I),I=1,NBK)                                  READ1090
00602         READ (5,800) (ALPHA(I),I=NTAK,NTAP)                              READ1100
00610         READ (5,800) (BETA(I),I=NTAK,NTAP)                               READ1110
00616         READ (5,800) (SIGZO(I),I=NTAK,NTAP)                              READ1120
00624         READ (5,800) (SIGXO(I),I=NTAK,NTAP)                              READ1130
00632         READ (5,800) ZRL,SIGARL,SIGERL,UBARRL                            READ1140
00640         NTAR = NBK*2                                                     READ1150
00641         READ (5,800) (THETAL(I),I=1,NTAR)                                READ1160
00647         READ (5,800) (TAUL(I),I=1,NBK)                                   READ1170
00655         READ (5,800) (TAUOL(I),I=1,NBK)                                  READ1180
00663         READ (5,800) (TAST(I),I=1,NBK)                                   READ1190
00671         READ (5,802) (JBOT(I),JTOP(I),I=1,NBK)                           READ1200
00700         DO 43 I=1,NBK                                                    READ1210
00703         IF (SIGAL(I) .LT. .5) SIGAL(I) = .5                              READ1220
00705         IF (SIGEL(I) .LT. .1) SIGEL(I) = .1                              READ1230
00707         IF (UBARL(I) .LT. .1) UBARL(I) = .1                              READ1240
00711      43 CONTINUE                                                         READ1250
00713         IF (SIGARL .LT. .5) SIGARL = .5                                  READ1260
00715         IF (SIGERL .LT. .1) SIGERL = .1                                  READ1270
00717         IF (UBARRL .LT. .1) UBARRL = .1                                  READ1280
00721         GO TO 60                                                         READ1290
00722      50 CONTINUE                                                         READ1300
00723         READ (5,800) (VS(I),I=1,NVS)                                     READ1310
00731         READ (5,800) (PERC(I),I=1,NVS)                                   READ1320
00737         READ (5,800) ACCUR                                               READ1330
00742         IF (ISKIP(3) .EQ. 0) GO TO 60                                    READ1340
00744         READ (5,800) (VB(I),I=1,NVB)                                     READ1350
00752         READ (5,800) (PERCB(I),I=1,NVB)                                  READ1360
00760         READ (5,800) HR                                                  READ1370
00763      60 CONTINUE                                                         READ1380
00764         IF (ISKIP(1) .EQ. 2) GO TO 62                                    READ1390
00766         IF (Z(1)-0.0) 62,61,62                                           READ1400
00771      61 Z(1) = 2.0                                                       READ1410
00772      62 CONTINUE                                                         READ1420
00773         S = (Z(2)/ZRK)                                                   READ1430
00774         S1 = ALOG(S)                                                     READ1440
00775         P = ALOG(UBARK(1)/UBARRK)/S1                                     READ1450
00776         IF (P+1.0)  65,64,65                                             READ1460
01001      64 P = -.9999999                                                    READ1470
01002      65 CONTINUE                                                         READ1480
01003         UBAR(1) = (UBARRK/((1.0+P)*(Z(2)-ZRK)*ZRK**P))*(Z(2)**(1.0+P)-ZRK*READ1490
01003        1*(1.0+P))                                                        READ1500
```

```
C1004          PPWR = P                                                            READ1510
01005          DO 150 I=2,NNZ                                                      READ1520
01010      150 UBAR(I) = (UBARK(I)+UBARK(I-1))/2.0                                 READ1530
01012          P = ALOG(SIGAK(I)/SIGARK)/S1                                        READ1540
01013          IF (P + 1.0) 155,154,155                                            READ1550
01016      154 P = -.9999999                                                       READ1560
01017      155 CONTINUE                                                            READ1570
01020          SIGAP(1) = ((SIGARK*(TAUK(1)/TAUDK(1))**(1.0/5.0)*RAD)/((1.0+P)*    READ1580
01020         1(Z(2)-ZRK)*ZRK**P))*(Z(2)**(1.0+P)-ZRK**(1.0+P))                   READ1590
01021          HPWR = P                                                            READ1600
01022          DO 160 I=2,NNZ                                                      READ1610
01025      160 SIGAP(I) = ((SIGAK(I)+SIGAK(I-1))*(TAUK(I)/TAUDK(I))**(1.0/5.0)*    READ1620
01025         1RAD)/2.0                                                            READ1630
01027          P = ALOG(SIGEK(1)/SIGERK)/S1                                        READ1640
01030          IF (P + 1.0) 165,164,165                                            READ1650
01033      164 P = -.9999999                                                       READ1660
01034      165 CONTINUE                                                            READ1670
01035          SIGEP(1) = (SIGERK/((1.0+P)*(Z(2)-ZRK)*ZRK**P))*(Z(2)**(1.0+P)-ZRKREAD1680
01035         1**(1.0+P))*RAD                                                      READ1690
01036          QPWR = P                                                            READ1700
01037          DO 170 I=2,NNZ                                                      READ1710
01042      170 SIGEP(I) = ((SIGEK(I)+SIGEK(I-1))*RAD)/2.0                          READ1720
01044          DO 180 I=1,NNZ                                                      READ1730
01047          J = I*2-1                                                           READ1740
01050          IF (ABS(THETAK(J)-THETAK(J+1)) .LT. 180.0) GO TO 178                READ1750
01052          IF (THETAK(J) .GT. THETAK(J+1)) THETAK(J+1) = THETAK(J+1)+360.0     READ1760
01054          IF (THETAK(J) .LT. THETAK(J+1)) THETAK(J) = THETAK(J)+360.0         READ1770
01056      178 CONTINUE                                                            READ1780
01057          THETA(I) = (THETAK(J)+THETAK(J+1))/2.0                              READ1790
01060          IF (THETA(I) .GE. 360.0) THETA(I) = THETA(I)-360.0                  READ1800
01062      180 DELTHP(I) = (THETAK(J+1)-THETAK(J))                                 READ1810
01064          DELU(1) = UBARK(1)-UBARRK                                           READ1820
01065          DO 190 I=2,NNZ                                                      READ1830
01070      190 DELU(I) = UBARK(I)-UBARK(I-1)                                       READ1840
01072          IF (ISKIP(1) .EQ. 2) GO TO 260                                      READ1850
01074          IF (ISKIP(13) .EQ. 0) GO TO 250                                     READ1860
01076          M = JTOP(1)                                                         READ1870
01077          IF (JBOT(1) .GT. 1) GO TO 193                                       READ1880
01101          S = (Z(M+1)/ZRL)                                                    READ1890
01102          S1 = ALOG(S)                                                        READ1900
01103          P = ALOG(UBARL(1)/UBARRL)/S1                                        READ1910
01104          IF (P + 1.0) 192,191,192                                            READ1920
01107      191 P = -.9999999                                                       READ1930
01110      192 CONTINUE                                                            READ1940
01111          UBAR(NNZ+1) = (UBARRL/((1.0+P)*(Z(M+1)-ZRL)*ZRL**P))*(Z(M+1)**(1.0READ1950
01111         1+P)-ZRL**(1.0+P))                                                   READ1960
01112          QPWR = P                                                            READ1970
01113          GO TO 197                                                           READ1980
01114      193 UBAR(NNZ+1) = (UBARRL+UBARL(1))/2.0                                 READ1990
01115      197 DO 200 I=2,NBK                                                      READ2000
01120      200 UBAR(NNZ+I) = (UBARL(I)+UBARL(I-1))/2.0                             READ2010
01122          IF (JBOT(1' .GT. 1) GO TO 210                                       READ2020
01124          P = ALOG(SIGEL(1)/SIGERL)/S1                                        READ2030
01125          IF (P + 1.0) 205,204,205                                            READ2040
01130      204 P = -.9999999                                                       READ2050
01131      205 CONTINUE                                                            READ2060
01132          SIGEP(NNZ+1) = (SIGERL/((1.0+P)*(Z(M+1)-ZRL)*ZRL**P))*(Z(M+1)**(1.READ2070
01132         10+P)-ZRL**(1.0+P))*RAD                                              READ2080
```

```
      GO TO 215                                                         READ2090
  210 SIGEP(NNZ+I) = ((SIGEL(I)+SIGERL)*RAD)/2.0                        READ2100
  215 DO 220 I=2,NBK                                                    READ2110
  220 SIGEP(NNZ+I) = ((SIGEL(I)+SIGEL(I-1))*RAD)/2.0                    READ2120
      DO 230 I=1,NBK                                                    READ2130
      J = I*2-1                                                         READ2140
      IF (ABS(THETAL(J)-THETAL(J+1)) .LT. 180.0) GO TO 228              READ2150
      IF (THETAL(J) .GT. THETAL(J+1)) THETAL(J+1) = THETAL(J+1)+360.0   READ2160
      IF (THETAL(J) .LT. THETAL(J+1)) THETAL(J) = THETAL(J)+360.0       READ2170
  228 CONTINUE                                                          READ2180
      THETA(NNZ+I) = (THETAL(J)+THETAL(J+1))/2.0                        READ2190
      IF (THETA(NNZ+I) .GE. 360.0) THETA(NNZ+I) = THETA(NNZ+I)-360.0    READ2200
  230 DELTHP(NNZ+I) = (THETAL(J+1)-THETAL(J))                           READ2210
      DELU(NNZ+1) = UBARL(1)-UBARRL                                     READ2220
      DO 235 I=2,NBK                                                    READ2230
  235 DELU(NNZ+I) = UBARL(I)-UBARL(I-1)                                 READ2240
      IF (JBOT(1) .GT. 1) GO TO 242                                     READ2250
      P = ALOG(SIGAL(1)/SIGARL)/S1                                      READ2260
      IF (P + 1.0) 240,239,240                                          READ2270
  239 P = -.9999999                                                     READ2280
  240 CONTINUE                                                          READ2290
      SIGAP(NNZ+1)= ((SIGARL*(TAUL(1)/TAUOL(1))**(1.0/5.0)*RAD)/((1.0+P)READ2300
     1*(Z(M+1)-ZRL)*ZRL**P))*(Z(M+1)**(1.0+P)-ZRL**(1.0+P))             READ2310
      GO TO 243                                                         READ2320
  242 SIGAP(NNZ+1) = ((SIGAL(1)+SIGARL)*RAD)/2.0                        READ2330
  243 CONTINUE                                                          READ2340
      DO 245 I=2,NBK                                                    READ2350
  245 SIGAP(NNZ+I) = ((SIGAL(I)+SIGAL(I-1))*(TAUL(I)/TAUOL(I))**(1.0/5.0READ2360
     1)*RAD)/2.0                                                        READ2370
  250 CONTINUE                                                          READ2380
      IF (ISKIP(1) .EQ. 0) DECAY = 0.0                                  READ2390
  260 CONTINUE                                                          READ2400
      RETURN                                                            READ2410
  800 FORMAT (8F10.0)                                                   READ2420
  801 FORMAT (6E12.6)                                                   READ2430
  802 FORMAT (40I2)                                                     READ2440
  803 FORMAT (A1,12A6)                                                  READ2450
  900 FORMAT (1H0,12H***** ERROR ,A4,1H=,I6,10H LIMIT IS ,A3,17H, GO TO READ2460
     1NEXT CASE//)                                                      READ2470
  901 FORMAT (51H0 ***** ERROR (A) INDICATOR FOR NEXT CASE NOT FOUND)   READ2480
      END                                                               READ2490

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
```

@ XQT MODEL

APPENDIX C

FLOW CHART FOR MULTI-LAYER DIFFUSION MODEL COMPUTER PROGRAM

Appendix C contains the complete flow diagram of the computer program for the Multi-Layer Diffusion Model. The program requires 102034_8 locations of executable storage and consists of the main driver routine plus 21 subroutines. Diagrams of the call linkage between subroutines are given in Sections A. 7 and A. 8 of Appendix A.

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SECTION C.1

MAIN PROGRAM

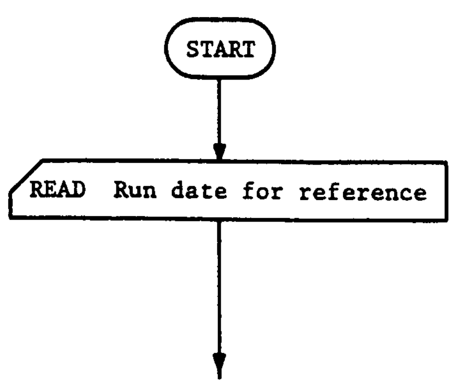
This section contains the flow chart for the main driver routine that initiates communication between the various subroutines. This routine is executed NP times, or until an end-of-file is read. Storage used for the main driver routine is 2742_8.

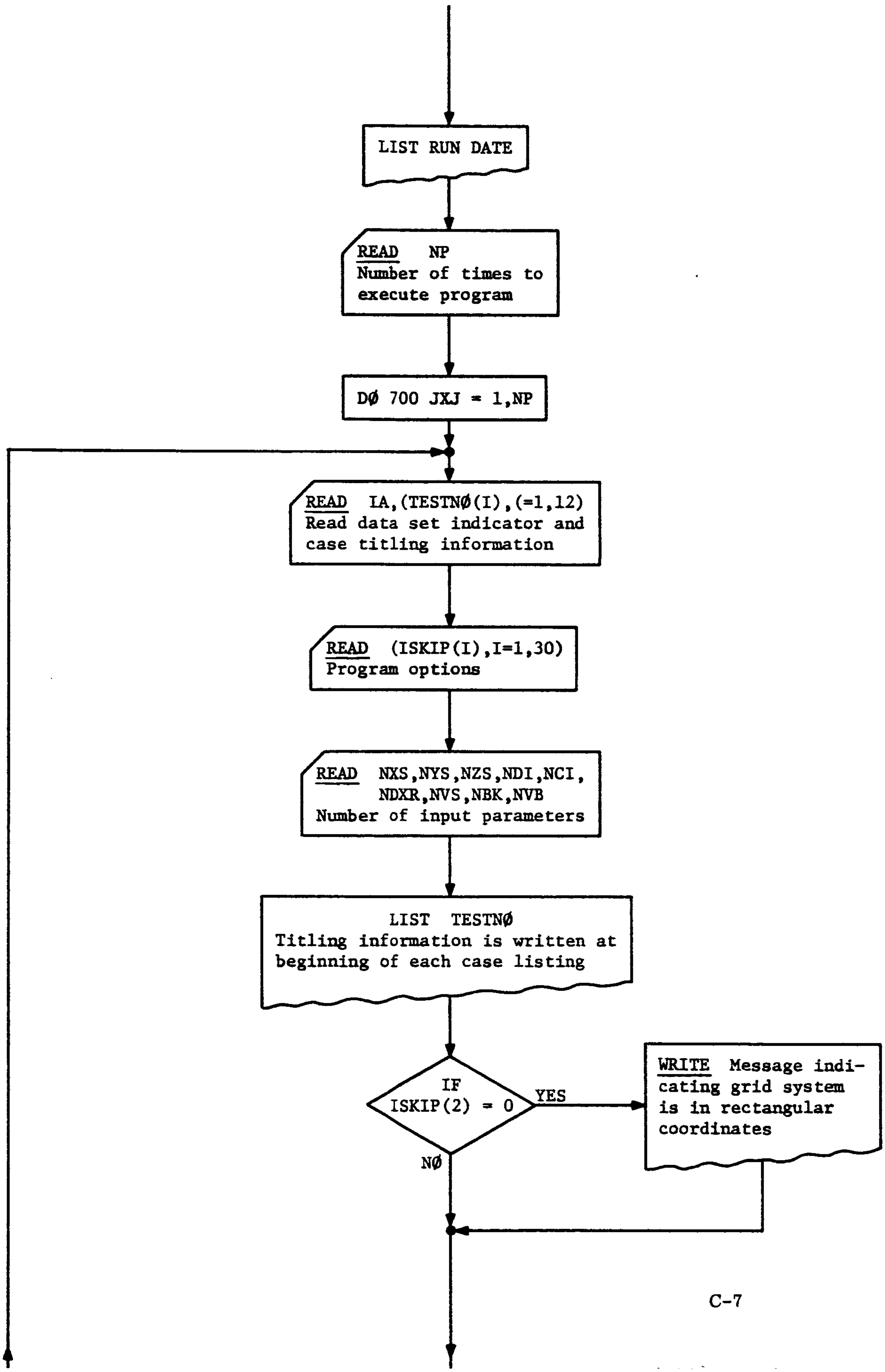
```
ISKIP  = PROGRAM CONTROL OPTIONS
H      = EFFECTIVE RELEASE HEIGHT IN LAYER (METERS)
Z      = BOUNDARY HEIGHTS OF LAYERS (METERS)
Q      = SOURCE STRENGTH IN LAYER (MASS/HEIGHT)
UBAR   = CALCULATED TRANSPORT SPEED IN LAYER
ALPHA  = LATERAL POWER LAW EXPANSION COEFFICIENT
BETA   = VERTICAL POWER LAW EXPANSION COEFFICIENT
SIGYØ  = STANDARD DEVIATION OF THE LATERAL SOURCE DIMENSION (METER)
SIGAP  = CALCULATED LATERAL DIFFUSION COEFFICIENT IN LAYER
SIGXØ  = STANDARD DEVIATION OF THE ALONGWIND SOURCE DIMENSION (METERS)
DELTHP = CALCULATED WIND DIRECTION SHEAR IN LAYER
SIGZØ  = STANDARD DEVIATION OF THE VERTICAL SOURCE DIMENSION (METERS)
SIGEP  = CALCULATED VERTICAL DIFFUSION COEFFICIENT
DELX   = X COORDINATE OF SOURCE IN LAYER RELATIVE TO ORIGIN OF FIXED
         GRID SYSTEM (METERS, RECTANGULAR OR POLAR)
DELY   = Y COORDINATE OF SOURCE IN LAYER RELATIVE TO ORIGIN OF FIXED
         GRID SYSTEM (METERS, DEGREES**RECTANGULAR, POLAR)
THETA  = CALCULATED MEAN WIND DIRECTION IN LAYER
IZMØD  = MODEL NO TO USE IN LAYER (1, 2 OR 3)
NPT    = NUMBER OF CALCULATION HEIGHTS ZZL DESIRED IN LAYER
DELU   = CALCULATED WIND SPEED SHEAR
ZZL    = CALCULATION HEIGHTS IN LAYER
XR     = CLOUD HALF WIDTHS
DØS    = CALCULATED VALUE OF DOSAGE
CØN    = CALCULATED VALUE OF CONCENTRATION
PEAKD  = PART OF DOSAGE EQUATION
XX     = X COORDINATE OF RECEPTOR RELATIVE TO FIXED GRID SYSTEM (POSITIVE
         X AXIS EAST 90 DEGREES, METERS, RECTANGULAR OR POLAR)
YY     = Y COORDINATE OF RECEPTOR RELATIVE TO FIXED GRID SYSTEM (POSITIVE
         Y AXIS NORTH 0 DEGREES, METERS OR DEGREES, RECTANGULAR OR POLAR)
PLT    = CALCULATED VALUES OF DOSAGE AND CONCENTRATION ISOPLETHS
LAT    = LATERAL TERM OF DOSAGE EQUATION
VER    = VERTICAL TERM OF DOSAGE EQUATION
VREF   = REFLECTION TERM OF DOSAGE EQUATION
ALØNGW = ALONGWIND TERM OF CONCENTRATION EQUATION
DXR    = RADIAL DISTANCES FOR MAXIMUM PEAK DOSAGE AND CONCENTRATION AND
         ISOPLETH AND CLOUD HALF-WIDTH CALCULATIONS
T      = TIME AFTER CLOUD STABILIZATION EXCEPT IN GRAVITATIONAL DEPOSI-
         TION MODEL SOURCE EMISSION TIME IN LAYER (SECONDS)
IFLAG  = FLAG TO INDICATE AT WHICH DISTANCES DXR VERTICAL ISOPLETHS ARE
         TO BE CALCULATED
ITAG   = FLAG TO INDICATE WHICH RECEPTOR COORDINATES ARE OUTSIDE OF
         CALCULATION SECTOR DELPHI
TESTNØ = CASE TITLE
DI     = DOSAGE ISOPLETH VALUES OF INTEREST
CI     = CONCENTRATION ISOPLETH VALUES OF INTEREST
SIGZ   = CALCULATED STANDARD DEVIATION OF THE VERTICAL DOSAGE DISTRIBUTION
SIGY   = CALCULATED STANDARD DEVIATION OF THE LATERAL DOSAGE DISTRIBUTION
SIGX   = CALCULATED STANDARD DEVIATION OF THE ALONGWIND DOSAGE DISTRIBUTION
SQR2P  = SQUARE ROOT TWO PI
L      = LENGTH OF CLOUD IN ALONGWIND DIRECTION
TH     = THETA*PI/180
I      = INDEX OF X COORDINATES
J      = INDEX OF Y COORDINATES
```

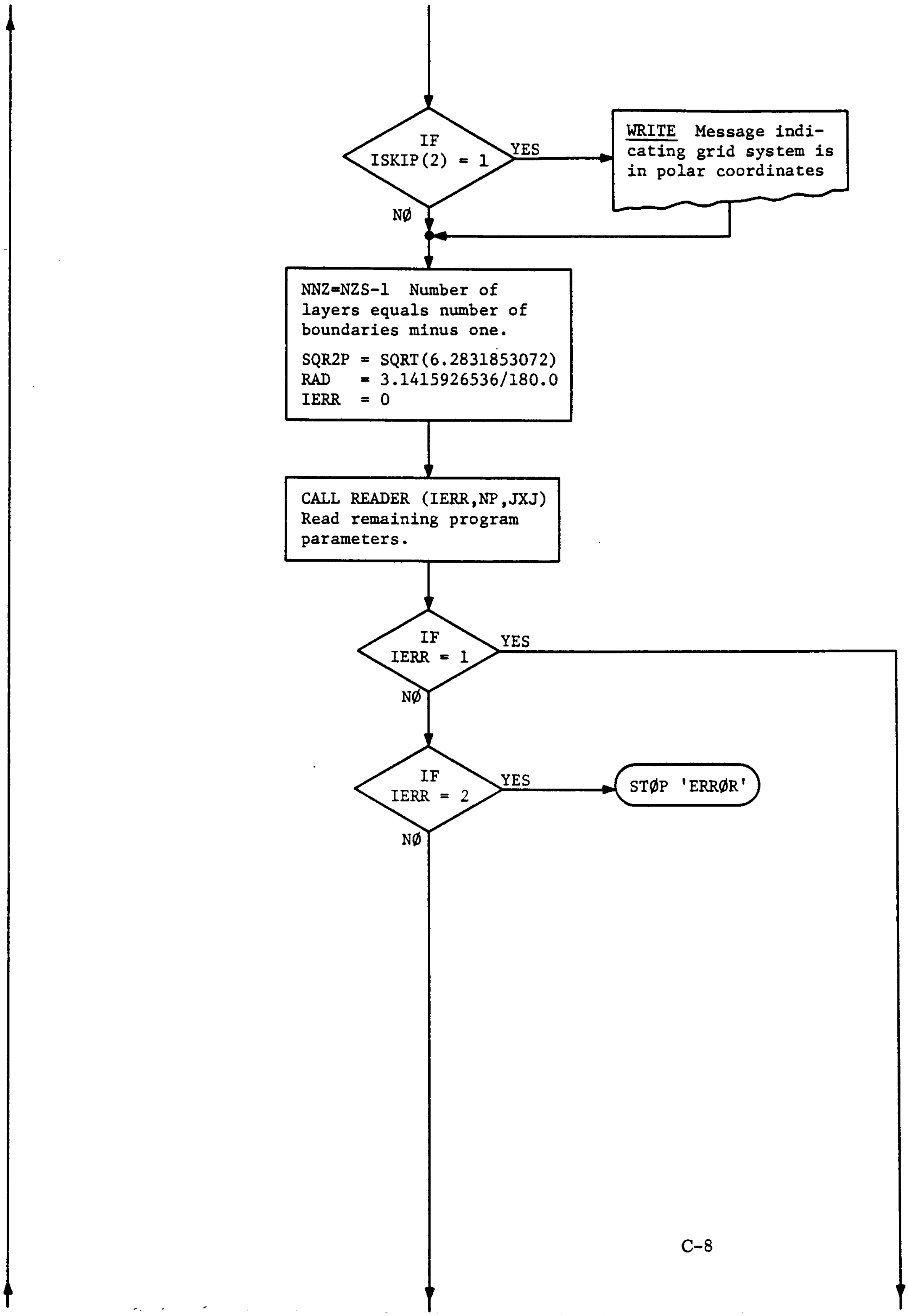
KK = INDEX OF LAYERS
K = INDEX OVER CALCULATION HEIGHTS ZZL
STØ1 = TEMP STORAGE
STØ2 = TEMP STORAGE
STØ3 = TEMP STORAGE
TRD = HALF CALCULATION SECTOR DELPHI
TAST = TIME OF LAYER STRUCTURE CHANGE (SECONDS)
NBK = NO OF DISTINCT GROUPS OF LAYERS THAT FORM INTO ONE AT TIME TAST
ILK = INDEX ON NEW LAYERS AFTER TIME TAST
NXS = NO OF X COORDINATES
NYS = NO OF Y COORDINATES
NZS = NO OF LAYER BOUNDARIES
NDI = NO OF DOSAGE ISOPLETHS
NCI = NO OF CONCENTRATION ISOPLETHS
NDXR = NO OF RADIAL DISTANCES DXR ALONG CLOUD AXIS
RAD = PI/180
NNZ = NZS-1 NO OF LAYERS
ITØP = TOP OF NEW LAYER AFTER TAST IN TERMS OF OLD LAYER STRUCTURE
IBØT = BOTTOM OF NEW LAYER AFTER TAST IN TERMS OF OLD LAYER STRUCTURE (ITØP AND IBØT INDEXES)
XAST = CALCULATE DISTANCE TO TAST
SIGXNK = SIGX OF NEW LAYER STRUCTURE
LAMBDA = WASHOUT COEFFICIENT
TIM1 = TIME OF START OF RAIN (SECONDS)
TIM2 = TIME RAIN STOPS (SECONDS)
ZLIM = MAXIMUM HEIGHT OF WASHOUT
WASHOU = CALCULATE WASHOUT AT GROUND
UBARK = WIND SPEED AT TOP OF LAYER (METERS/SEC)
SIGAK = SIGAP AT TOP OF LAYER (DEGREES)
SIGEK = SIGEP AT TOP OF LAYER (DEGREES)
ZRK = REFERENCE HEIGHT IN SURFACE LAYER (METERS)
SIGARK = SIGAP AT ZRK (DEGREES)
SIGERK = SIGEP AT ZRK (DEGREES)
UBARRK = WIND SPEED AT ZRK (METERS/SEC)
THETAK = WIND DIRECTION AT LAYER BOUNDARIES (DEGREES)
TAUK = TIME IN SECONDS REQUIRED FOR LATERAL CLOUD STABILIZATION
TAUØK = SAMPLING PERIOD IN SECONDS AT THE TOP OF THE LAYER
DECAY = DECAY COEFFICIENT IN DOSAGE EQUATION
UBARL = WIND SPEED AT TOP OF NEW LAYER AFTER TAST (METERS/SEC)
SIGAL = SIGAP AT TOP OF NEW LAYER AFTER TAST (DEGREES)
SIGEL = SIGEP AT TOP OF NEW LAYER AFTER TAST (DEGREES)
ZRL = REFERENCE HEIGHT IN SURFACE LAYER OF NEW STRUCTURE (METERS)
SIGARL = SIGAP AT ZRL IF FIRST LAYER INCLUDES OLD SURFACE LAYER ELSE EQUALS SIGAP AT BOTTOM OF FIRST NEW LAYER (DEGREES)
SIGERL = SIGAP AT ZRL IF FIRST LAYER INCLUDES OLD SURFACE LAYER ELSE EQUALS SIGEP AT BOTTOM OF FIRST NEW LAYER (DEGREES)
UBARRL = WIND SPEED AT ZRL IF FIRST LAYER INCLUDES OLD SURFACE LAYER ELSE EQUALS WIND SPEED AT BOTTOM OF FIRST NEW LAYER (METERS/SEC)
THETAL = WIND DIRECTION AT BOUNDARIES OF NEW LAYER STRUCTURE (DEGREES)
TAUL = TIME IN SECONDS FOR LATERAL CLOUD STABILIZATION IN NEW LAYER STRUCTURE
TAUØL = TIME IN SECONDS OF SAMPLING PERIOD AT TOP OF NEW LAYER
JBØT = INPUT LAYER NUMBER OF BOTTOM OF NEW LAYER STRUCTURE RELATIVE TO OLD

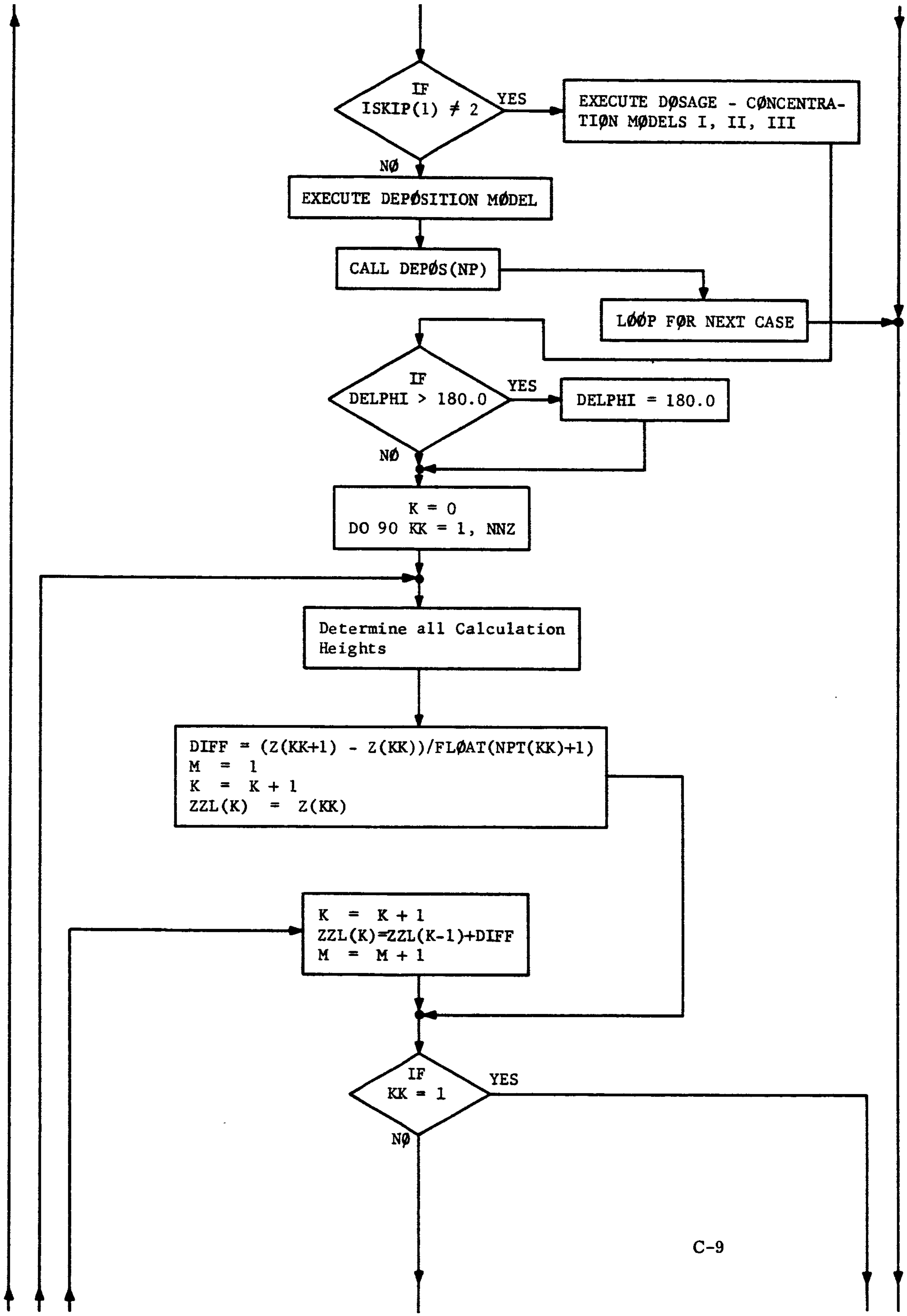
JTØP	= INPUT LAYER NUMBER OF TOP OF NEW LAYER STRUCTURE RELATIVE TO OLD
VS	= SETTLING VELOCITY IN GRAVITATIONAL DEPOSITION MODEL
PERC	= FREQUENCY OF VS
ACCUR	= DESIRED ACCURACY COEFFICIENT (.45) INSURES THAT GROUND DEPOSITION FROM NXCI POINT SOURCES IN THE LAYER VARIES LESS THAN TEN PERCENT FROM DEPOSITION EXPECTED FROM A VERTICAL LINE SOURCE IN THE LAYER. FOR (.32) REDUCED TO FIVE PERCENT
VB	= SETTLING VELOCITIES FROM A BURST OR DESTRUCT IN LAYER NNZ
PERCB	= FREQUENCY OF VB
HB	= HEIGHT OF BURST (METERS)
PPWR	= CALCULATED WIND SPEED POWER LAW EXPONENT
QPWR	= CALCULATED SIGEP POWER LAW EXPONENT
MPWR	= CALCULATED SIGAP POWER LAW EXPONENT
DTHK	= WIND ANGLE SHEAR
NVS	= NUMBER OF SETTLING VELOCITIES VS
NVB	= NUMBER OF SETTLING VELOCITIES VB
LB1	= PRINTED INFORMATION =LB2, LB3, LB4
DATE	= RUN DATE
II	= INDEX ON VS AND VB
DEP	= TEMP STORAGE
YBARY	= CALCULATED COORDINATE OF POINT ON CLOUD AXIS OF VS AT INTERSECTION WITH GROUND (DEPOSITION)
XBARX	= CALCULATED COORDINATE OF POINT ON CLOUD AXIS OF VS AT INTERSECTION WITH GROUND (DEPOSITION)
UBARNK	= CALCULATED WIND SPEED (DEPOSITION)
BETANK	= CALCULATED BETA (DEPOSITION)
ALPHNK	= CALCULATED ALPHA (DEPOSITION)
SQBAR	= TEMP STORAGE
ANG	= ANGLE TO POINT XBARX, YBARY (DEPOSITION)
NXCI	= NUMBER OF POINT SOURCES IN LAYER (DEPOSITION)
DEPN	= CALCULATED VALUE OF GRAVITATIONAL DEPOSITION
SIGYNK	= SIGY OF NEW LAYER STRUCTURE IN CALCULATION OF DOSAGE AND CONCENTRATION
SIGENK	= CALCULATED SIGEP (DEPOSITION)
SIGANK	= CALCULATED SIGAP (DEPOSITION)

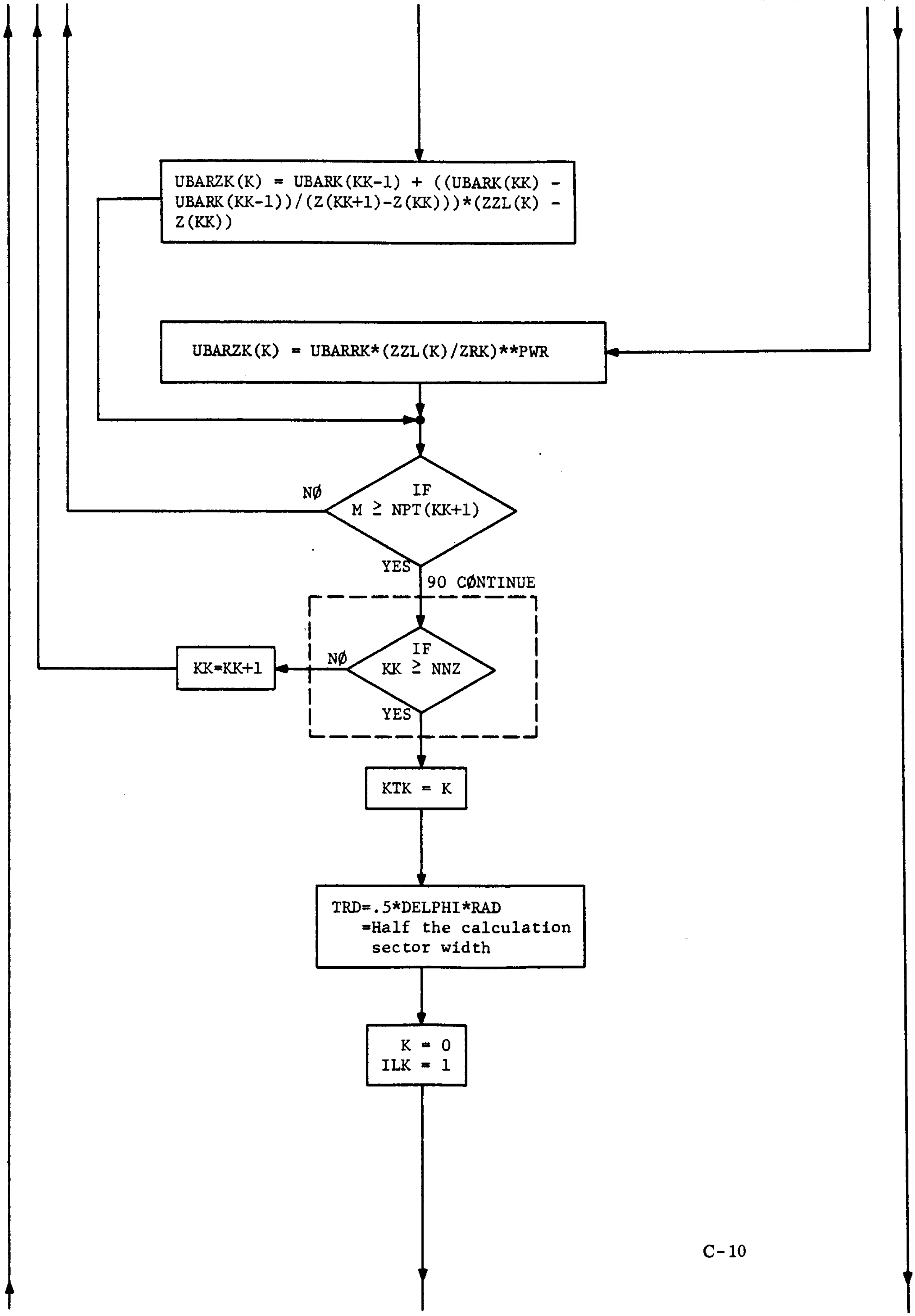
DIMENSION AND COMMON SUBSCRIPTED VARIABLES COMMON TO THE VARIOUS SUBROUTINES.
(COMMON STORAGE USED 61553_8)

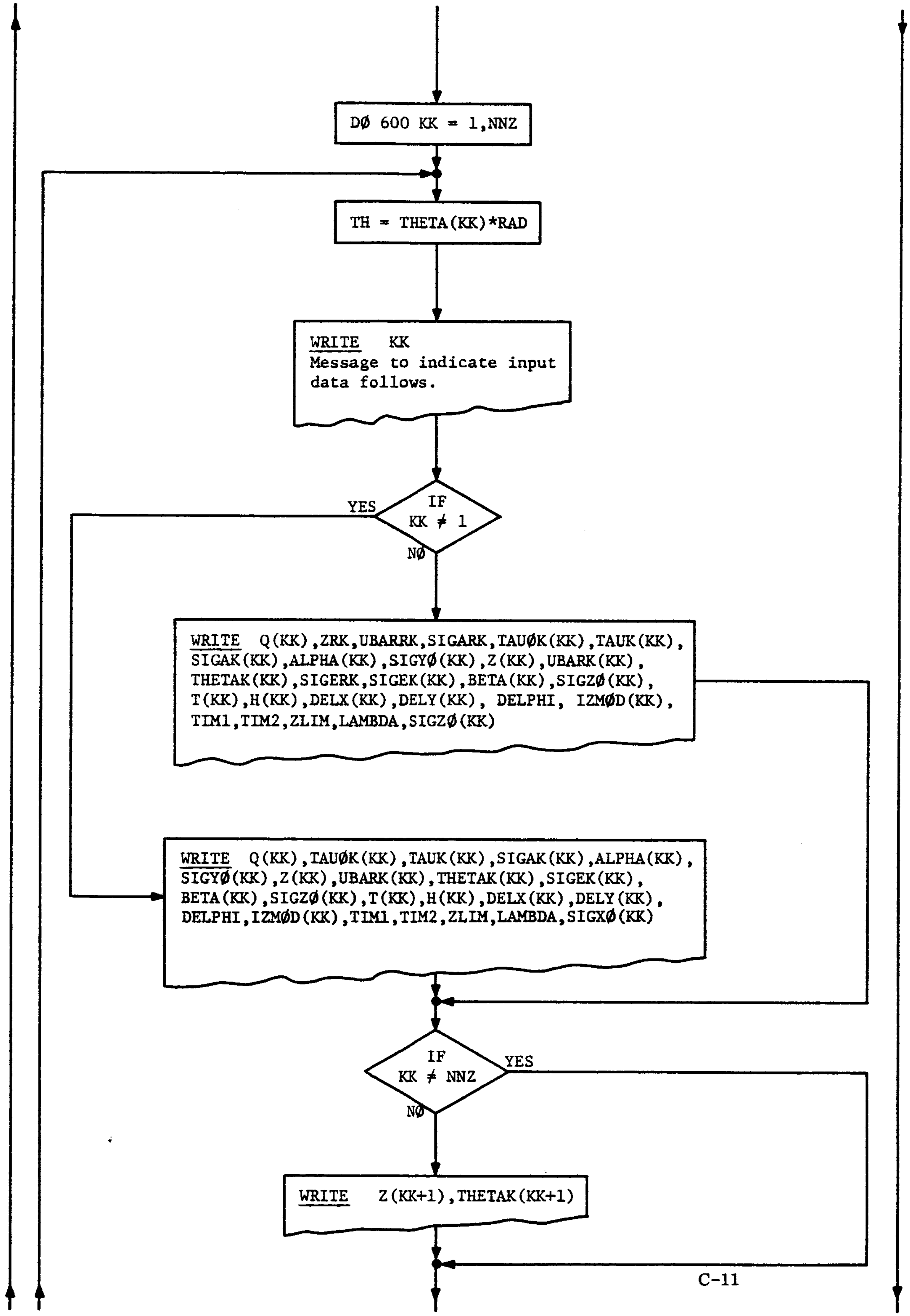


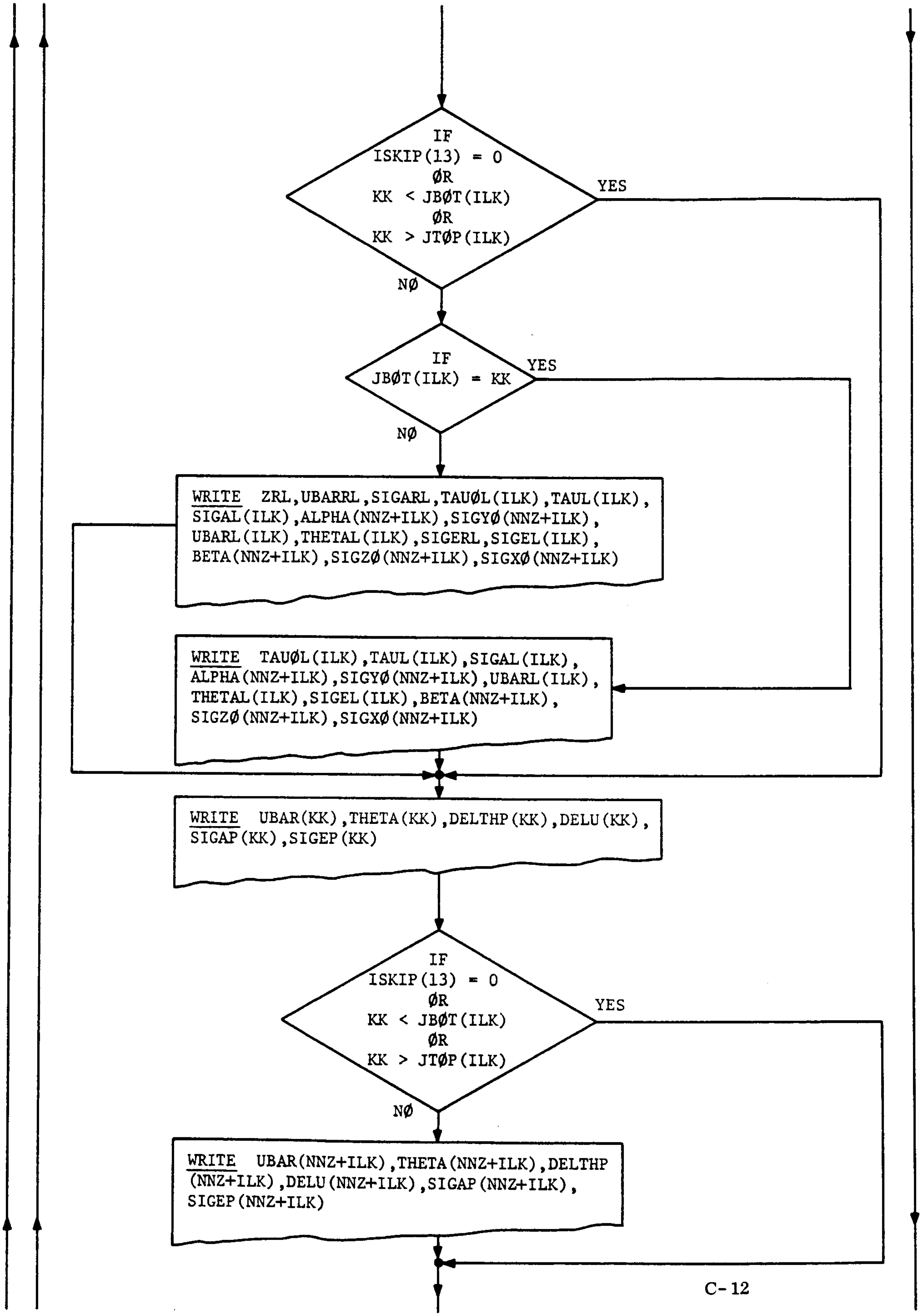

LIST RUN DATE
READ NP
Number of times to execute program
DØ 700 JXJ = 1,NP
READ IA,(TESTNØ(I),(=1,12)
Read data set indicator and case titling information
READ (ISKIP(I),I=1,30)
Program options
READ NXS,NYS,NZS,NDI,NCI,
NDXR,NVS,NBK,NVB
Number of input parameters
LIST TESTNØ
Titling information is written at beginning of each case listing
IF ISKIP(2) = 0
YES
NØ
WRITE Message indicating grid system is in rectangular coordinates

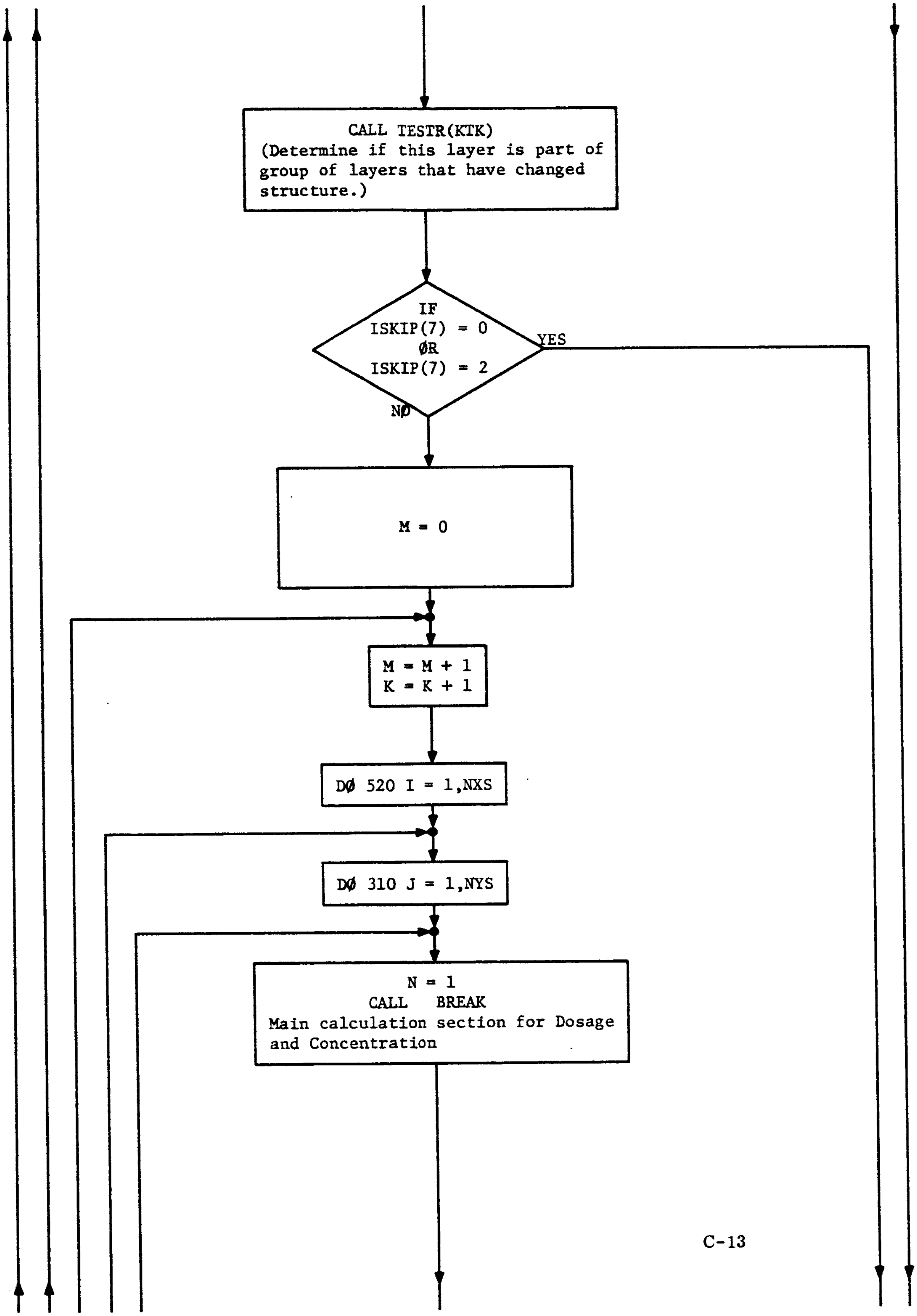

IF
ISKIP(2) = 1
YES
WRITE Message indicating grid system is in polar coordinates
NØ
NNZ=NZS-1 Number of layers equals number of boundaries minus one.
SQR2P = SQRT(6.2831853072)
RAD = 3.1415926536/180.0
IERR = 0
CALL READER (IERR,NP,JXJ)
Read remaining program parameters.
IF
IERR = 1
YES
NØ
IF
IERR = 2
YES
STØP 'ERRØR'
NØ


IF ISKIP(1) ≠ 2
YES
EXECUTE DØSAGE - CØNCENTRA-TIØN MØDELS I, II, III
NØ
EXECUTE DEPØSITION MØDEL
CALL DEPØS(NP)
LØØP FØR NEXT CASE
IF DELPHI > 180.0
YES
DELPHI = 180.0
NØ
K = 0
DO 90 KK = 1, NNZ
Determine all Calculation Heights
DIFF = (Z(KK+1) - Z(KK))/FLØAT(NPT(KK)+1)
M = 1
K = K + 1
ZZL(K) = Z(KK)
K = K + 1
ZZL(K)=ZZL(K-1)+DIFF
M = M + 1
IF KK = 1
YES
NØ

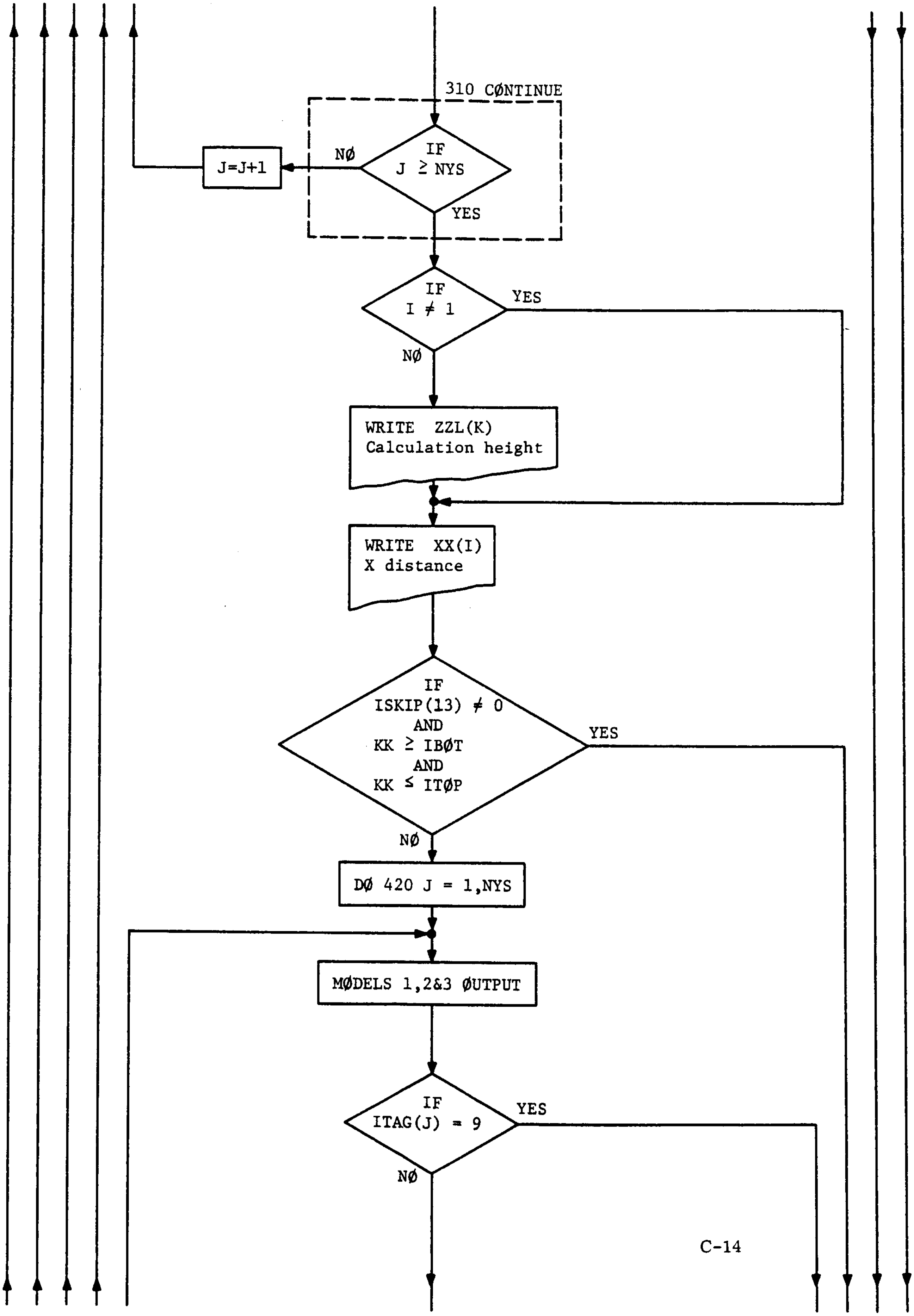

UBARZK(K) = UBARK(KK-1) + ((UBARK(KK) - UBARK(KK-1))/(Z(KK+1)-Z(KK)))*(ZZL(K) - Z(KK))
UBARZK(K) = UBARRK*(ZZL(K)/ZRK)**PWR
NØ
IF M ≥ NPT(KK+1)
YES
90 CØNTINUE
KK=KK+1
NØ
IF KK ≥ NNZ
YES
KTK = K
TRD=.5*DELPHI*RAD =Half the calculation sector width
K = 0
ILK = 1


DØ 600 KK = 1,NNZ
TH = THETA(KK)*RAD
WRITE KK
Message to indicate input data follows.
IF KK ≠ 1
YES
NØ
WRITE Q(KK),ZRK,UBARRK,SIGARK,TAUØK(KK),TAUK(KK),
SIGAK(KK),ALPHA(KK),SIGYØ(KK),Z(KK),UBARK(KK),
THETAK(KK),SIGERK,SIGEK(KK),BETA(KK),SIGZØ(KK),
T(KK),H(KK),DELX(KK),DELY(KK), DELPHI, IZMØD(KK),
TIM1,TIM2,ZLIM,LAMBDA,SIGZØ(KK)
WRITE Q(KK),TAUØK(KK),TAUK(KK),SIGAK(KK),ALPHA(KK),
SIGYØ(KK),Z(KK),UBARK(KK),THETAK(KK),SIGEK(KK),
BETA(KK),SIGZØ(KK),T(KK),H(KK),DELX(KK),DELY(KK),
DELPHI,IZMØD(KK),TIM1,TIM2,ZLIM,LAMBDA,SIGXØ(KK)
IF KK ≠ NNZ
YES
NØ
WRITE Z(KK+1),THETAK(KK+1)

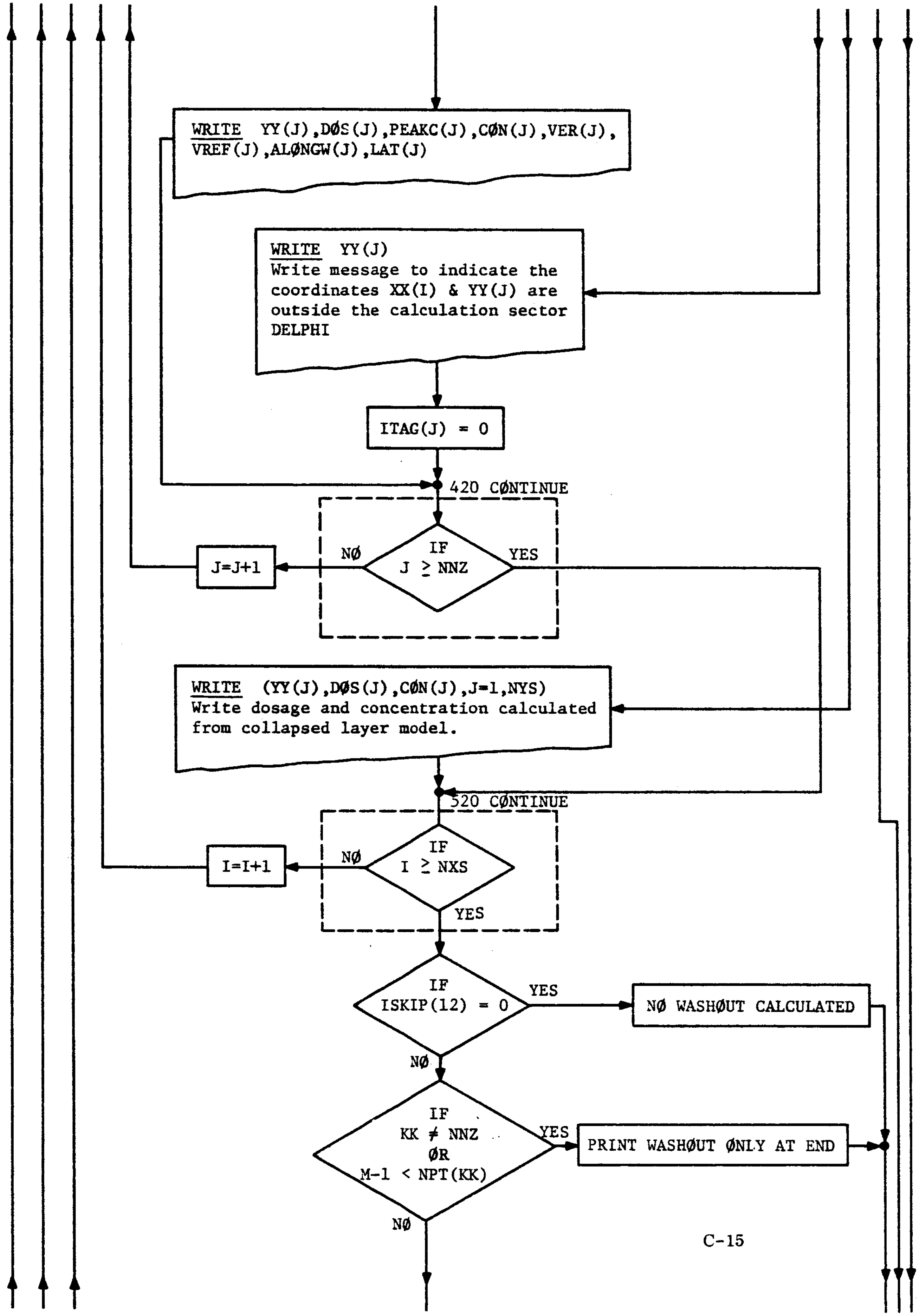

IF ISKIP(13) = 0 ØR KK < JBØT(ILK) ØR KK > JTØP(ILK)
YES
NØ
IF JBØT(ILK) = KK
YES
NØ
WRITE ZRL,UBARRL,SIGARL,TAUØL(ILK),TAUL(ILK), SIGAL(ILK),ALPHA(NNZ+ILK),SIGYØ(NNZ+ILK), UBARL(ILK),THETAL(ILK),SIGERL,SIGEL(ILK), BETA(NNZ+ILK),SIGZØ(NNZ+ILK),SIGXØ(NNZ+ILK)
WRITE TAUØL(ILK),TAUL(ILK),SIGAL(ILK), ALPHA(NNZ+ILK),SIGYØ(NNZ+ILK),UBARL(ILK), THETAL(ILK),SIGEL(ILK),BETA(NNZ+ILK), SIGZØ(NNZ+ILK),SIGXØ(NNZ+ILK)
WRITE UBAR(KK),THETA(KK),DELTHP(KK),DELU(KK), SIGAP(KK),SIGEP(KK)
IF ISKIP(13) = 0 ØR KK < JBØT(ILK) ØR KK > JTØP(ILK)
YES
NØ
WRITE UBAR(NNZ+ILK),THETA(NNZ+ILK),DELTHP (NNZ+ILK),DELU(NNZ+ILK),SIGAP(NNZ+ILK), SIGEP(NNZ+ILK)



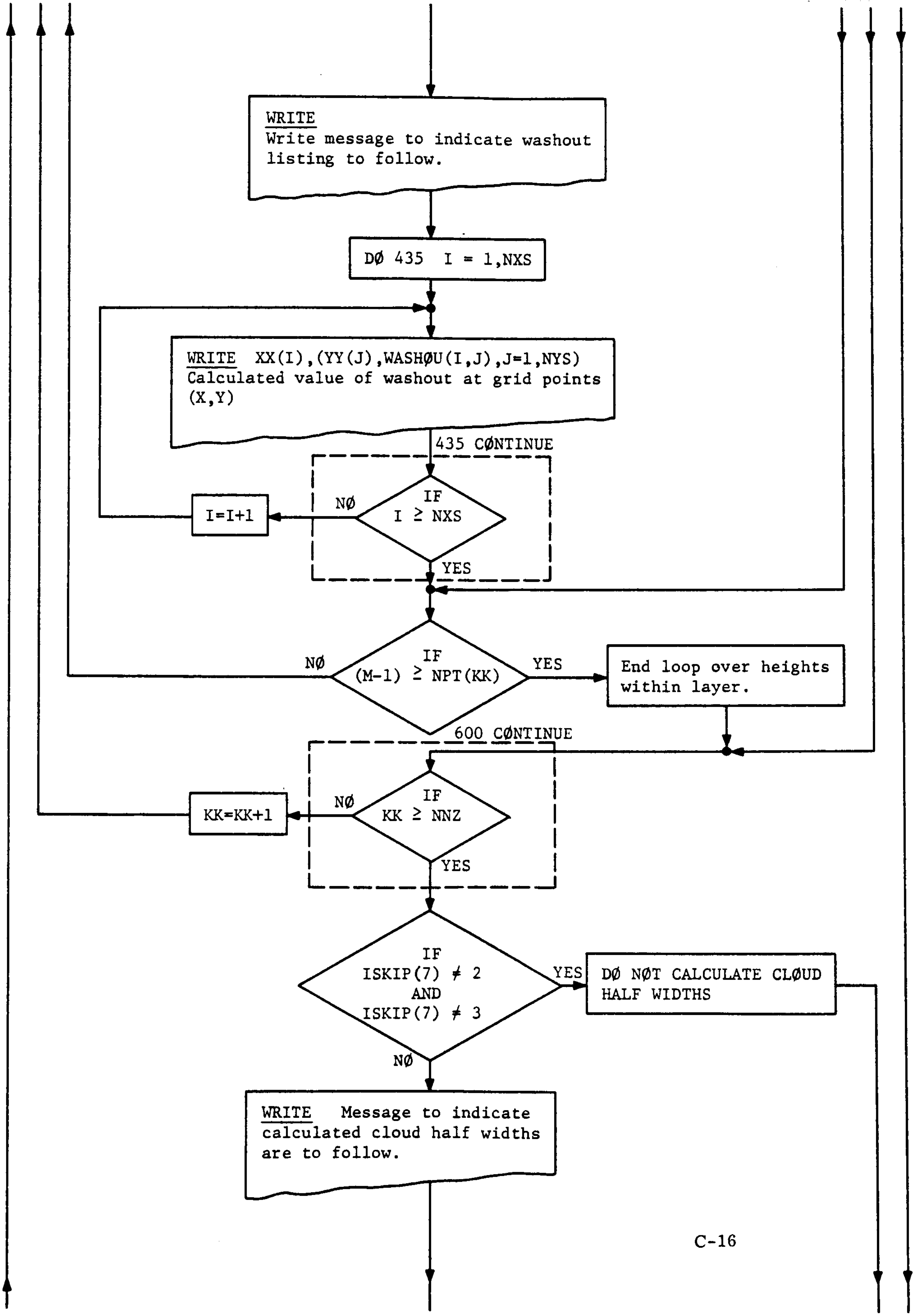
CALL TESTR(KTK)
(Determine if this layer is part of group of layers that have changed structure.)
IF ISKIP(7) = 0 ØR ISKIP(7) = 2
YES
NØ
M = 0
M = M + 1
K = K + 1
DØ 520 I = 1,NXS
DØ 310 J = 1,NYS
N = 1
CALL BREAK
Main calculation section for Dosage and Concentration



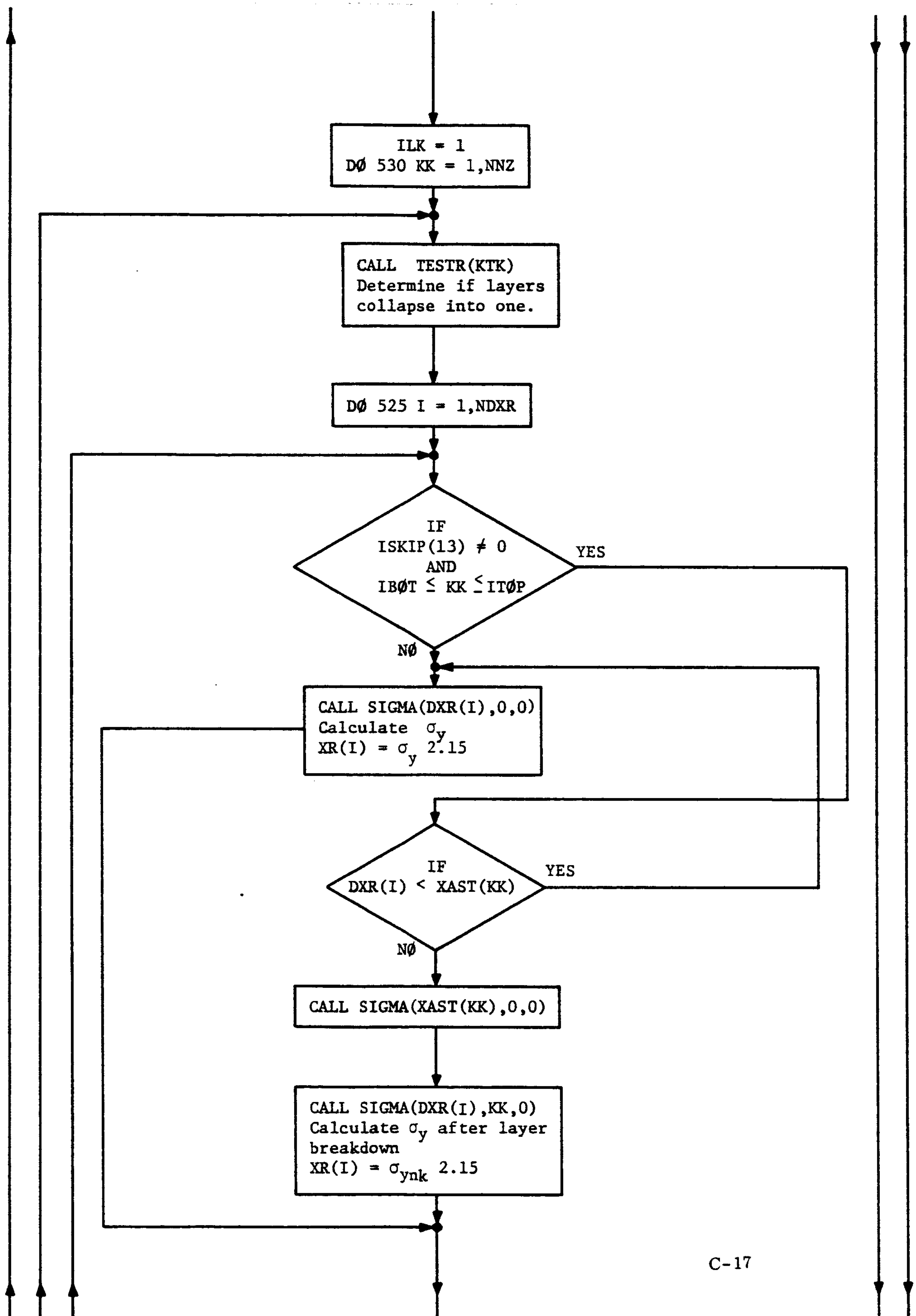
310 CØNTINUE
IF J ≥ NYS
NØ
J=J+1
YES
IF I ≠ 1
YES
NØ
WRITE ZZL(K) Calculation height
WRITE XX(I) X distance
IF ISKIP(13) ≠ 0 AND KK ≥ IBØT AND KK ≤ ITØP
YES
NØ
DØ 420 J = 1,NYS
MØDELS 1,2&3 ØUTPUT
IF ITAG(J) = 9
YES
NØ

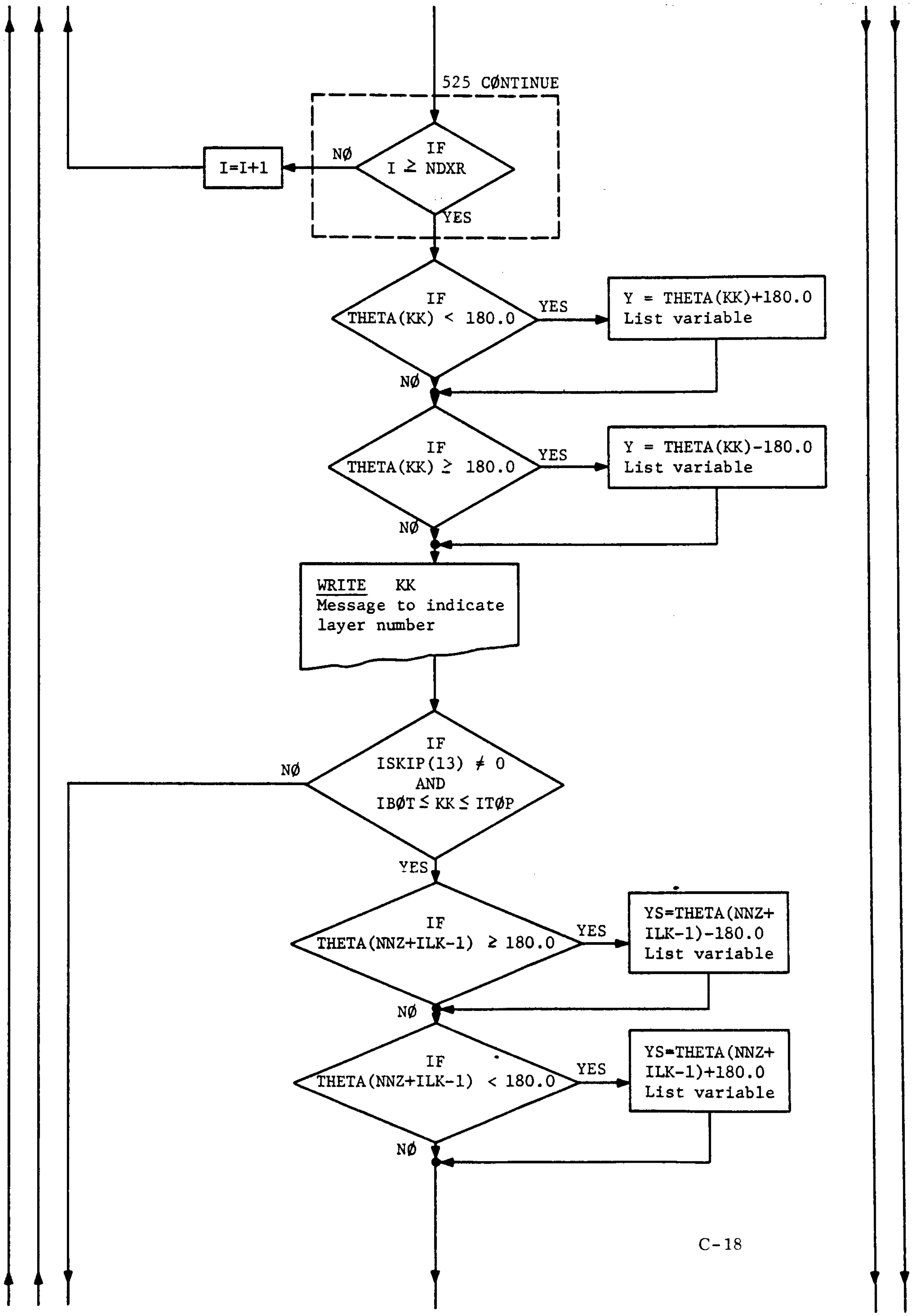


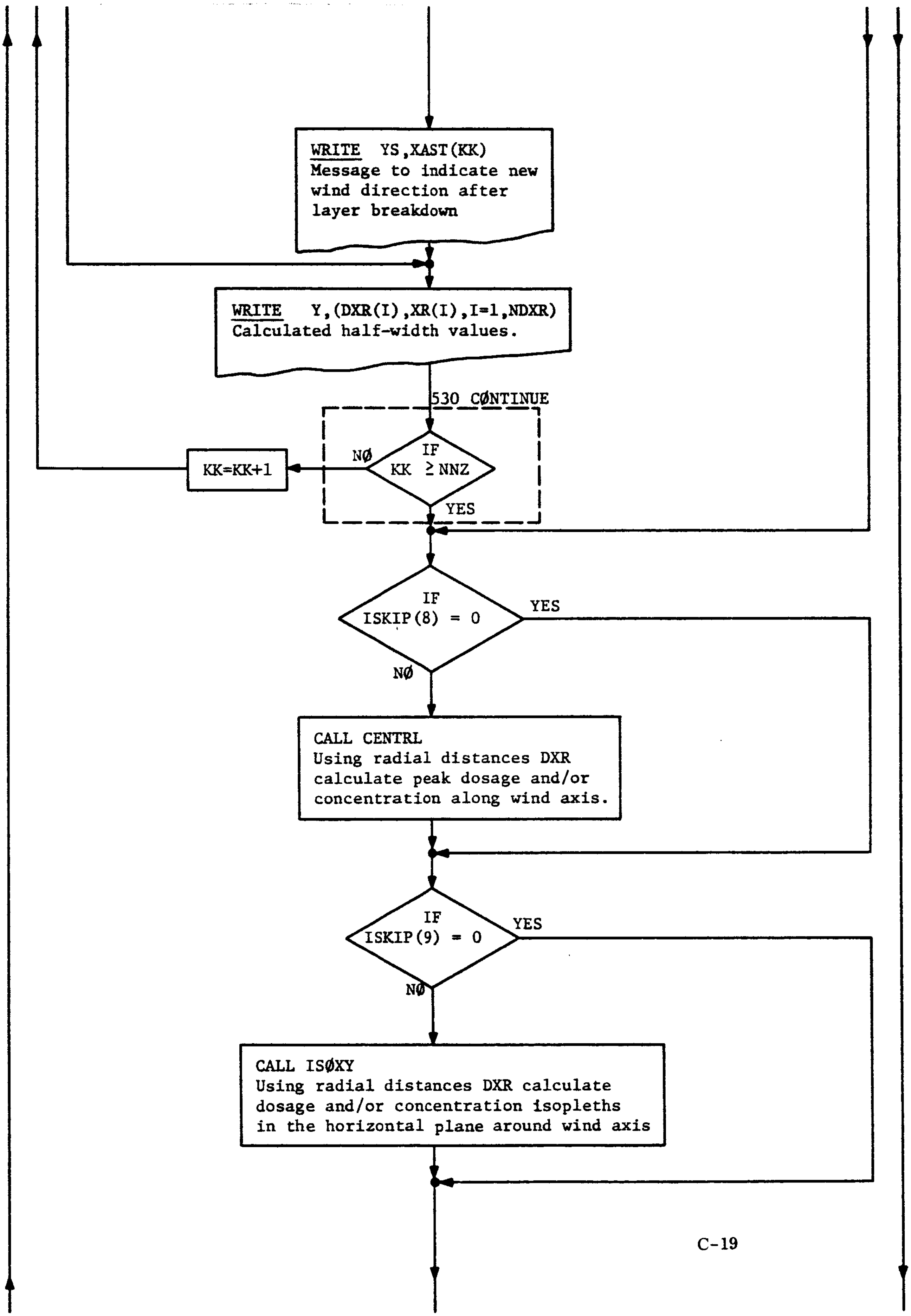
WRITE YY(J),DØS(J),PEAKC(J),CØN(J),VER(J), VREF(J),ALØNGW(J),LAT(J)
WRITE YY(J)
Write message to indicate the coordinates XX(I) & YY(J) are outside the calculation sector DELPHI
ITAG(J) = 0
420 CØNTINUE
IF J ≥ NNZ
NØ
YES
J=J+1
WRITE (YY(J),DØS(J),CØN(J),J=1,NYS)
Write dosage and concentration calculated from collapsed layer model.
520 CØNTINUE
IF I ≥ NXS
NØ
YES
I=I+1
IF ISKIP(12) = 0
YES
NØ
NØ WASHØUT CALCULATED
IF KK ≠ NNZ ØR M-1 < NPT(KK)
YES
NØ
PRINT WASHØUT ØNLY AT END

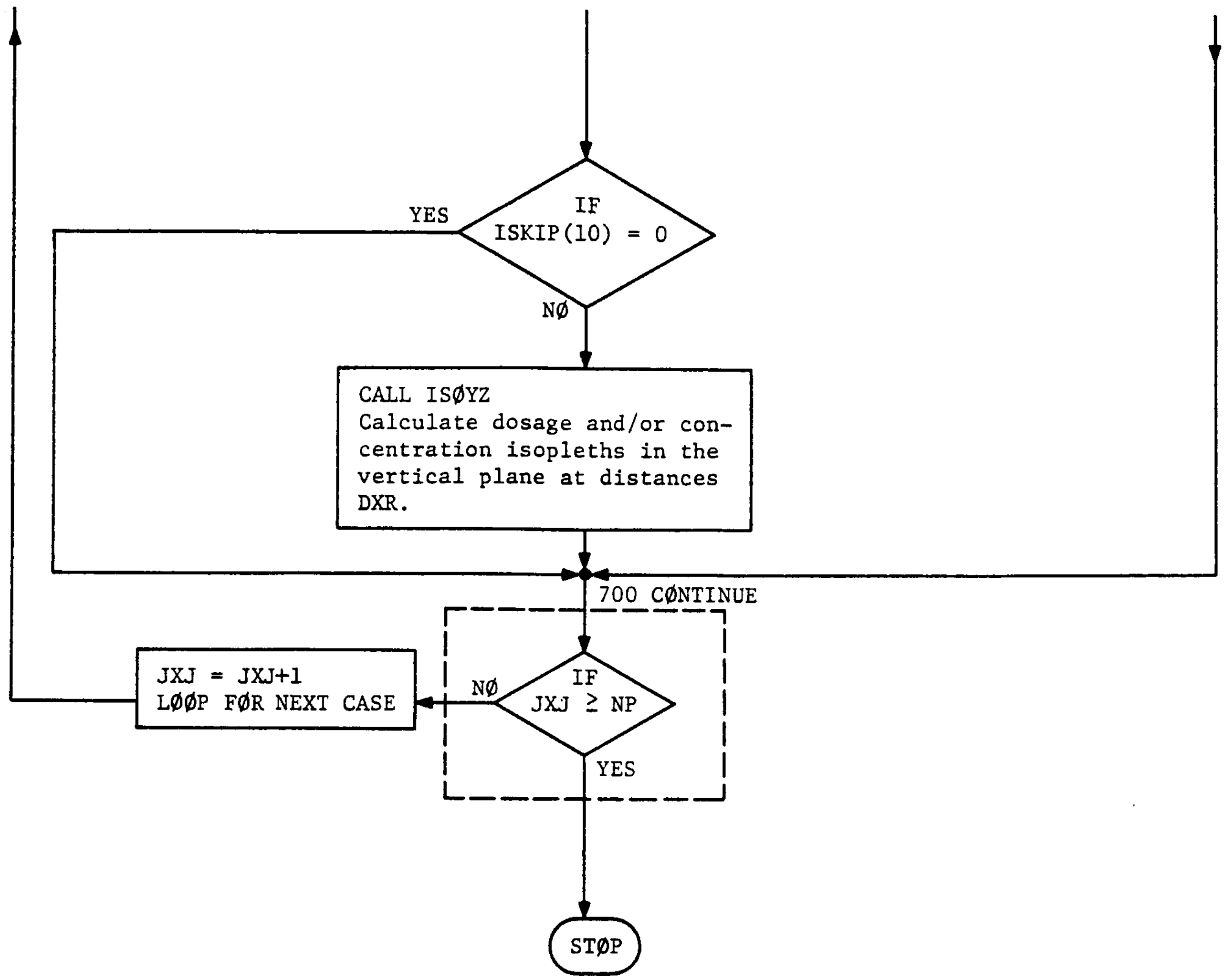


WRITE
Write message to indicate washout listing to follow.
DØ 435 I = 1,NXS
WRITE XX(I),(YY(J),WASHØU(I,J),J=1,NYS)
Calculated value of washout at grid points (X,Y)
435 CØNTINUE
IF
I ≥ NXS
NØ
I=I+1
YES
IF
(M-1) ≥ NPT(KK)
NØ
YES
End loop over heights within layer.
600 CØNTINUE
IF
KK ≥ NNZ
NØ
KK=KK+1
YES
IF
ISKIP(7) ≠ 2
AND
ISKIP(7) ≠ 3
YES
DØ NØT CALCULATE CLØUD HALF WIDTHS
NØ
WRITE Message to indicate calculated cloud half widths are to follow.


ILK = 1
DØ 530 KK = 1,NNZ
CALL TESTR(KTK)
Determine if layers collapse into one.
DØ 525 I = 1,NDXR
IF
ISKIP(13) ≠ 0
AND
IBØT ≤ KK ≤ ITØP
YES
NØ
CALL SIGMA(DXR(I),0,0)
Calculate σy
XR(I) = σy 2.15
IF
DXR(I) < XAST(KK)
YES
NØ
CALL SIGMA(XAST(KK),0,0)
CALL SIGMA(DXR(I),KK,0)
Calculate σy after layer breakdown
XR(I) = σynk 2.15


525 CØNTINUE
IF
I ≥ NDXR
NØ
I=I+1
YES
IF
THETA(KK) < 180.0
YES
Y = THETA(KK)+180.0
List variable
NØ
IF
THETA(KK) ≥ 180.0
YES
Y = THETA(KK)-180.0
List variable
NØ
WRITE KK
Message to indicate
layer number
IF
ISKIP(13) ≠ 0
AND
IBØT ≤ KK ≤ ITØP
NØ
YES
IF
THETA(NNZ+ILK-1) ≥ 180.0
YES
YS=THETA(NNZ+
ILK-1)-180.0
List variable
NØ
IF
THETA(NNZ+ILK-1) < 180.0
YES
YS=THETA(NNZ+
ILK-1)+180.0
List variable
NØ


WRITE YS,XAST(KK)
Message to indicate new wind direction after layer breakdown
WRITE Y,(DXR(I),XR(I),I=1,NDXR)
Calculated half-width values.
530 CØNTINUE
IF KK ≥ NNZ
NØ
KK=KK+1
YES
IF ISKIP(8) = 0
YES
NØ
CALL CENTRL
Using radial distances DXR calculate peak dosage and/or concentration along wind axis.
IF ISKIP(9) = 0
YES
NØ
CALL ISØXY
Using radial distances DXR calculate dosage and/or concentration isopleths in the horizontal plane around wind axis


IF
ISKIP(10) = 0
YES
NØ
CALL ISØYZ
Calculate dosage and/or concentration isopleths in the vertical plane at distances DXR.
700 CØNTINUE
IF
JXJ ≥ NP
NØ
JXJ = JXJ+1
LØØP FØR NEXT CASE
YES
STØP

E - N - D

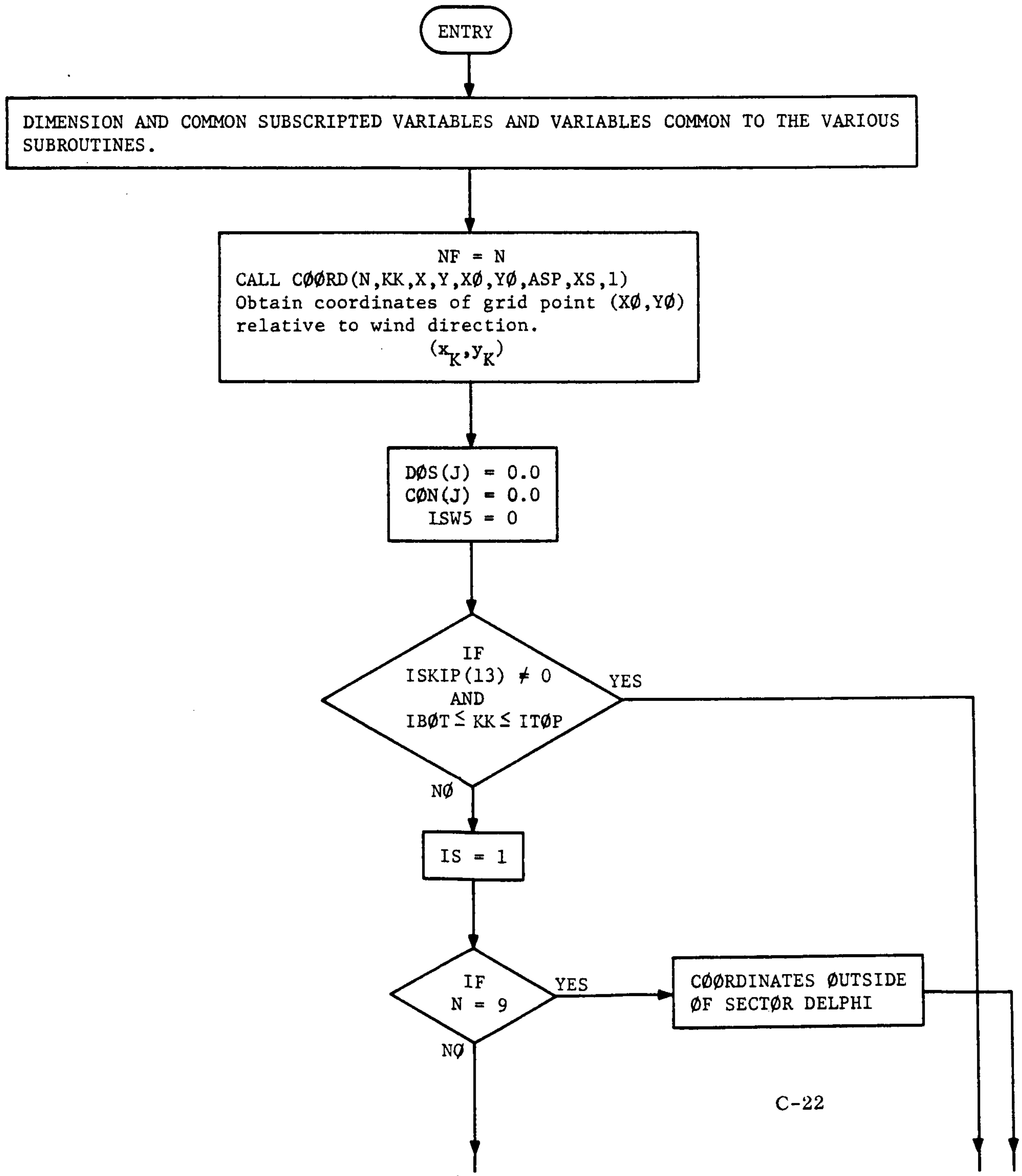
SECTION C.2

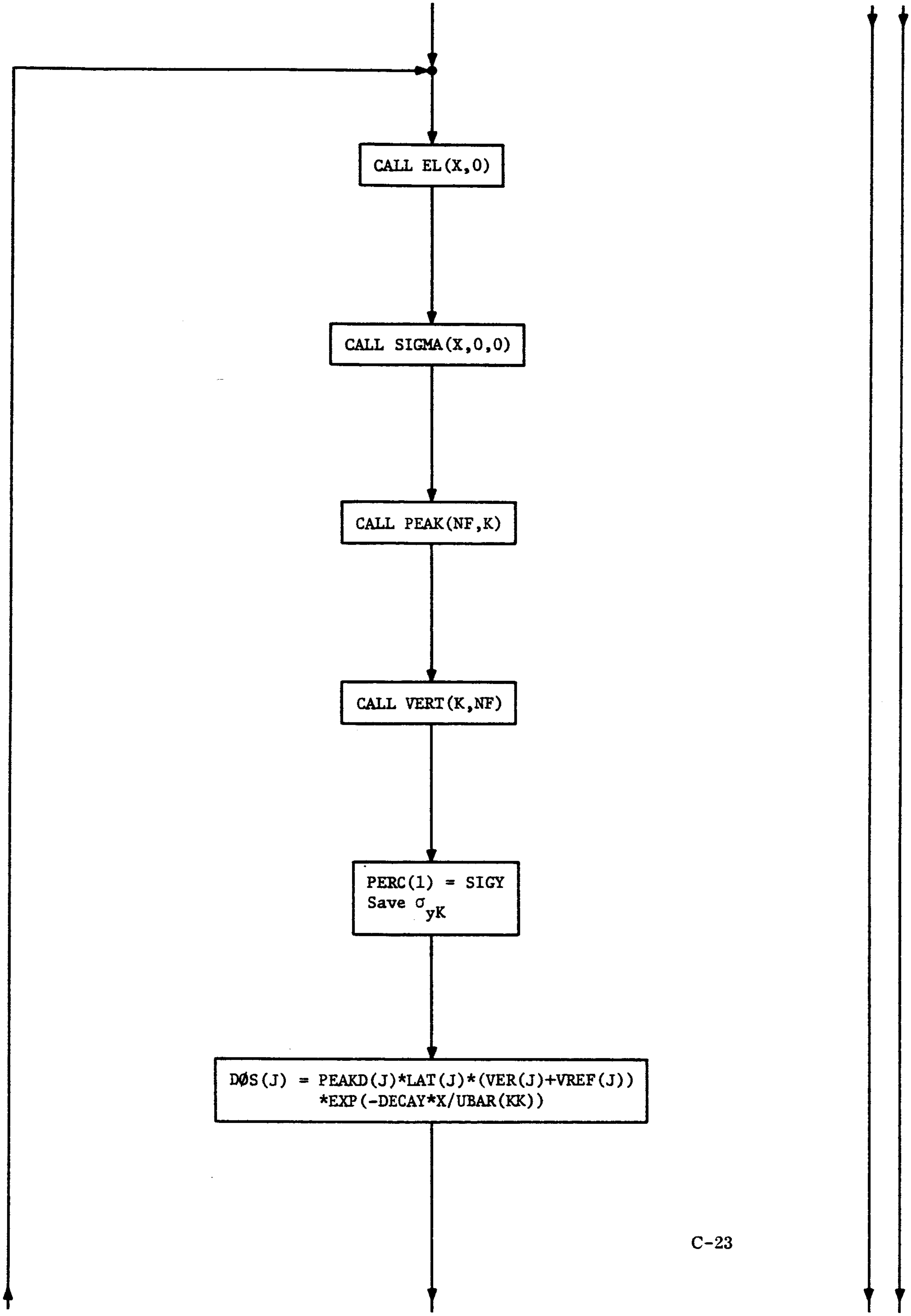
SUBROUTINE BREAK

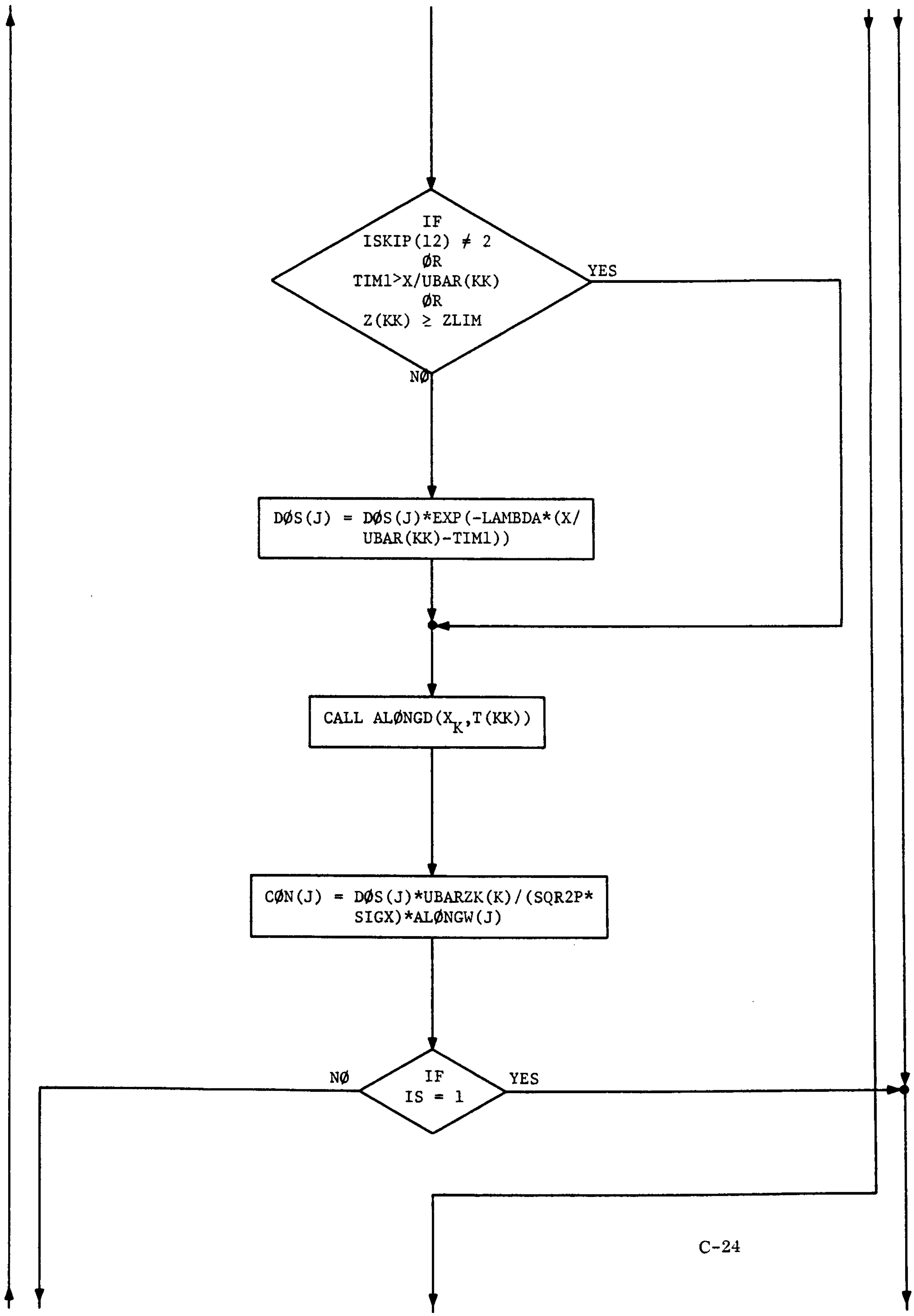
SUBROUTINE BREAK (K,N,XØ,YØ)

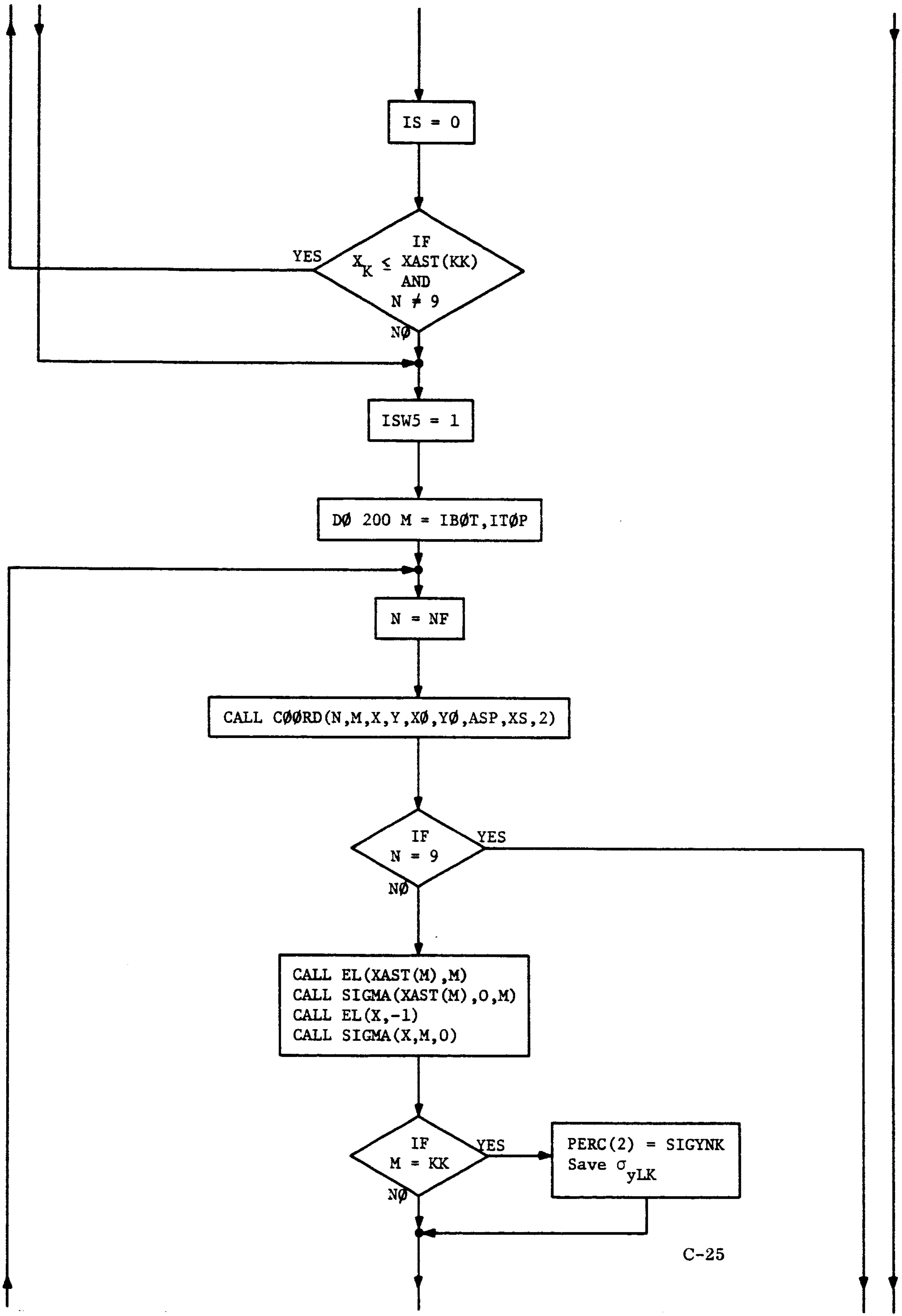
THIS SUBROUTINE IS THE MAIN CALCULATION ROUTINE FOR GENERAL DOSAGE AND CONCENTRATION PATTERNS. THIS ROUTINE CONTAINS CHANGE IN LAYER STRUCTURE MODELS AND ASSEMBLES PARTS OF MODELS I, II, III FOR CALCULATIONS. THIS ROUTINE ALSO CALLS THE WASHOUT MODEL ON OPTION (ISKIP(12) = 1 OR = 2).

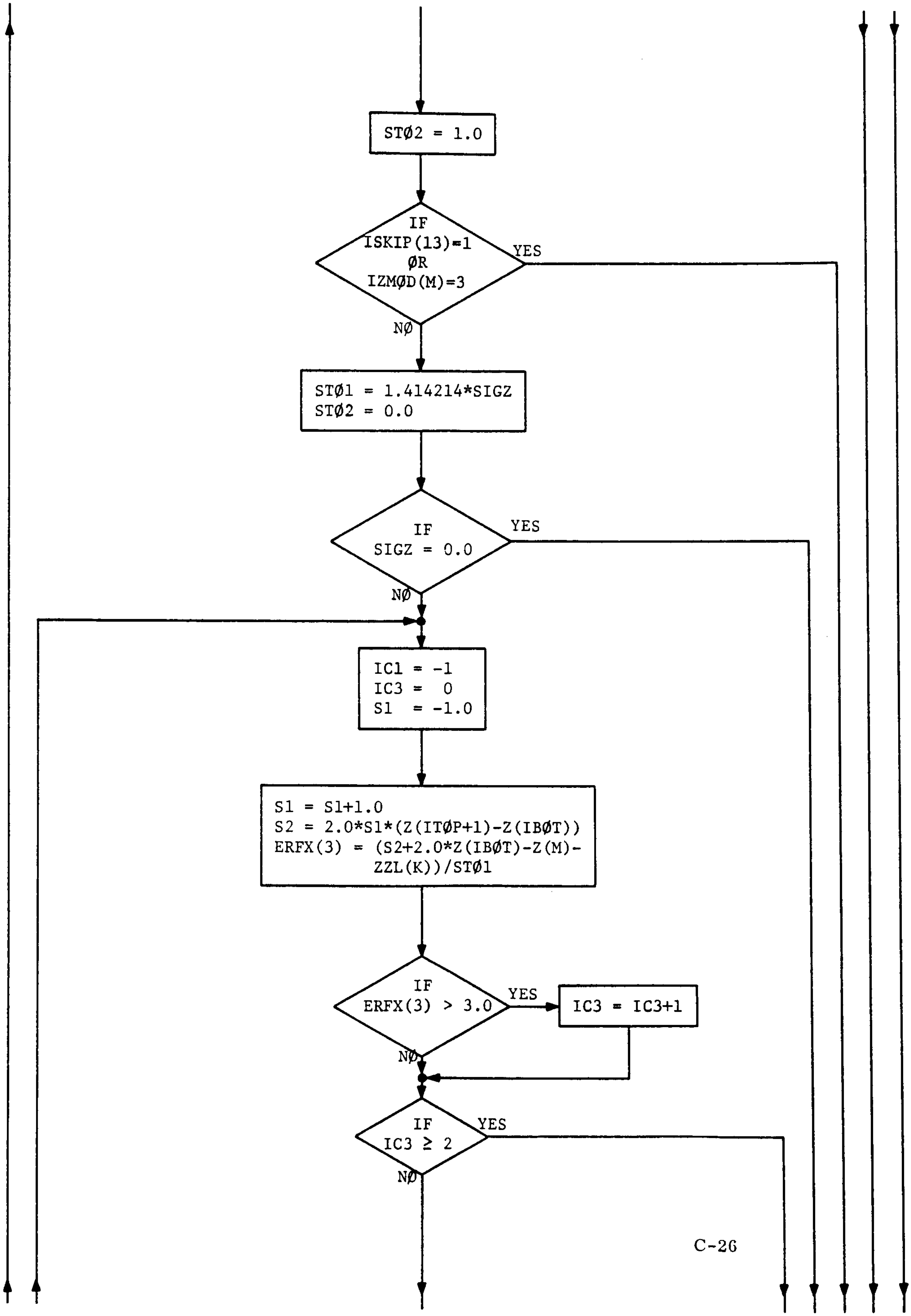
(STØRAGE USED 1155_8)

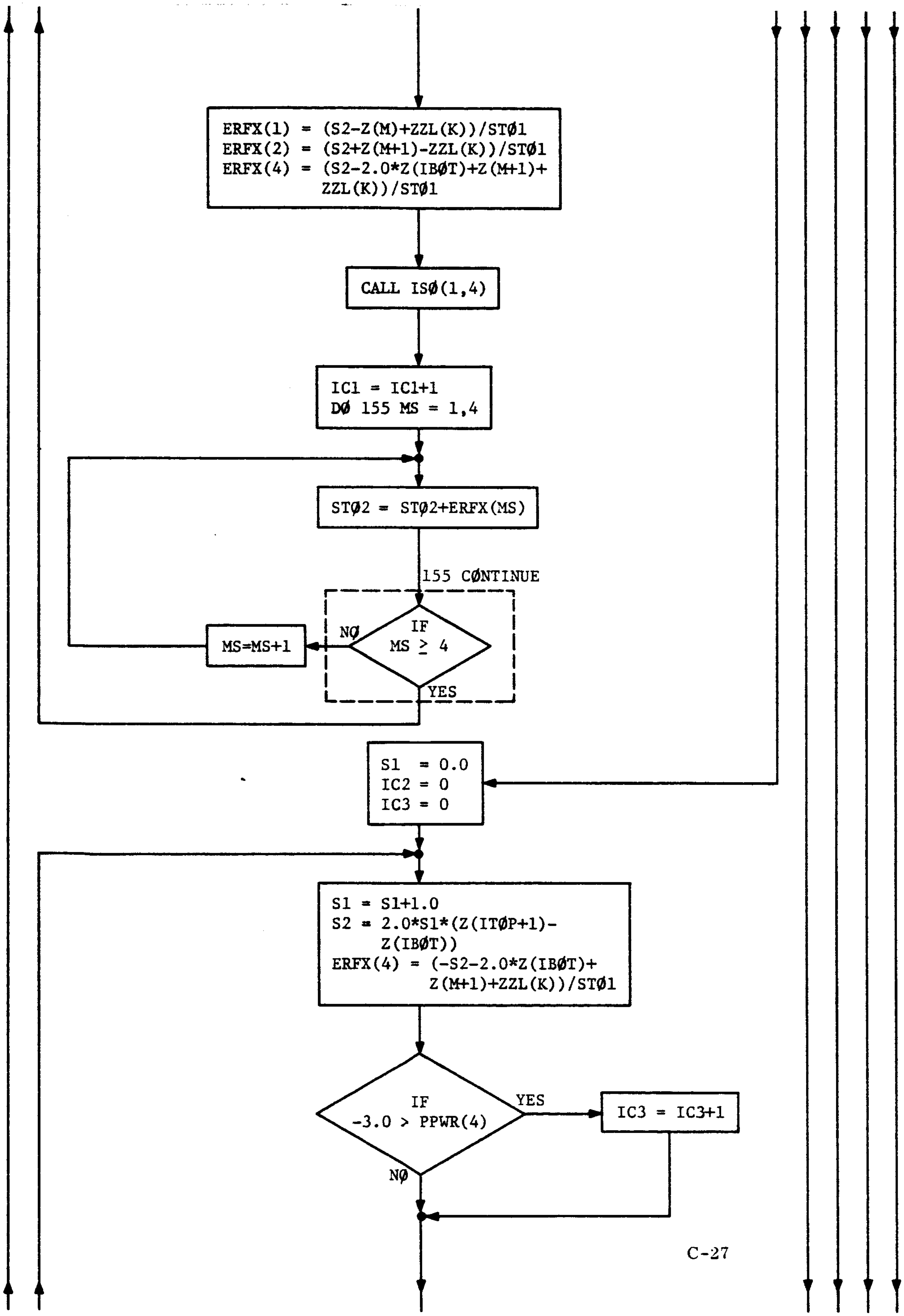


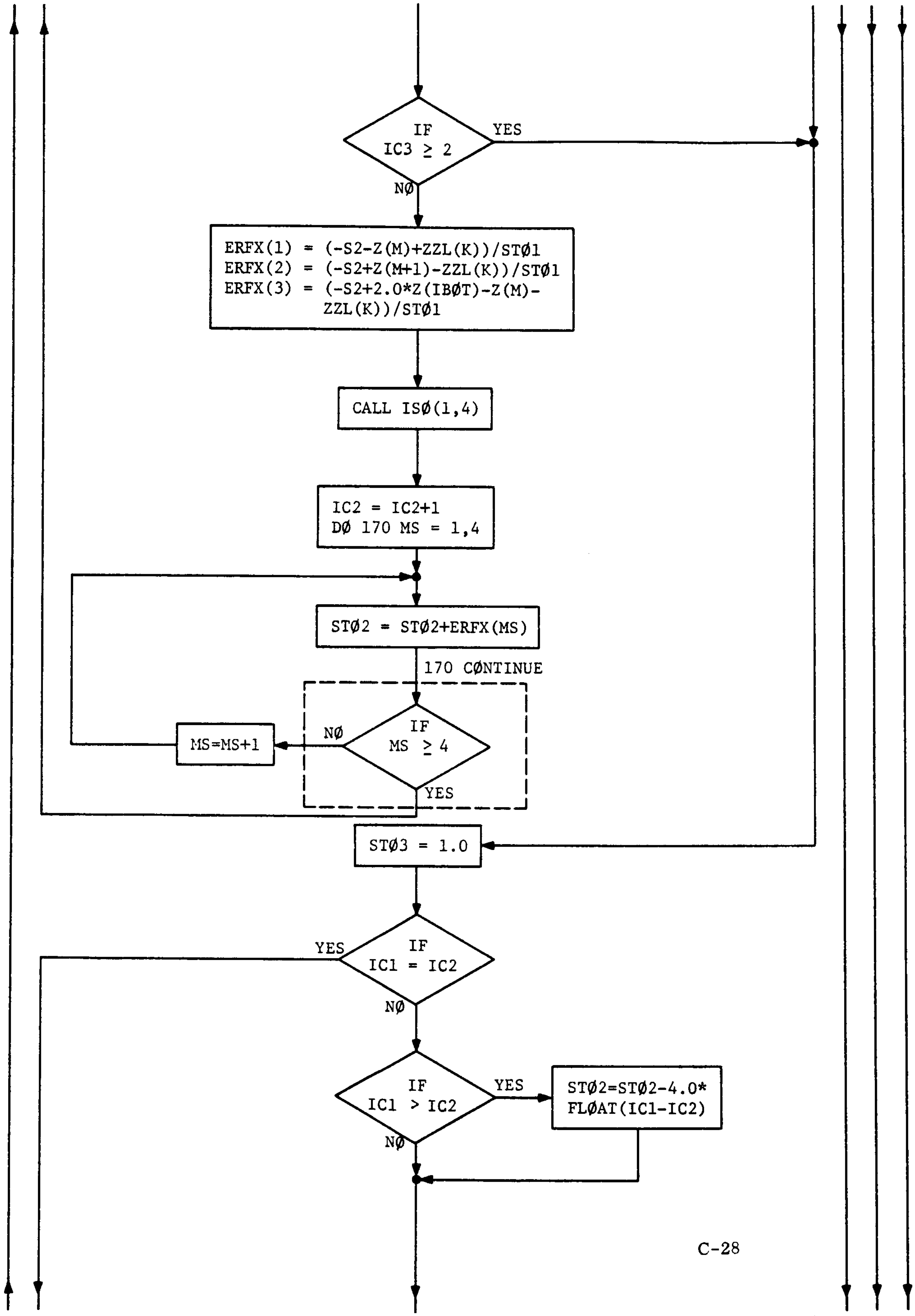

CALL EL(X,0)
CALL SIGMA(X,0,0)
CALL PEAK(NF,K)
CALL VERT(K,NF)
PERC(1) = SIGY
Save σ_{yK}
DØS(J) = PEAKD(J)*LAT(J)*(VER(J)+VREF(J))
*EXP(-DECAY*X/UBAR(KK))

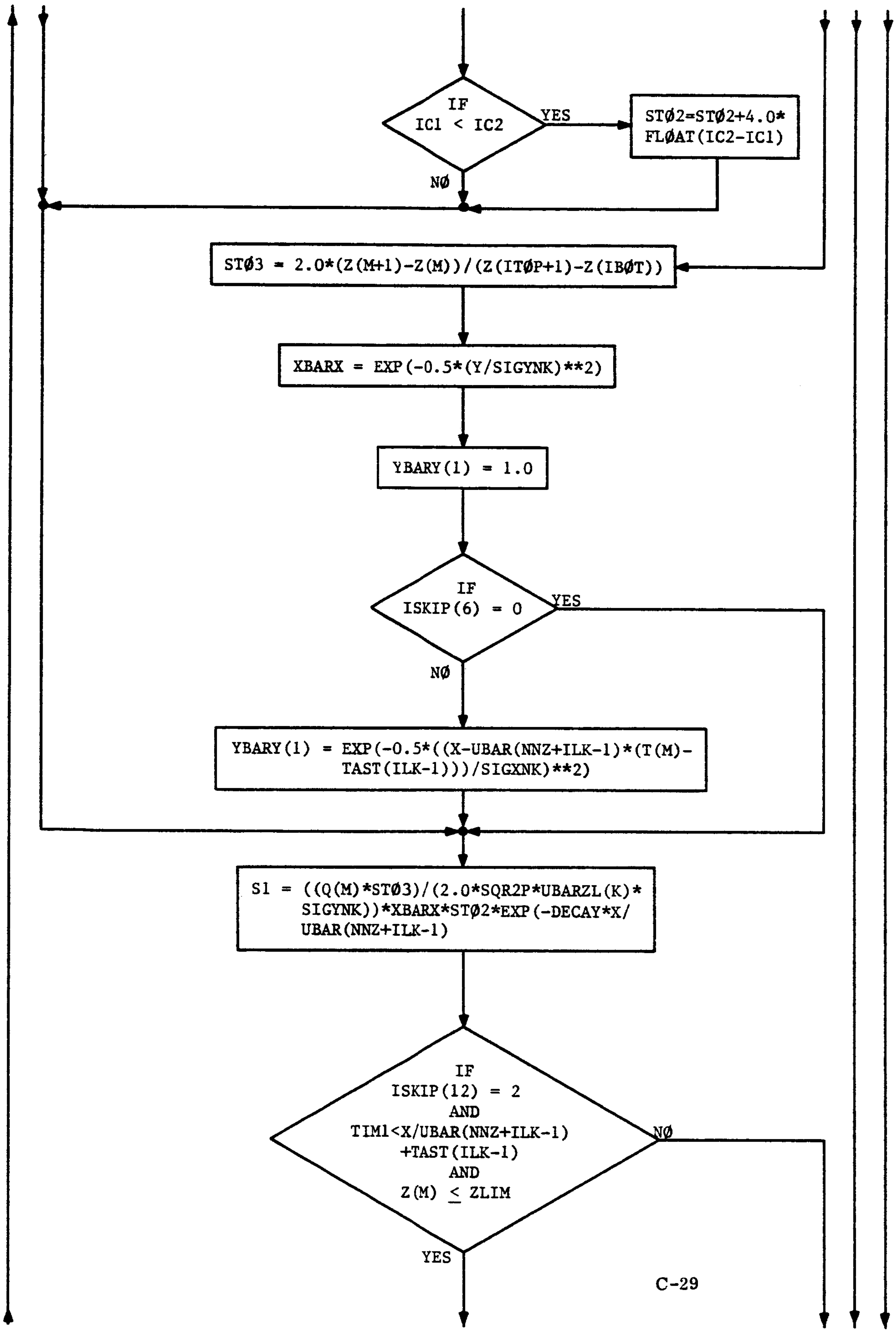

IF
ISKIP(12) ≠ 2
ØR
TIM1>X/UBAR(KK)
ØR
Z(KK) ≥ ZLIM
YES
NØ
DØS(J) = DØS(J)*EXP(-LAMBDA*(X/
UBAR(KK)-TIM1))
CALL ALØNGD(X_K,T(KK))
CØN(J) = DØS(J)*UBARZK(K)/(SQR2P*
SIGX)*ALØNGW(J)
NØ
IF
IS = 1
YES

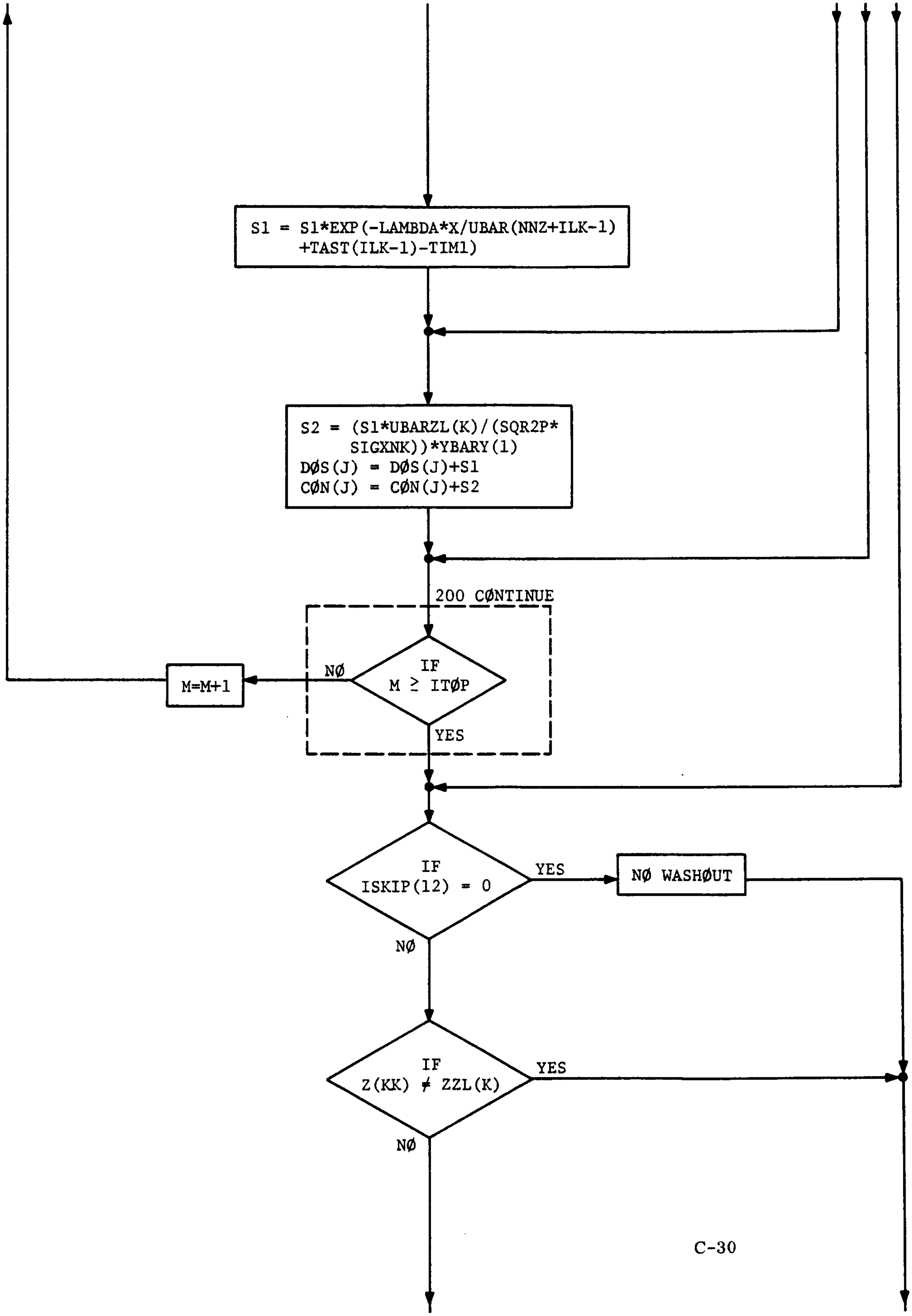

IS = 0
IF
X K ≤ XAST(KK)
AND
N ≠ 9
YES
NØ
ISW5 = 1
DØ 200 M = IBØT,ITØP
N = NF
CALL CØØRD(N,M,X,Y,XØ,YØ,ASP,XS,2)
IF
N = 9
YES
NØ
CALL EL(XAST(M),M)
CALL SIGMA(XAST(M),O,M)
CALL EL(X,-1)
CALL SIGMA(X,M,O)
IF
M = KK
YES
NØ
PERC(2) = SIGYNK
Save σ yLK


STØ2 = 1.0
IF ISKIP(13)=1 ØR IZMØD(M)=3
YES
NØ
STØ1 = 1.414214*SIGZ
STØ2 = 0.0
IF SIGZ = 0.0
YES
NØ
IC1 = -1
IC3 = 0
S1 = -1.0
S1 = S1+1.0
S2 = 2.0*S1*(Z(ITØP+1)-Z(IBØT))
ERFX(3) = (S2+2.0*Z(IBØT)-Z(M)-ZZL(K))/STØ1
IF ERFX(3) > 3.0
YES
IC3 = IC3+1
NØ
IF IC3 ≥ 2
YES
NØ

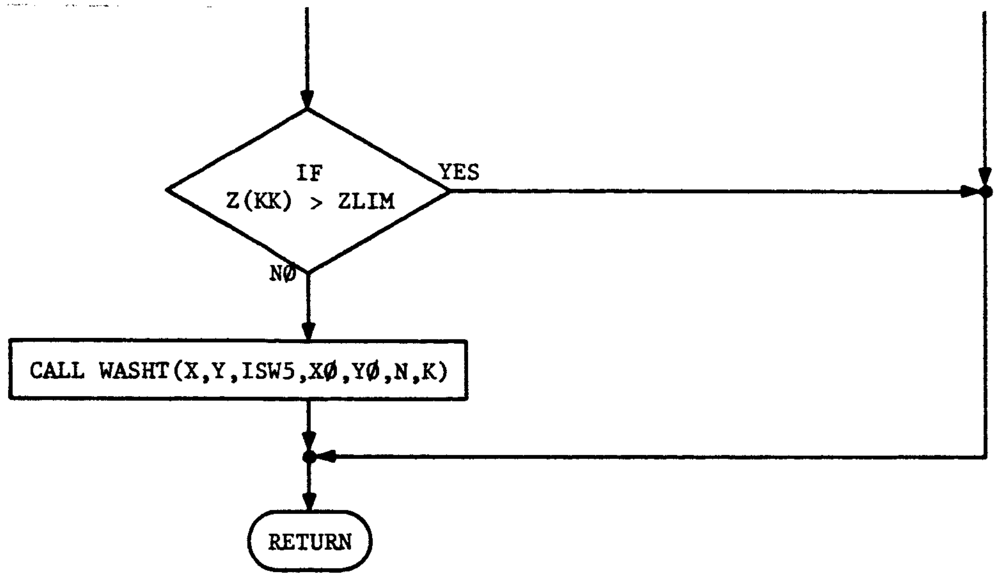

ERFX(1) = (S2-Z(M)+ZZL(K))/STØ1
ERFX(2) = (S2+Z(M+1)-ZZL(K))/STØ1
ERFX(4) = (S2-2.0*Z(IBØT)+Z(M+1)+ZZL(K))/STØ1
CALL ISØ(1,4)
IC1 = IC1+1
DØ 155 MS = 1,4
STØ2 = STØ2+ERFX(MS)
155 CØNTINUE
IF MS ≥ 4
NØ
YES
MS=MS+1
S1 = 0.0
IC2 = 0
IC3 = 0
S1 = S1+1.0
S2 = 2.0*S1*(Z(ITØP+1)-Z(IBØT))
ERFX(4) = (-S2-2.0*Z(IBØT)+Z(M+1)+ZZL(K))/STØ1
IF -3.0 > PPWR(4)
YES
NØ
IC3 = IC3+1


IF
IC3 ≥ 2
YES
NØ
ERFX(1) = (-S2-Z(M)+ZZL(K))/STØ1
ERFX(2) = (-S2+Z(M+1)-ZZL(K))/STØ1
ERFX(3) = (-S2+2.0*Z(IBØT)-Z(M)-
ZZL(K))/STØ1
CALL ISØ(1,4)
IC2 = IC2+1
DØ 170 MS = 1,4
STØ2 = STØ2+ERFX(MS)
170 CØNTINUE
NØ
IF
MS ≥ 4
MS=MS+1
YES
STØ3 = 1.0
YES
IF
IC1 = IC2
NØ
IF
IC1 > IC2
YES
STØ2=STØ2-4.0*
FLØAT(IC1-IC2)
NØ


IF
IC1 < IC2
YES
NØ
STØ2=STØ2+4.0*
FLØAT(IC2-IC1)
STØ3 = 2.0*(Z(M+1)-Z(M))/(Z(ITØP+1)-Z(IBØT))
XBARX = EXP(-0.5*(Y/SIGYNK)**2)
YBARY(1) = 1.0
IF
ISKIP(6) = 0
YES
NØ
YBARY(1) = EXP(-0.5*((X-UBAR(NNZ+ILK-1)*(T(M)-
TAST(ILK-1)))/SIGXNK)**2)
S1 = ((Q(M)*STØ3)/(2.0*SQR2P*UBARZL(K)*
SIGYNK))*XBARX*STØ2*EXP(-DECAY*X/
UBAR(NNZ+ILK-1)
IF
ISKIP(12) = 2
AND
TIM1<X/UBAR(NNZ+ILK-1)
+TAST(ILK-1)
AND
Z(M) ≤ ZLIM
NØ
YES

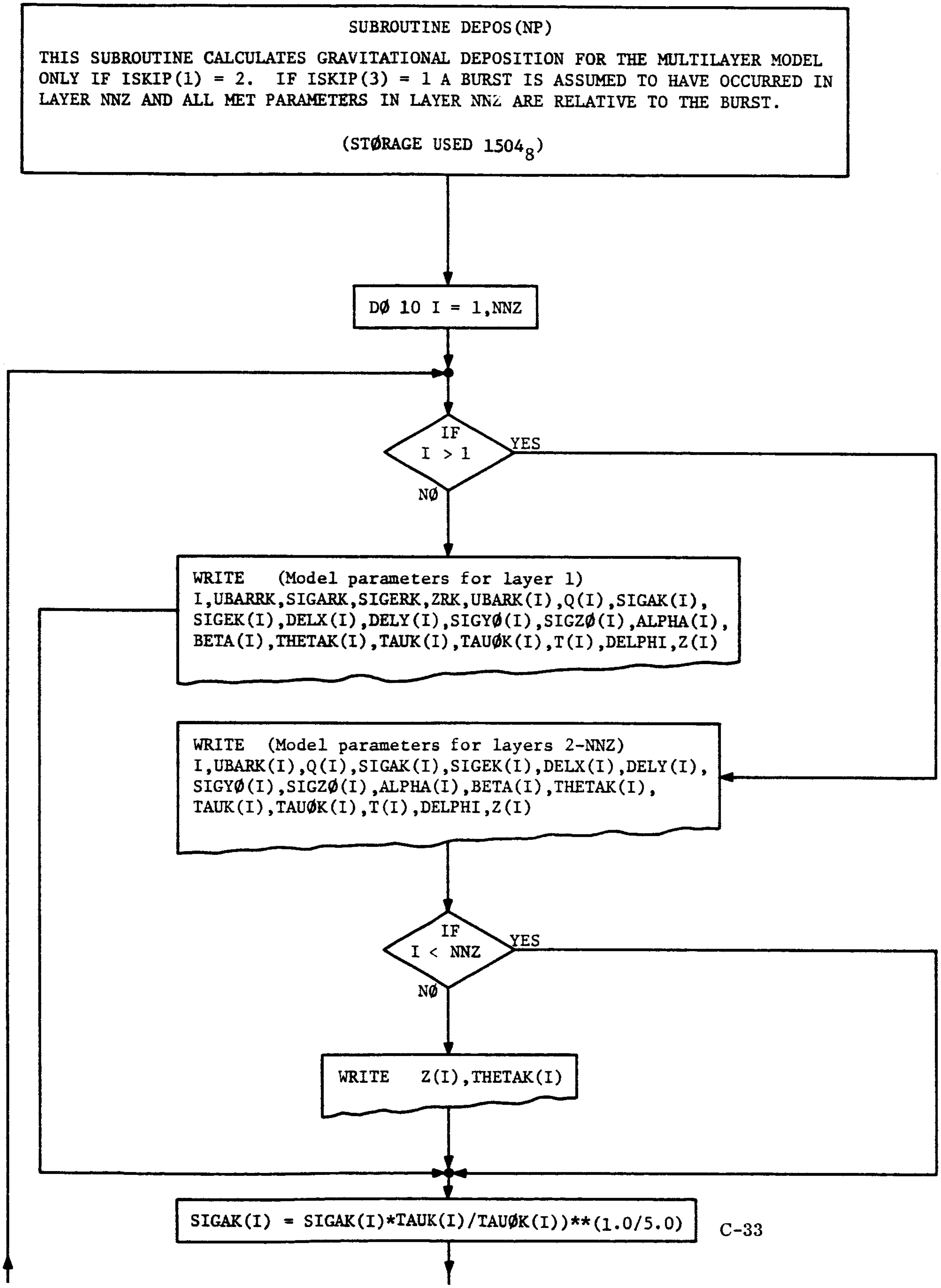


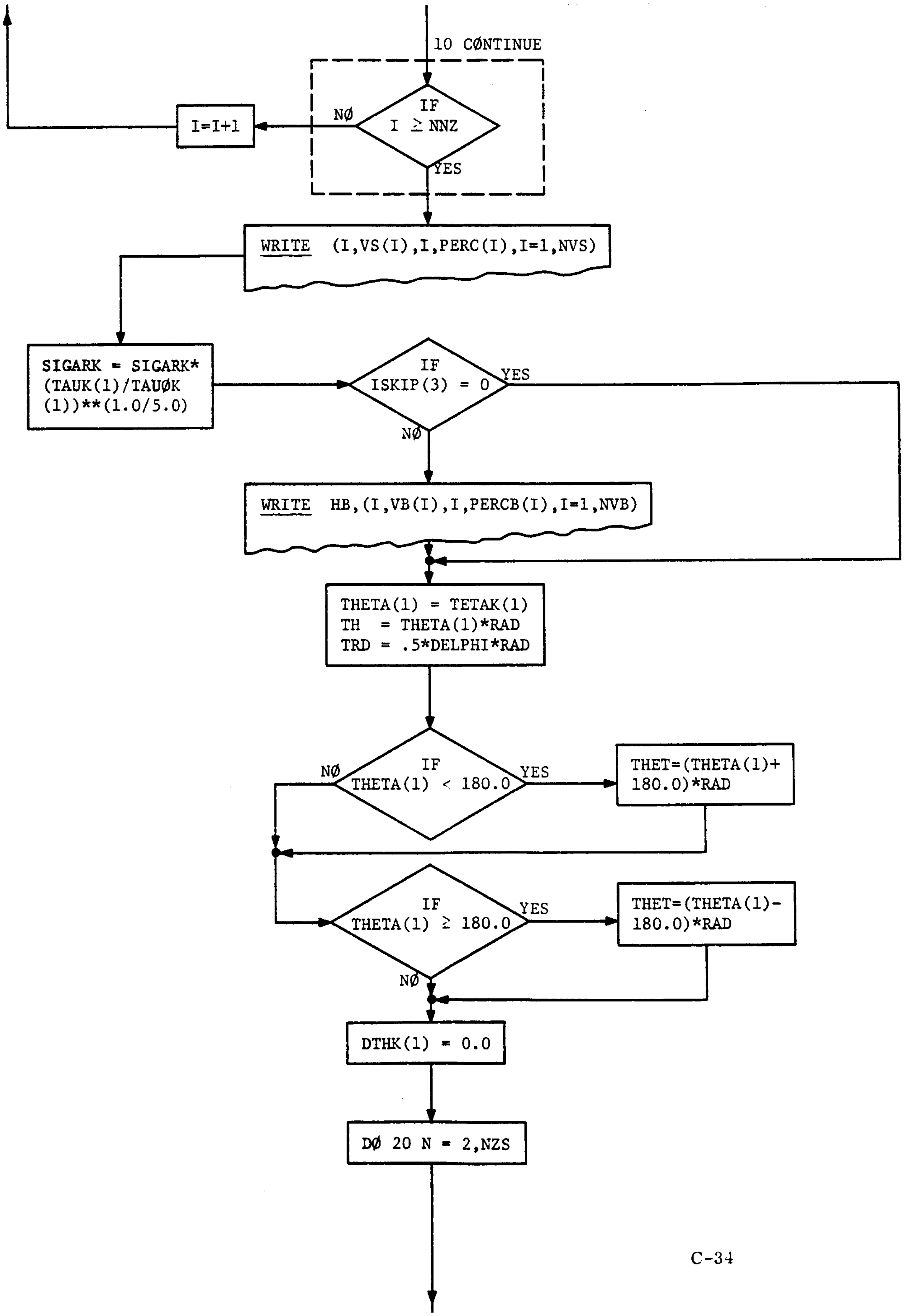
S1 = S1*EXP(-LAMBDA*X/UBAR(NNZ+ILK-1)
+TAST(ILK-1)-TIM1)
S2 = (S1*UBARZL(K)/(SQR2P*
SIGXNK))*YBARY(1)
DØS(J) = DØS(J)+S1
CØN(J) = CØN(J)+S2
200 CØNTINUE
IF
M ≥ ITØP
NØ
M=M+1
YES
IF
ISKIP(12) = 0
YES
NØ WASHØUT
NØ
IF
Z(KK) ≠ ZZL(K)
YES
NØ

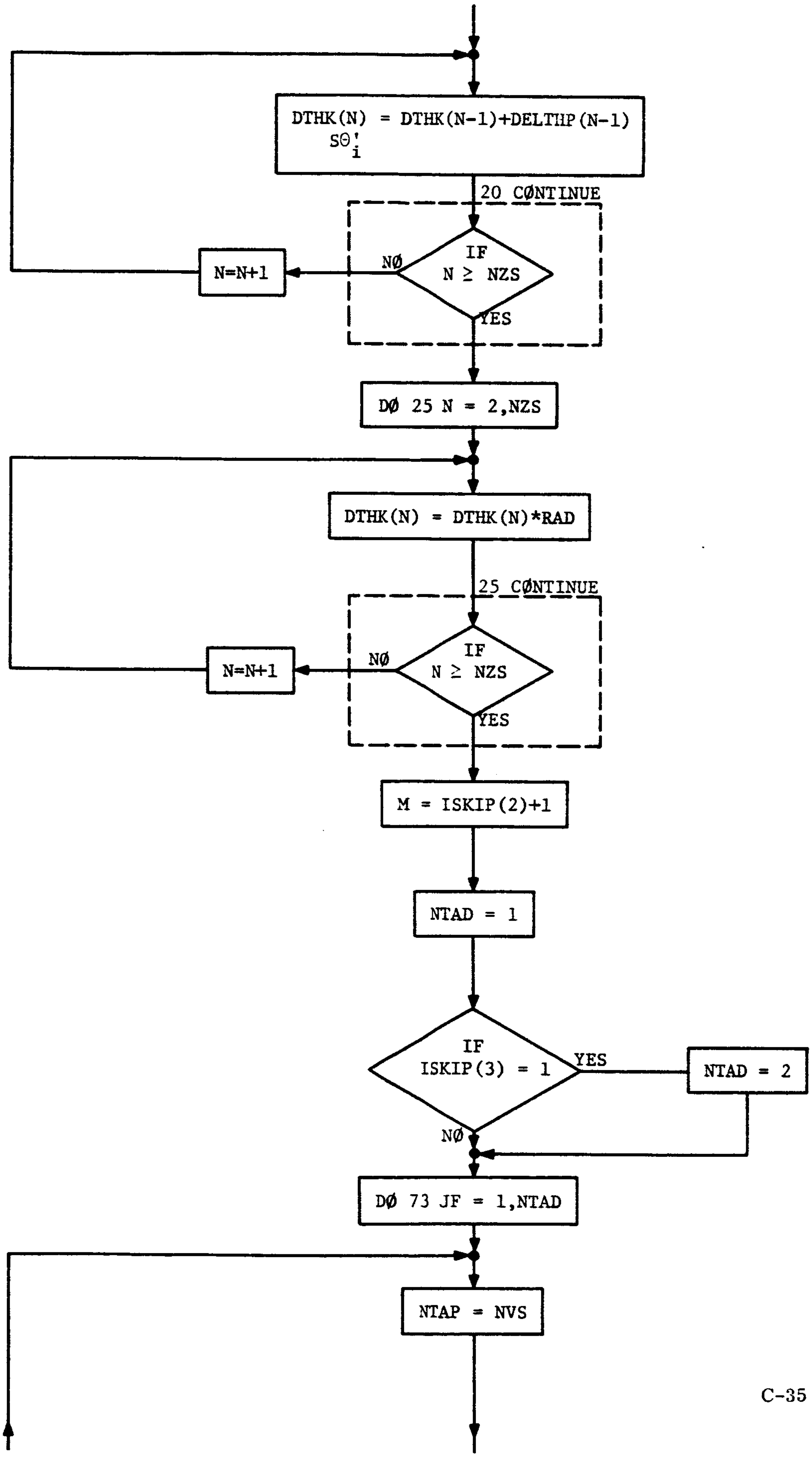

IF
Z(KK) > ZLIM
YES
NØ
CALL WASHT(X,Y,ISW5,XØ,YØ,N,K)
RETURN

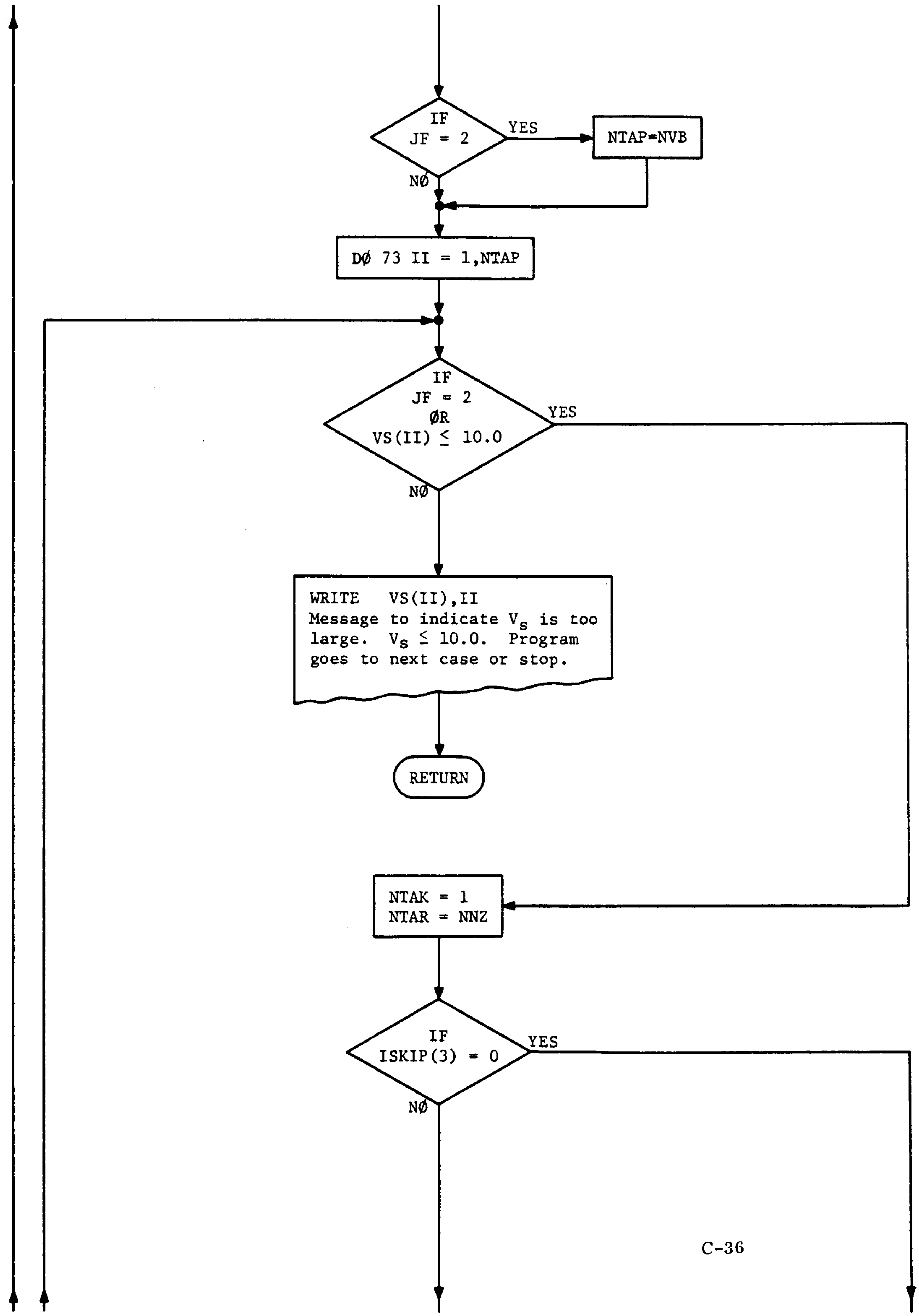
SECTION C.3

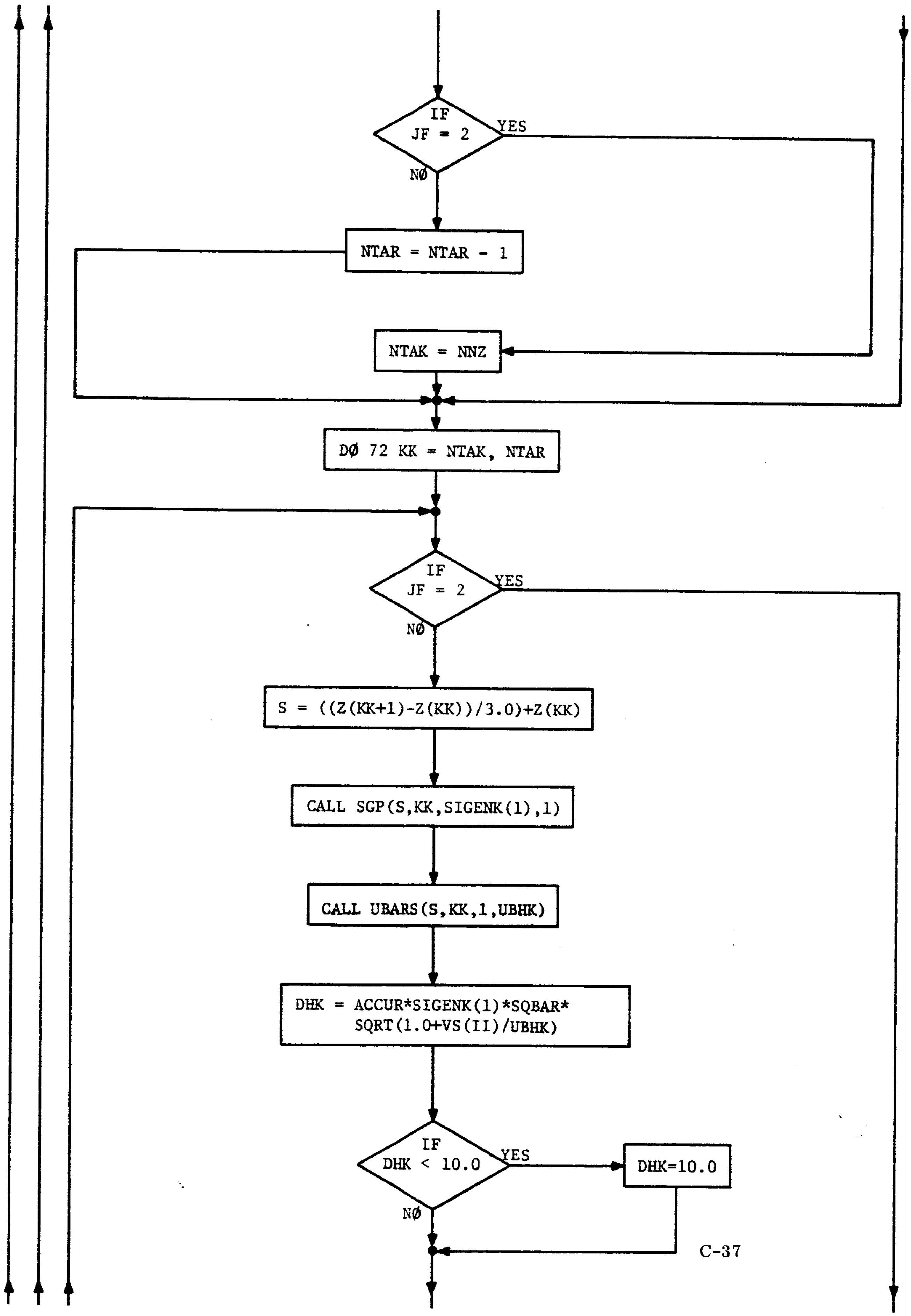
SUBROUTINE DEPOS

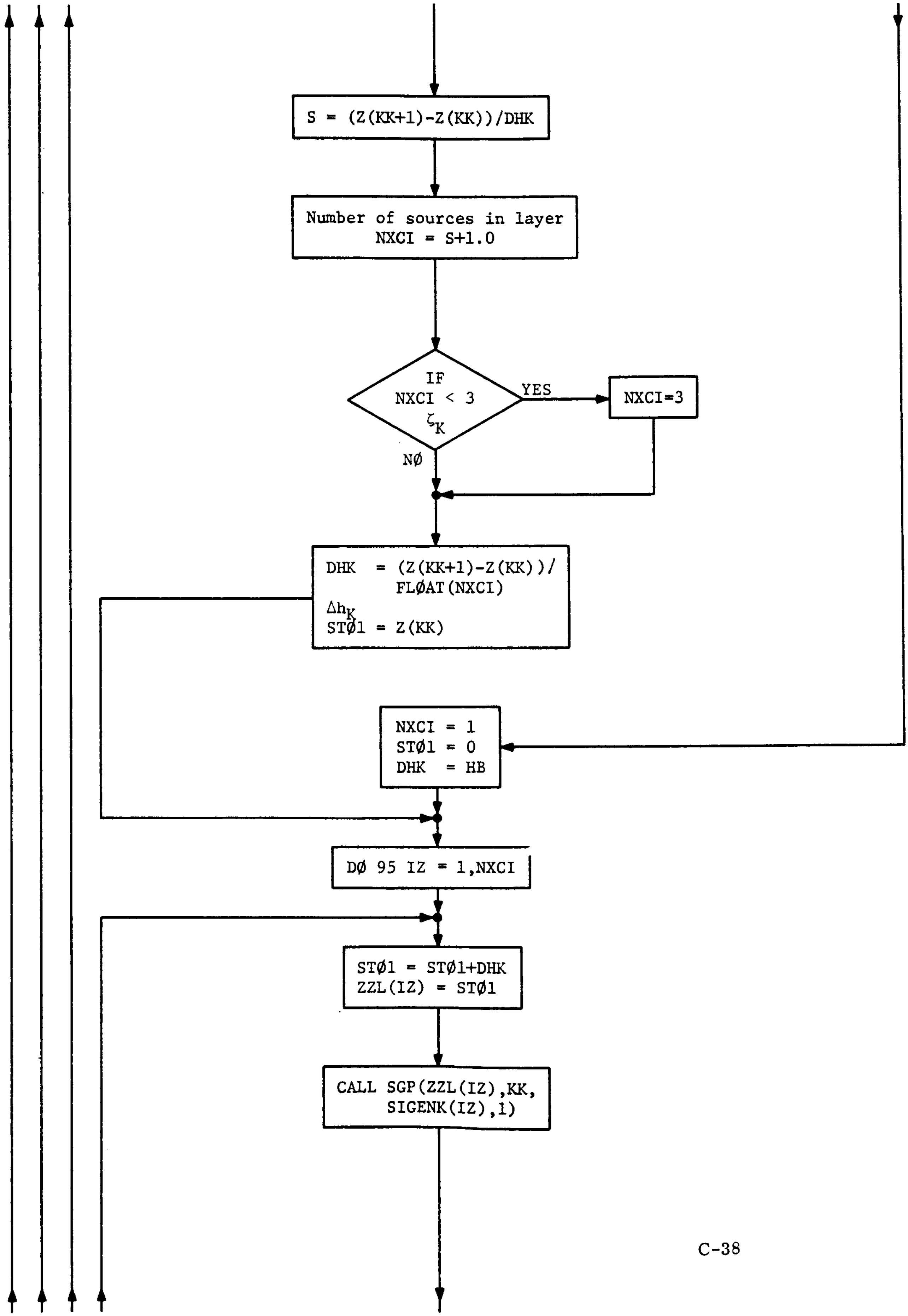

SUBROUTINE DEPOS(NP)
THIS SUBROUTINE CALCULATES GRAVITATIONAL DEPOSITION FOR THE MULTILAYER MODEL ONLY IF ISKIP(1) = 2. IF ISKIP(3) = 1 A BURST IS ASSUMED TO HAVE OCCURRED IN LAYER NNZ AND ALL MET PARAMETERS IN LAYER NNZ ARE RELATIVE TO THE BURST.
(STØRAGE USED 1504_8)
DØ 10 I = 1,NNZ
IF I > 1
YES
NØ
WRITE (Model parameters for layer 1) I,UBARRK,SIGARK,SIGERK,ZRK,UBARK(I),Q(I),SIGAK(I), SIGEK(I),DELX(I),DELY(I),SIGYØ(I),SIGZØ(I),ALPHA(I), BETA(I),THETAK(I),TAUK(I),TAUØK(I),T(I),DELPHI,Z(I)
WRITE (Model parameters for layers 2-NNZ) I,UBARK(I),Q(I),SIGAK(I),SIGEK(I),DELX(I),DELY(I), SIGYØ(I),SIGZØ(I),ALPHA(I),BETA(I),THETAK(I), TAUK(I),TAUØK(I),T(I),DELPHI,Z(I)
IF I < NNZ
YES
NØ
WRITE Z(I),THETAK(I)
SIGAK(I) = SIGAK(I)*TAUK(I)/TAUØK(I))**(1.0/5.0)

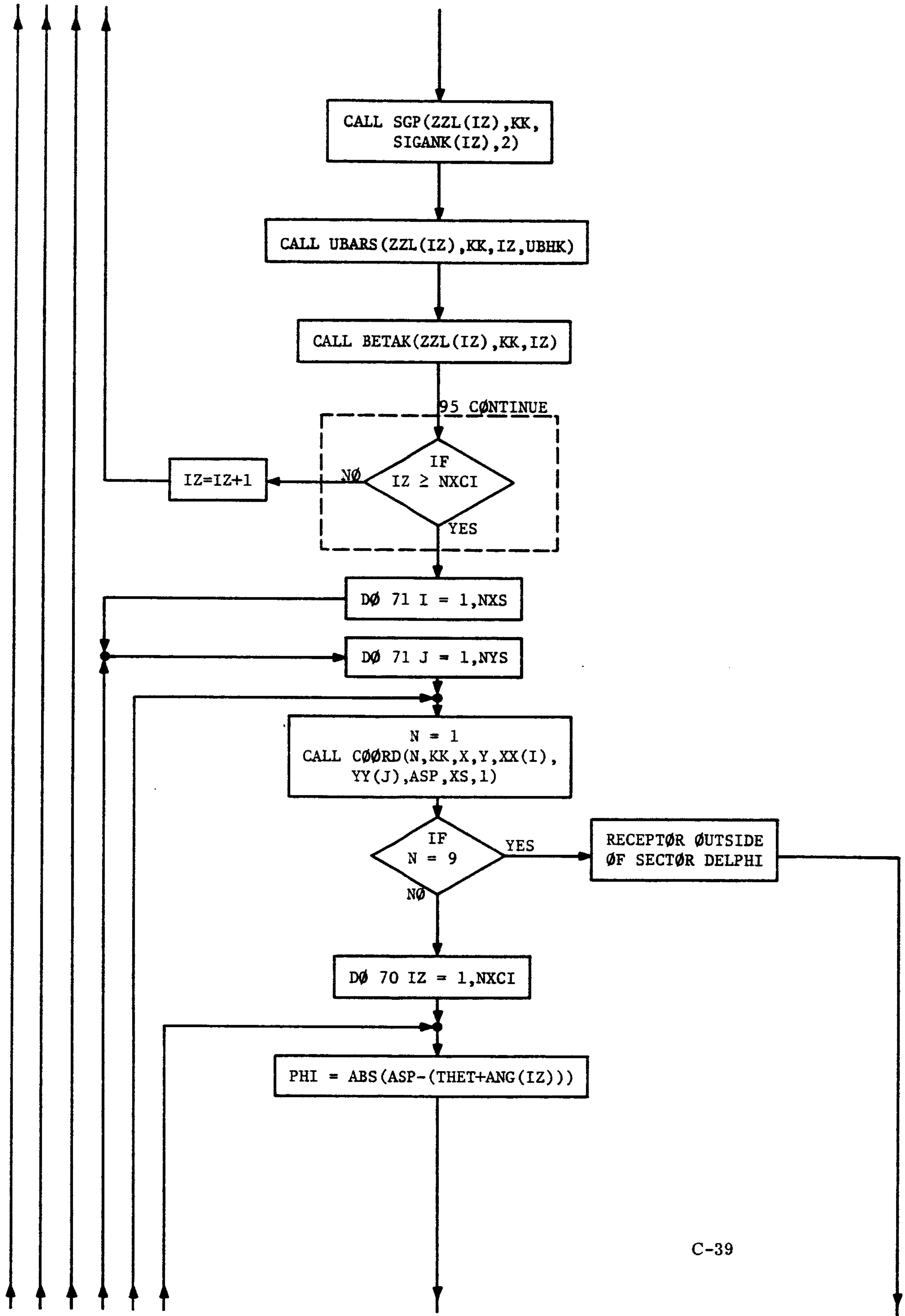

10 CØNTINUE
IF I ≥ NNZ
NØ
YES
I=I+1
WRITE (I,VS(I),I,PERC(I),I=1,NVS)
SIGARK = SIGARK* (TAUK(1)/TAUØK (1))**(1.0/5.0)
IF ISKIP(3) = 0
YES
NØ
WRITE HB,(I,VB(I),I,PERCB(I),I=1,NVB)
THETA(1) = TETAK(1)
TH = THETA(1)*RAD
TRD = .5*DELPHI*RAD
IF THETA(1) < 180.0
NØ
YES
THET=(THETA(1)+ 180.0)*RAD
IF THETA(1) ≥ 180.0
YES
NØ
THET=(THETA(1)- 180.0)*RAD
DTHK(1) = 0.0
DØ 20 N = 2,NZS

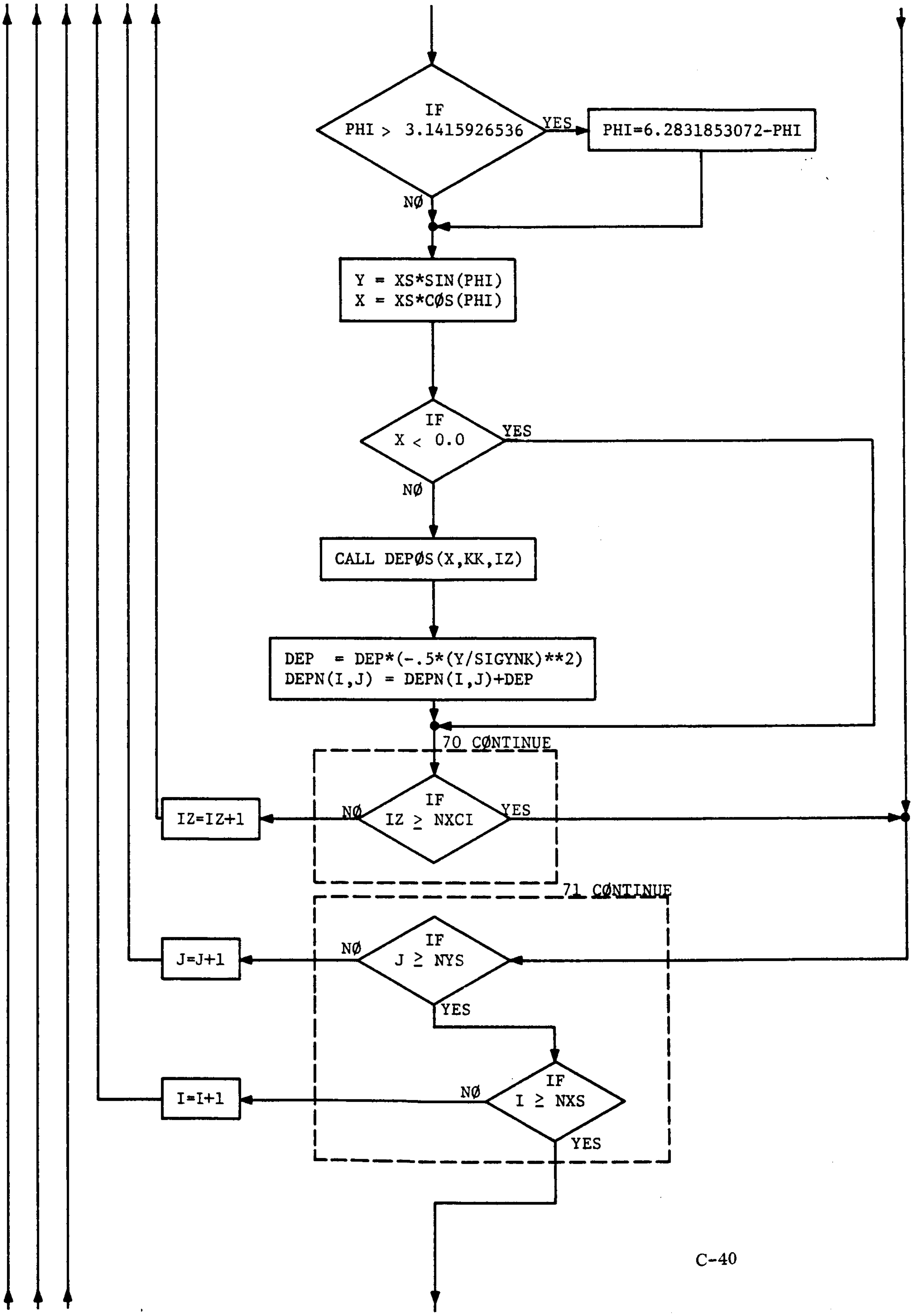

DTHK(N) = DTHK(N-1)+DELTHP(N-1)
SΘ'i
20 CØNTINUE
IF
N ≥ NZS
NØ
YES
N=N+1
DØ 25 N = 2,NZS
DTHK(N) = DTHK(N)*RAD
25 CØNTINUE
IF
N ≥ NZS
NØ
YES
N=N+1
M = ISKIP(2)+1
NTAD = 1
IF
ISKIP(3) = 1
YES
NØ
NTAD = 2
DØ 73 JF = 1,NTAD
NTAP = NVS

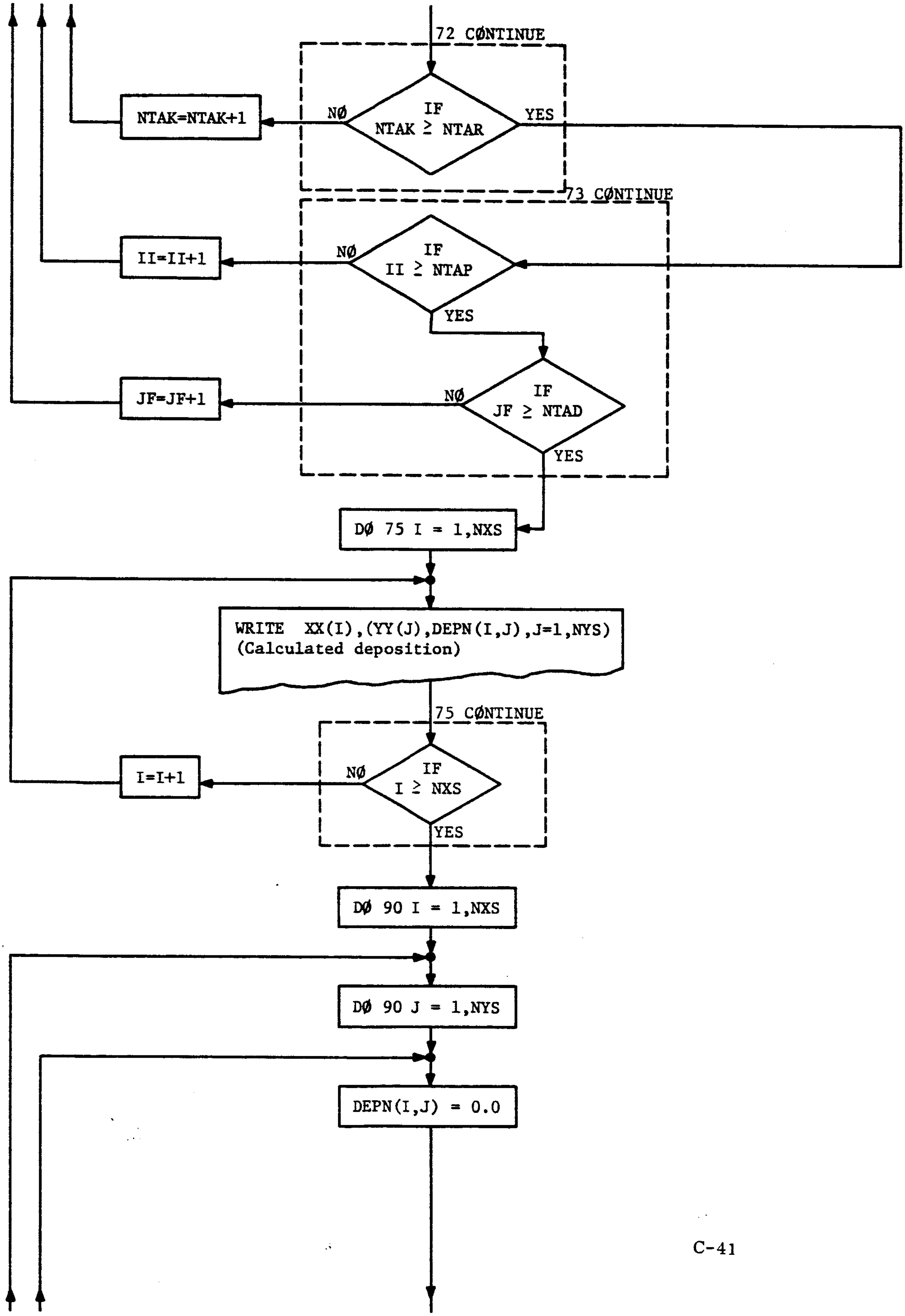

IF
JF = 2
YES
NTAP=NVB
NØ
DØ 73 II = 1,NTAP
IF
JF = 2
ØR
VS(II) ≤ 10.0
YES
NØ
WRITE VS(II),II
Message to indicate Vs is too large. Vs ≤ 10.0. Program goes to next case or stop.
RETURN
NTAK = 1
NTAR = NNZ
IF
ISKIP(3) = 0
YES
NØ

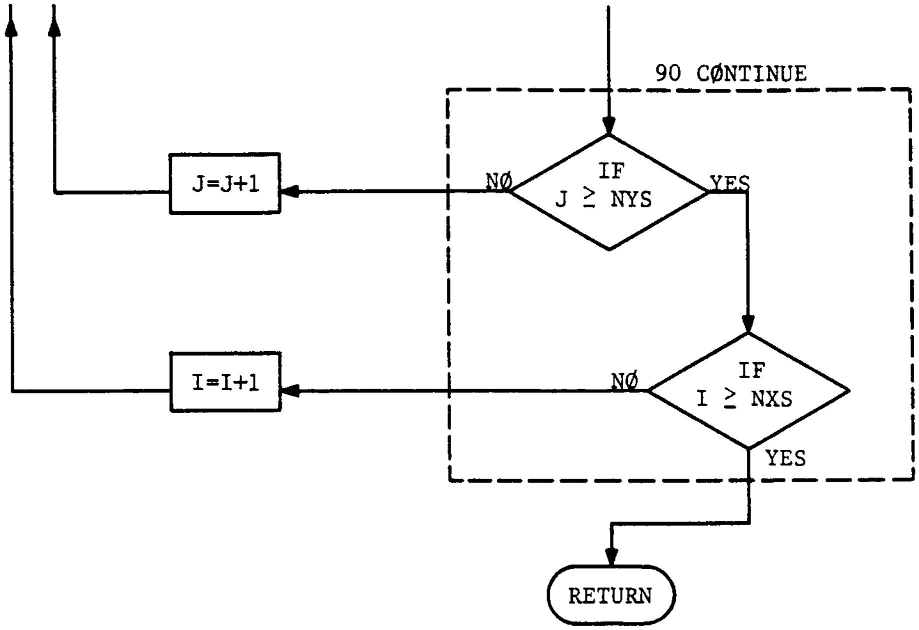

IF
JF = 2
YES
NØ
NTAR = NTAR - 1
NTAK = NNZ
DØ 72 KK = NTAK, NTAR
IF
JF = 2
YES
NØ
S = ((Z(KK+1)-Z(KK))/3.0)+Z(KK)
CALL SGP(S,KK,SIGENK(1),1)
CALL UBARS(S,KK,1,UBHK)
DHK = ACCUR*SIGENK(1)*SQBAR*
SQRT(1.0+VS(II)/UBHK)
IF
DHK < 10.0
YES
DHK=10.0
NØ


S = (Z(KK+1)-Z(KK))/DHK
Number of sources in layer
NXCI = S+1.0
IF
NXCI < 3
ζK
YES
NXCI=3
NØ
DHK = (Z(KK+1)-Z(KK))/
FLØAT(NXCI)
ΔhK
STØ1 = Z(KK)
NXCI = 1
STØ1 = 0
DHK = HB
DØ 95 IZ = 1,NXCI
STØ1 = STØ1+DHK
ZZL(IZ) = STØ1
CALL SGP(ZZL(IZ),KK,
SIGENK(IZ),1)


CALL SGP(ZZL(IZ),KK,
SIGANK(IZ),2)
CALL UBARS(ZZL(IZ),KK,IZ,UBHK)
CALL BETAK(ZZL(IZ),KK,IZ)
95 CØNTINUE
IF
IZ ≥ NXCI
NØ
IZ=IZ+1
YES
DØ 71 I = 1,NXS
DØ 71 J = 1,NYS
N = 1
CALL CØØRD(N,KK,X,Y,XX(I),
YY(J),ASP,XS,1)
IF
N = 9
YES
RECEPTØR ØUTSIDE
ØF SECTØR DELPHI
NØ
DØ 70 IZ = 1,NXCI
PHI = ABS(ASP-(THET+ANG(IZ)))

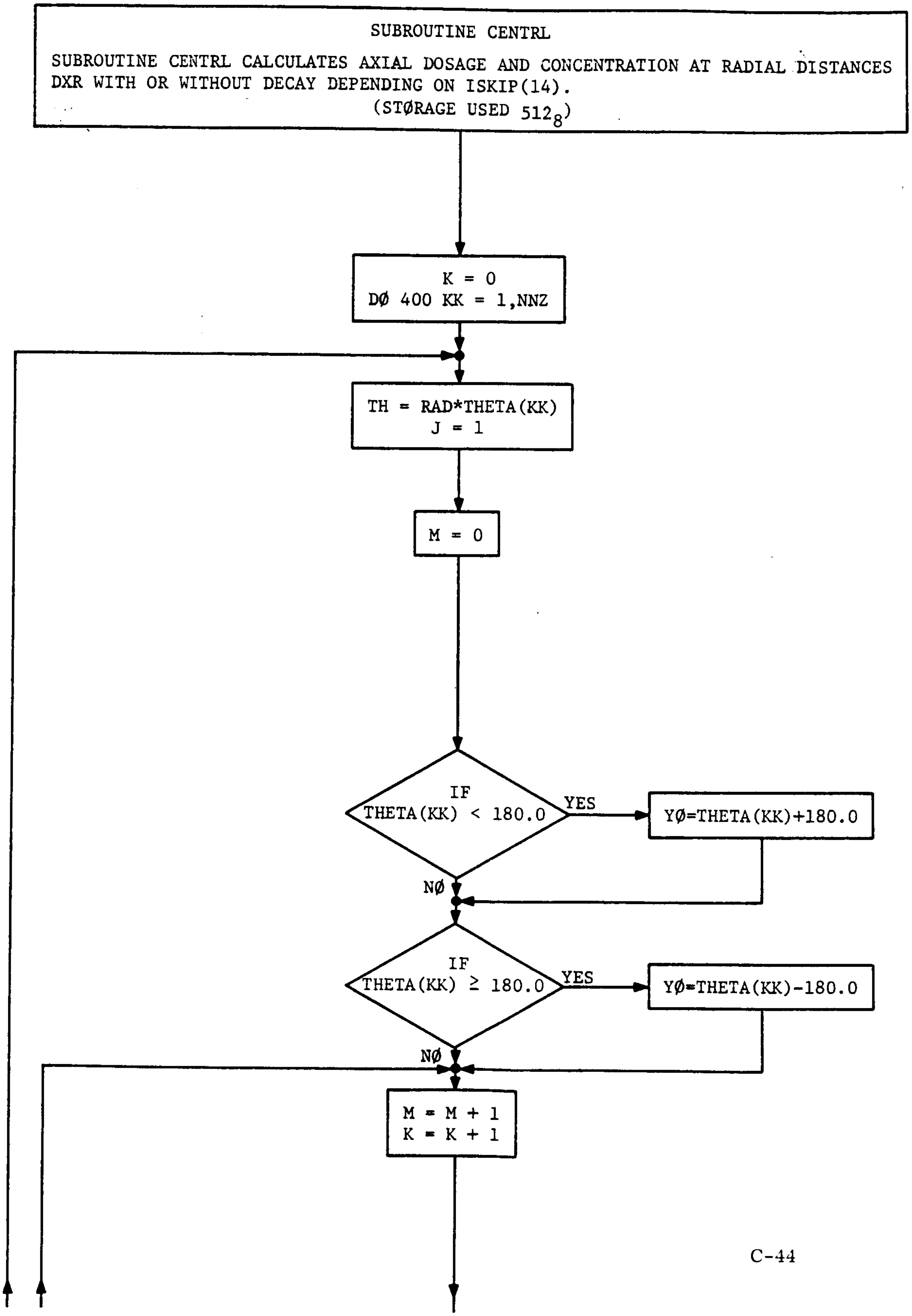

IF
PHI > 3.1415926536
YES
PHI=6.2831853072-PHI
NØ
Y = XS*SIN(PHI)
X = XS*CØS(PHI)
IF
X < 0.0
YES
NØ
CALL DEPØS(X,KK,IZ)
DEP = DEP*(-.5*(Y/SIGYNK)**2)
DEPN(I,J) = DEPN(I,J)+DEP
70 CØNTINUE
IF
IZ ≥ NXCI
NØ
YES
IZ=IZ+1
71 CØNTINUE
IF
J ≥ NYS
NØ
J=J+1
YES
IF
I ≥ NXS
NØ
I=I+1
YES

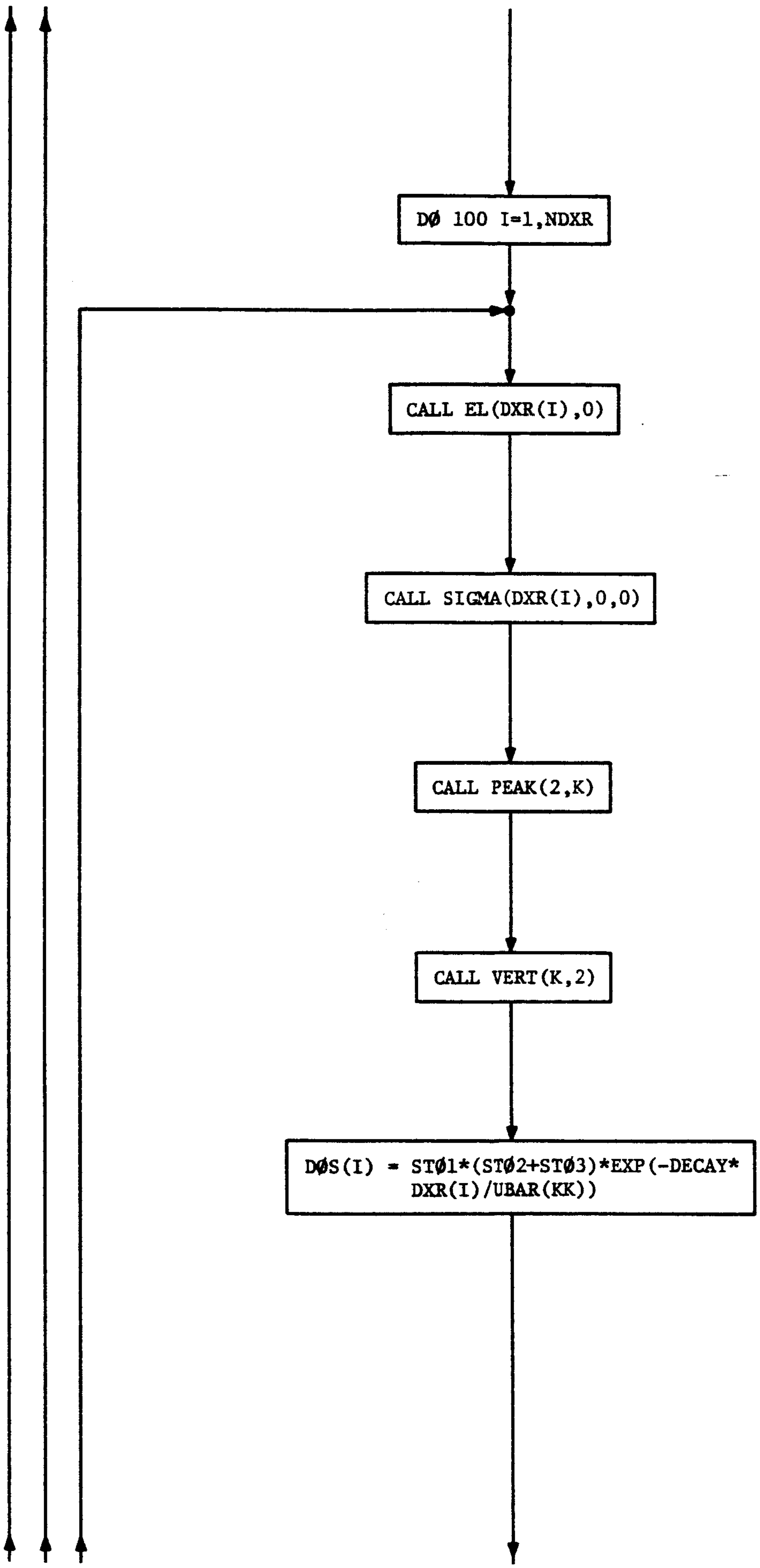

72 CØNTINUE
IF NTAK ≥ NTAR
NØ
YES
NTAK=NTAK+1
73 CØNTINUE
IF II ≥ NTAP
NØ
YES
II=II+1
IF JF ≥ NTAD
NØ
YES
JF=JF+1
DØ 75 I = 1,NXS
WRITE XX(I),(YY(J),DEPN(I,J),J=1,NYS)
(Calculated deposition)
75 CØNTINUE
IF I ≥ NXS
NØ
YES
I=I+1
DØ 90 I = 1,NXS
DØ 90 J = 1,NYS
DEPN(I,J) = 0.0

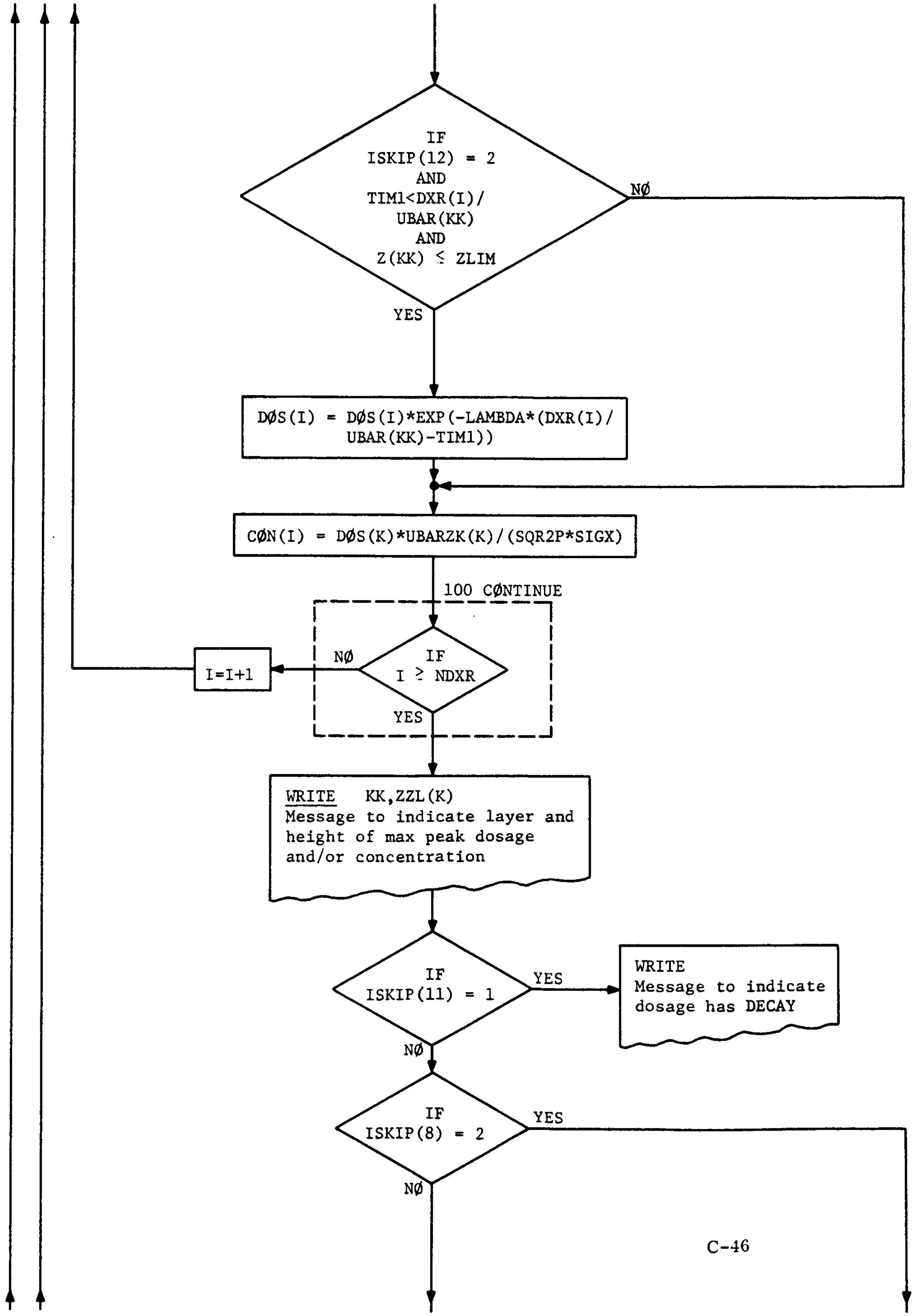

90 CØNTINUE
J=J+1
NØ
IF
J ≥ NYS
YES
I=I+1
NØ
IF
I ≥ NXS
YES
RETURN

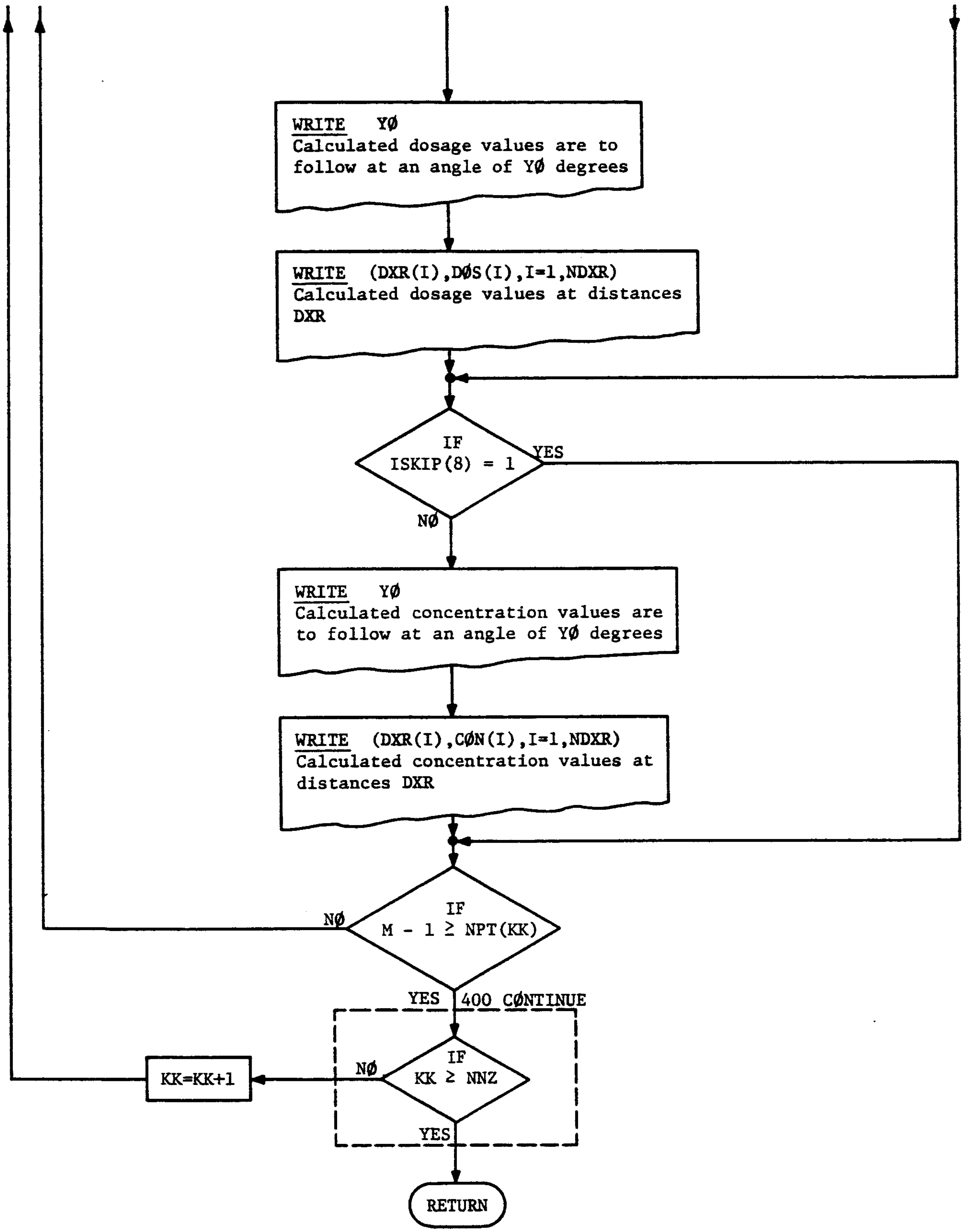
SECTION C.4

SUBROUTINE CENTRL


SUBROUTINE CENTRL
SUBROUTINE CENTRL CALCULATES AXIAL DOSAGE AND CONCENTRATION AT RADIAL DISTANCES DXR WITH OR WITHOUT DECAY DEPENDING ON ISKIP(14).
(STØRAGE USED 512₈)
K = 0
DØ 400 KK = 1,NNZ
TH = RAD*THETA(KK)
J = 1
M = 0
IF THETA(KK) < 180.0
YES
YØ=THETA(KK)+180.0
NØ
IF THETA(KK) ≥ 180.0
YES
YØ=THETA(KK)-180.0
NØ
M = M + 1
K = K + 1

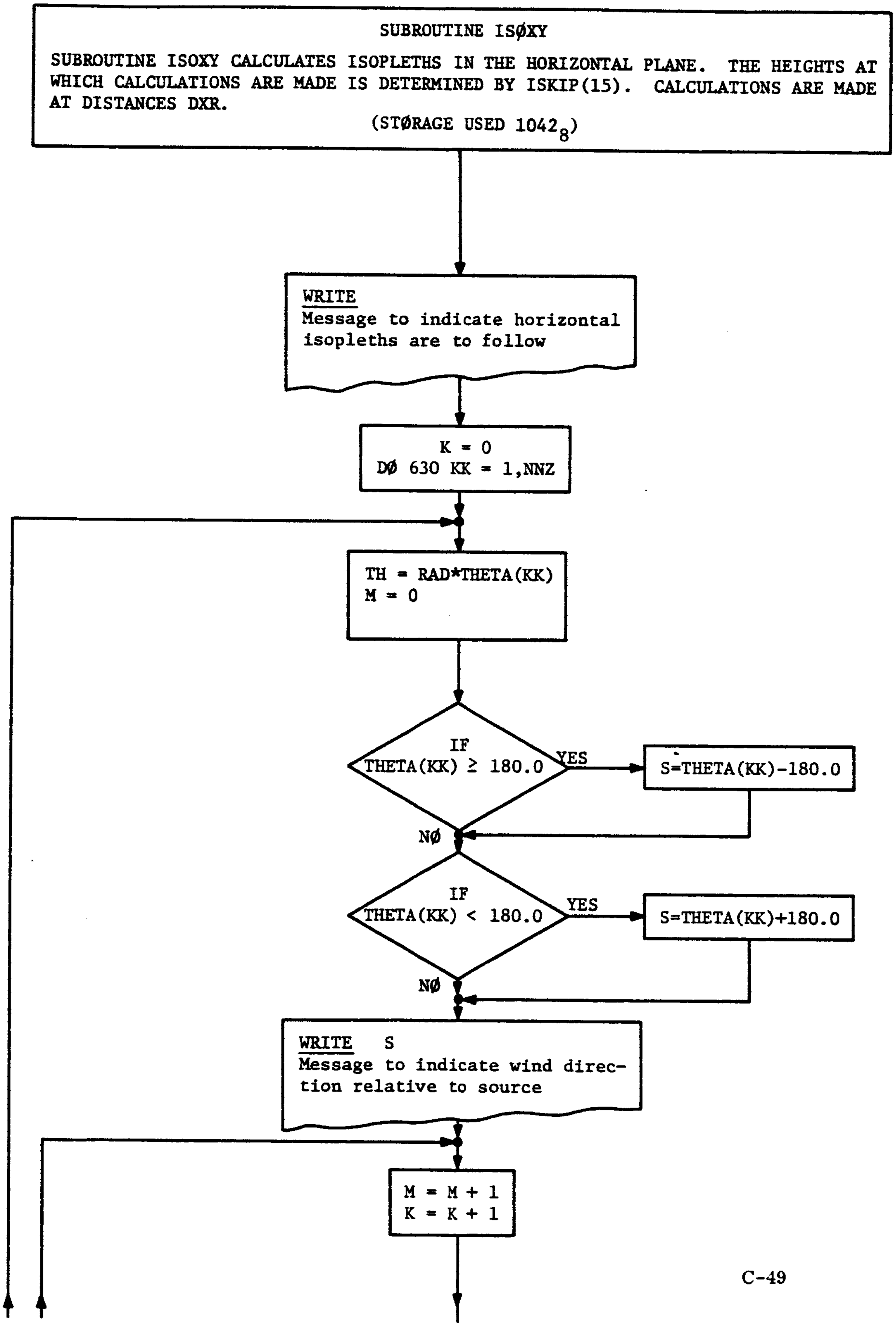

DØ 100 I=1,NDXR
CALL EL(DXR(I),0)
CALL SIGMA(DXR(I),0,0)
CALL PEAK(2,K)
CALL VERT(K,2)
DØS(I) = STØ1*(STØ2+STØ3)*EXP(-DECAY*
DXR(I)/UBAR(KK))

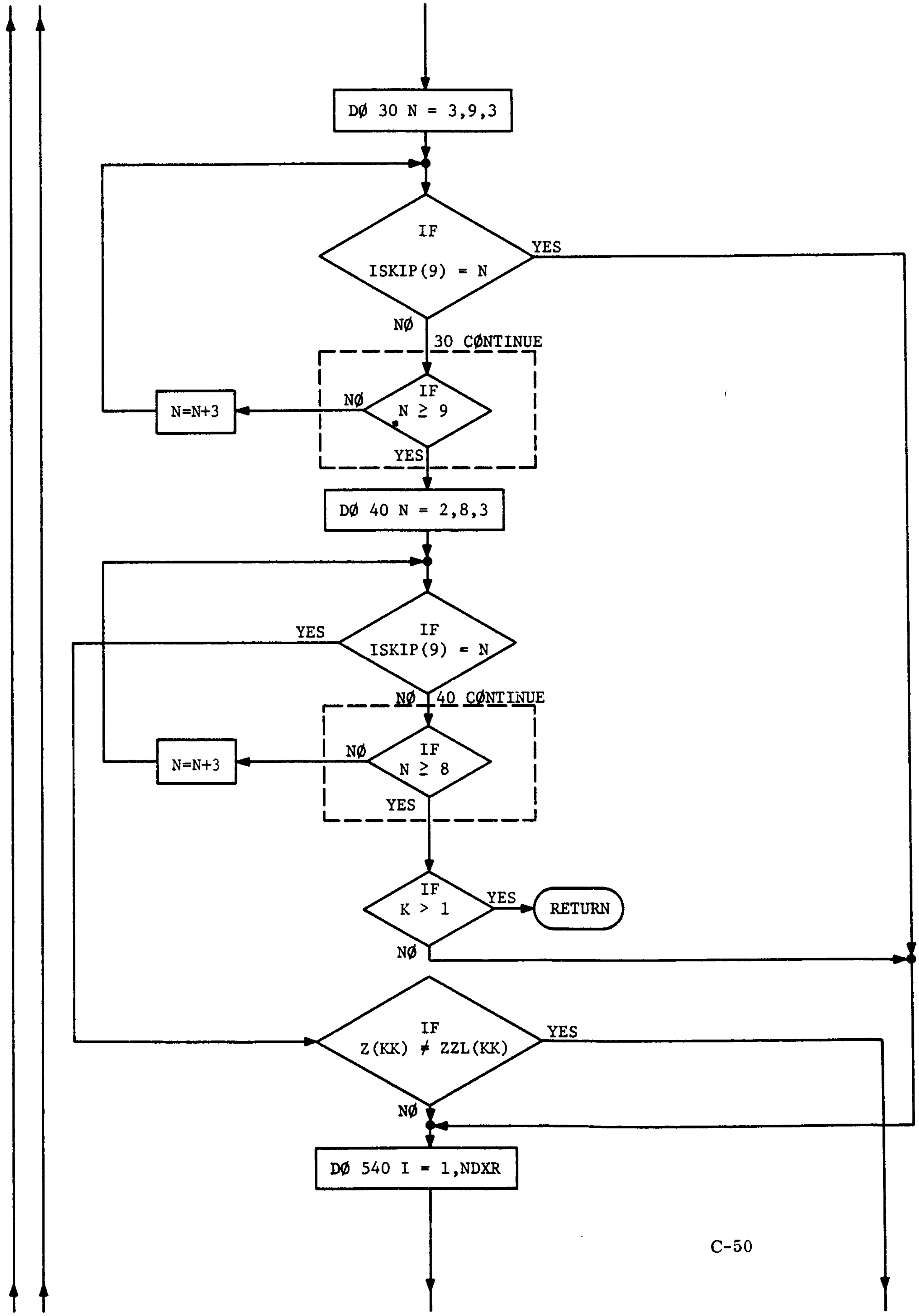

IF
ISKIP(12) = 2
AND
TIM1<DXR(I)/
UBAR(KK)
AND
Z(KK) ≤ ZLIM
NØ
YES
DØS(I) = DØS(I)*EXP(-LAMBDA*(DXR(I)/
UBAR(KK)-TIM1))
CØN(I) = DØS(K)*UBARZK(K)/(SQR2P*SIGX)
100 CØNTINUE
IF
I ≥ NDXR
NØ
I=I+1
YES
WRITE KK,ZZL(K)
Message to indicate layer and
height of max peak dosage
and/or concentration
IF
ISKIP(11) = 1
YES
WRITE
Message to indicate
dosage has DECAY
NØ
IF
ISKIP(8) = 2
YES
NØ

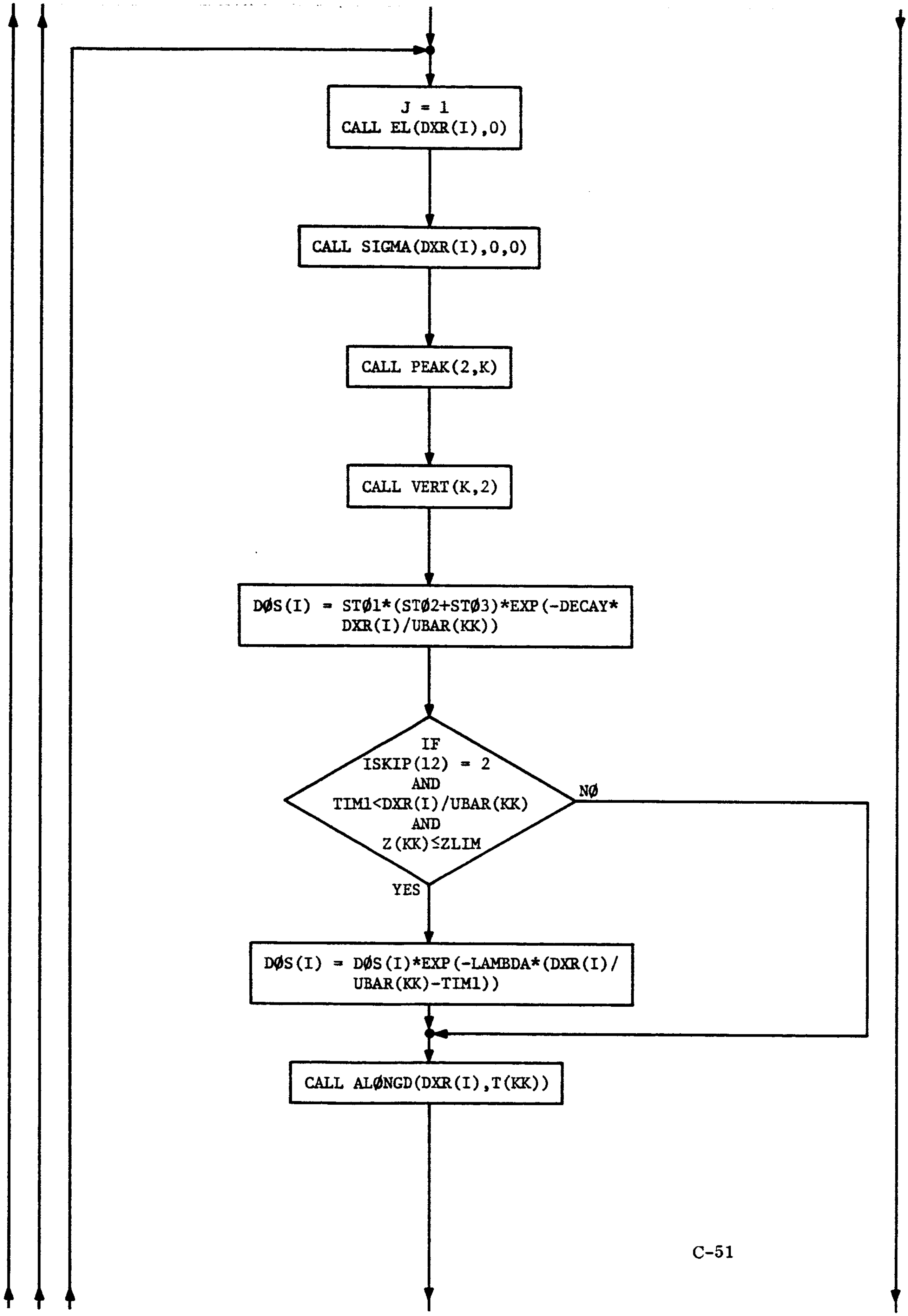

WRITE YØ
Calculated dosage values are to follow at an angle of YØ degrees
WRITE (DXR(I),DØS(I),I=1,NDXR)
Calculated dosage values at distances DXR
IF ISKIP(8) = 1
YES
NØ
WRITE YØ
Calculated concentration values are to follow at an angle of YØ degrees
WRITE (DXR(I),CØN(I),I=1,NDXR)
Calculated concentration values at distances DXR
IF M - 1 ≥ NPT(KK)
NØ
YES
400 CØNTINUE
IF KK ≥ NNZ
NØ
KK=KK+1
YES
RETURN

SECTION C. 5

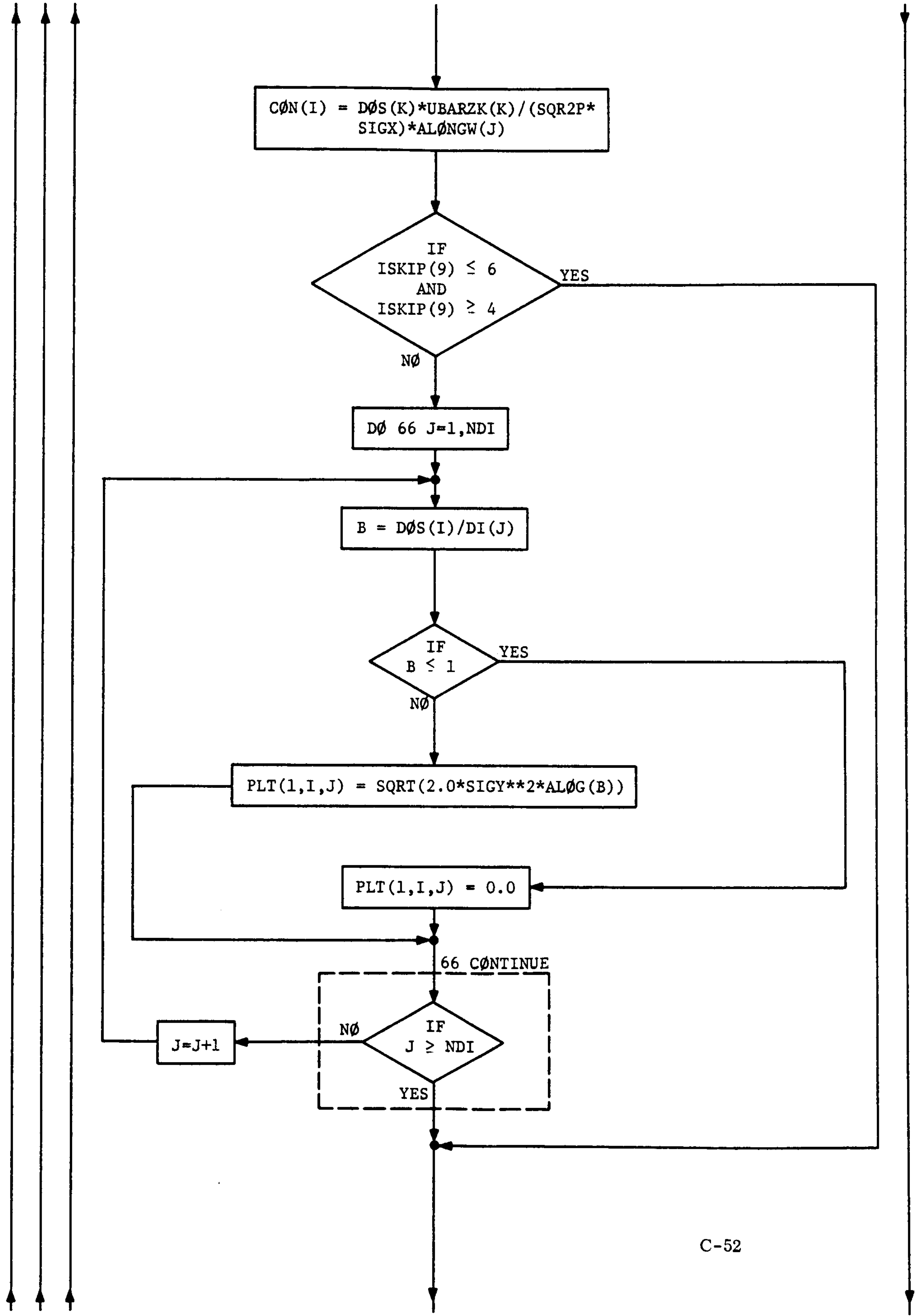
SUBROUTINE ISOXY

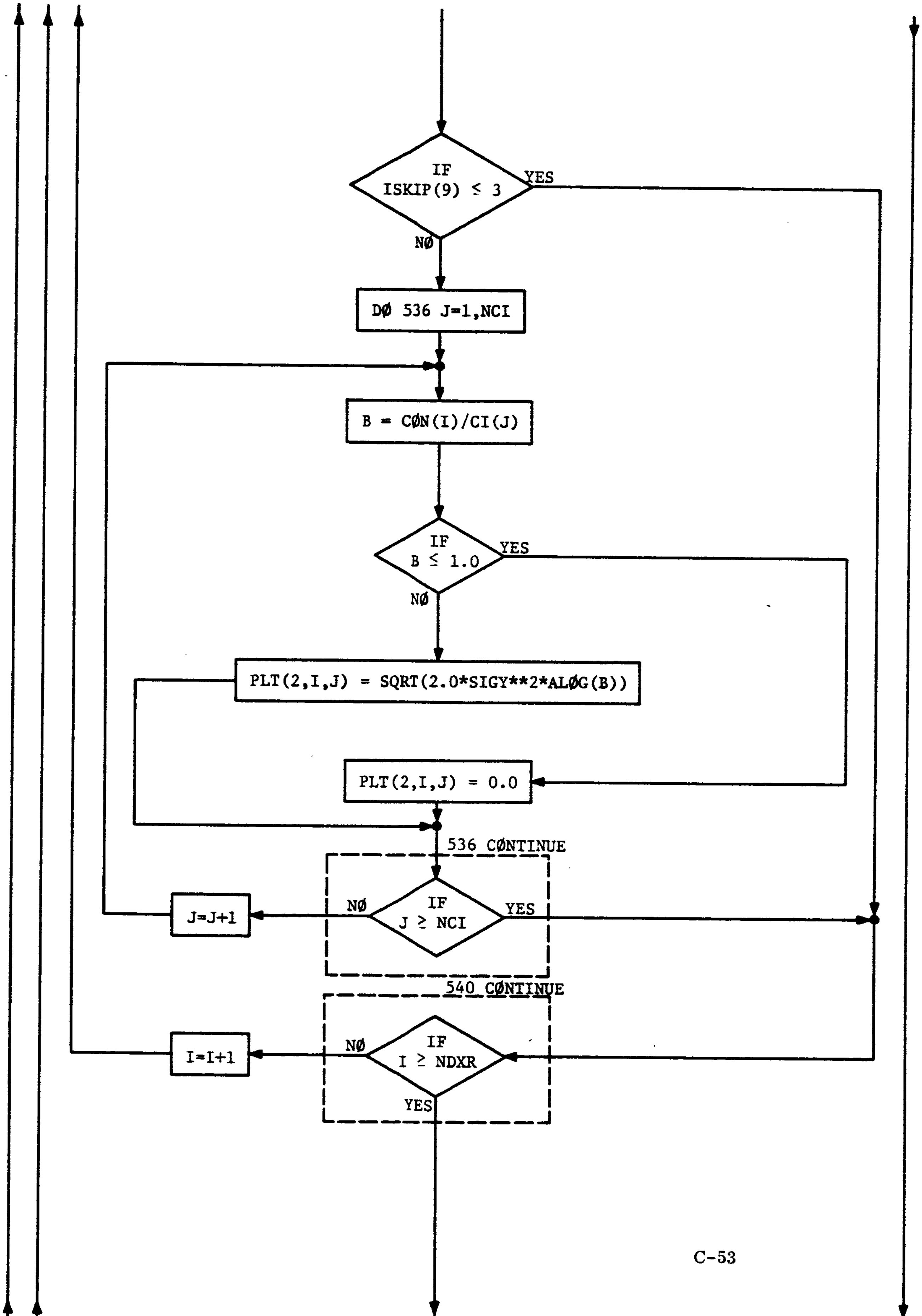

SUBROUTINE ISØXY
SUBROUTINE ISOXY CALCULATES ISOPLETHS IN THE HORIZONTAL PLANE. THE HEIGHTS AT WHICH CALCULATIONS ARE MADE IS DETERMINED BY ISKIP(15). CALCULATIONS ARE MADE AT DISTANCES DXR.
(STØRAGE USED 1042_8)
WRITE
Message to indicate horizontal isopleths are to follow
K = 0
DØ 630 KK = 1,NNZ
TH = RAD*THETA(KK)
M = 0
IF
THETA(KK) ≥ 180.0
YES
S=THETA(KK)-180.0
NØ
IF
THETA(KK) < 180.0
YES
S=THETA(KK)+180.0
NØ
WRITE S
Message to indicate wind direction relative to source
M = M + 1
K = K + 1

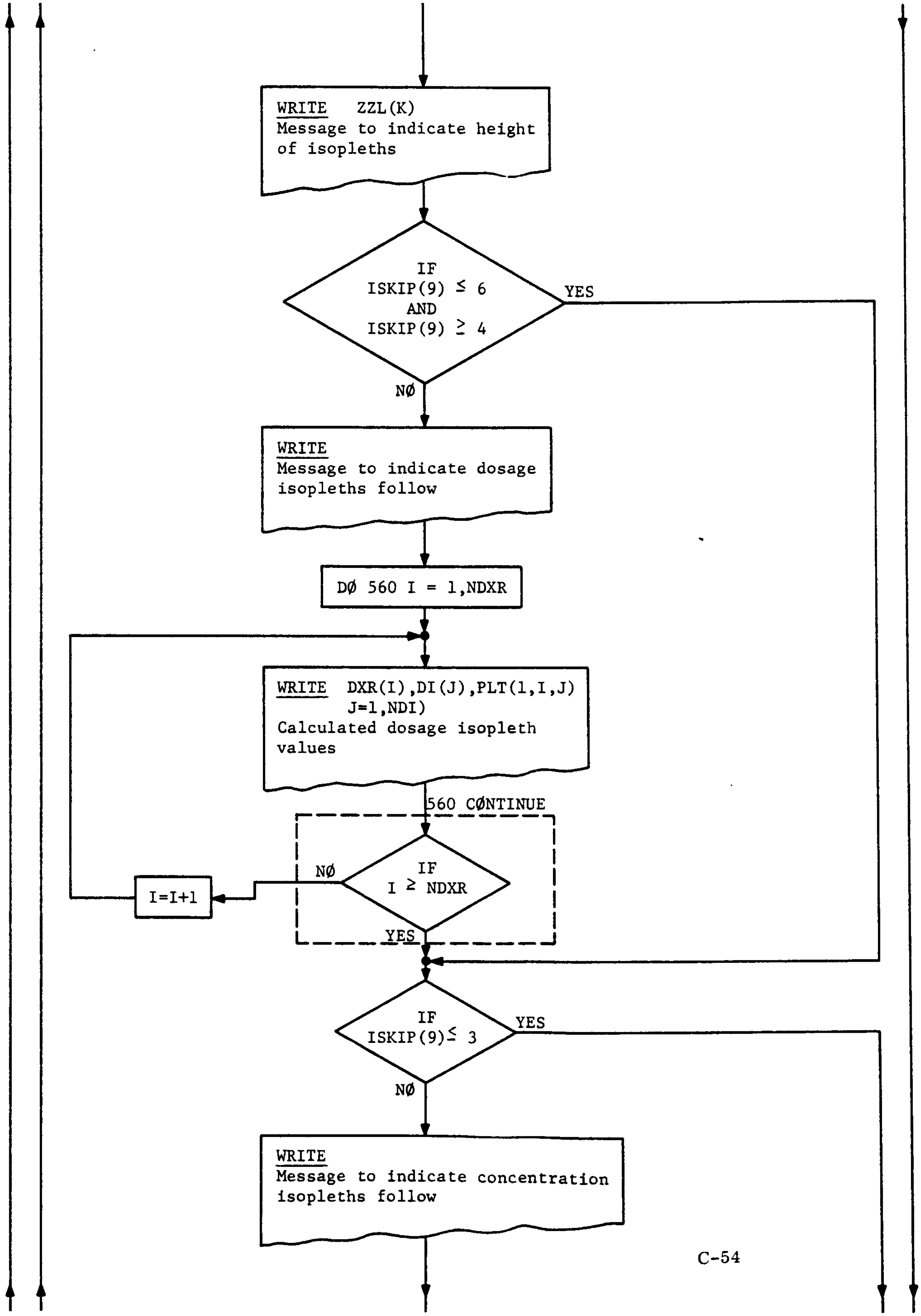

DØ 30 N = 3,9,3
IF
ISKIP(9) = N
YES
NØ
30 CØNTINUE
IF
N ≥ 9
NØ
N=N+3
YES
DØ 40 N = 2,8,3
IF
ISKIP(9) = N
YES
NØ
40 CØNTINUE
IF
N ≥ 8
NØ
N=N+3
YES
IF
K > 1
YES
RETURN
NØ
IF
Z(KK) ≠ ZZL(KK)
YES
NØ
DØ 540 I = 1,NDXR

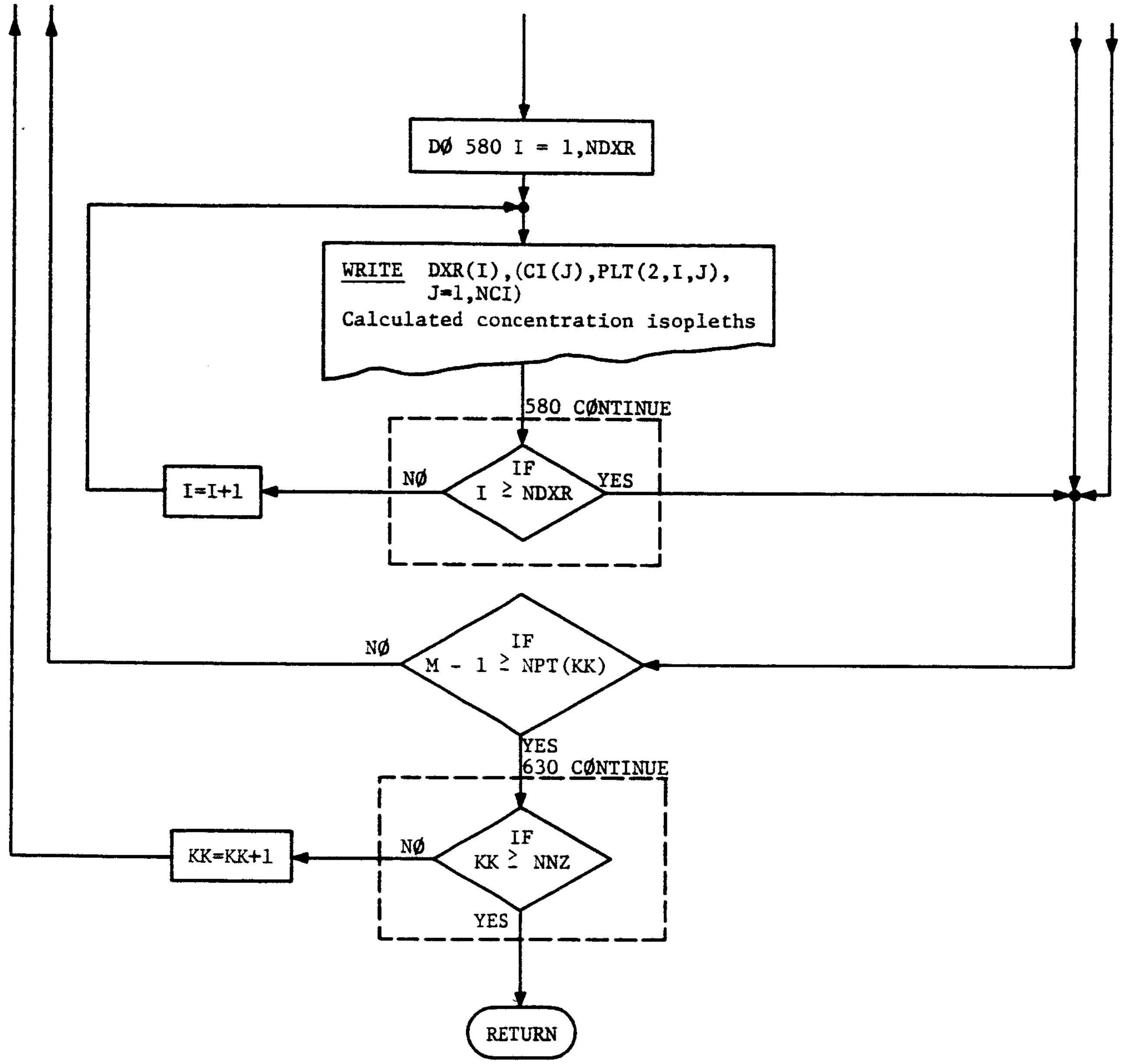


J = 1
CALL EL(DXR(I),0)
CALL SIGMA(DXR(I),0,0)
CALL PEAK(2,K)
CALL VERT(K,2)
DØS(I) = STØ1*(STØ2+STØ3)*EXP(-DECAY*DXR(I)/UBAR(KK))
IF ISKIP(12) = 2 AND TIM1<DXR(I)/UBAR(KK) AND Z(KK)≤ZLIM
NØ
YES
DØS(I) = DØS(I)*EXP(-LAMBDA*(DXR(I)/UBAR(KK)-TIM1))
CALL ALØNGD(DXR(I),T(KK))


CØN(I) = DØS(K)*UBARZK(K)/(SQR2P*
SIGX)*ALØNGW(J)
IF
ISKIP(9) ≤ 6
AND
ISKIP(9) ≥ 4
YES
NØ
DØ 66 J=1,NDI
B = DØS(I)/DI(J)
IF
B ≤ 1
YES
NØ
PLT(1,I,J) = SQRT(2.0*SIGY**2*ALØG(B))
PLT(1,I,J) = 0.0
66 CØNTINUE
NØ
IF
J ≥ NDI
J=J+1
YES

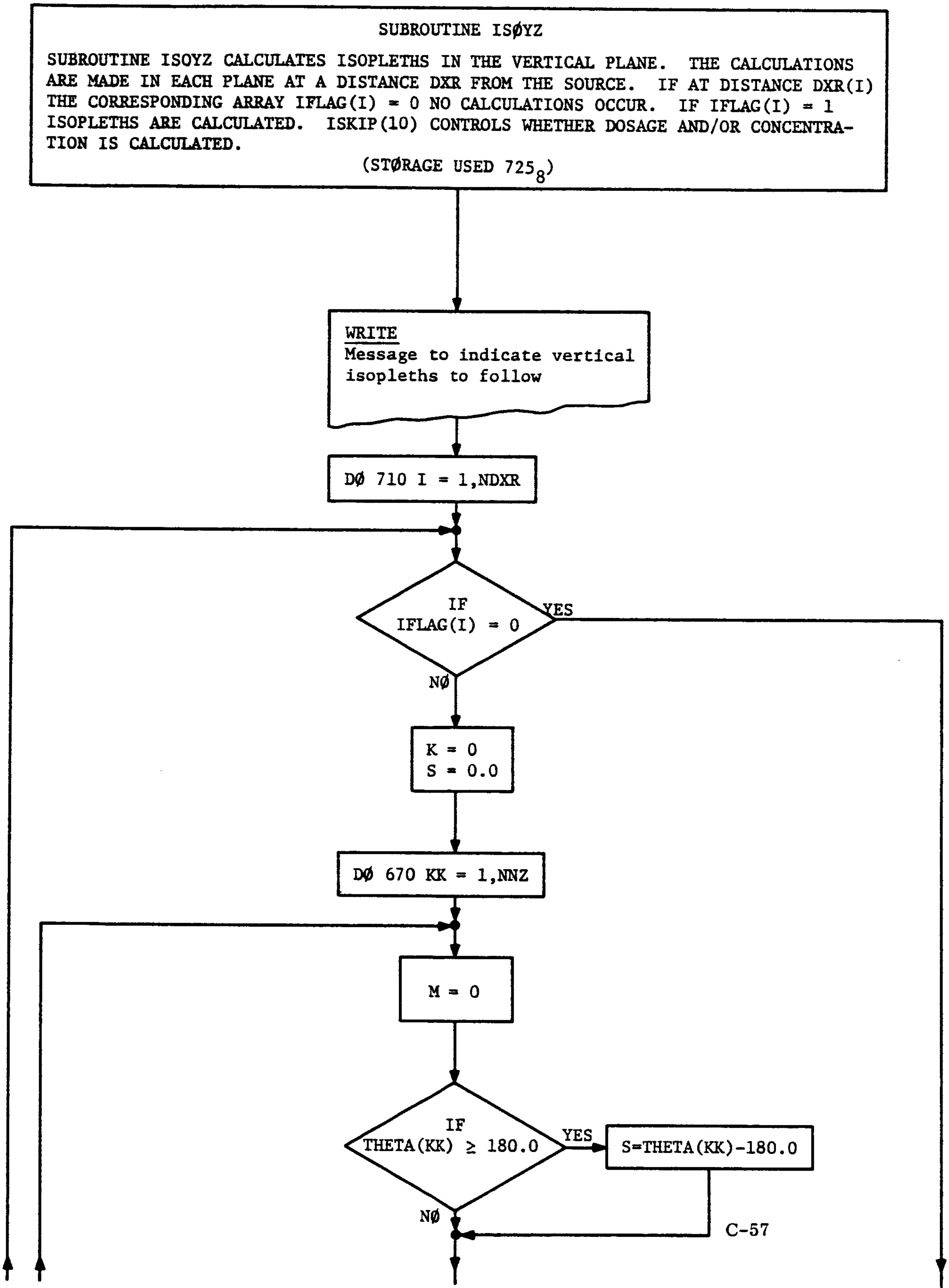

IF
ISKIP(9) ≤ 3
YES
NØ
DØ 536 J=1,NCI
B = CØN(I)/CI(J)
IF
B ≤ 1.0
YES
NØ
PLT(2,I,J) = SQRT(2.0*SIGY**2*ALØG(B))
PLT(2,I,J) = 0.0
536 CØNTINUE
NØ
IF
J ≥ NCI
YES
J=J+1
540 CØNTINUE
NØ
IF
I ≥ NDXR
YES
I=I+1

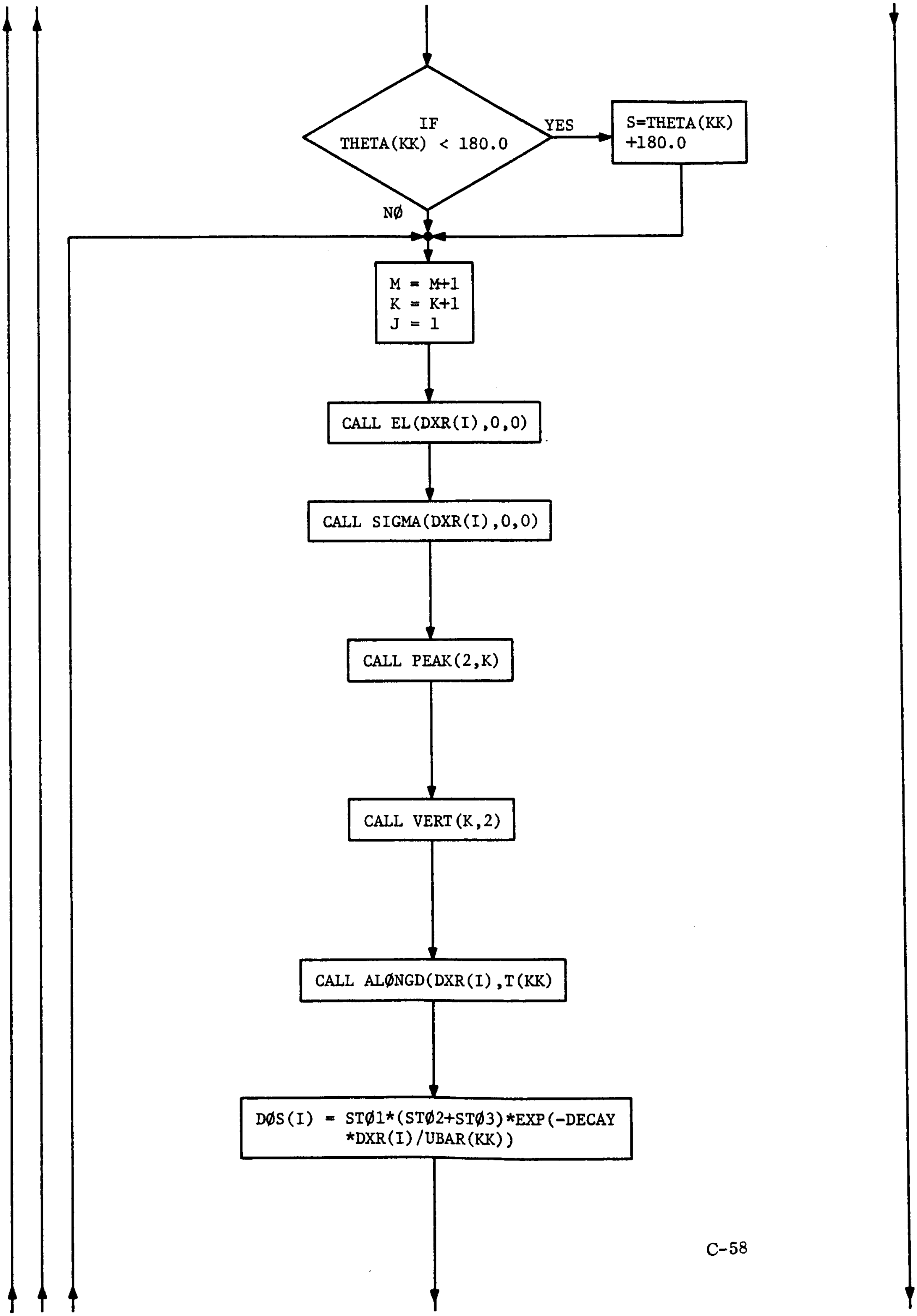

WRITE ZZL(K)
Message to indicate height of isopleths
IF ISKIP(9) ≤ 6 AND ISKIP(9) ≥ 4
YES
NØ
WRITE
Message to indicate dosage isopleths follow
DØ 560 I = 1,NDXR
WRITE DXR(I),DI(J),PLT(1,I,J) J=1,NDI)
Calculated dosage isopleth values
560 CØNTINUE
IF I ≥ NDXR
NØ
YES
I=I+1
IF ISKIP(9)≤ 3
YES
NØ
WRITE
Message to indicate concentration isopleths follow

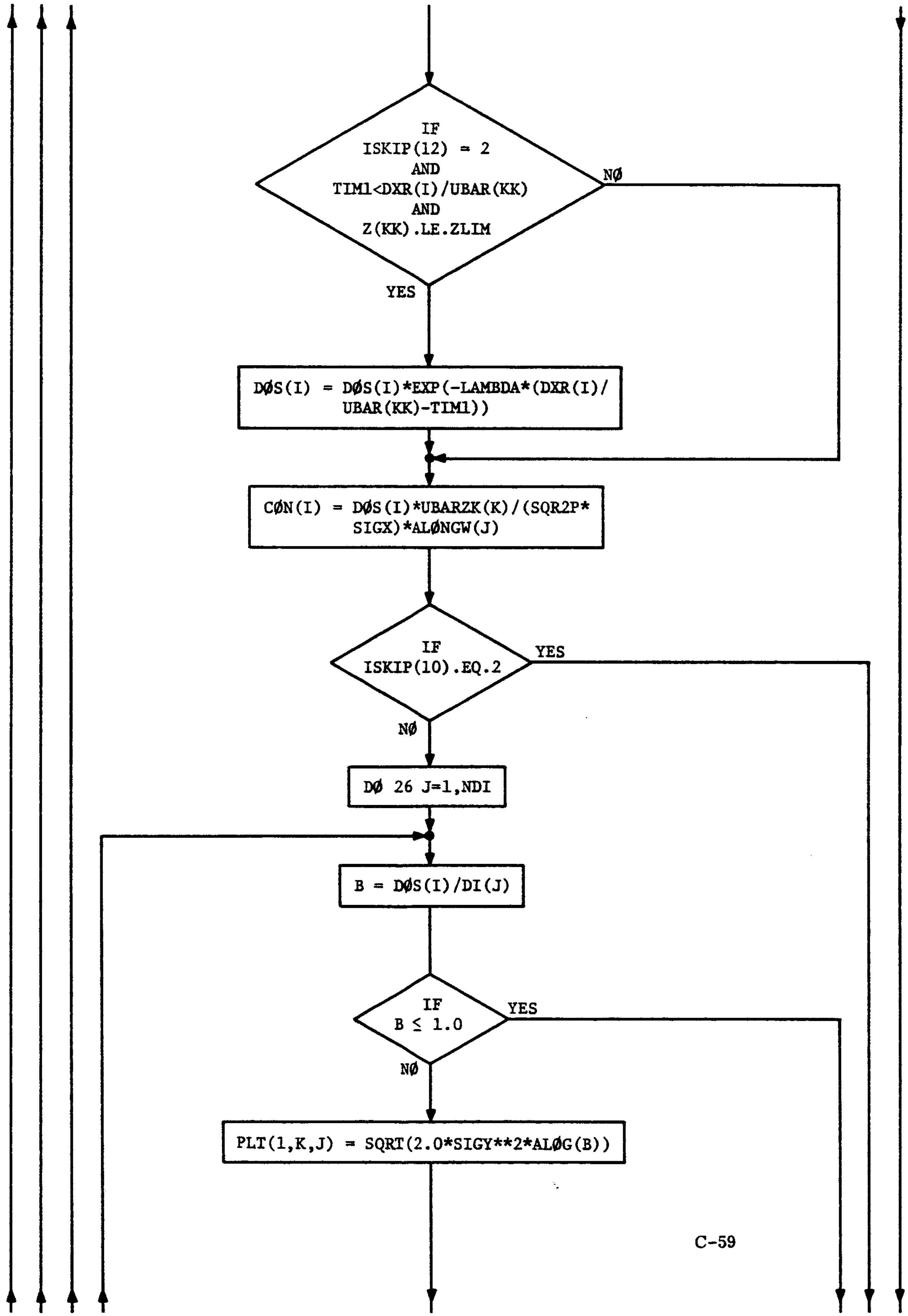

DØ 580 I = 1,NDXR
WRITE DXR(I),(CI(J),PLT(2,I,J), J=1,NCI)
Calculated concentration isopleths
580 CØNTINUE
IF I ≥ NDXR
NØ
YES
I=I+1
IF M - 1 ≥ NPT(KK)
NØ
YES
630 CØNTINUE
IF KK ≥ NNZ
NØ
YES
KK=KK+1
RETURN

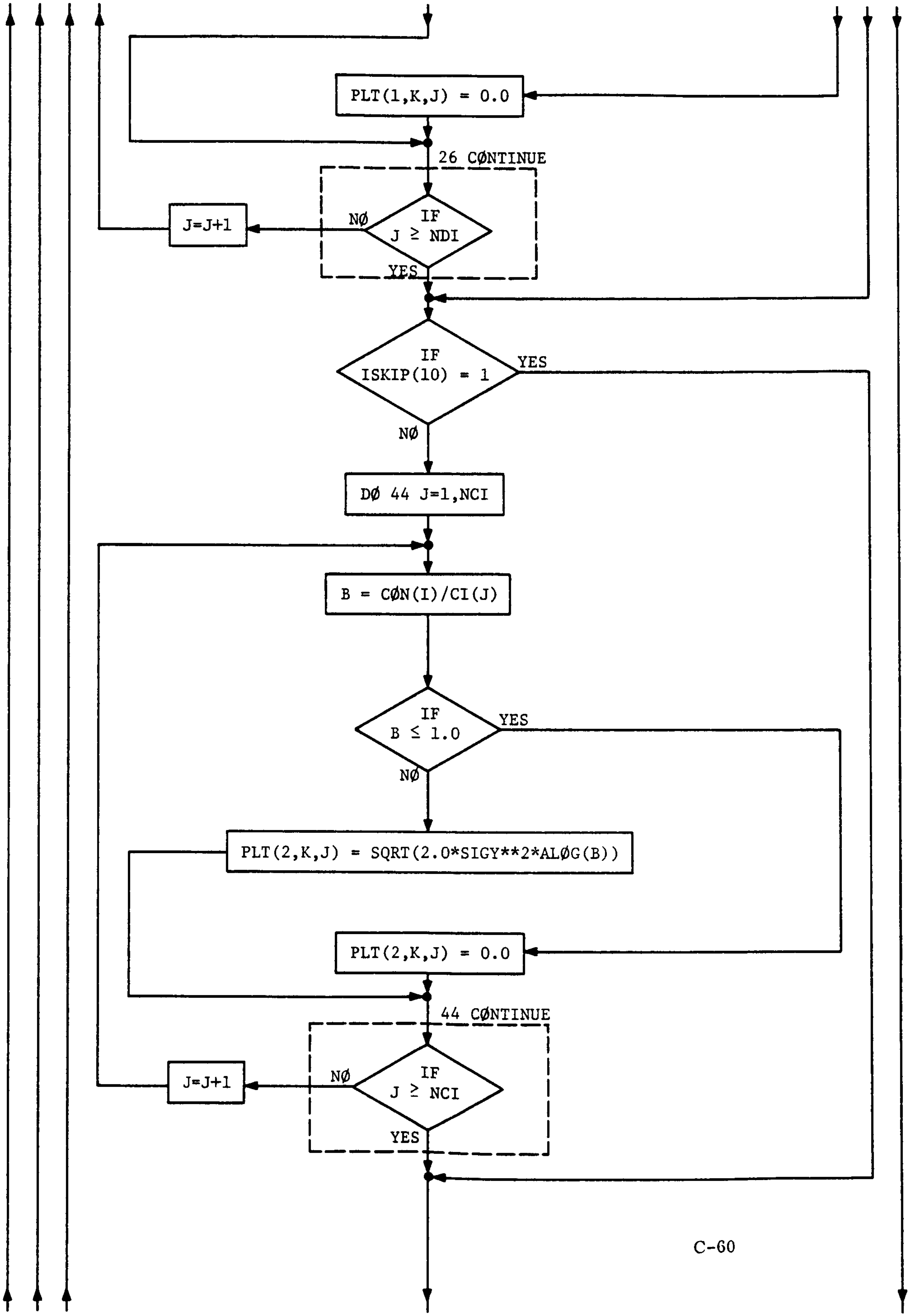
SECTION C.6

SUBROUTINE ISOYZ

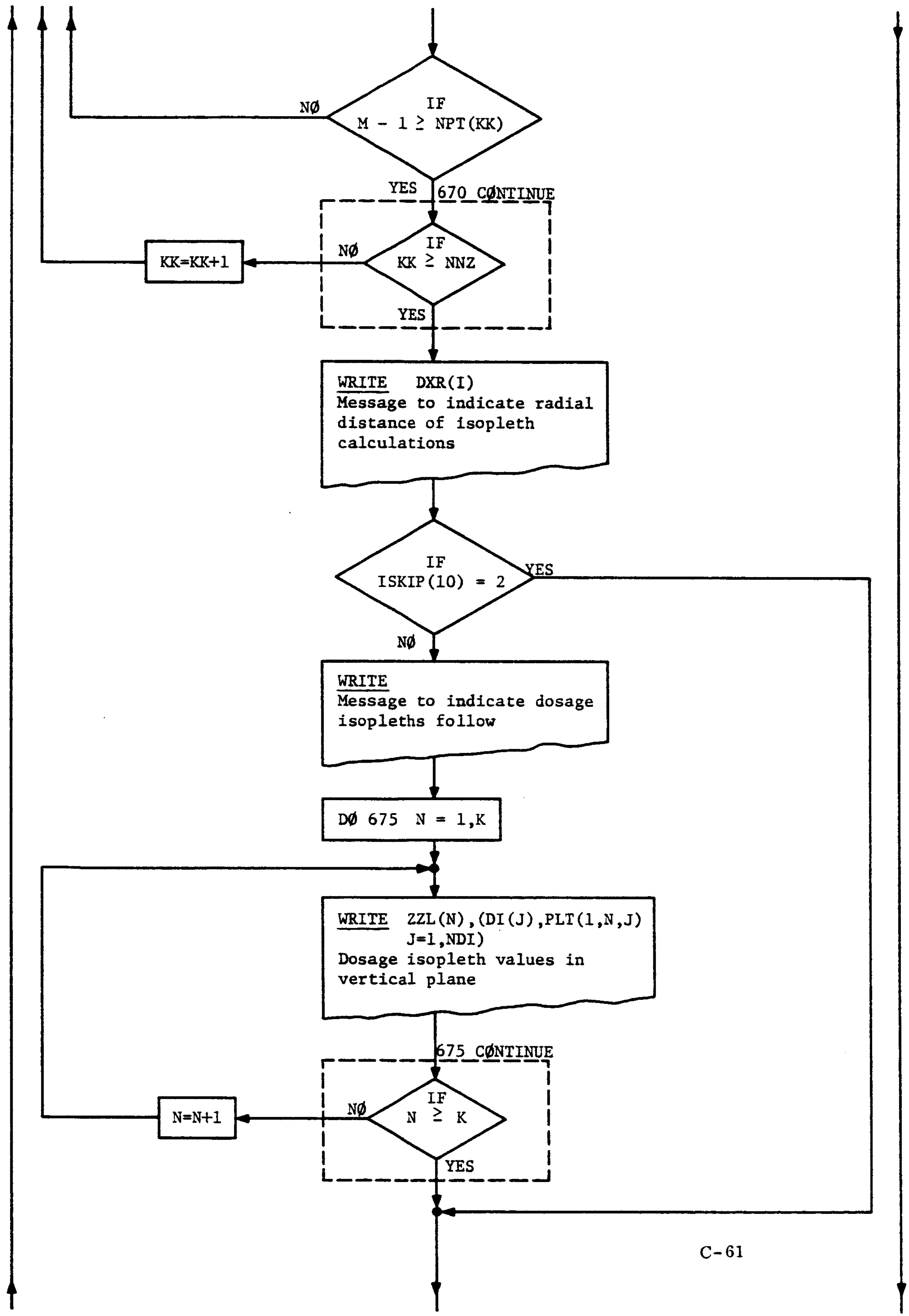

SUBROUTINE ISØYZ
SUBROUTINE ISOYZ CALCULATES ISOPLETHS IN THE VERTICAL PLANE. THE CALCULATIONS ARE MADE IN EACH PLANE AT A DISTANCE DXR FROM THE SOURCE. IF AT DISTANCE DXR(I) THE CORRESPONDING ARRAY IFLAG(I) = 0 NO CALCULATIONS OCCUR. IF IFLAG(I) = 1 ISOPLETHS ARE CALCULATED. ISKIP(10) CONTROLS WHETHER DOSAGE AND/OR CONCENTRATION IS CALCULATED.
(STØRAGE USED 725_8)
WRITE
Message to indicate vertical isopleths to follow
DØ 710 I = 1,NDXR
IF IFLAG(I) = 0
YES
NØ
K = 0
S = 0.0
DØ 670 KK = 1,NNZ
M = 0
IF THETA(KK) ≥ 180.0
YES
S=THETA(KK)-180.0
NØ

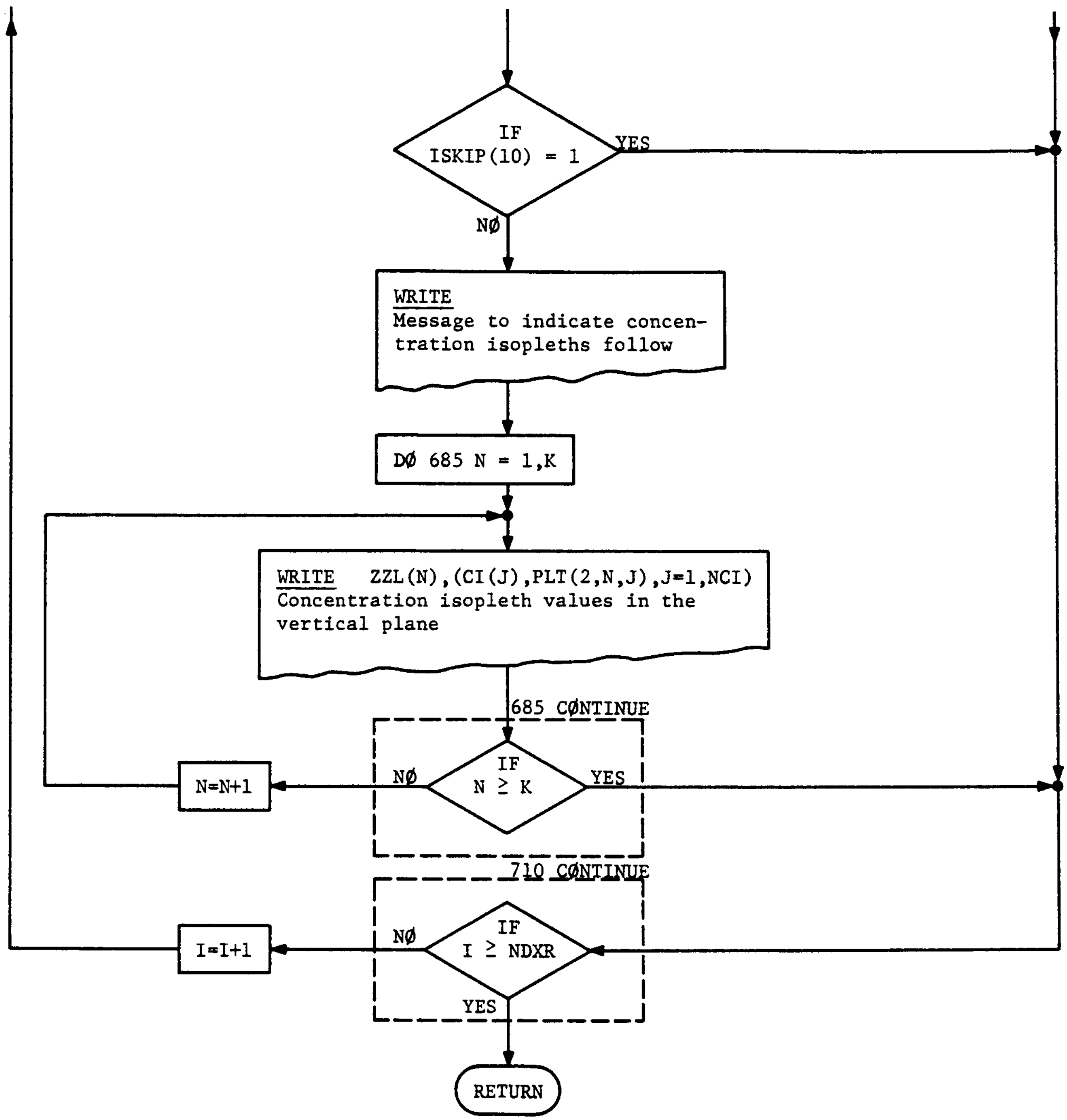

IF
THETA(KK) < 180.0
YES
S=THETA(KK)
+180.0
NØ
M = M+1
K = K+1
J = 1
CALL EL(DXR(I),0,0)
CALL SIGMA(DXR(I),0,0)
CALL PEAK(2,K)
CALL VERT(K,2)
CALL ALØNGD(DXR(I),T(KK)
DØS(I) = STØ1*(STØ2+STØ3)*EXP(-DECAY
*DXR(I)/UBAR(KK))


IF
ISKIP(12) = 2
AND
TIM1<DXR(I)/UBAR(KK)
AND
Z(KK).LE.ZLIM
NØ
YES
DØS(I) = DØS(I)*EXP(-LAMBDA*(DXR(I)/
UBAR(KK)-TIM1))
CØN(I) = DØS(I)*UBARZK(K)/(SQR2P*
SIGX)*ALØNGW(J)
IF
ISKIP(10).EQ.2
YES
NØ
DØ 26 J=1,NDI
B = DØS(I)/DI(J)
IF
B ≤ 1.0
YES
NØ
PLT(1,K,J) = SQRT(2.0*SIGY**2*ALØG(B))



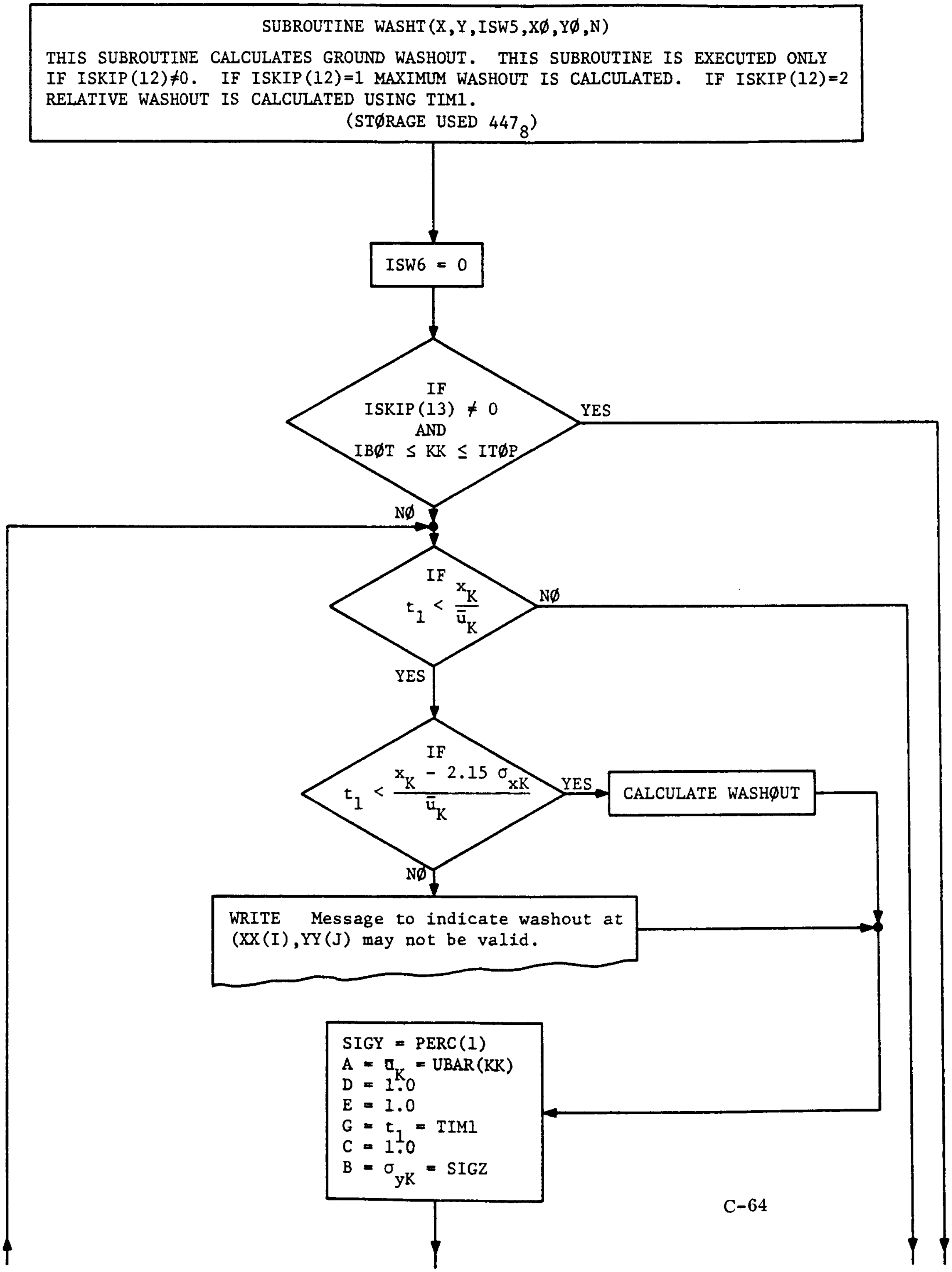
PLT(1,K,J) = 0.0
26 CØNTINUE
IF
J ≥ NDI
NØ
YES
J=J+1
IF
ISKIP(10) = 1
YES
NØ
DØ 44 J=1,NCI
B = CØN(I)/CI(J)
IF
B ≤ 1.0
YES
NØ
PLT(2,K,J) = SQRT(2.0*SIGY**2*ALØG(B))
PLT(2,K,J) = 0.0
44 CØNTINUE
IF
J ≥ NCI
NØ
YES
J=J+1

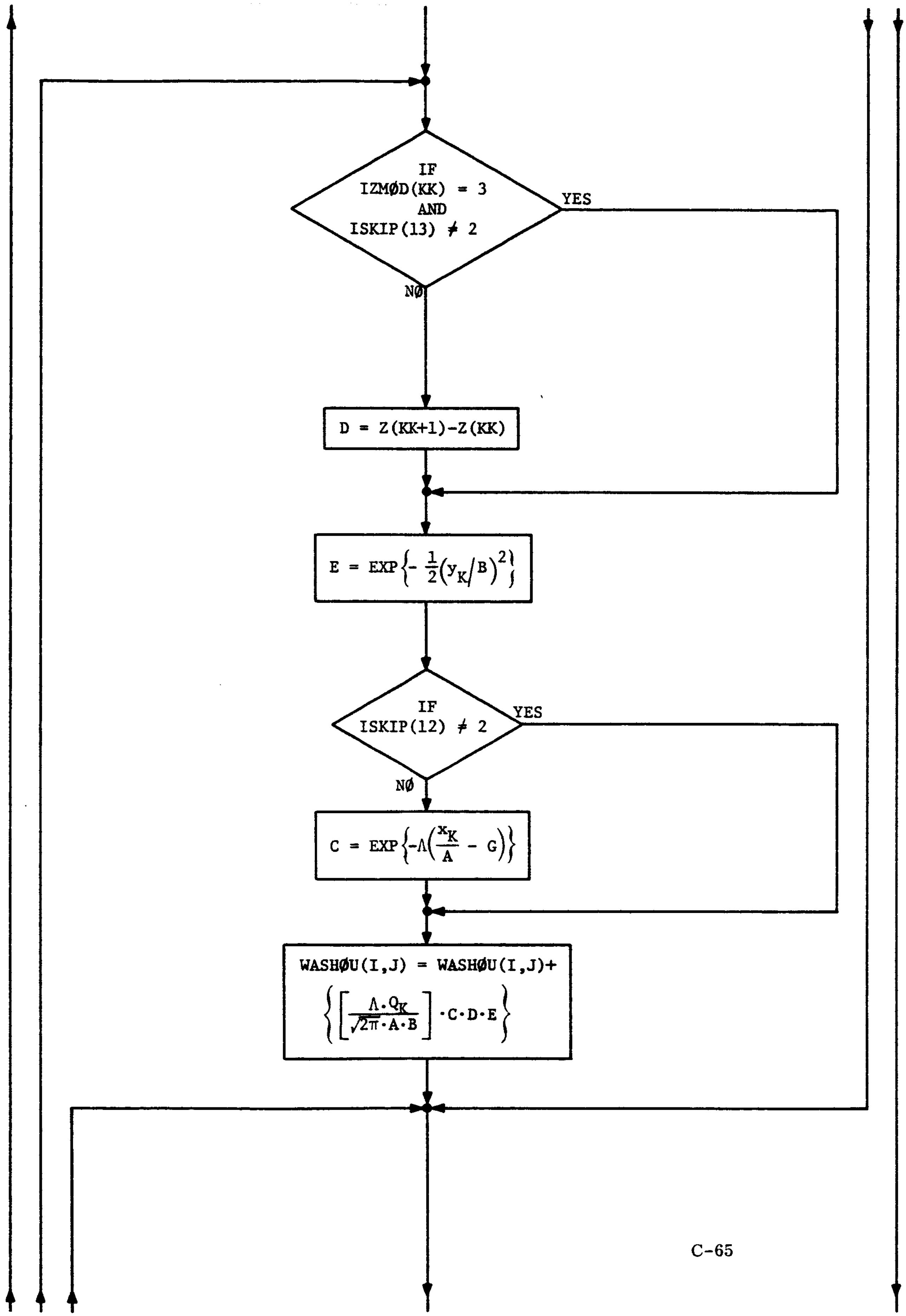

IF
M - 1 ≥ NPT(KK)
NØ
YES
670 CØNTINUE
IF
KK ≥ NNZ
NØ
KK=KK+1
YES
WRITE DXR(I)
Message to indicate radial distance of isopleth calculations
IF
ISKIP(10) = 2
YES
NØ
WRITE
Message to indicate dosage isopleths follow
DØ 675 N = 1,K
WRITE ZZL(N),(DI(J),PLT(1,N,J) J=1,NDI)
Dosage isopleth values in vertical plane
675 CØNTINUE
IF
N ≥ K
NØ
N=N+1
YES

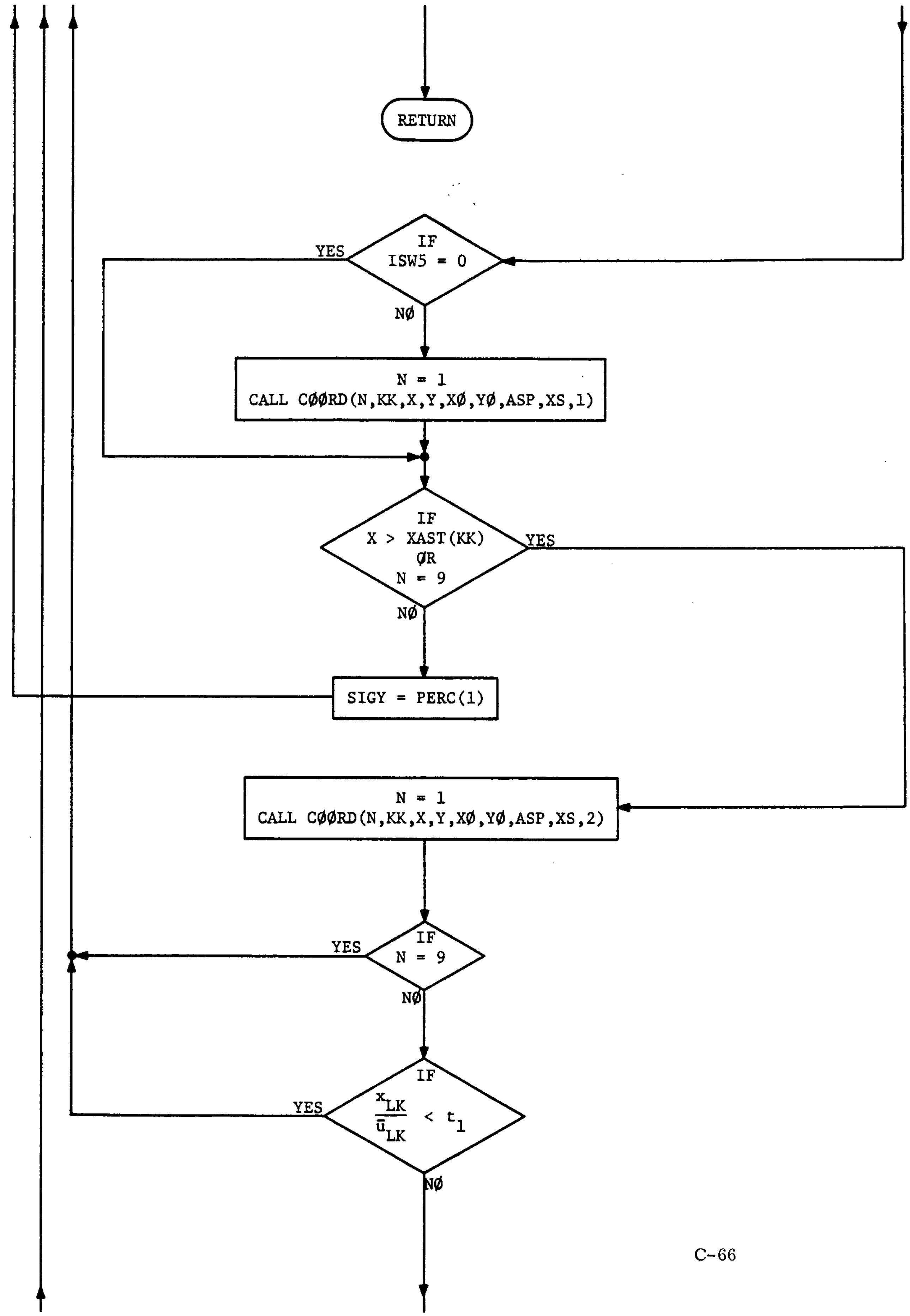

IF
ISKIP(10) = 1
YES
NØ
WRITE
Message to indicate concen-
tration isopleths follow
DØ 685 N = 1,K
WRITE ZZL(N),(CI(J),PLT(2,N,J),J=1,NCI)
Concentration isopleth values in the
vertical plane
685 CØNTINUE
IF
N ≥ K
NØ
YES
N=N+1
710 CØNTINUE
IF
I ≥ NDXR
NØ
YES
I=I+1
RETURN

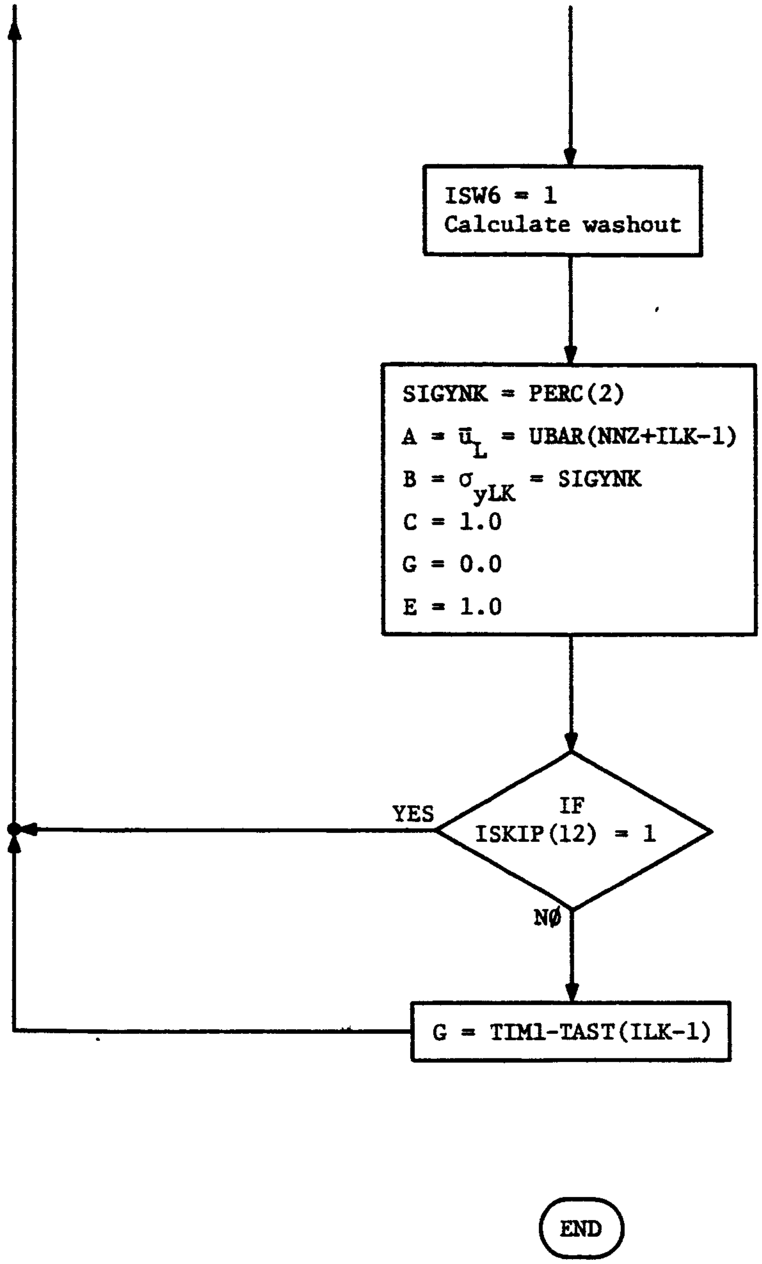
SECTION C. 7

SUBROUTINE WASHT


SUBROUTINE WASHT(X,Y,ISW5,XØ,YØ,N)
THIS SUBROUTINE CALCULATES GROUND WASHOUT. THIS SUBROUTINE IS EXECUTED ONLY IF ISKIP(12)≠0. IF ISKIP(12)=1 MAXIMUM WASHOUT IS CALCULATED. IF ISKIP(12)=2 RELATIVE WASHOUT IS CALCULATED USING TIM1.
(STØRAGE USED 447_8)
ISW6 = 0
IF ISKIP(13) ≠ 0 AND IBØT ≤ KK ≤ ITØP
YES
NØ
IF $t_1 < \frac{x_K}{\bar{u}_K}$
NØ
YES
IF $t_1 < \frac{x_K - 2.15\,\sigma_{xK}}{\bar{u}_K}$
YES
CALCULATE WASHØUT
NØ
WRITE Message to indicate washout at (XX(I),YY(J) may not be valid.
SIGY = PERC(1)
A = $\bar{u}_K$ = UBAR(KK)
D = 1.0
E = 1.0
G = t_1 = TIM1
C = 1.0
B = σ_{yK} = SIGZ


IF
IZMØD(KK) = 3
AND
ISKIP(13) ≠ 2
YES
NØ
D = Z(KK+1)-Z(KK)
$E = EXP\left\{-\frac{1}{2}\left(y_K/B\right)^2\right\}$
IF
ISKIP(12) ≠ 2
YES
NØ
$C = EXP\left\{-\Lambda\left(\frac{x_K}{A} - G\right)\right\}$
WASHØU(I,J) = WASHØU(I,J)+
$\left\{\left[\frac{\Lambda \cdot Q_K}{\sqrt{2\pi} \cdot A \cdot B}\right] \cdot C \cdot D \cdot E\right\}$


RETURN
IF ISW5 = 0
YES
NØ
N = 1
CALL CØØRD(N,KK,X,Y,XØ,YØ,ASP,XS,1)
IF X > XAST(KK) ØR N = 9
YES
NØ
SIGY = PERC(1)
N = 1
CALL CØØRD(N,KK,X,Y,XØ,YØ,ASP,XS,2)
IF N = 9
YES
NØ
IF $\frac{x_{LK}}{\bar{u}_{LK}} < t_1$
YES
NØ


ISW6 = 1
Calculate washout
SIGYNK = PERC(2)
A = ū_L = UBAR(NNZ+ILK-1)
B = σ_yLK = SIGYNK
C = 1.0
G = 0.0
E = 1.0
IF
ISKIP(12) = 1
YES
NØ
G = TIM1-TAST(ILK-1)
END

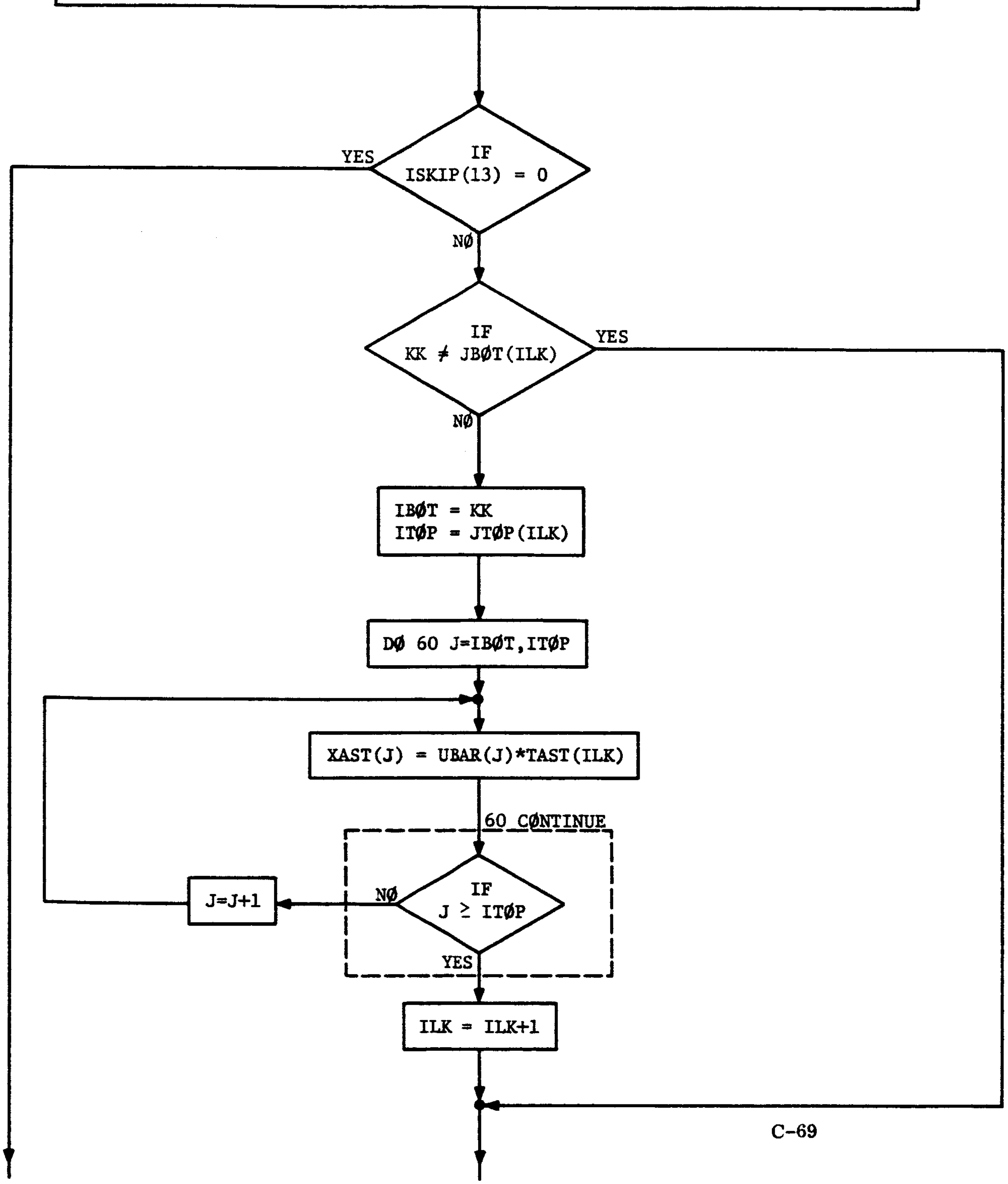
SECTION C.8

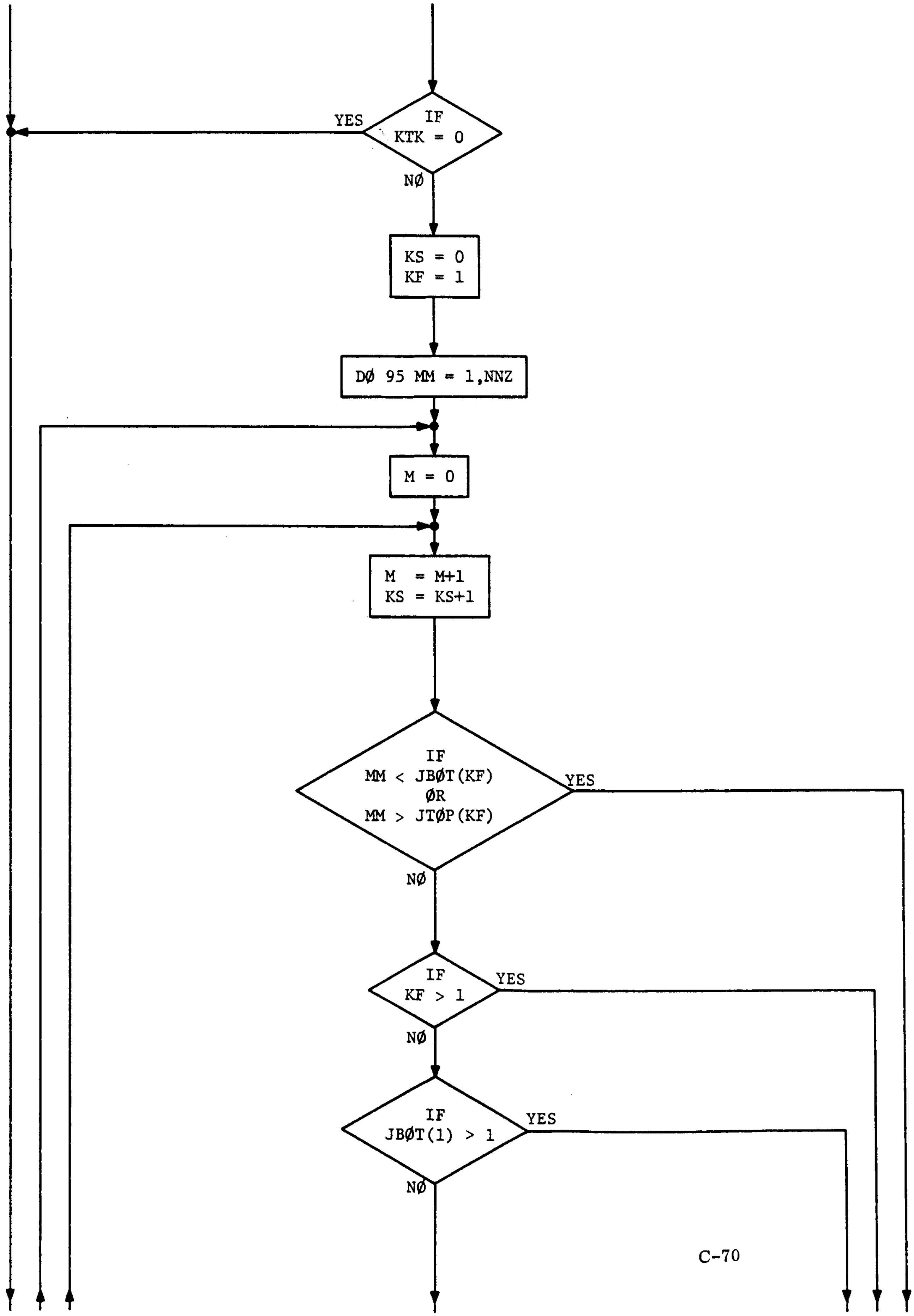
SUBROUTINE TESTR

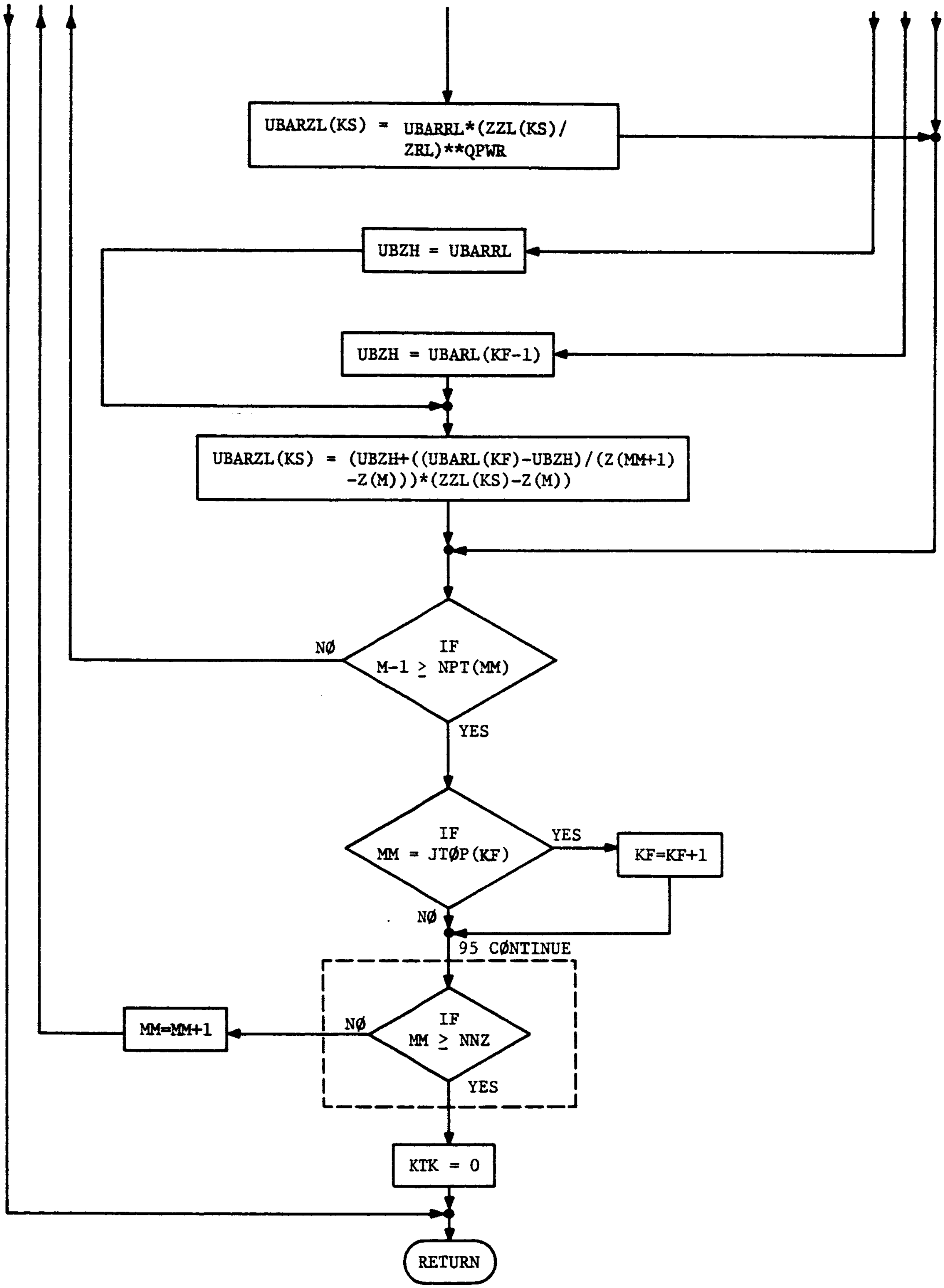
SUBROUTINE TESTR(KTK)

THIS SUBROUTINE DETERMINES THE INDEX VALUES OF MET PARAMETERS USED IN LAYER TRANSITION. THE PROGRAM ALSO CALCULATES THE DISTANCE AT WHICH T* OCCURS IN EACH LAYER CONTAINED IN THE NEW LAYER. IT ALSO CALCULATES WIND SPEED AT EACH CALCULATION HEIGHT IN THE NEW LAYER.

(STØRAGE USED 254_8)




IF
KTK = 0
YES
NØ
KS = 0
KF = 1
DØ 95 MM = 1,NNZ
M = 0
M = M+1
KS = KS+1
IF
MM < JBØT(KF)
ØR
MM > JTØP(KF)
YES
NØ
IF
KF > 1
YES
NØ
IF
JBØT(1) > 1
YES
NØ



UBARZL(KS) = UBARRL*(ZZL(KS)/ZRL)**QPWR
UBZH = UBARRL
UBZH = UBARL(KF-1)
UBARZL(KS) = (UBZH+((UBARL(KF)-UBZH)/(Z(MM+1)-Z(M)))*(ZZL(KS)-Z(M))
IF M-1 ≥ NPT(MM)
NØ
YES
IF MM = JTØP(KF)
YES
KF=KF+1
NØ
95 CØNTINUE
IF MM ≥ NNZ
NØ
MM=MM+1
YES
KTK = 0
RETURN

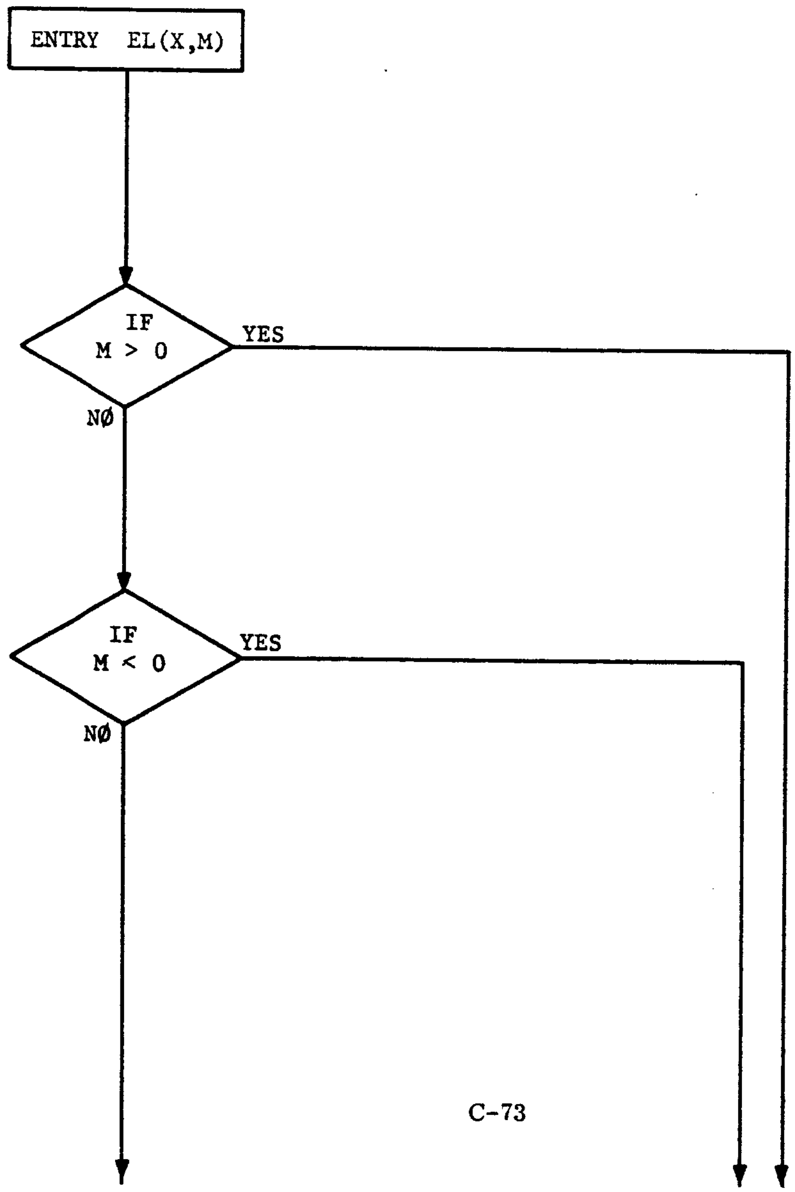
SECTION C. 9

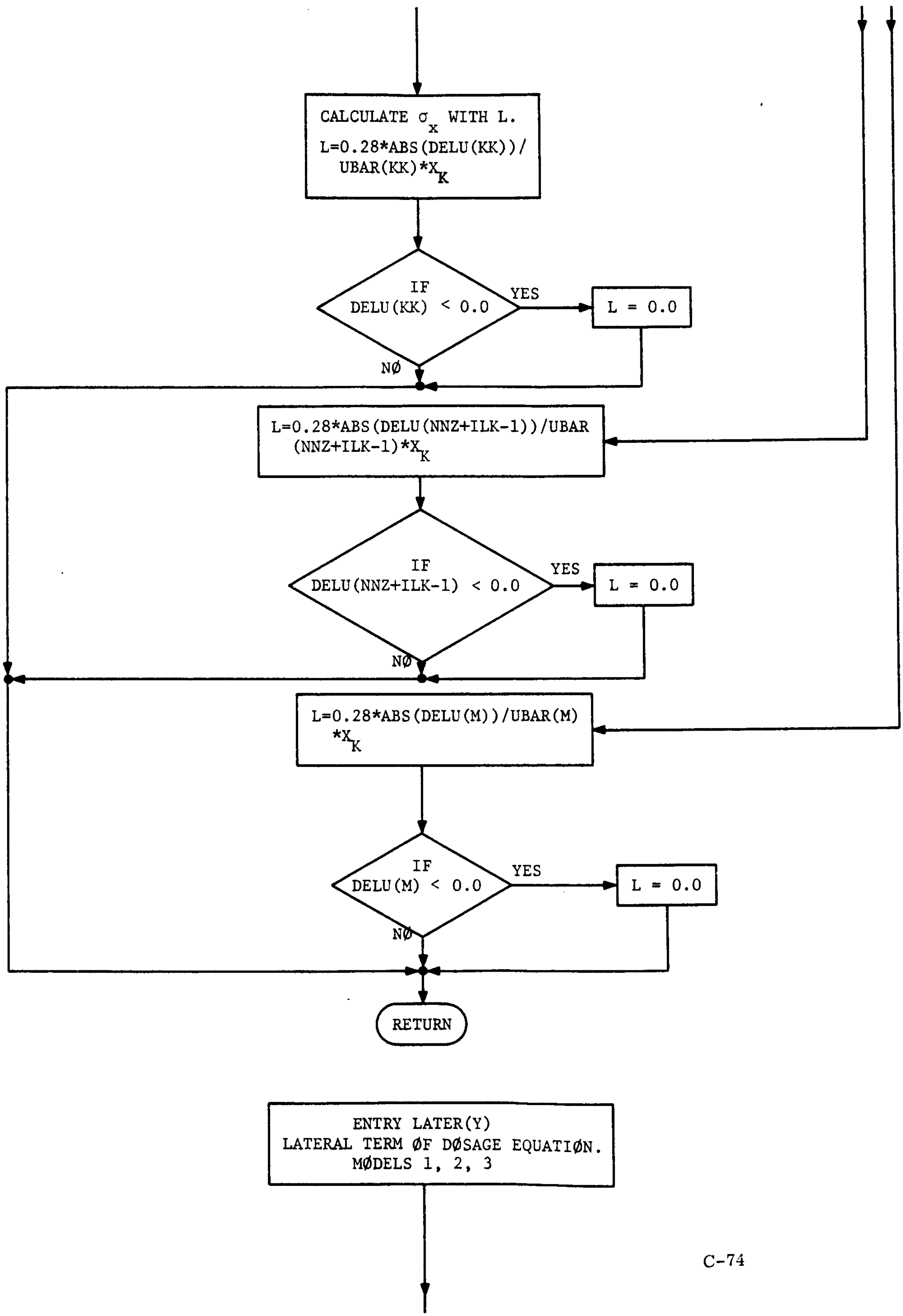
SUBROUTINE ACH

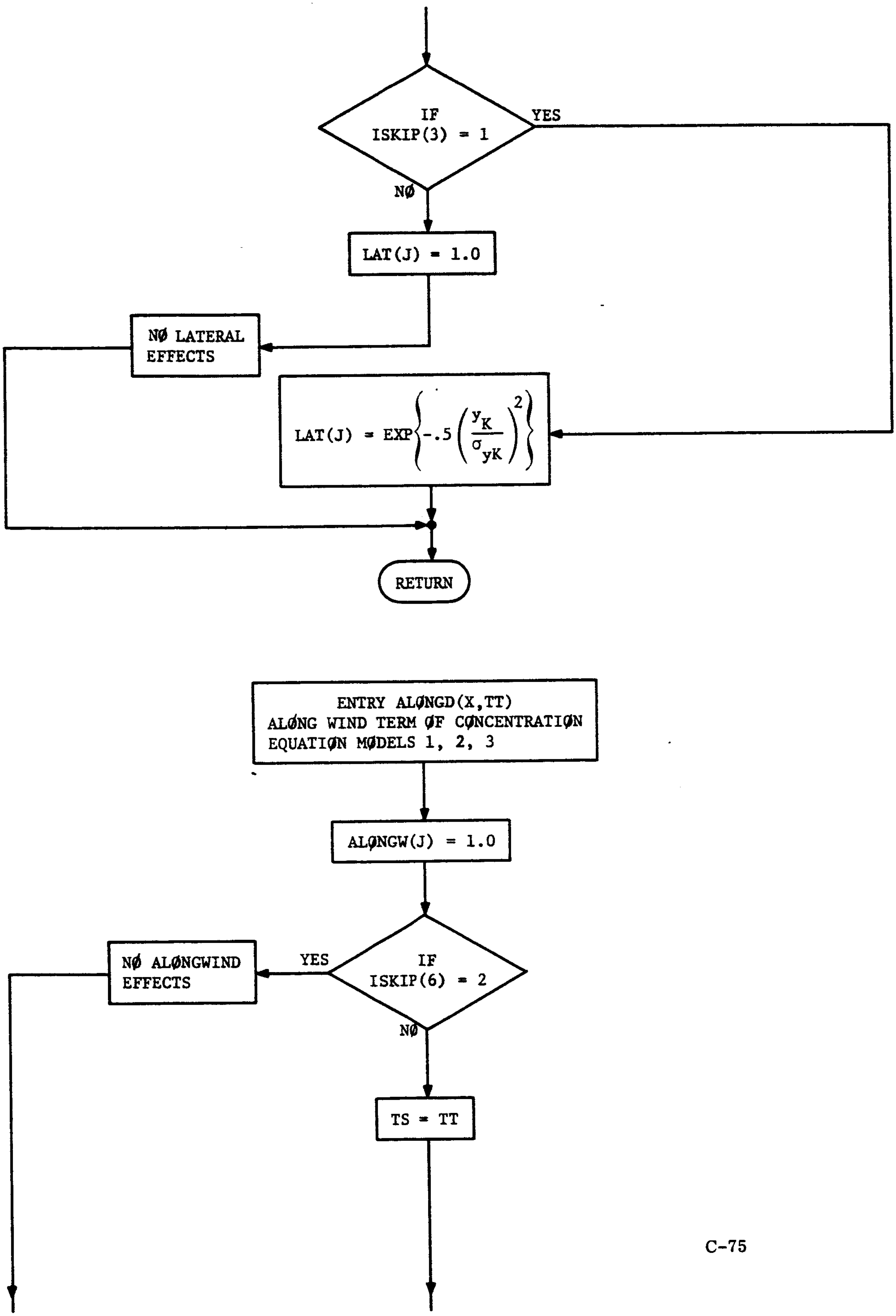
SUBROUTINE ACH

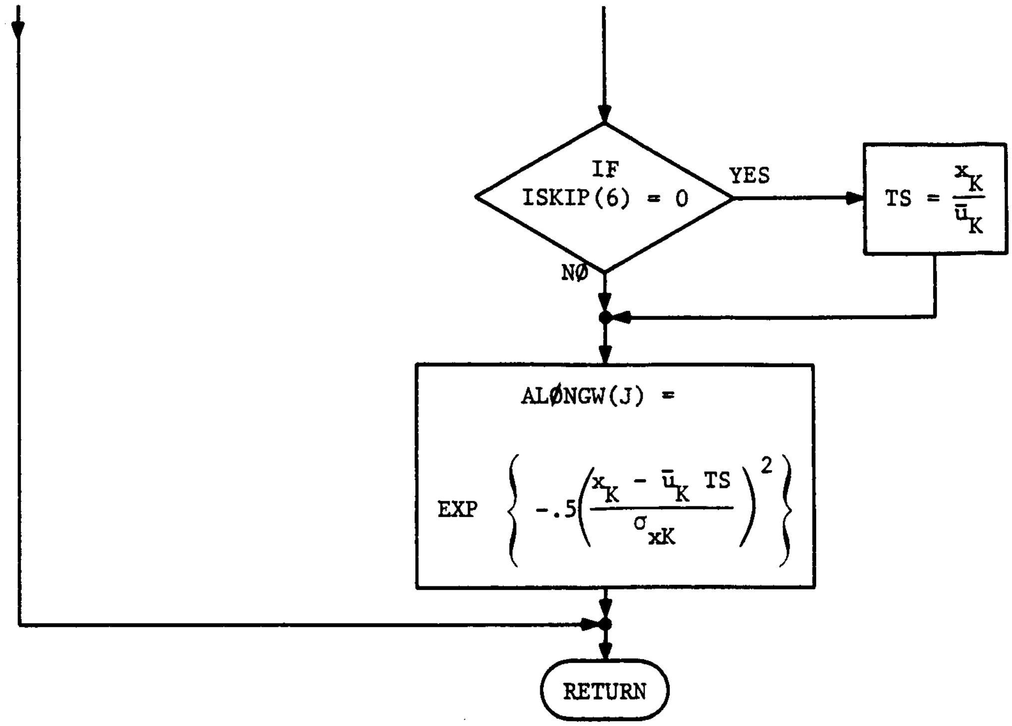
SUBROUTINE ACH CONSISTS OF THREE SUBROUTINES. THE ENTRY TO EL CALCULATES L $\{x_j\}$. THE ENTRY TO LATER CALCULATES THE LATERAL TERM ON OPTION. THE ENTRY TO ALONGD CALCULATES THE ALONGWIND TERM OF THE CONCENTRATION EQUATION ON OPTION

(STORAGE USED 254_8)




CALCULATE σx WITH L.
L=0.28*ABS(DELU(KK))/UBAR(KK)*XK
IF DELU(KK) < 0.0
YES
L = 0.0
NØ
L=0.28*ABS(DELU(NNZ+ILK-1))/UBAR(NNZ+ILK-1)*XK
IF DELU(NNZ+ILK-1) < 0.0
YES
L = 0.0
NØ
L=0.28*ABS(DELU(M))/UBAR(M)*XK
IF DELU(M) < 0.0
YES
L = 0.0
NØ
RETURN
ENTRY LATER(Y)
LATERAL TERM ØF DØSAGE EQUATIØN.
MØDELS 1, 2, 3


IF
ISKIP(3) = 1
YES
NØ
LAT(J) = 1.0
NØ LATERAL
EFFECTS
LAT(J) = EXP{-.5 (yK/σyK)2}
RETURN
ENTRY ALØNGD(X,TT)
ALØNG WIND TERM ØF CØNCENTRATIØN
EQUATIØN MØDELS 1, 2, 3
ALØNGW(J) = 1.0
IF
ISKIP(6) = 2
YES
NØ
NØ ALØNGWIND
EFFECTS
TS = TT


IF
ISKIP(6) = 0
YES
NØ
TS = $\frac{x_K}{\bar{u}_K}$
ALØNGW(J) =
EXP $\left\{ -.5\left(\frac{x_K - \bar{u}_K\ TS}{\sigma_{xK}}\right)^2 \right\}$
RETURN

SECTION C.10

SUBROUTINE VERT

SUBROUTINE VERT(K,NN)

THIS SUBROUTINE CALCULATES THE VERTICAL AND VERTICAL REFLECTION TERMS IN THE DOSAGE EQUATION. IF ISKIP(4) EQUALS 1 VERTICAL IS CALCULATED. IF ISKIP(5) EQUALS 1 VERTICAL REFLECTION IS CALCULATED. VERTICAL AND VERTICAL REFLECTION ARE CALCULATED ONLY FOR MODEL 3 FOR CASE IN WHICH PLUME VERTICAL EXTENT IS LESS THAN THE DEPTH OF THE LAYER AND TURBULENT MIXING IS OCCURRING.

VERTICAL TERM VER(J) = STØ2 =

$$\left\{ EXP\left\{\frac{-\left(H_K-Z_K\right)^2}{2\sigma_{Z_K}^{\ 2}}\right\} + EXP\left\{\frac{-\left(H_K-2Z_1+Z_K\right)^2}{2\sigma_{Z_K}^{\ 2}}\right\}\right\}$$

VERTICAL REFLECTION TERM VREF(J) = STØ3 =

$$\sum_{i=1}^{\infty}\left\{ EXP\left\{\frac{-\left(2i(Z_2-Z_1)+H_K-2Z_1+Z_K\right)^2}{2\sigma_{Z_K}^{\ 2}}\right\} + EXP\left\{\frac{-\left(2i(Z_2-Z_1)-H_K+Z_K\right)^2}{2\sigma_{Z_K}^{\ 2}}\right\} + EXP\left\{\frac{-\left(2i(Z_2-Z_1)+H_K-Z_K\right)^2}{2\sigma_{Z_K}^{\ 2}}\right\} + EXP\left\{\frac{-\left(2i(Z_2-Z_1)+H_K-2Z_1+Z_K\right)^2}{2\sigma_{Z_K}^{\ 2}}\right\}\right\}$$

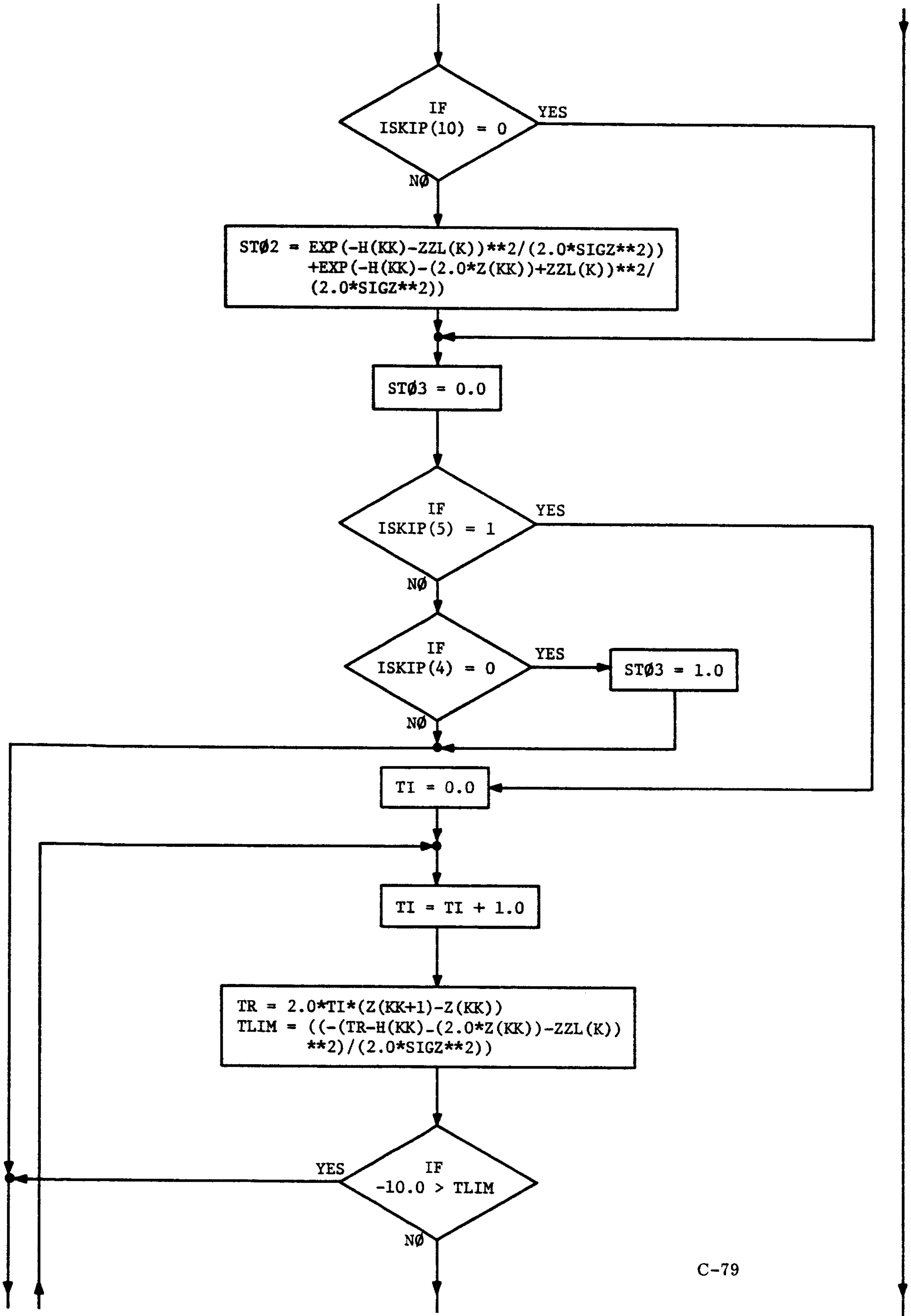
(STØRAGE USED 263_8)

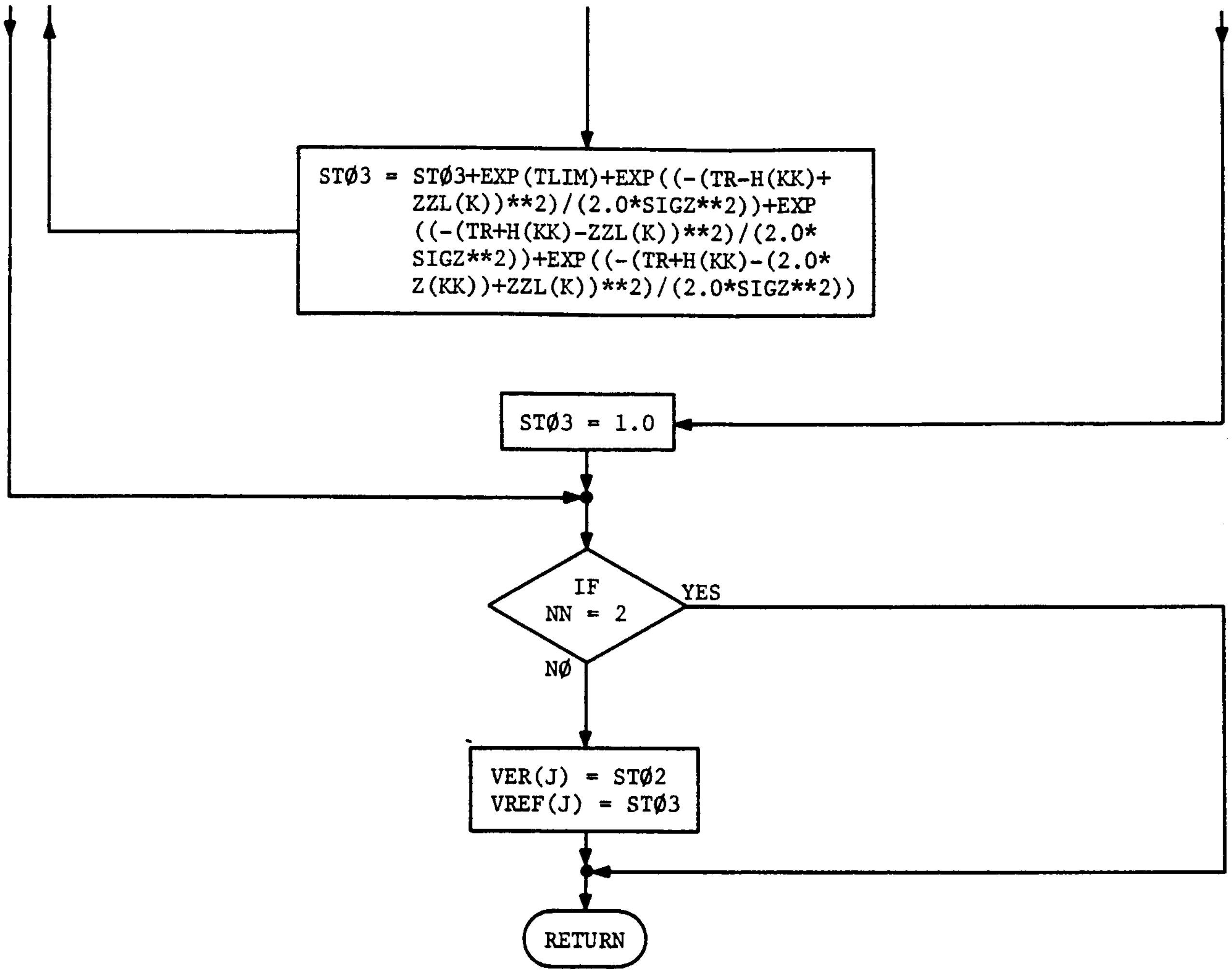
STØ2 = 0.0
N = IZMØD(KK)

IF N = 1 ØR N = 2

YES

NØ


IF
ISKIP(10) = 0
YES
NØ
STØ2 = EXP(-H(KK)-ZZL(K))**2/(2.0*SIGZ**2))
+EXP(-H(KK)-(2.0*Z(KK))+ZZL(K))**2/
(2.0*SIGZ**2))
STØ3 = 0.0
IF
ISKIP(5) = 1
YES
NØ
IF
ISKIP(4) = 0
YES
STØ3 = 1.0
NØ
TI = 0.0
TI = TI + 1.0
TR = 2.0*TI*(Z(KK+1)-Z(KK))
TLIM = ((-(TR-H(KK)-(2.0*Z(KK))-ZZL(K))
2)/(2.0*SIGZ2))
YES
IF
-10.0 > TLIM
NØ


STØ3 = STØ3+EXP(TLIM)+EXP((-(TR-H(KK)+
ZZL(K))**2)/(2.0*SIGZ**2))+EXP
((-(TR+H(KK)-ZZL(K))**2)/(2.0*
SIGZ**2))+EXP((-(TR+H(KK)-(2.0*
Z(KK))+ZZL(K))**2)/(2.0*SIGZ**2))
STØ3 = 1.0
IF
NN = 2
YES
NØ
VER(J) = STØ2
VREF(J) = STØ3
RETURN

SECTION C.11

SUBROUTINE PEAK

SUBROUTINE PEAK(K)

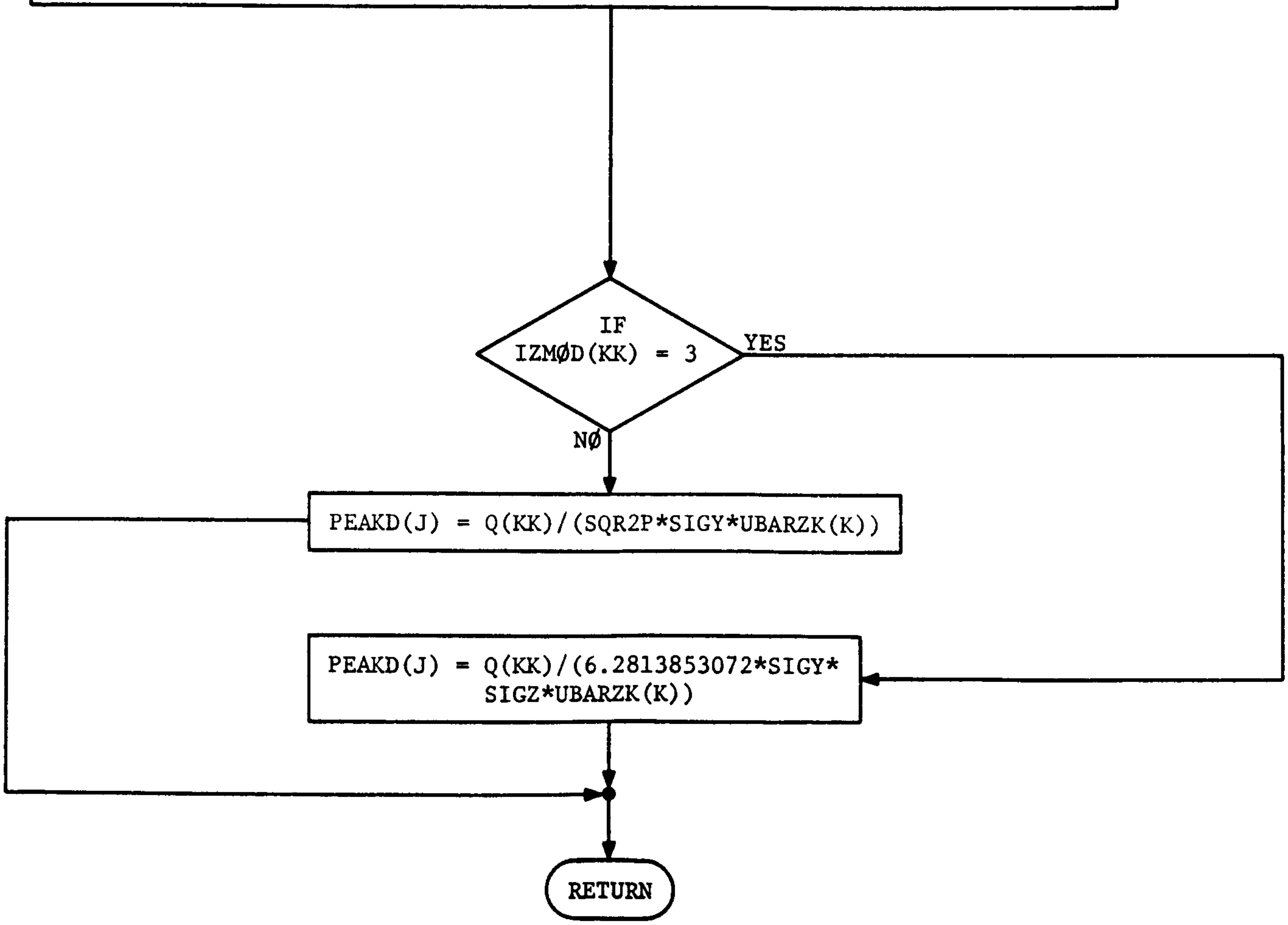
THIS SUBROUTINE CALCULATES THE PEAK TERM OF THE DOSAGE EQUATION. THE PEAK TERM FOR MODELS 1 AND 2 IS GIVEN BY

$$\frac{Q_K}{\sqrt{2\pi}\,\sigma_{yK}\,\bar{u}_{ZK}}$$

THE PEAK TERM FOR MODEL 3 IS GIVEN BY

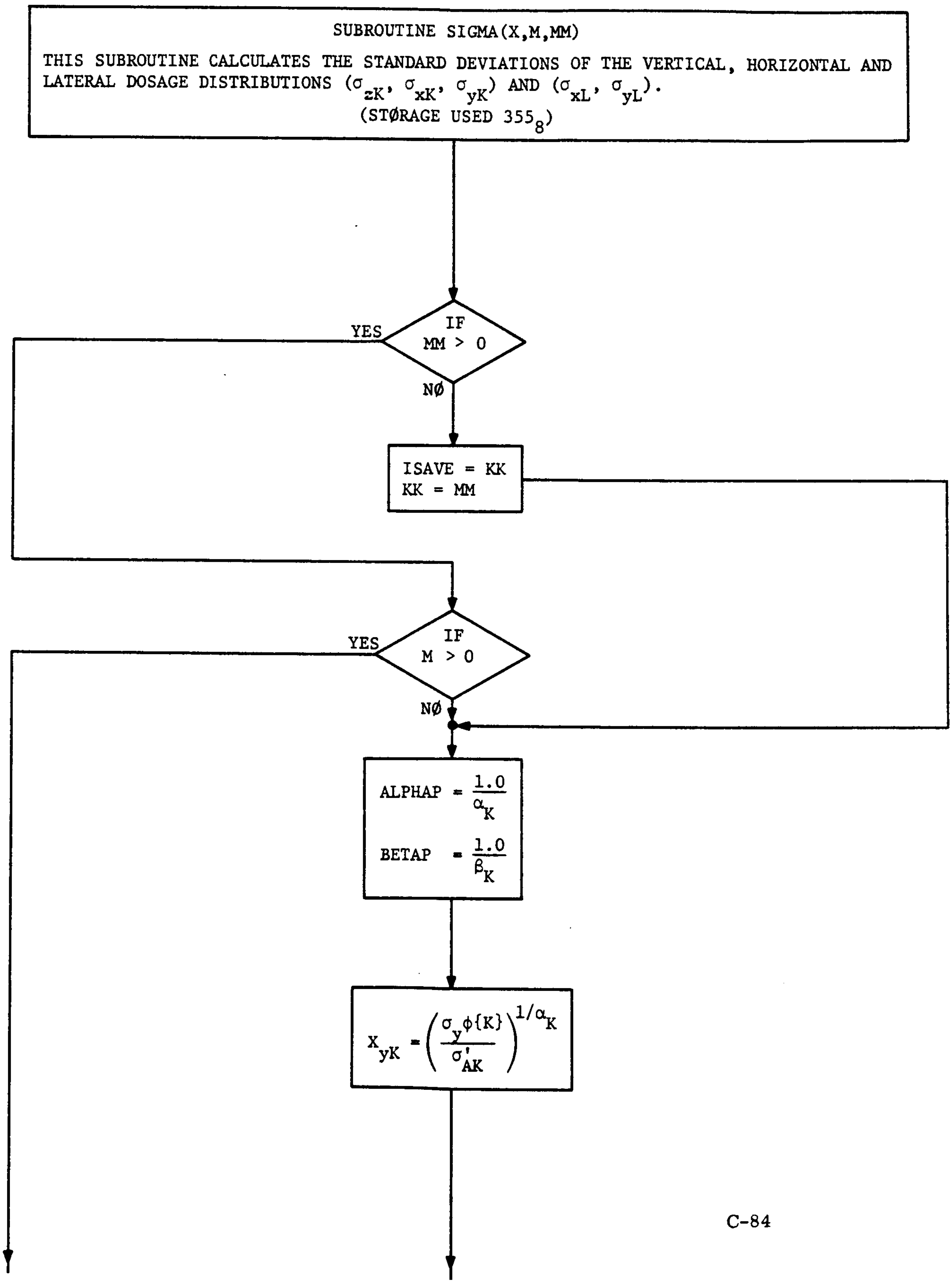
$$\frac{Q_K}{2\pi\,\sigma_{yK}\,\sigma_{Z_K}\,\bar{u}_{ZK}}$$

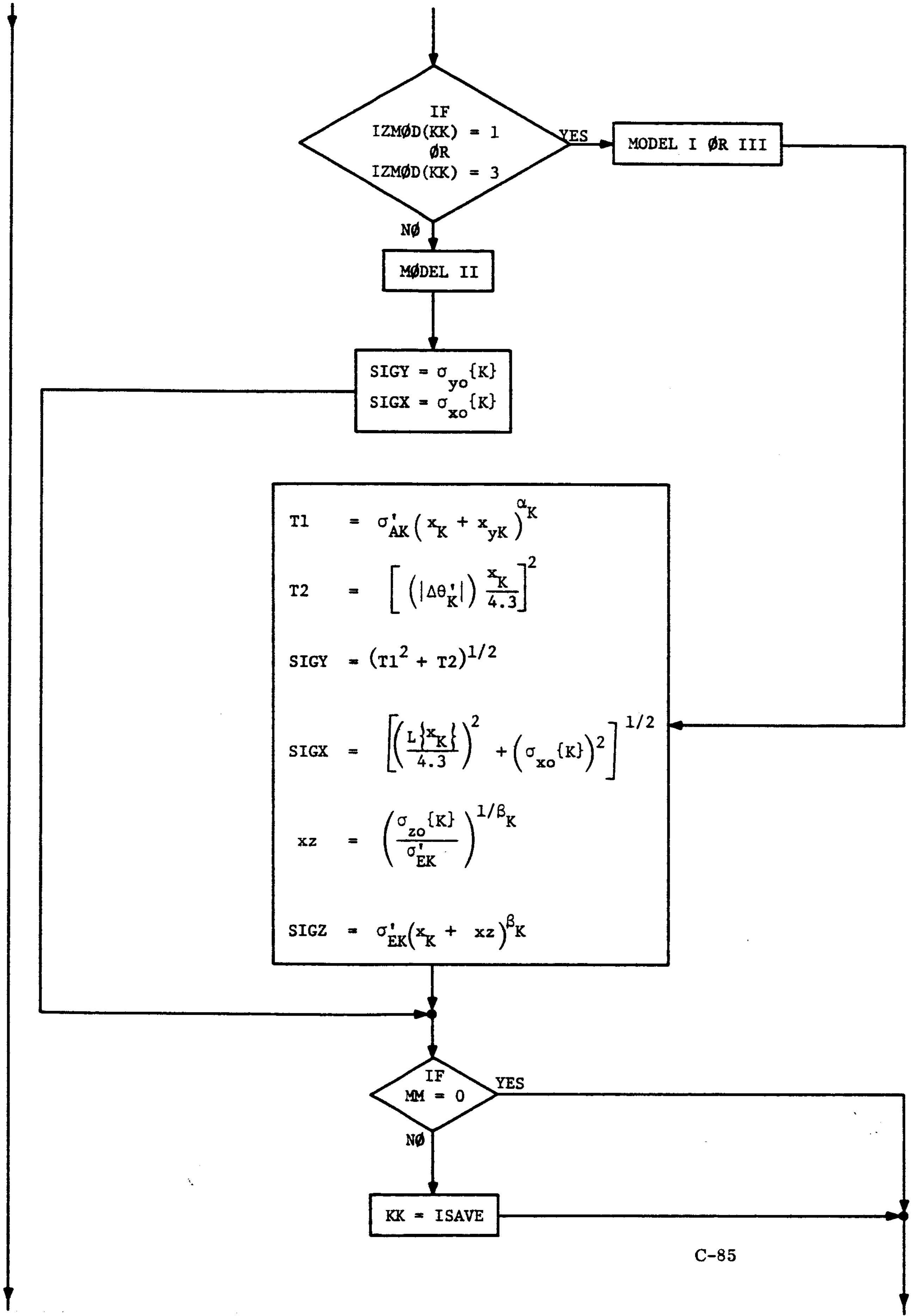
(STØRAGE USED 103_8)



SECTION C. 12

SUBROUTINE SIGMA


SUBROUTINE SIGMA(X,M,MM)
THIS SUBROUTINE CALCULATES THE STANDARD DEVIATIONS OF THE VERTICAL, HORIZONTAL AND LATERAL DOSAGE DISTRIBUTIONS (σ_{zK}, σ_{xK}, σ_{yK}) AND (σ_{xL}, σ_{yL}).
(STØRAGE USED 355_8)
IF MM > 0
YES
NØ
ISAVE = KK
KK = MM
IF M > 0
YES
NØ
$ALPHAP = \frac{1.0}{\alpha_K}$
$BETAP = \frac{1.0}{\beta_K}$
$X_{yK} = \left(\frac{\sigma_y \phi\{K\}}{\sigma'_{AK}}\right)^{1/\alpha_K}$


IF IZMØD(KK) = 1 ØR IZMØD(KK) = 3
YES
MODEL I ØR III
NØ
MØDEL II
SIGY = $\sigma_{yo}\{K\}$
SIGX = $\sigma_{xo}\{K\}$
T1 = $\sigma'_{AK}\left(x_K + x_{yK}\right)^{\alpha_K}$
T2 = $\left[\left(|\Delta\theta'_K|\right)\frac{x_K}{4.3}\right]^2$
SIGY = $(T1^2 + T2)^{1/2}$
SIGX = $\left[\left(\frac{L\{x_K\}}{4.3}\right)^2 + \left(\sigma_{xo}\{K\}\right)^2\right]^{1/2}$
xz = $\left(\frac{\sigma_{zo}\{K\}}{\sigma'_{EK}}\right)^{1/\beta_K}$
SIGZ = $\sigma'_{EK}\left(x_K + xz\right)^{\beta_K}$
IF MM = 0
YES
NØ
KK = ISAVE

$$\mathrm{SIGYNK} = \left\{ \left[\sigma_{xK}\ \mathrm{SIN}\left(\theta'_K - \theta'_L\right) \right]^2 + \left[\sigma_{yK}\ \mathrm{C\O S}\left(\theta'_K - \theta'_L\right) \right]^2 \right\}^{1/2}$$

$$\mathrm{SQBAR} = \left(\frac{\mathrm{SIGYNK}}{\sigma'_{AL}} \right)^{1/\alpha_L}$$

$$\mathrm{SIGYNK} = \sigma_{yLK} = \left\{ \left[\sigma'_{AL}\{\tau\}\left(x_{LK} + \mathrm{SQBAR}\right)^{\alpha_L} \right]^2 + \left[\left(\left| \frac{\Delta\theta'_L}{4.3} \right| \right) \left(x_{LK} \right) \right]^2 \right\}^{1/2}$$

$$\mathrm{SIGZ} = \sigma'_{EL}\ x_{LK}^{\beta_L}$$

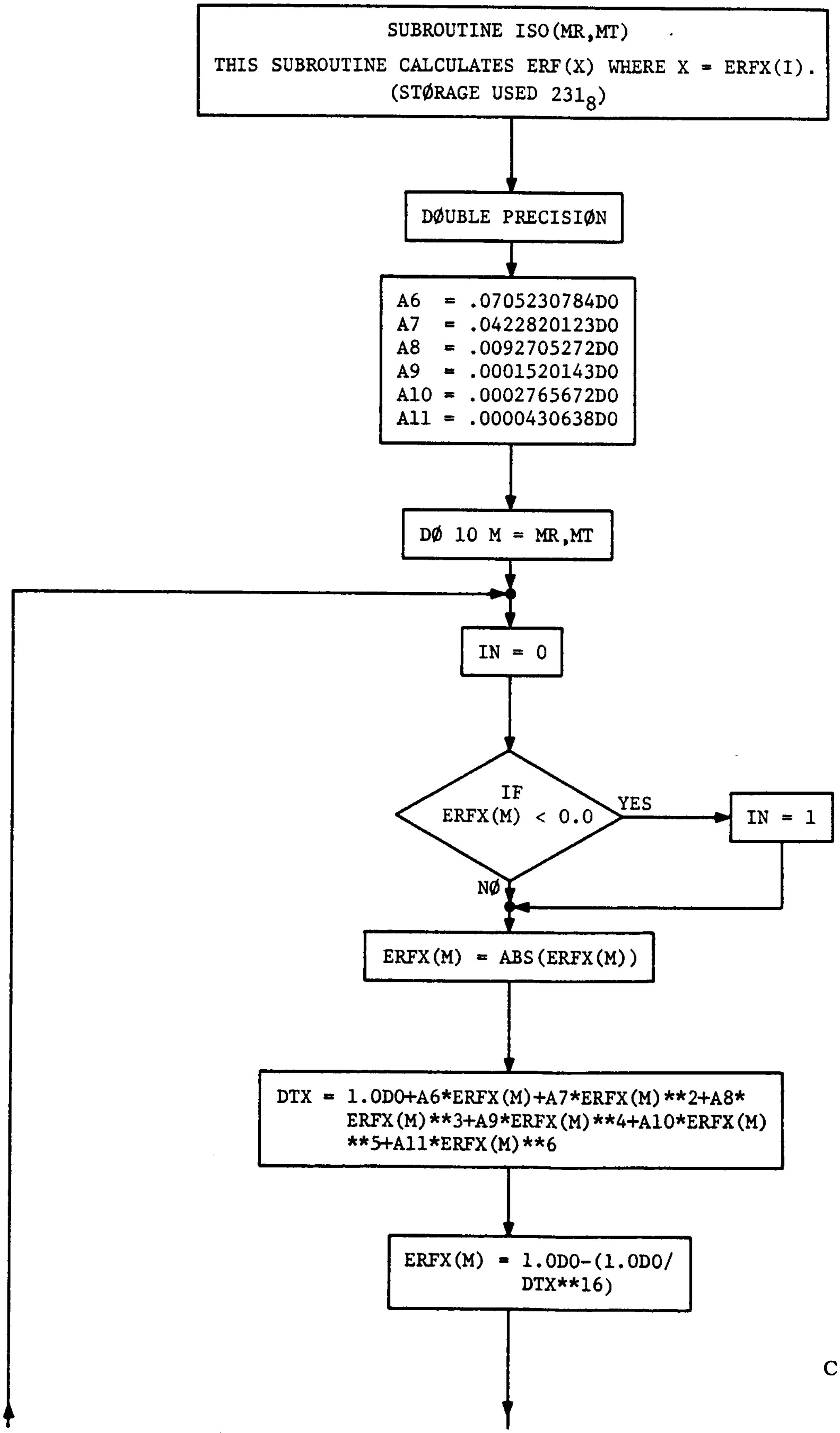
$$\mathrm{SQBAR} = \left\{ \left[\sigma_x \mathrm{C\O S}\left(\theta'_K - \theta'_L\right) \right]^2 + \left[\sigma_y \mathrm{SIN}\left(\theta'_K - \theta'_L\right) \right]^2 \right\}^{1/2}$$

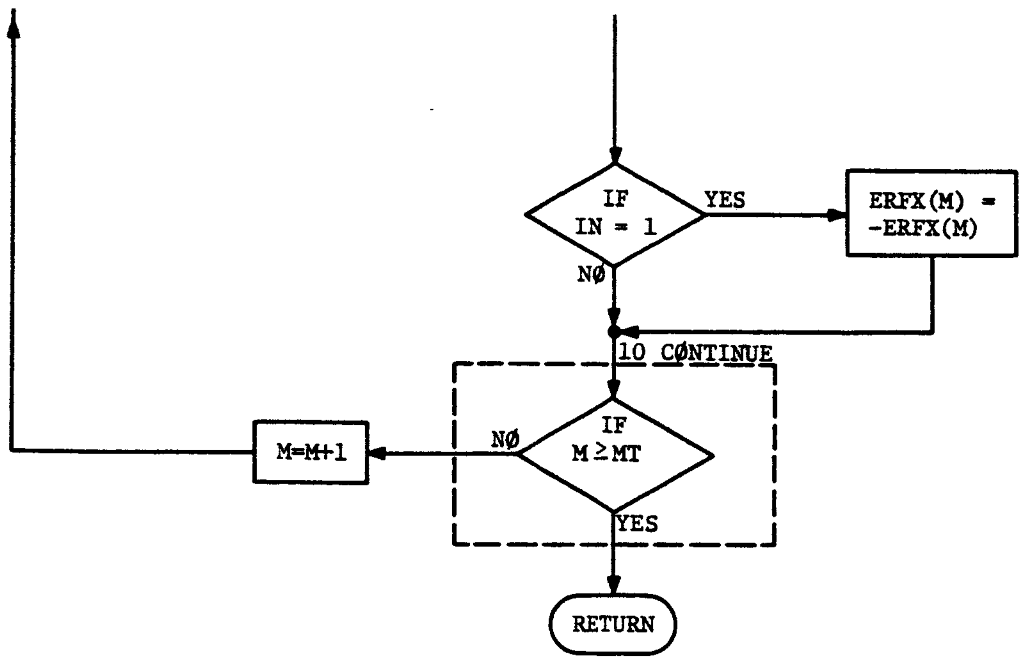
$$\mathrm{SIGXNK} = \left\{ \left(\frac{L\{x_K\}}{4.3} \right)^2 + \left(\mathrm{SQBAR}\right)^2 \right\}^{1/2}$$

RETURN

SECTION C. 13

SUBROUTINE ISO


SUBROUTINE ISO(MR,MT)
THIS SUBROUTINE CALCULATES ERF(X) WHERE X = ERFX(I).
(STØRAGE USED 231_8)
DØUBLE PRECISIØN
A6 = .0705230784D0
A7 = .0422820123D0
A8 = .0092705272D0
A9 = .0001520143D0
A10 = .0002765672D0
A11 = .0000430638D0
DØ 10 M = MR,MT
IN = 0
IF ERFX(M) < 0.0
YES
IN = 1
NØ
ERFX(M) = ABS(ERFX(M))
DTX = 1.0D0+A6*ERFX(M)+A7*ERFX(M)**2+A8*ERFX(M)**3+A9*ERFX(M)**4+A10*ERFX(M)**5+A11*ERFX(M)**6
ERFX(M) = 1.0D0-(1.0D0/DTX**16)


IF
IN = 1
YES
ERFX(M) =
-ERFX(M)
NØ
10 CØNTINUE
IF
M ≥ MT
NØ
M=M+1
YES
RETURN

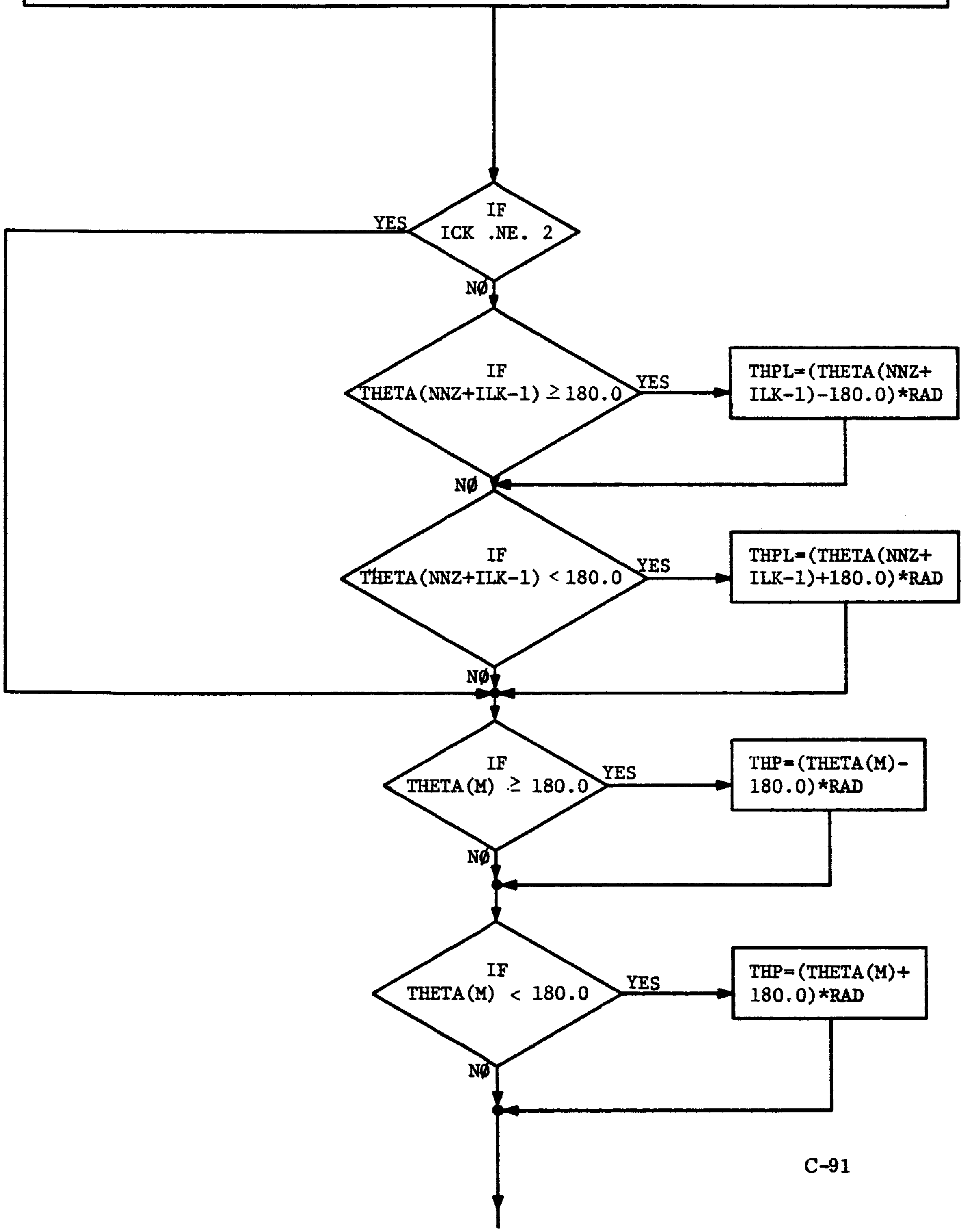
SECTION C. 14

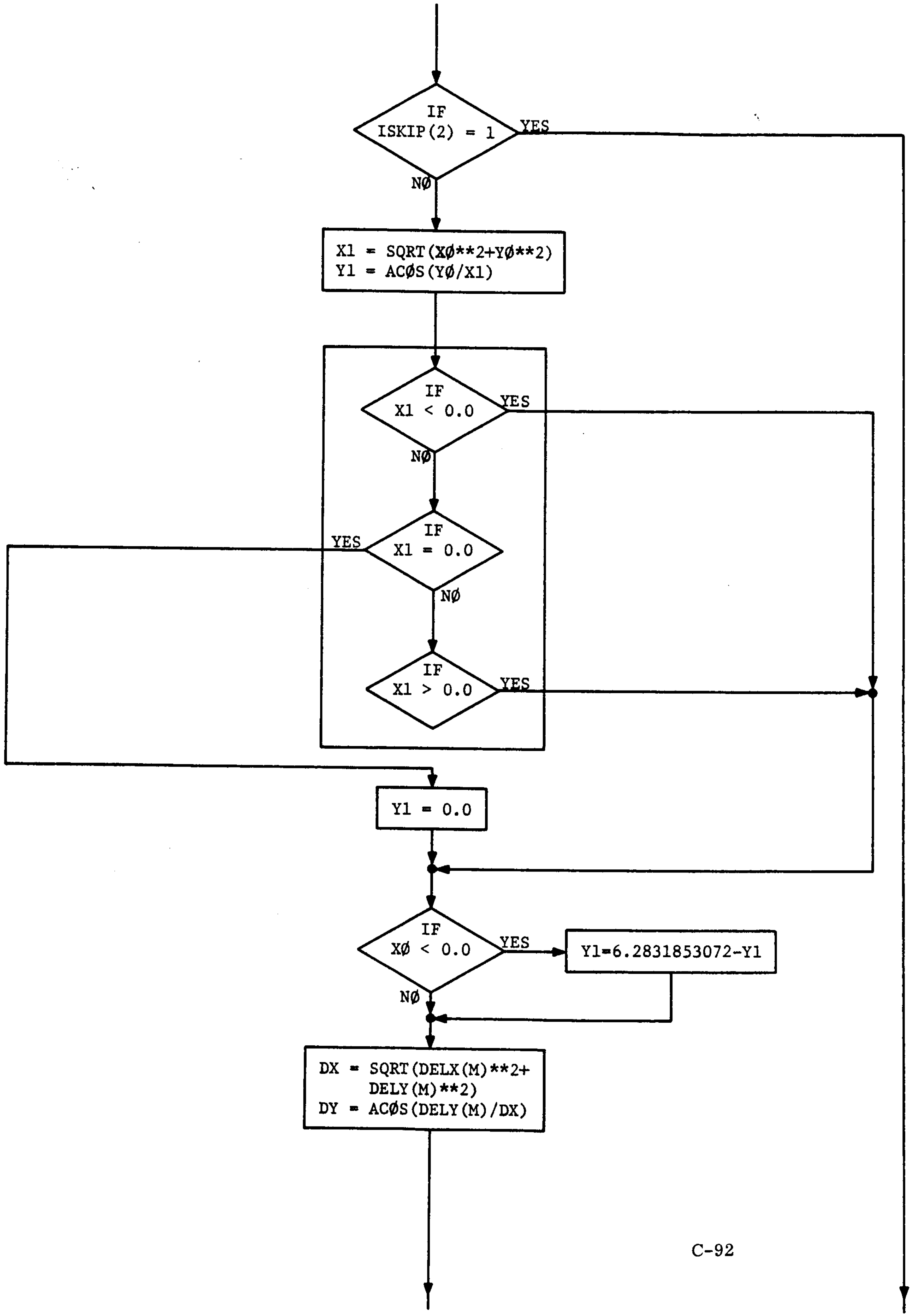
SUBROUTINE COORD

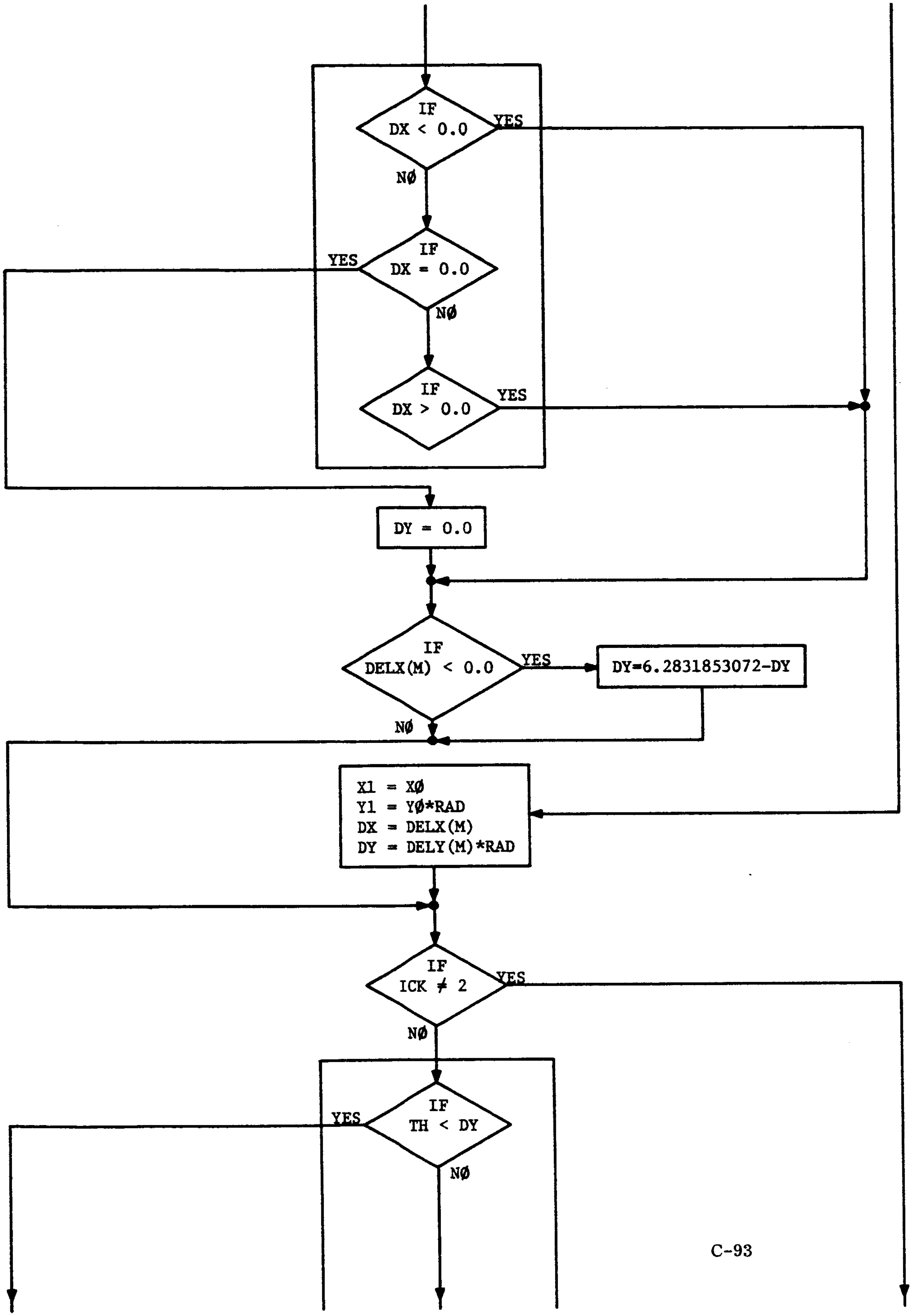
SUBROUTINE COORD(N,M,X,Y,XO,YO,ASP,XS,ICK)

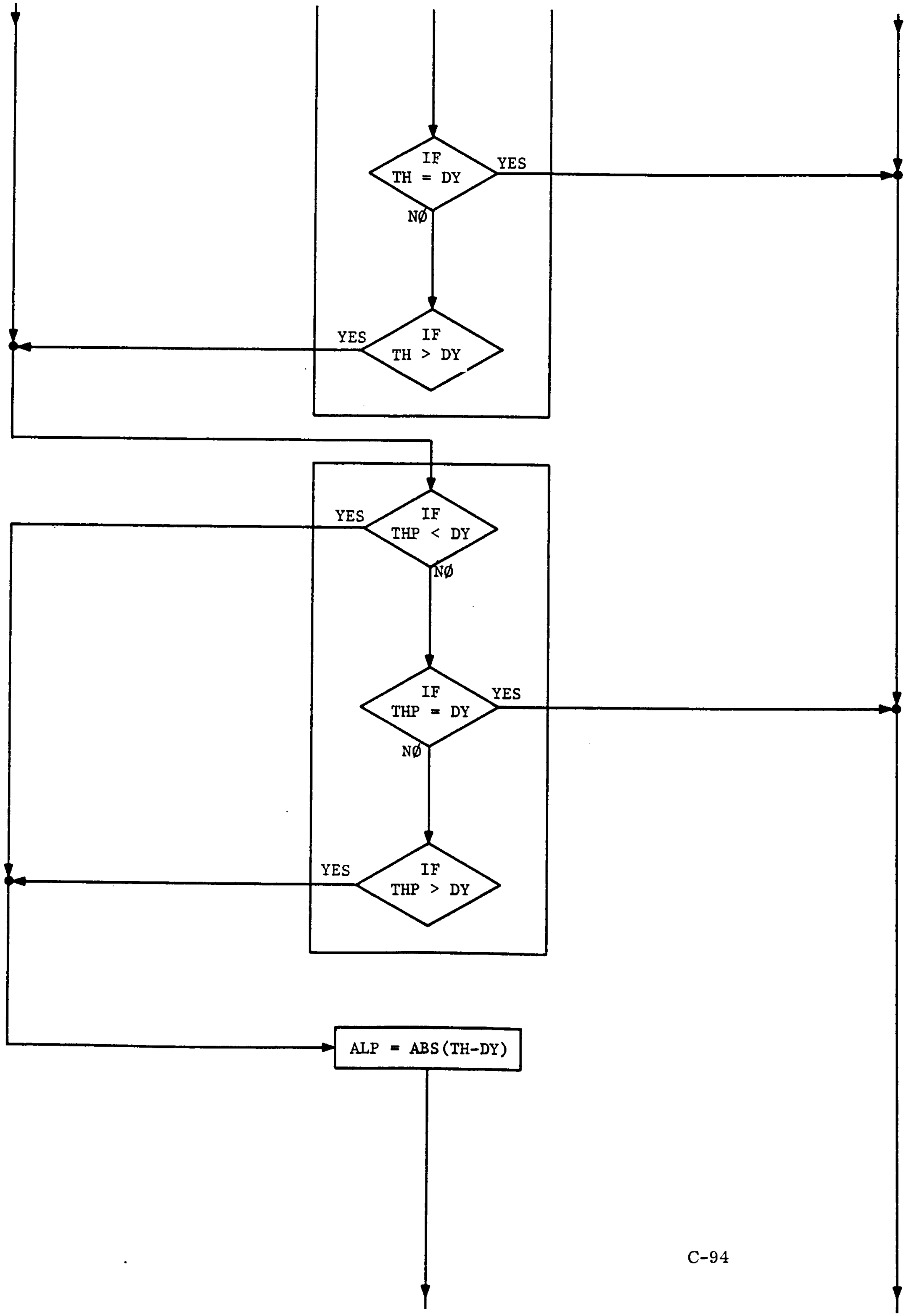
THIS SUBROUTINE TRANSFORMS THE RECEPTOR COORDINATES OF THE FIXED GRID SYSTEM TO COORDINATES RELATIVE TO A SYSTEM WITH POSITIVE X AXIS ALONG THE WIND DIRECTION THETA. IT ALSO DETERMINES IF THE RECEPTOR COORDINATES LIE WITHIN THE SECTOR OF CALCULATION DELPHI. DELPHI IS LESS THAN OR EQUAL TO 180.0 DEGREES.

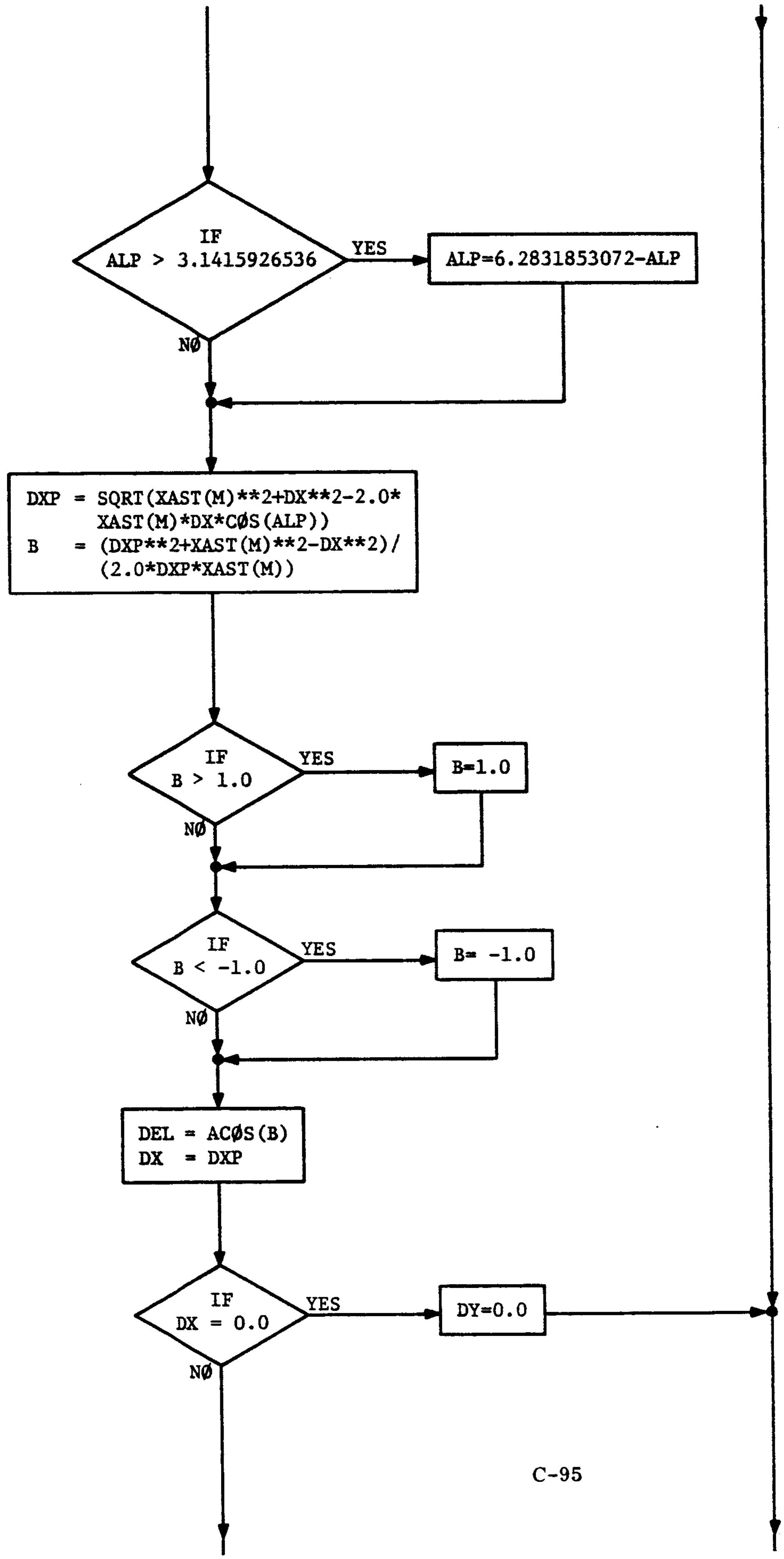
(STØRAGE USED 753_8)

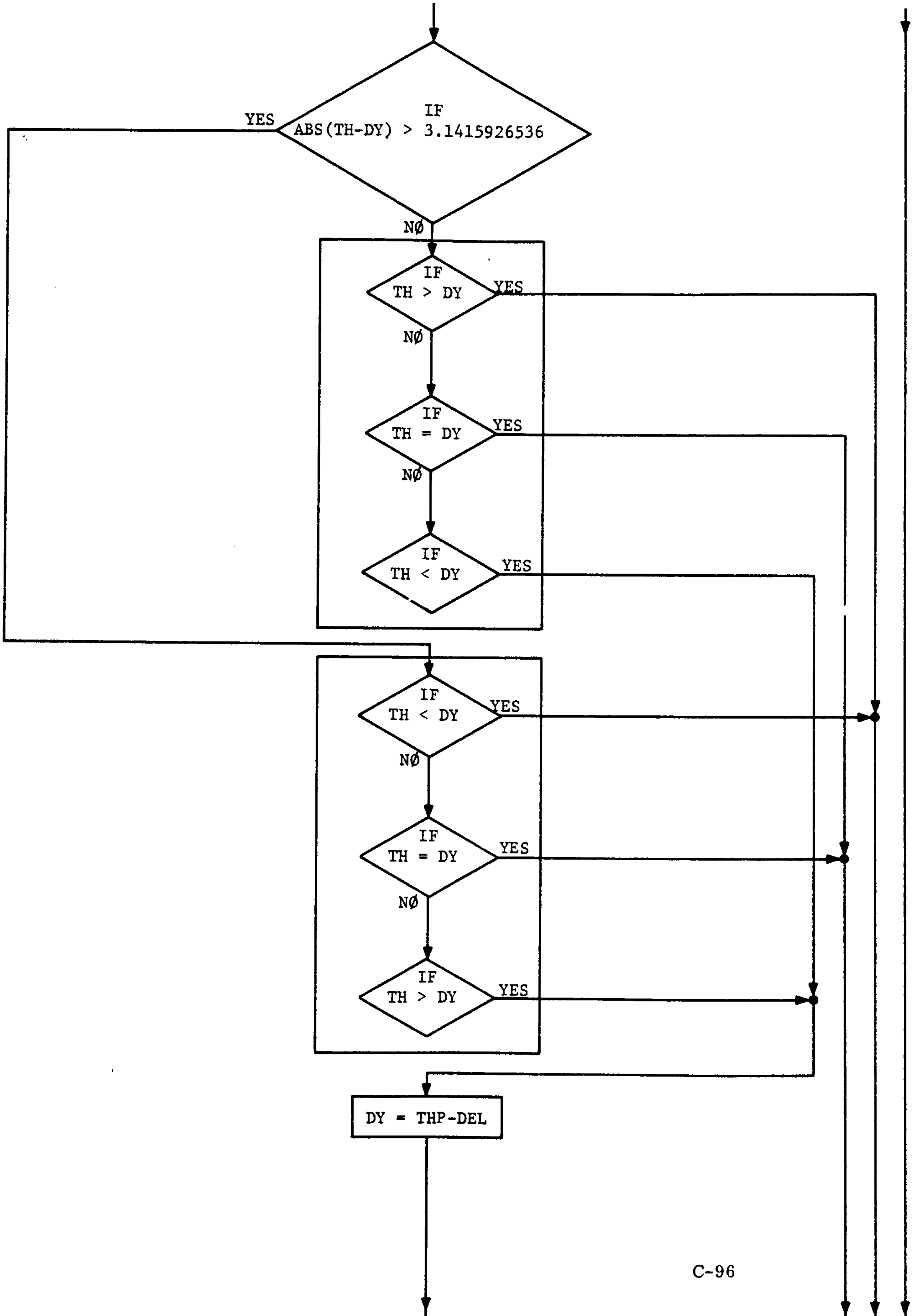


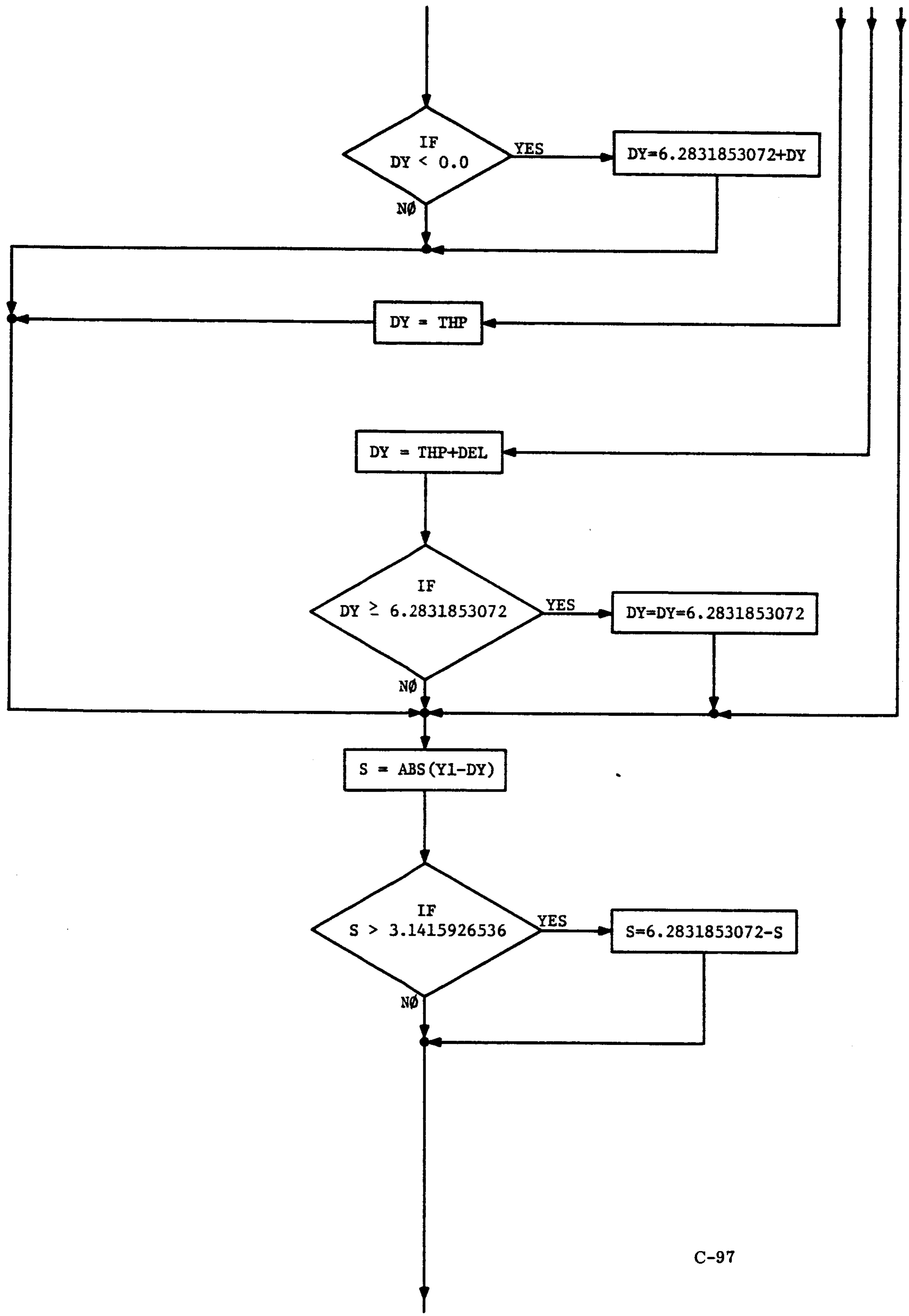

IF
ISKIP(2) = 1
YES
NØ
X1 = SQRT(XØ**2+YØ**2)
Y1 = ACØS(YØ/X1)
IF
X1 < 0.0
YES
NØ
IF
X1 = 0.0
YES
NØ
IF
X1 > 0.0
YES
Y1 = 0.0
IF
XØ < 0.0
YES
Y1=6.2831853072-Y1
NØ
DX = SQRT(DELX(M)**2+
DELY(M)**2)
DY = ACØS(DELY(M)/DX)

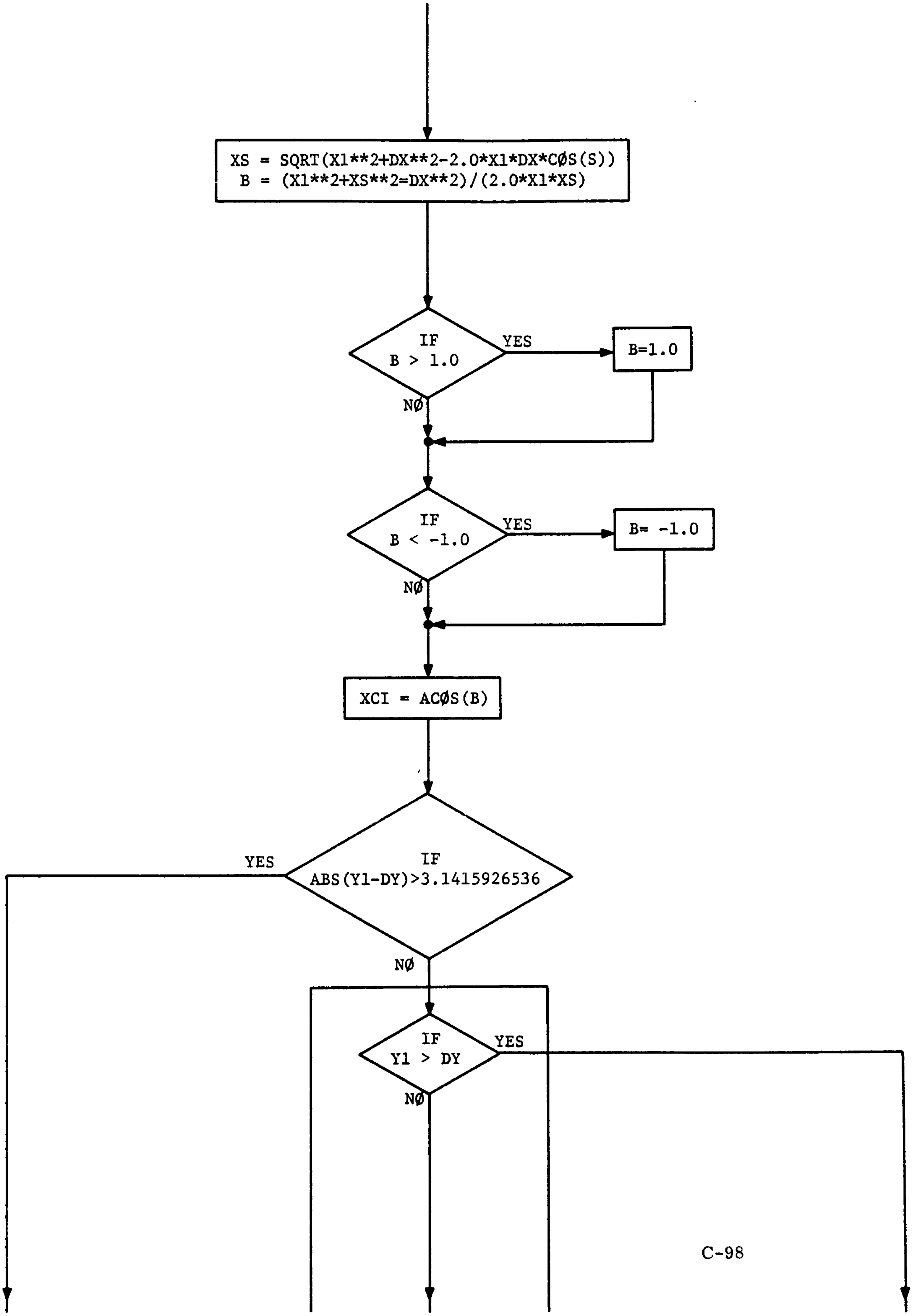

IF DX < 0.0
YES
NØ
IF DX = 0.0
YES
NØ
IF DX > 0.0
YES
DY = 0.0
IF DELX(M) < 0.0
YES
DY=6.2831853072-DY
NØ
X1 = XØ
Y1 = YØ*RAD
DX = DELX(M)
DY = DELY(M)*RAD
IF ICK ≠ 2
YES
NØ
IF TH < DY
YES
NØ

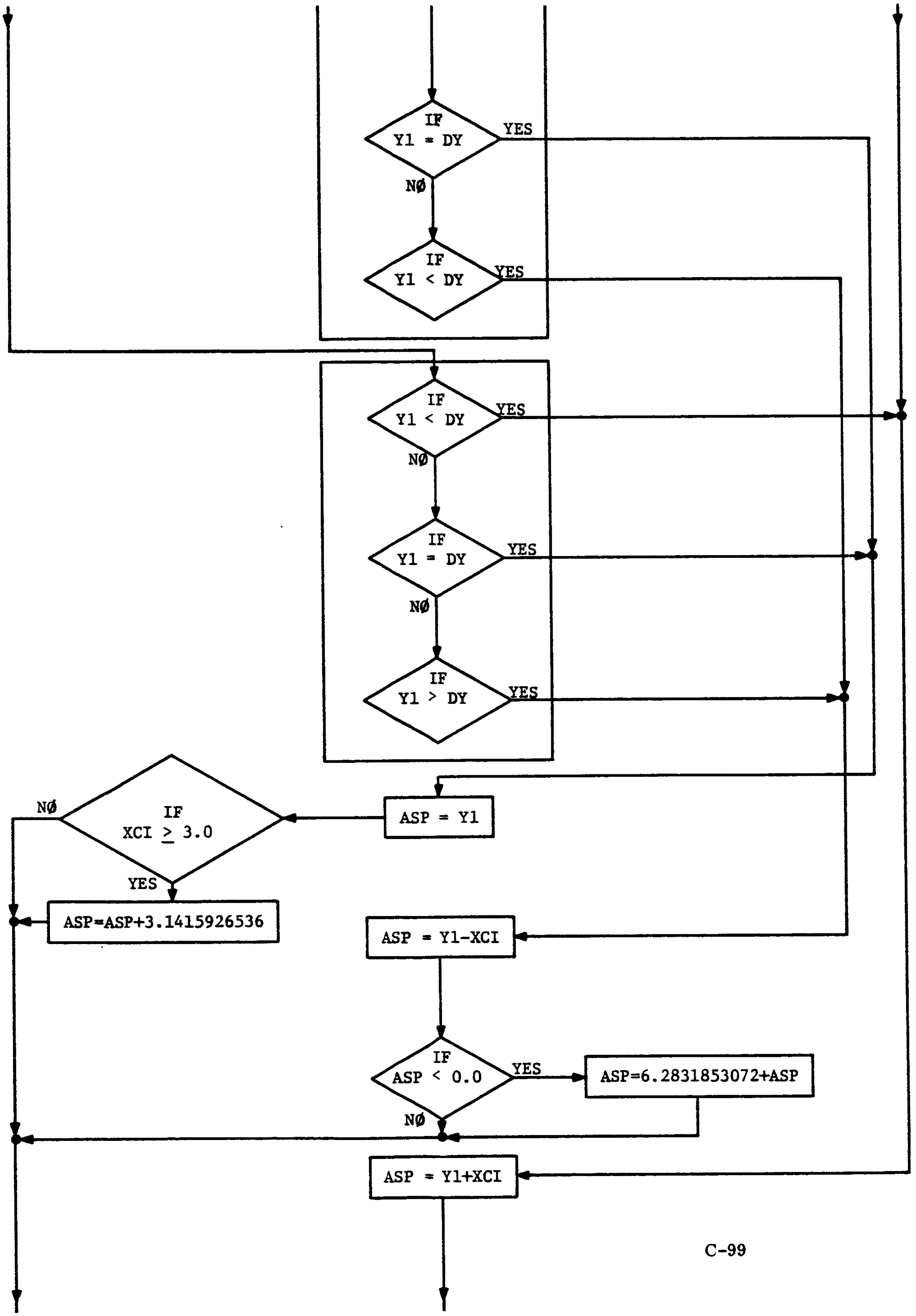

IF TH = DY
YES
NØ
IF TH > DY
YES
IF THP < DY
YES
NØ
IF THP = DY
YES
NØ
IF THP > DY
YES
ALP = ABS(TH-DY)

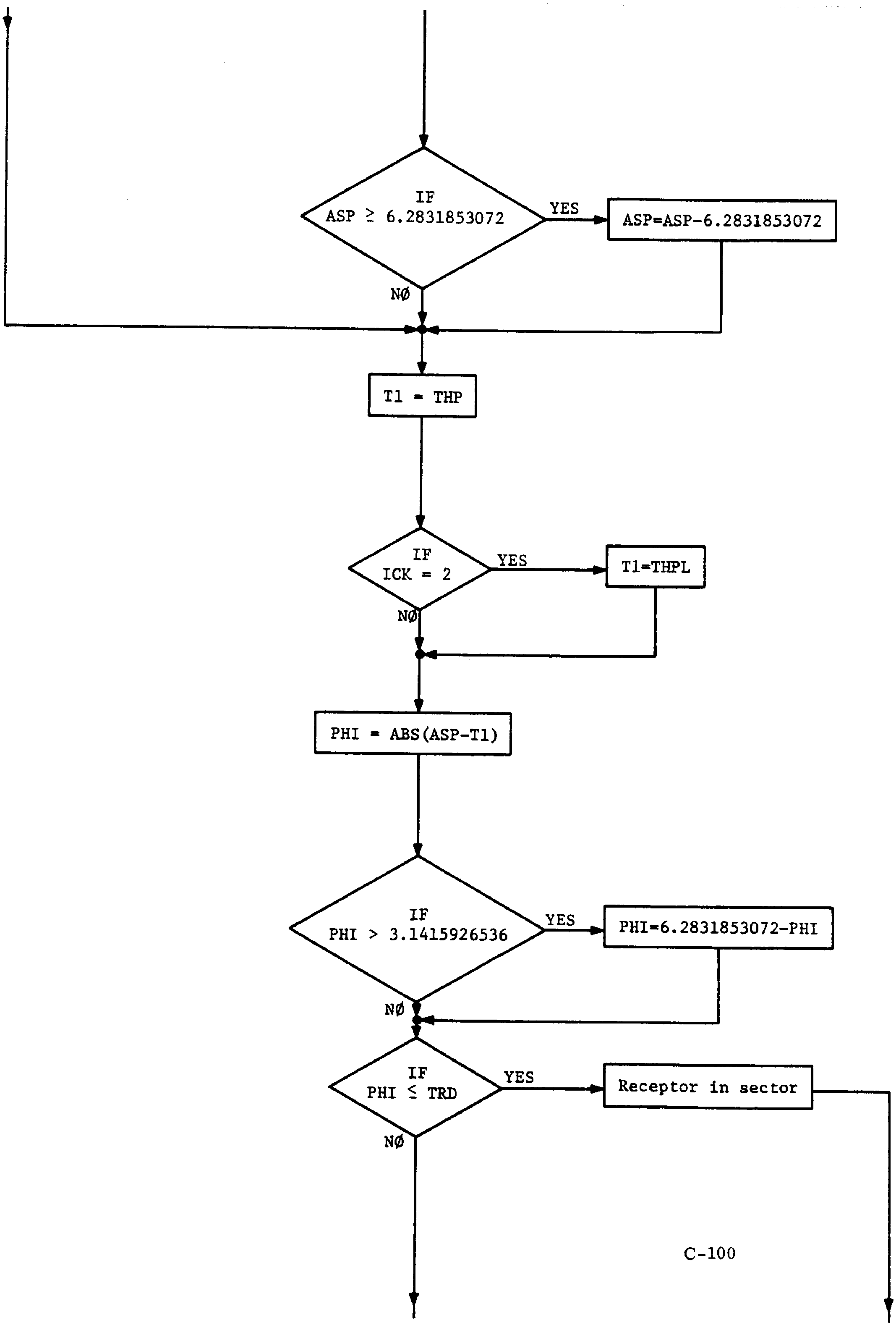

IF
ALP > 3.1415926536
YES
ALP=6.2831853072-ALP
NØ
DXP = SQRT(XAST(M)**2+DX**2-2.0*
XAST(M)*DX*CØS(ALP))
B = (DXP**2+XAST(M)**2-DX**2)/
(2.0*DXP*XAST(M))
IF
B > 1.0
YES
B=1.0
NØ
IF
B < -1.0
YES
B= -1.0
NØ
DEL = ACØS(B)
DX = DXP
IF
DX = 0.0
YES
DY=0.0
NØ

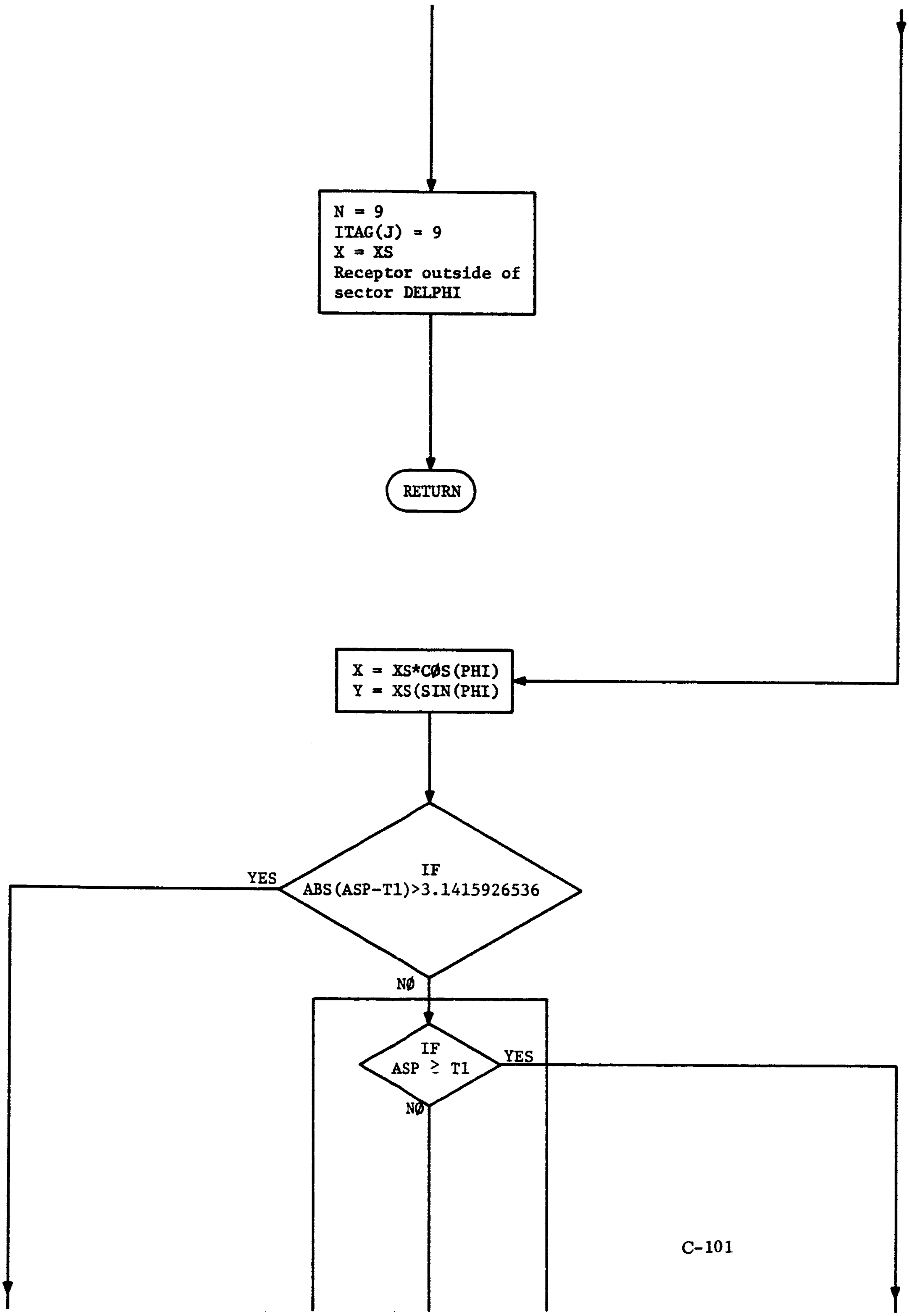

IF
ABS(TH-DY) > 3.1415926536
YES
NØ
IF
TH > DY
YES
NØ
IF
TH = DY
YES
NØ
IF
TH < DY
YES
IF
TH < DY
YES
NØ
IF
TH = DY
YES
NØ
IF
TH > DY
YES
DY = THP-DEL

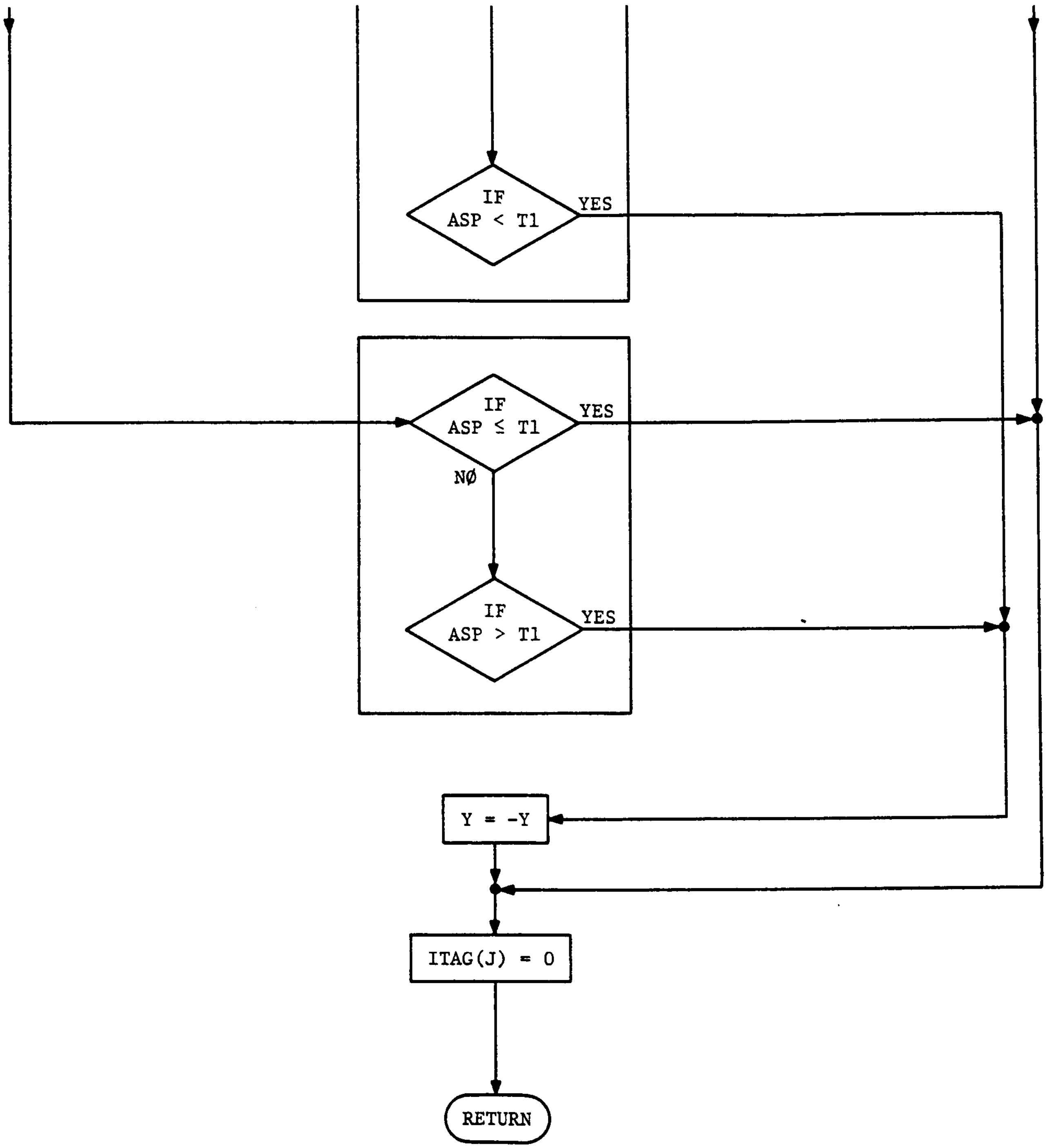

IF
DY < 0.0
YES
NØ
DY=6.2831853072+DY
DY = THP
DY = THP+DEL
IF
DY ≥ 6.2831853072
YES
NØ
DY=DY=6.2831853072
S = ABS(Y1-DY)
IF
S > 3.1415926536
YES
NØ
S=6.2831853072-S


XS = SQRT(X1**2+DX**2-2.0*X1*DX*CØS(S))
B = (X1**2+XS**2=DX**2)/(2.0*X1*XS)
IF
B > 1.0
YES
B=1.0
NØ
IF
B < -1.0
YES
B= -1.0
NØ
XCI = ACØS(B)
YES
IF
ABS(Y1-DY)>3.1415926536
NØ
IF
Y1 > DY
YES
NØ


IF
Y1 = DY
YES
NØ
IF
Y1 < DY
YES
IF
Y1 < DY
YES
NØ
IF
Y1 = DY
YES
NØ
IF
Y1 > DY
YES
NØ
IF
XCI ≥ 3.0
YES
ASP = Y1
ASP=ASP+3.1415926536
ASP = Y1-XCI
IF
ASP < 0.0
YES
ASP=6.2831853072+ASP
NØ
ASP = Y1+XCI

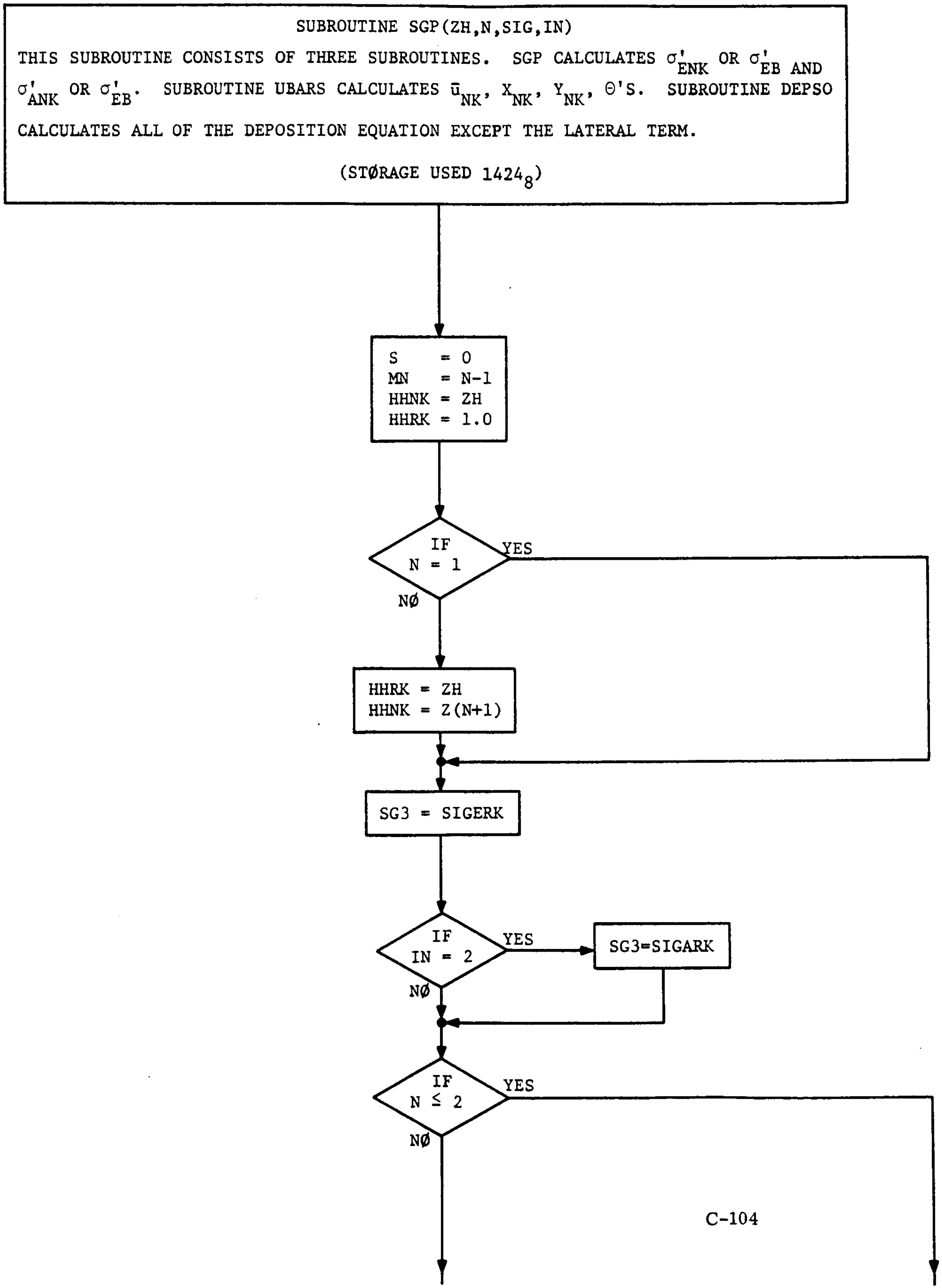

IF
ASP ≥ 6.2831853072
YES
ASP=ASP-6.2831853072
NØ
T1 = THP
IF
ICK = 2
YES
T1=THPL
NØ
PHI = ABS(ASP-T1)
IF
PHI > 3.1415926536
YES
PHI=6.2831853072-PHI
NØ
IF
PHI ≤ TRD
YES
Receptor in sector
NØ

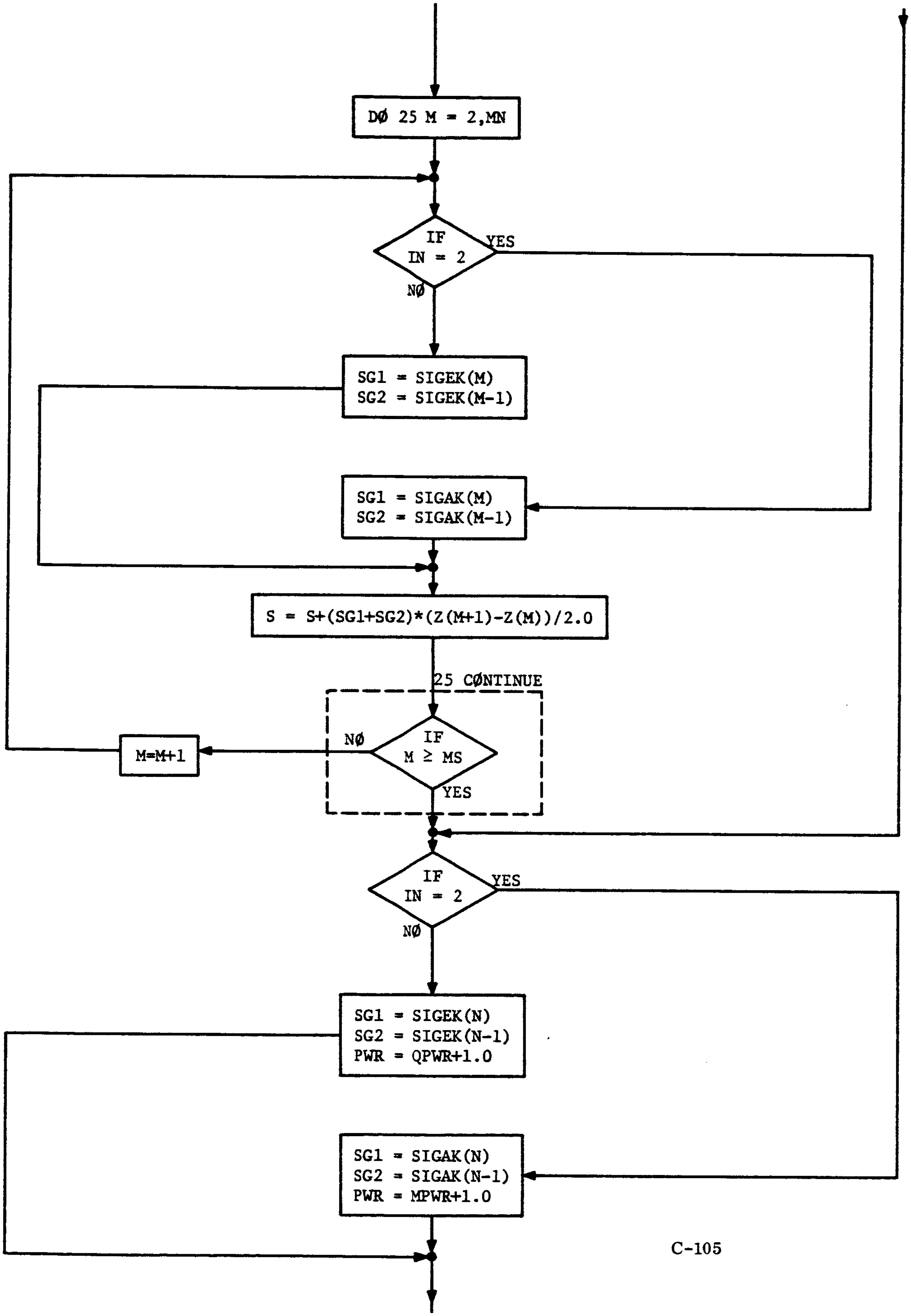

N = 9
ITAG(J) = 9
X = XS
Receptor outside of
sector DELPHI
RETURN
X = XS*CØS(PHI)
Y = XS(SIN(PHI)
IF
ABS(ASP-T1)>3.1415926536
YES
NØ
IF
ASP ≥ T1
YES
NØ

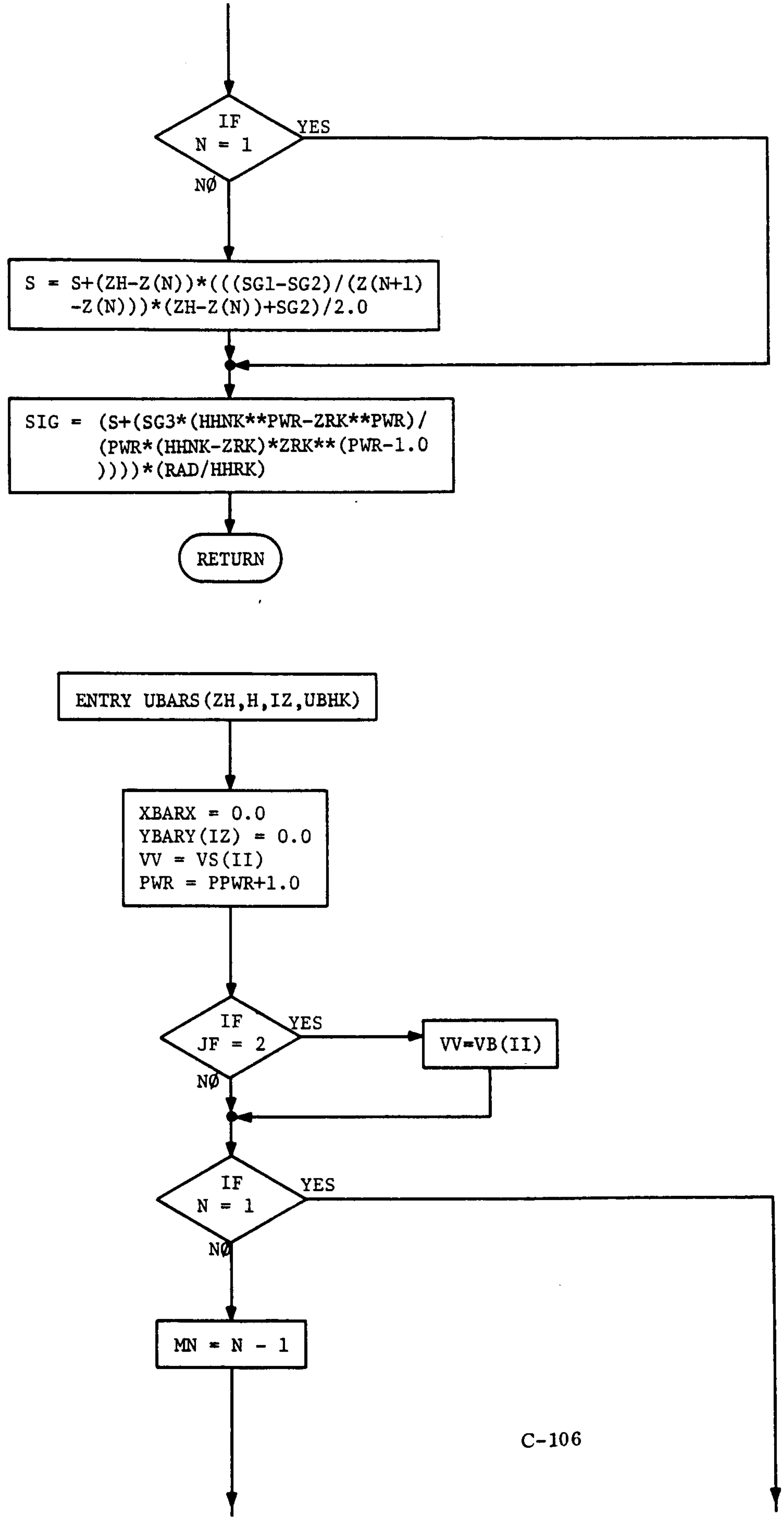

IF
ASP < T1
YES
IF
ASP ≤ T1
YES
NØ
IF
ASP > T1
YES
Y = -Y
ITAG(J) = 0
RETURN

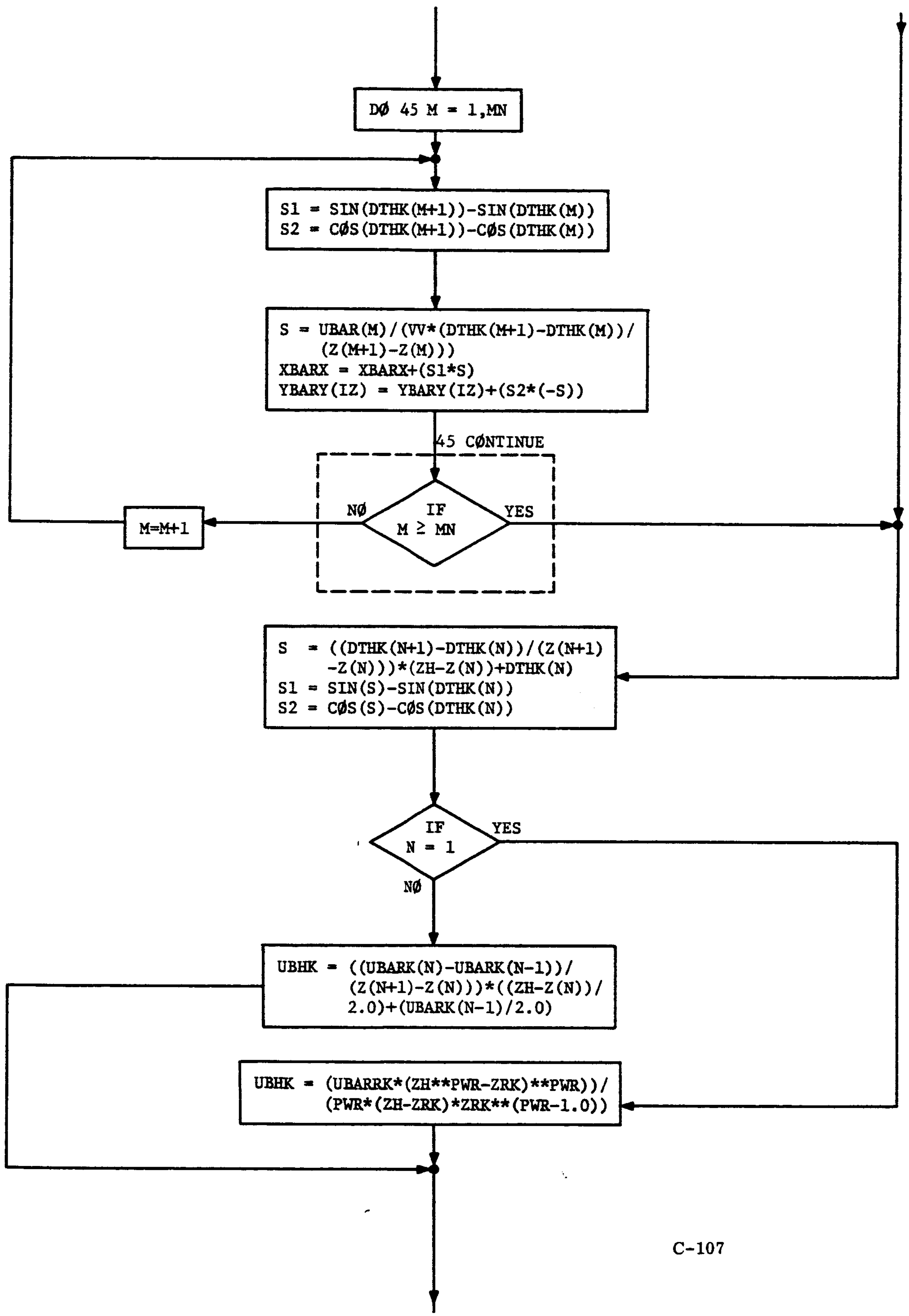
SECTION C. 15

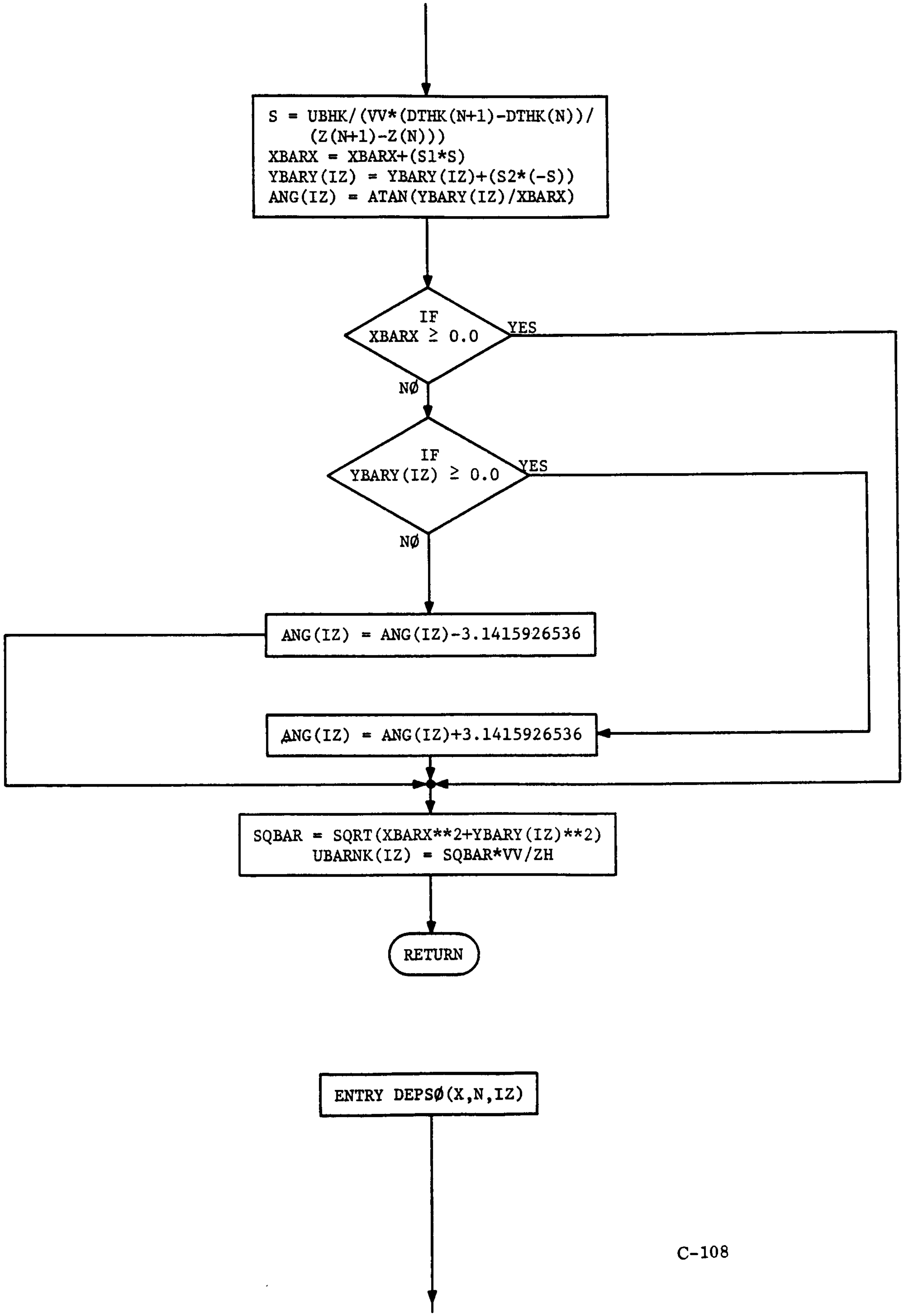
SUBROUTINE SGP

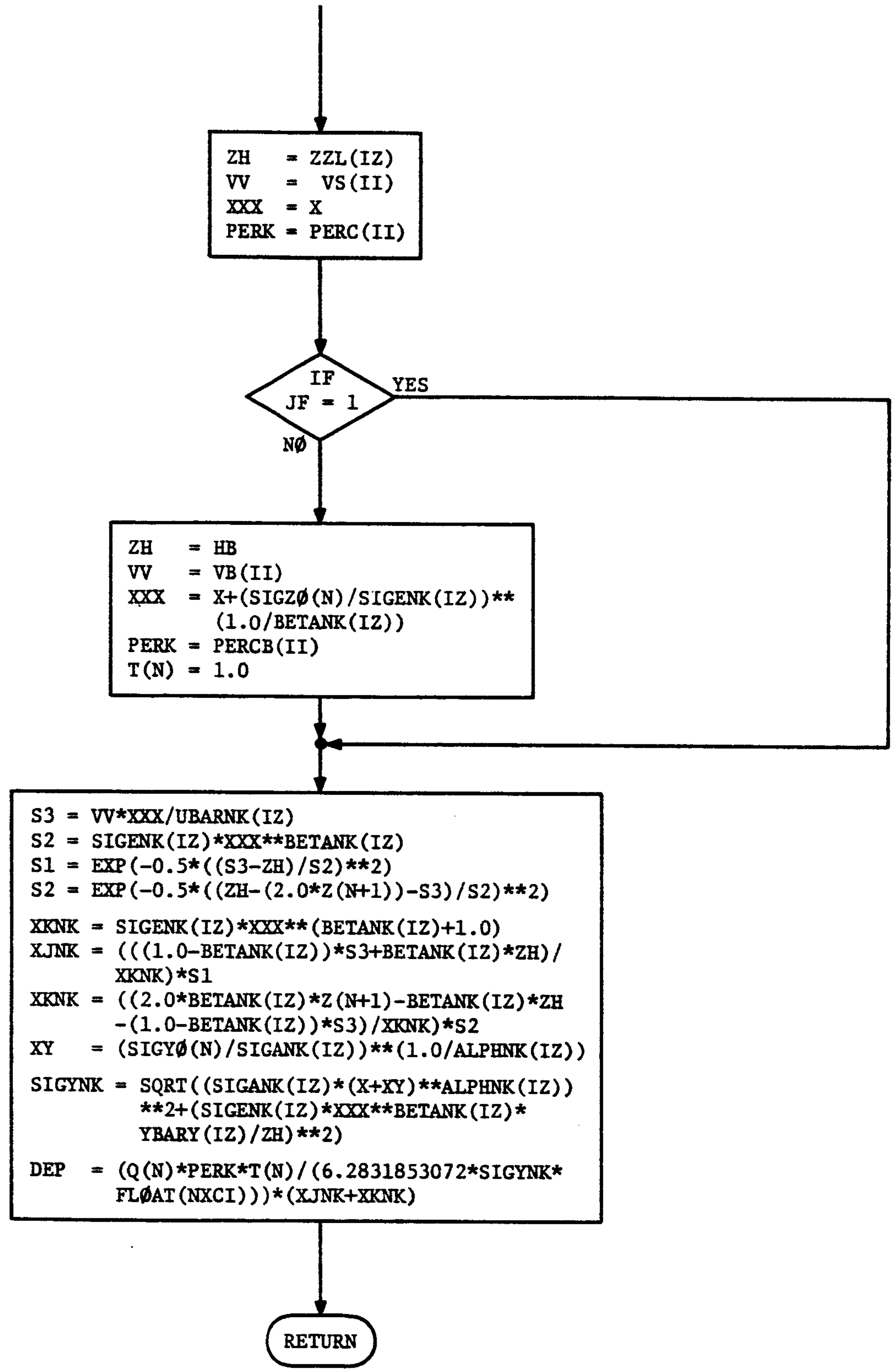

SUBROUTINE SGP(ZH,N,SIG,IN)
THIS SUBROUTINE CONSISTS OF THREE SUBROUTINES. SGP CALCULATES σ'_{ENK} OR σ'_{EB} AND σ'_{ANK} OR σ'_{EB}. SUBROUTINE UBARS CALCULATES $\bar{u}_{NK}$, X_{NK}, Y_{NK}, Θ'S. SUBROUTINE DEPSO CALCULATES ALL OF THE DEPOSITION EQUATION EXCEPT THE LATERAL TERM.
(STØRAGE USED 1424_8)
S = 0
MN = N-1
HHNK = ZH
HHRK = 1.0
IF N = 1
YES
NØ
HHRK = ZH
HHNK = Z(N+1)
SG3 = SIGERK
IF IN = 2
YES
NØ
SG3=SIGARK
IF N ≤ 2
YES
NØ

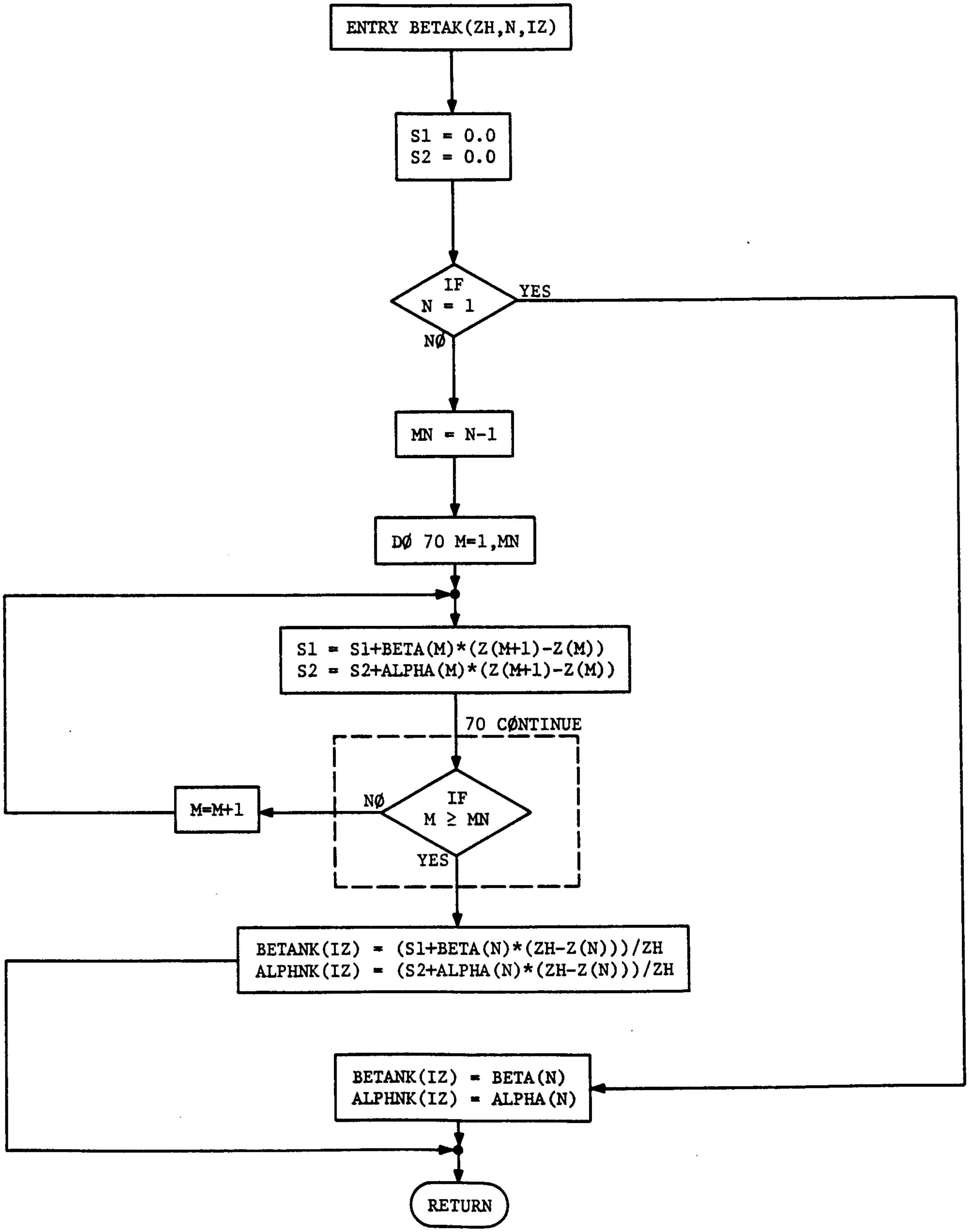

DØ 25 M = 2,MN
IF
IN = 2
YES
NØ
SG1 = SIGEK(M)
SG2 = SIGEK(M-1)
SG1 = SIGAK(M)
SG2 = SIGAK(M-1)
S = S+(SG1+SG2)*(Z(M+1)-Z(M))/2.0
25 CØNTINUE
NØ
IF
M ≥ MS
YES
M=M+1
IF
IN = 2
YES
NØ
SG1 = SIGEK(N)
SG2 = SIGEK(N-1)
PWR = QPWR+1.0
SG1 = SIGAK(N)
SG2 = SIGAK(N-1)
PWR = MPWR+1.0


IF
N = 1
YES
NØ
S = S+(ZH-Z(N))*(((SG1-SG2)/(Z(N+1)
-Z(N)))*(ZH-Z(N))+SG2)/2.0
SIG = (S+(SG3*(HHNK**PWR-ZRK**PWR)/
(PWR*(HHNK-ZRK)*ZRK**(PWR-1.0
))))*(RAD/HHRK)
RETURN
ENTRY UBARS(ZH,H,IZ,UBHK)
XBARX = 0.0
YBARY(IZ) = 0.0
VV = VS(II)
PWR = PPWR+1.0
IF
JF = 2
YES
NØ
VV=VB(II)
IF
N = 1
YES
NØ
MN = N - 1


DØ 45 M = 1,MN
S1 = SIN(DTHK(M+1))-SIN(DTHK(M))
S2 = CØS(DTHK(M+1))-CØS(DTHK(M))
S = UBAR(M)/(VV*(DTHK(M+1)-DTHK(M))/
(Z(M+1)-Z(M)))
XBARX = XBARX+(S1*S)
YBARY(IZ) = YBARY(IZ)+(S2*(-S))
45 CØNTINUE
NØ
IF
M ≥ MN
YES
M=M+1
S = ((DTHK(N+1)-DTHK(N))/(Z(N+1)
-Z(N)))*(ZH-Z(N))+DTHK(N)
S1 = SIN(S)-SIN(DTHK(N))
S2 = CØS(S)-CØS(DTHK(N))
IF
N = 1
YES
NØ
UBHK = ((UBARK(N)-UBARK(N-1))/
(Z(N+1)-Z(N)))*((ZH-Z(N))/
2.0)+(UBARK(N-1)/2.0)
UBHK = (UBARRK*(ZH**PWR-ZRK)**PWR))/
(PWR*(ZH-ZRK)*ZRK**(PWR-1.0))

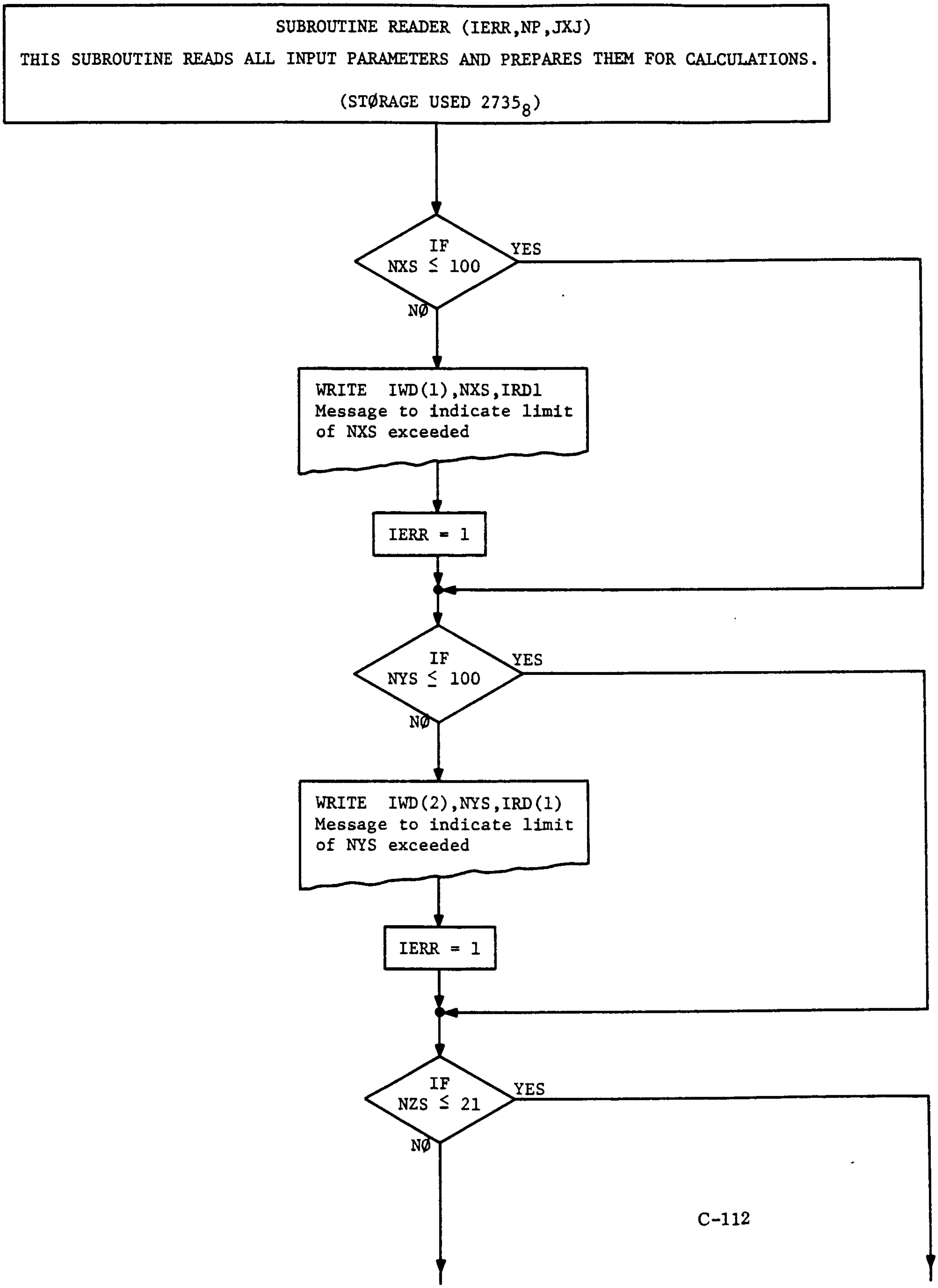

S = UBHK/(VV*(DTHK(N+1)-DTHK(N))/
(Z(N+1)-Z(N)))
XBARX = XBARX+(S1*S)
YBARY(IZ) = YBARY(IZ)+(S2*(-S))
ANG(IZ) = ATAN(YBARY(IZ)/XBARX)
IF
XBARX ≥ 0.0
YES
NØ
IF
YBARY(IZ) ≥ 0.0
YES
NØ
ANG(IZ) = ANG(IZ)-3.1415926536
ANG(IZ) = ANG(IZ)+3.1415926536
SQBAR = SQRT(XBARX**2+YBARY(IZ)**2)
UBARNK(IZ) = SQBAR*VV/ZH
RETURN
ENTRY DEPSØ(X,N,IZ)

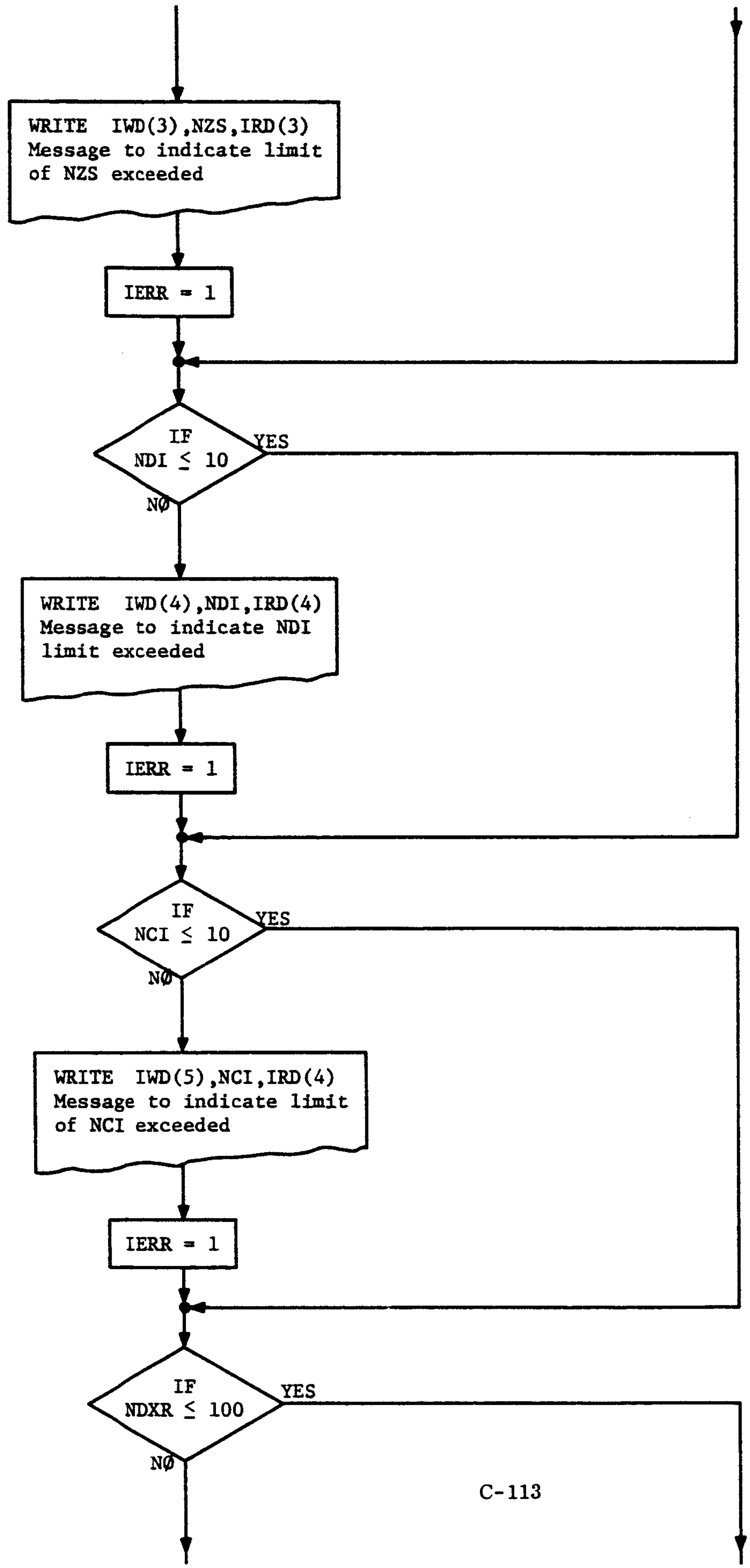

ZH = ZZL(IZ)
VV = VS(II)
XXX = X
PERK = PERC(II)
IF JF = 1
YES
NØ
ZH = HB
VV = VB(II)
XXX = X+(SIGZØ(N)/SIGENK(IZ))**(1.0/BETANK(IZ))
PERK = PERCB(II)
T(N) = 1.0
S3 = VV*XXX/UBARNK(IZ)
S2 = SIGENK(IZ)*XXX**BETANK(IZ)
S1 = EXP(-0.5*((S3-ZH)/S2)**2)
S2 = EXP(-0.5*((ZH-(2.0*Z(N+1))-S3)/S2)**2)
XKNK = SIGENK(IZ)*XXX**(BETANK(IZ)+1.0)
XJNK = (((1.0-BETANK(IZ))*S3+BETANK(IZ)*ZH)/XKNK)*S1
XKNK = ((2.0*BETANK(IZ)*Z(N+1)-BETANK(IZ)*ZH-(1.0-BETANK(IZ))*S3)/XKNK)*S2
XY = (SIGYØ(N)/SIGANK(IZ))**(1.0/ALPHNK(IZ))
SIGYNK = SQRT((SIGANK(IZ)*(X+XY)**ALPHNK(IZ))**2+(SIGENK(IZ)*XXX**BETANK(IZ)*YBARY(IZ)/ZH)**2)
DEP = (Q(N)*PERK*T(N)/(6.2831853072*SIGYNK*FLØAT(NXCI)))*(XJNK+XKNK)
RETURN

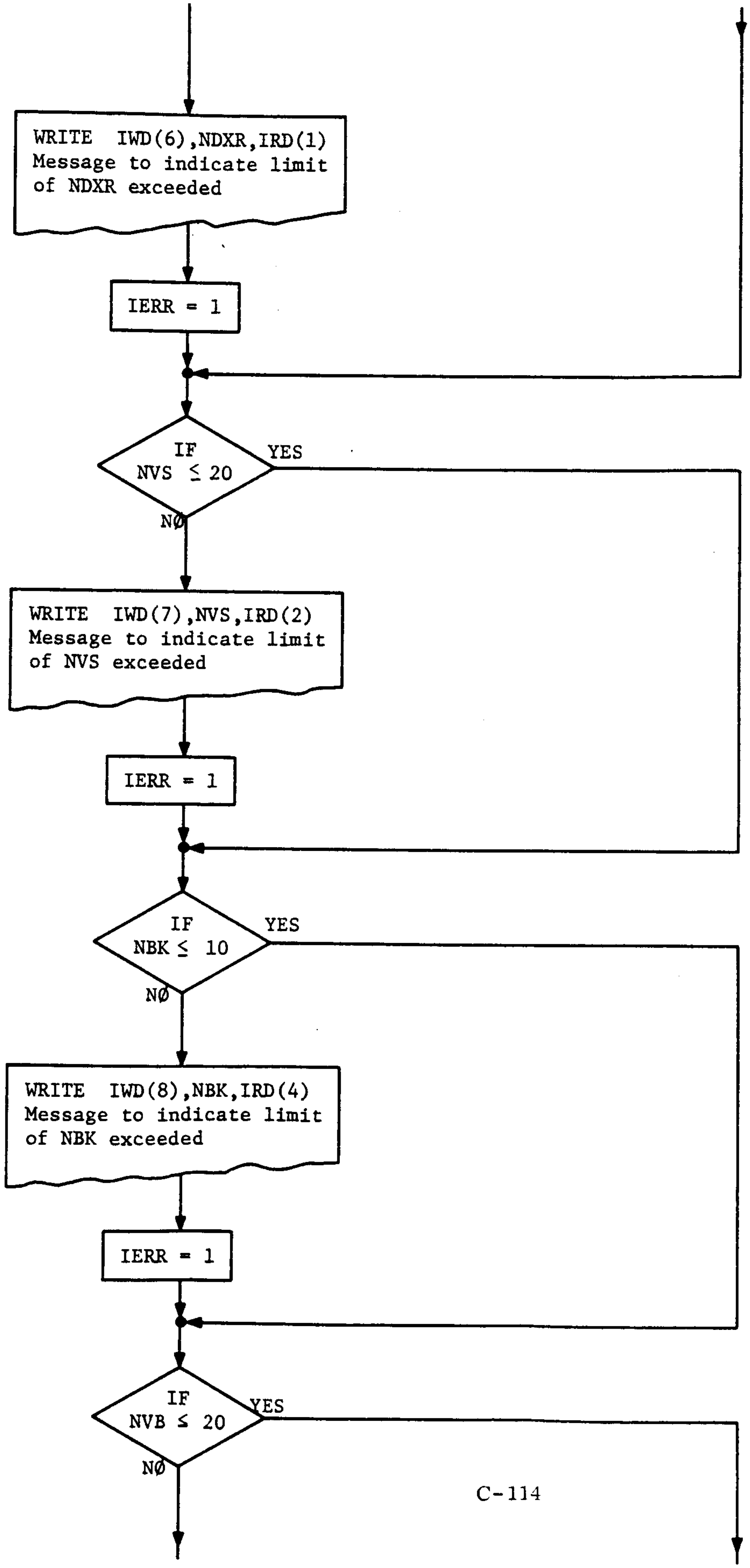

ENTRY BETAK(ZH,N,IZ)
S1 = 0.0
S2 = 0.0
IF
N = 1
YES
NØ
MN = N-1
DØ 70 M=1,MN
S1 = S1+BETA(M)*(Z(M+1)-Z(M))
S2 = S2+ALPHA(M)*(Z(M+1)-Z(M))
70 CØNTINUE
NØ
IF
M ≥ MN
YES
M=M+1
BETANK(IZ) = (S1+BETA(N)*(ZH-Z(N)))/ZH
ALPHNK(IZ) = (S2+ALPHA(N)*(ZH-Z(N)))/ZH
BETANK(IZ) = BETA(N)
ALPHNK(IZ) = ALPHA(N)
RETURN

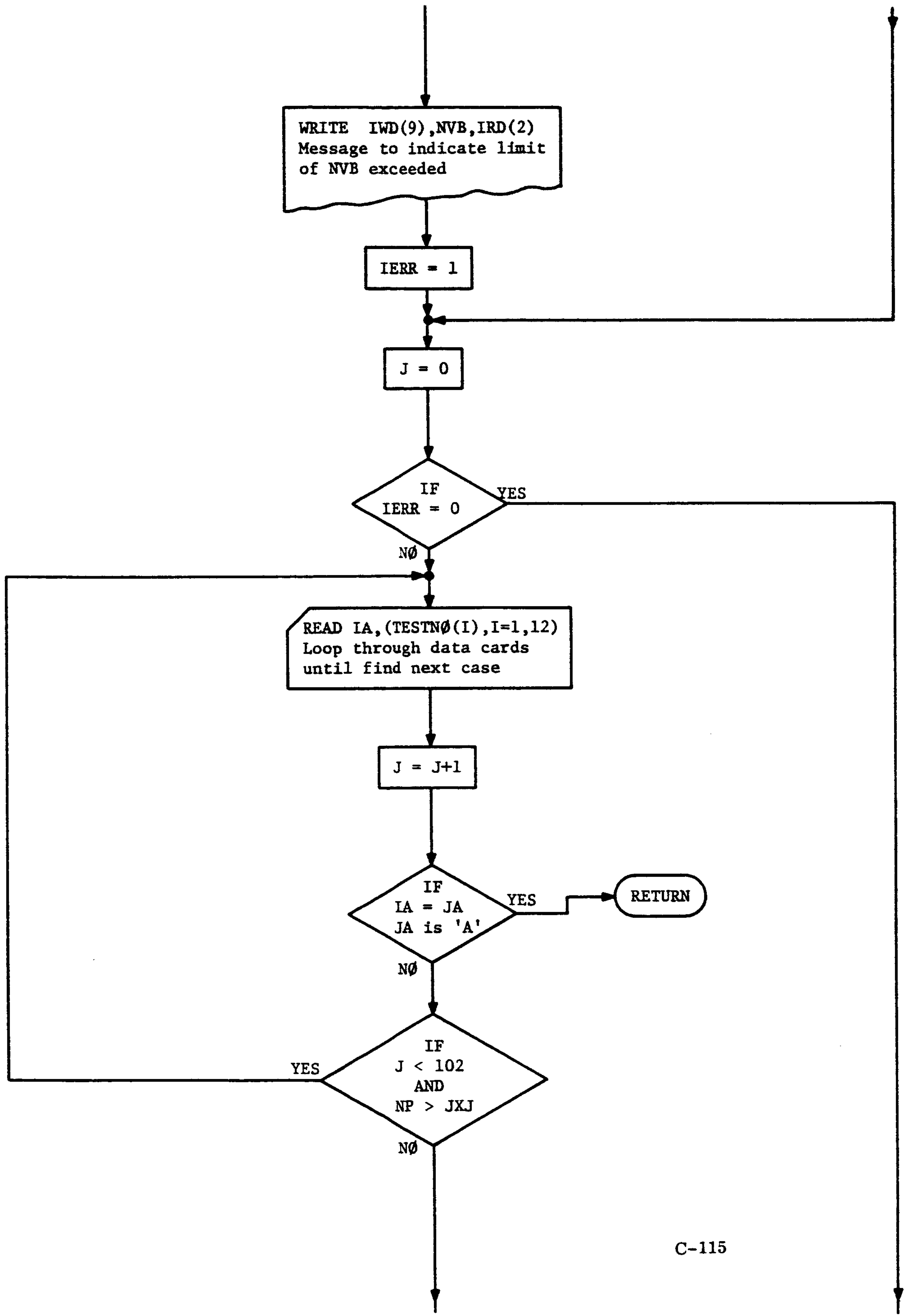
SECTION C. 16

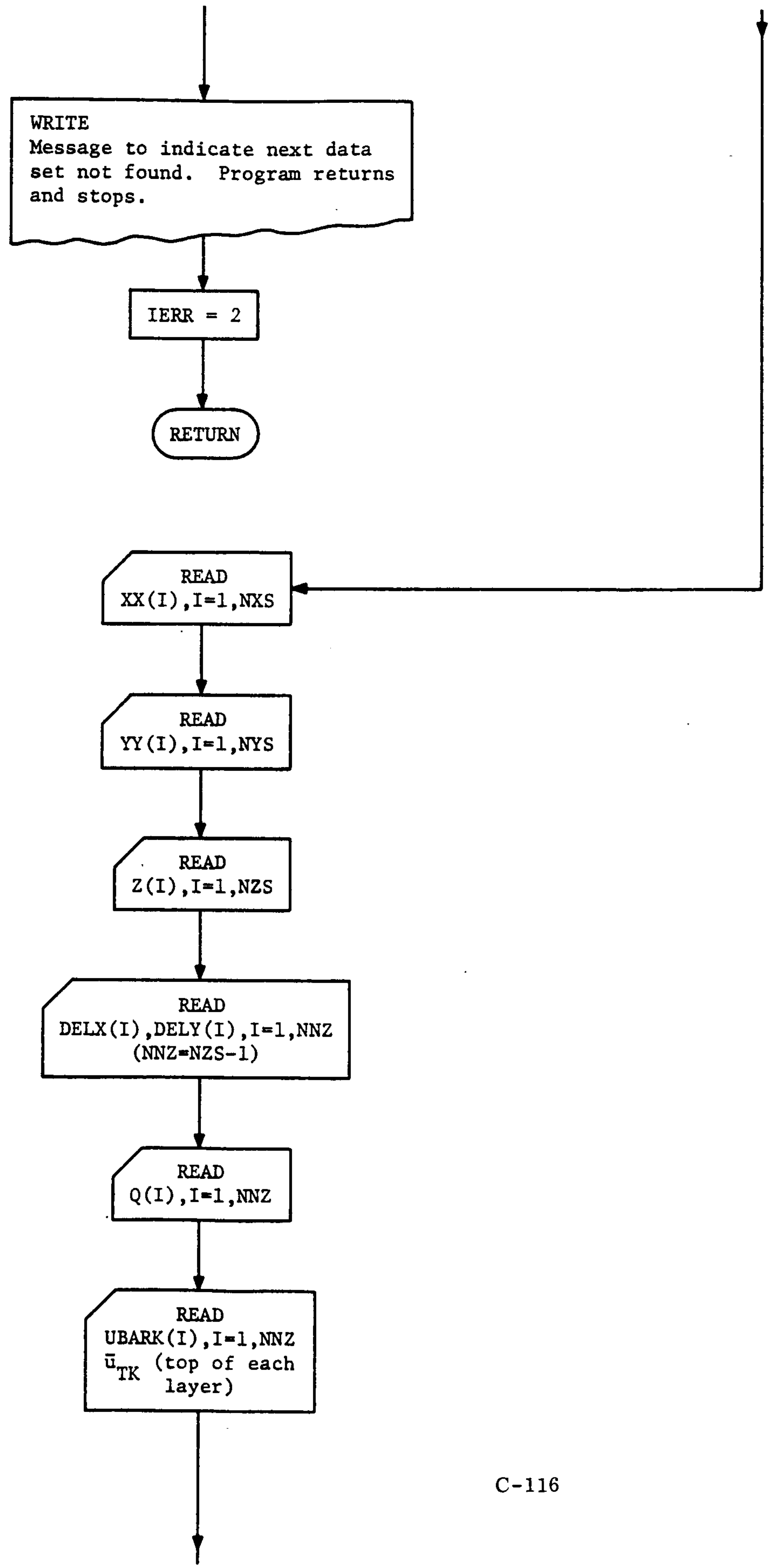
SUBROUTINE READER

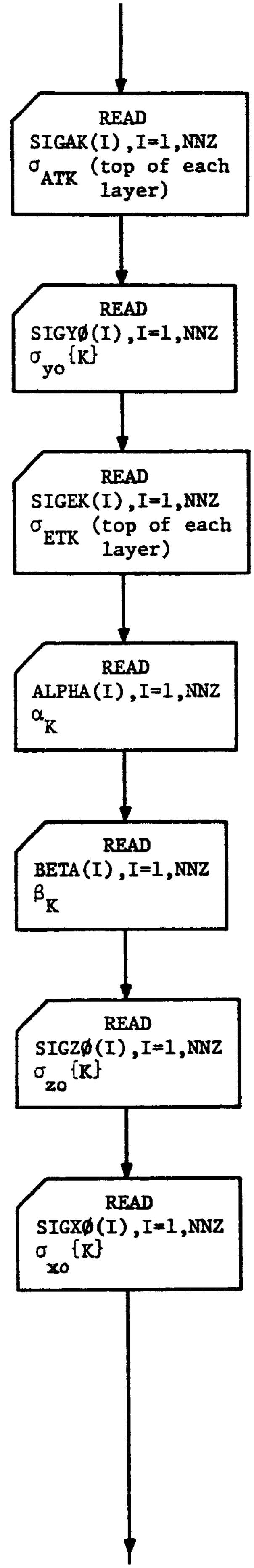

SUBROUTINE READER (IERR,NP,JXJ)
THIS SUBROUTINE READS ALL INPUT PARAMETERS AND PREPARES THEM FOR CALCULATIONS.
(STØRAGE USED 2735_8)
IF NXS ≤ 100
YES
NØ
WRITE IWD(1),NXS,IRD1
Message to indicate limit of NXS exceeded
IERR = 1
IF NYS ≤ 100
YES
NØ
WRITE IWD(2),NYS,IRD(1)
Message to indicate limit of NYS exceeded
IERR = 1
IF NZS ≤ 21
YES
NØ

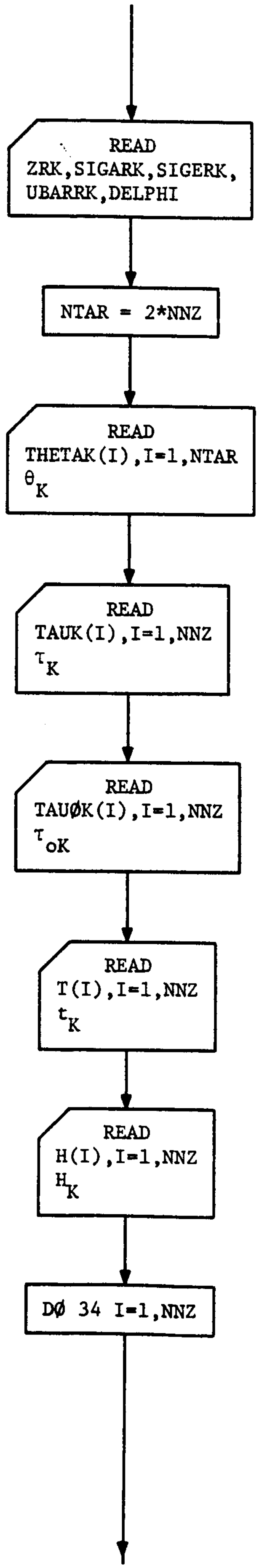

WRITE IWD(3),NZS,IRD(3)
Message to indicate limit
of NZS exceeded
IERR = 1
IF
NDI ≤ 10
YES
NØ
WRITE IWD(4),NDI,IRD(4)
Message to indicate NDI
limit exceeded
IERR = 1
IF
NCI ≤ 10
YES
NØ
WRITE IWD(5),NCI,IRD(4)
Message to indicate limit
of NCI exceeded
IERR = 1
IF
NDXR ≤ 100
YES
NØ

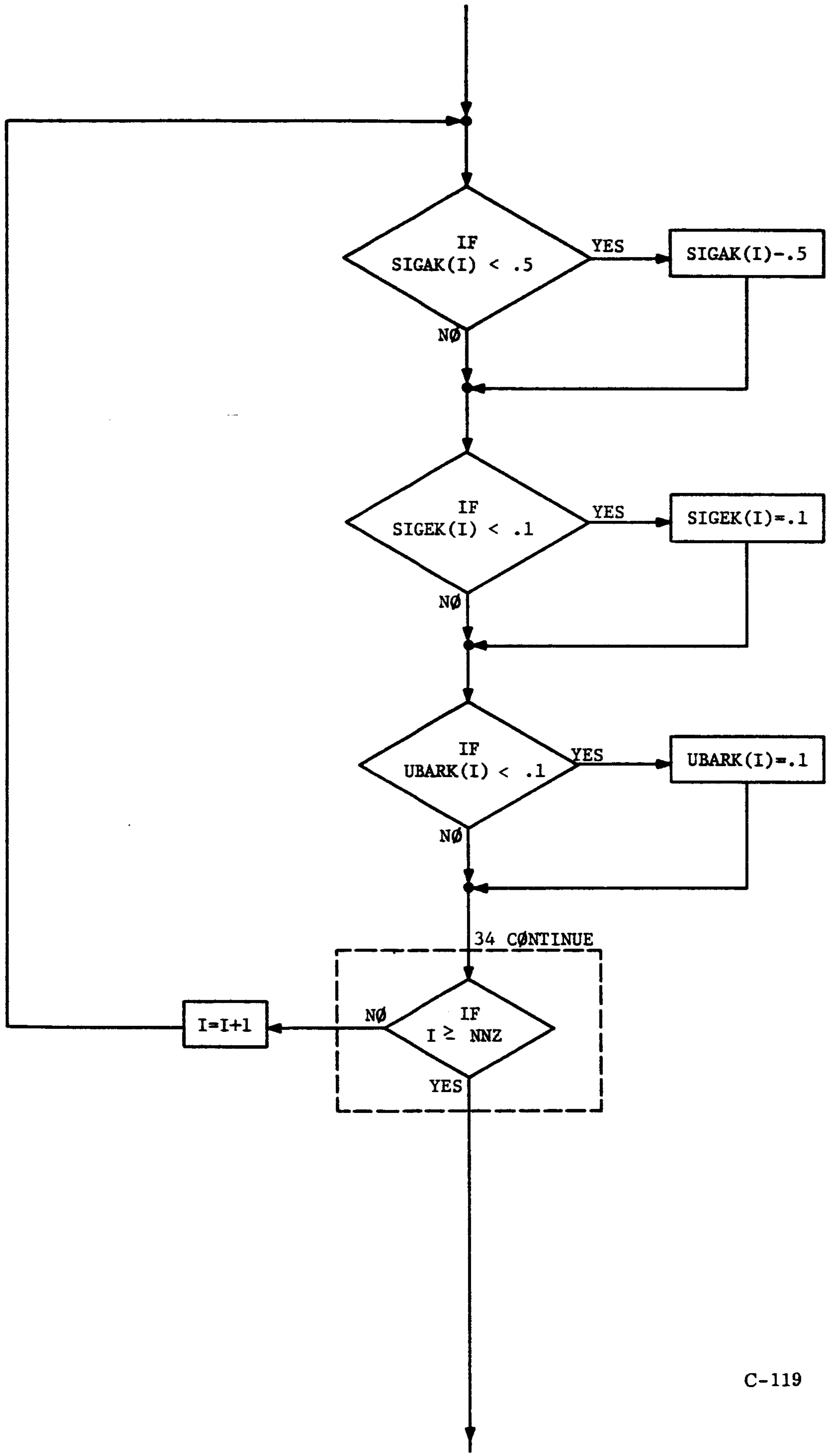

WRITE IWD(6),NDXR,IRD(1)
Message to indicate limit
of NDXR exceeded
IERR = 1
IF
NVS ≤ 20
YES
NØ
WRITE IWD(7),NVS,IRD(2)
Message to indicate limit
of NVS exceeded
IERR = 1
IF
NBK ≤ 10
YES
NØ
WRITE IWD(8),NBK,IRD(4)
Message to indicate limit
of NBK exceeded
IERR = 1
IF
NVB ≤ 20
YES
NØ

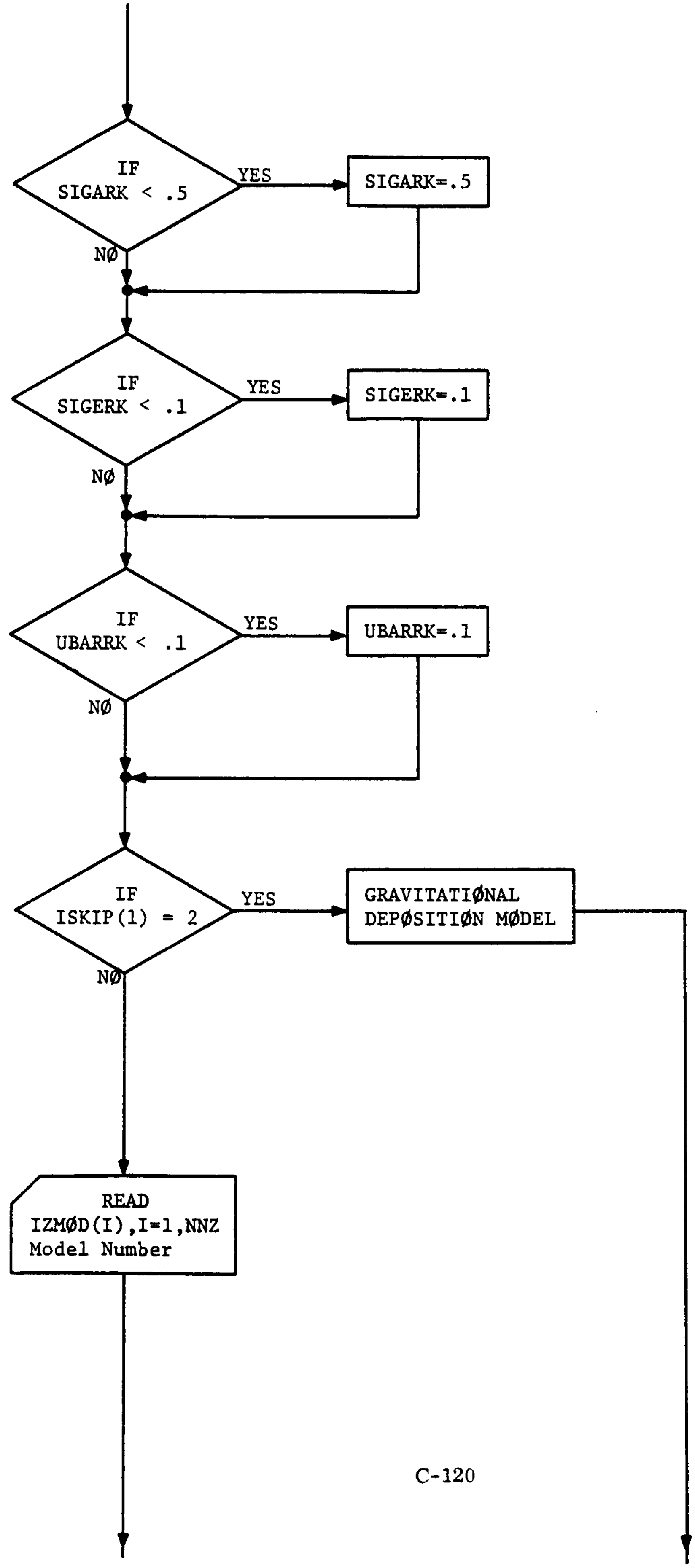

WRITE IWD(9),NVB,IRD(2)
Message to indicate limit
of NVB exceeded
IERR = 1
J = 0
IF
IERR = 0
YES
NØ
READ IA,(TESTNØ(I),I=1,12)
Loop through data cards
until find next case
J = J+1
IF
IA = JA
JA is 'A'
YES
RETURN
NØ
IF
J < 102
AND
NP > JXJ
YES
NØ

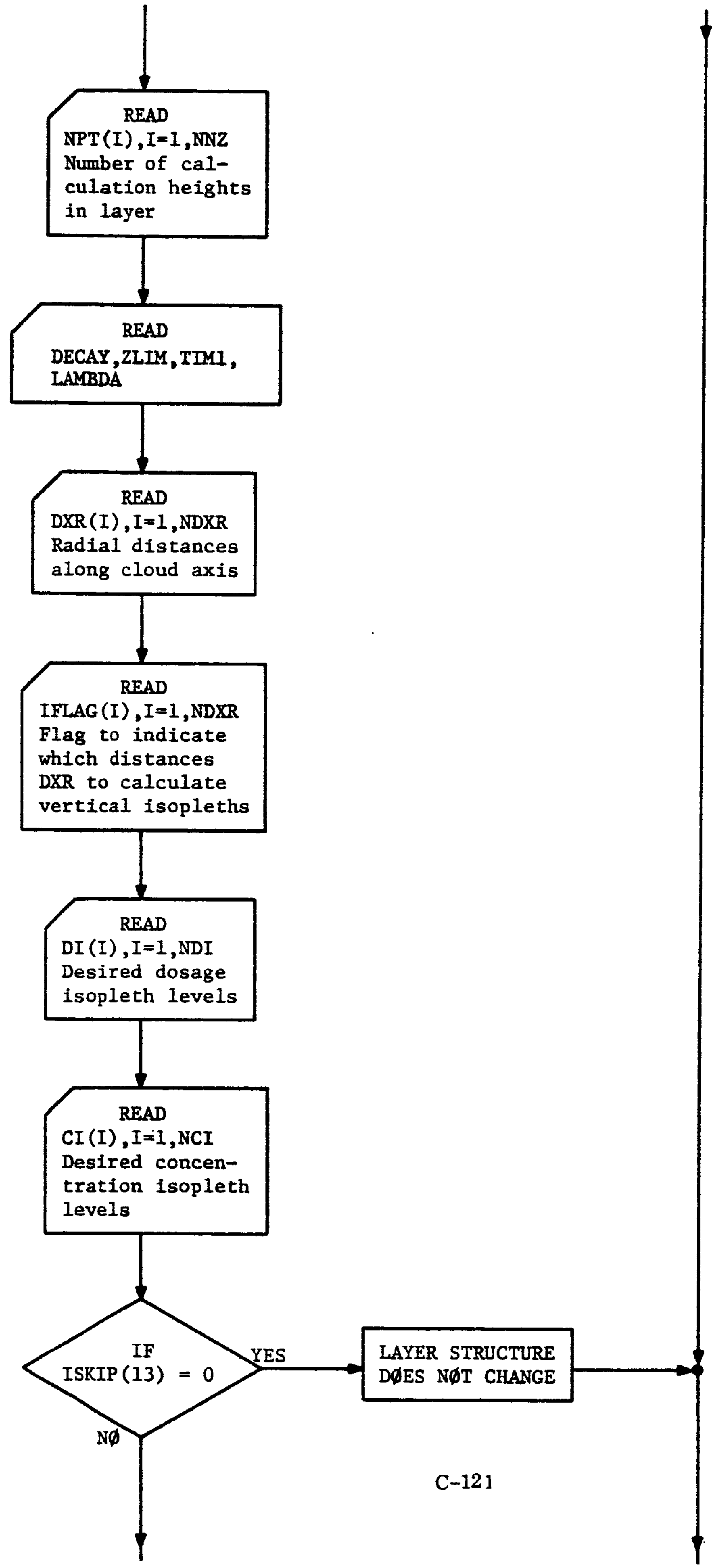

WRITE
Message to indicate next data set not found. Program returns and stops.
IERR = 2
RETURN
READ
XX(I),I=1,NXS
READ
YY(I),I=1,NYS
READ
Z(I),I=1,NZS
READ
DELX(I),DELY(I),I=1,NNZ
(NNZ=NZS-1)
READ
Q(I),I=1,NNZ
READ
UBARK(I),I=1,NNZ
ū_TK (top of each layer)

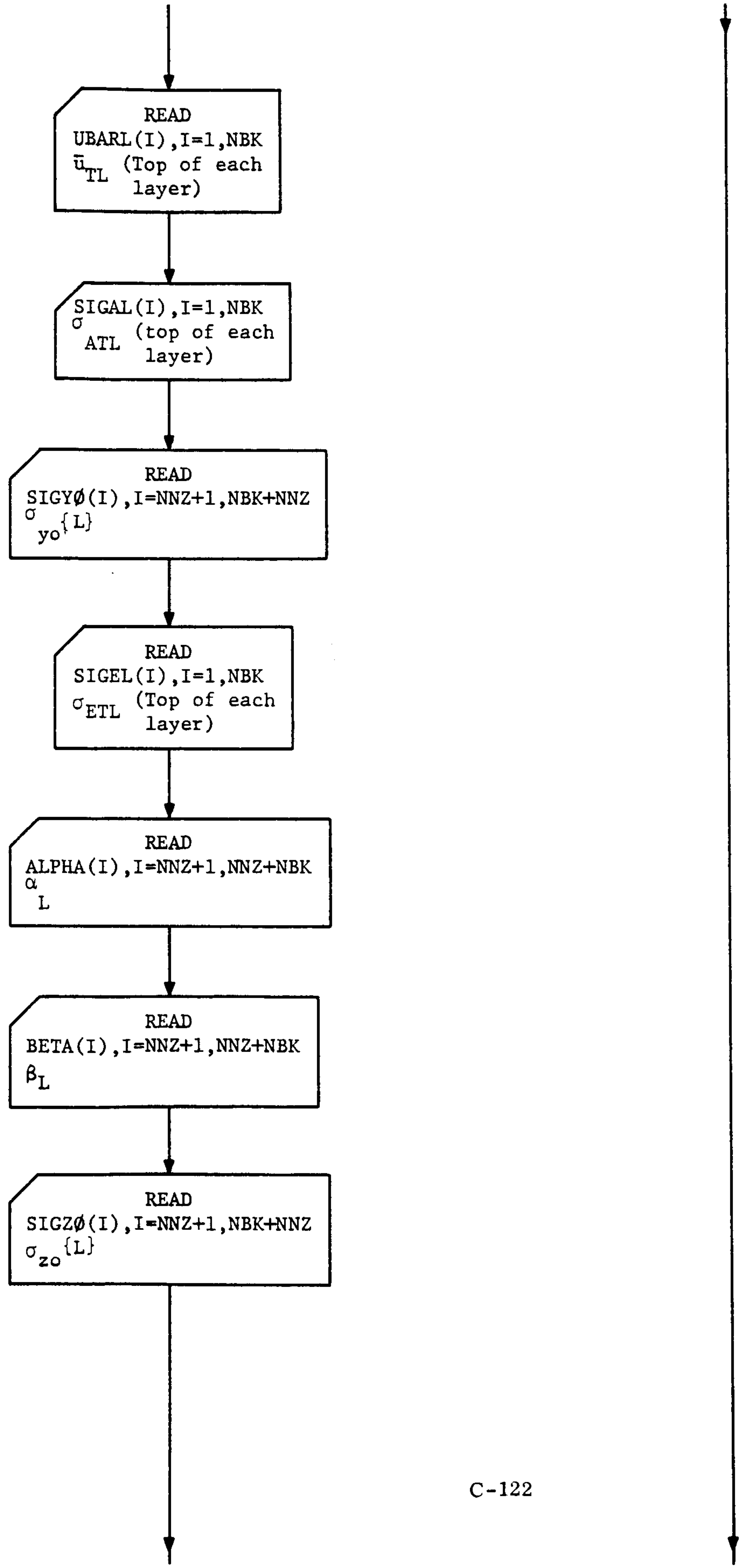

READ
SIGAK(I),I=1,NNZ
σ ATK (top of each layer)
READ
SIGYØ(I),I=1,NNZ
σ yo {K}
READ
SIGEK(I),I=1,NNZ
σ ETK (top of each layer)
READ
ALPHA(I),I=1,NNZ
α K
READ
BETA(I),I=1,NNZ
β K
READ
SIGZØ(I),I=1,NNZ
σ zo {K}
READ
SIGXØ(I),I=1,NNZ
σ xo {K}

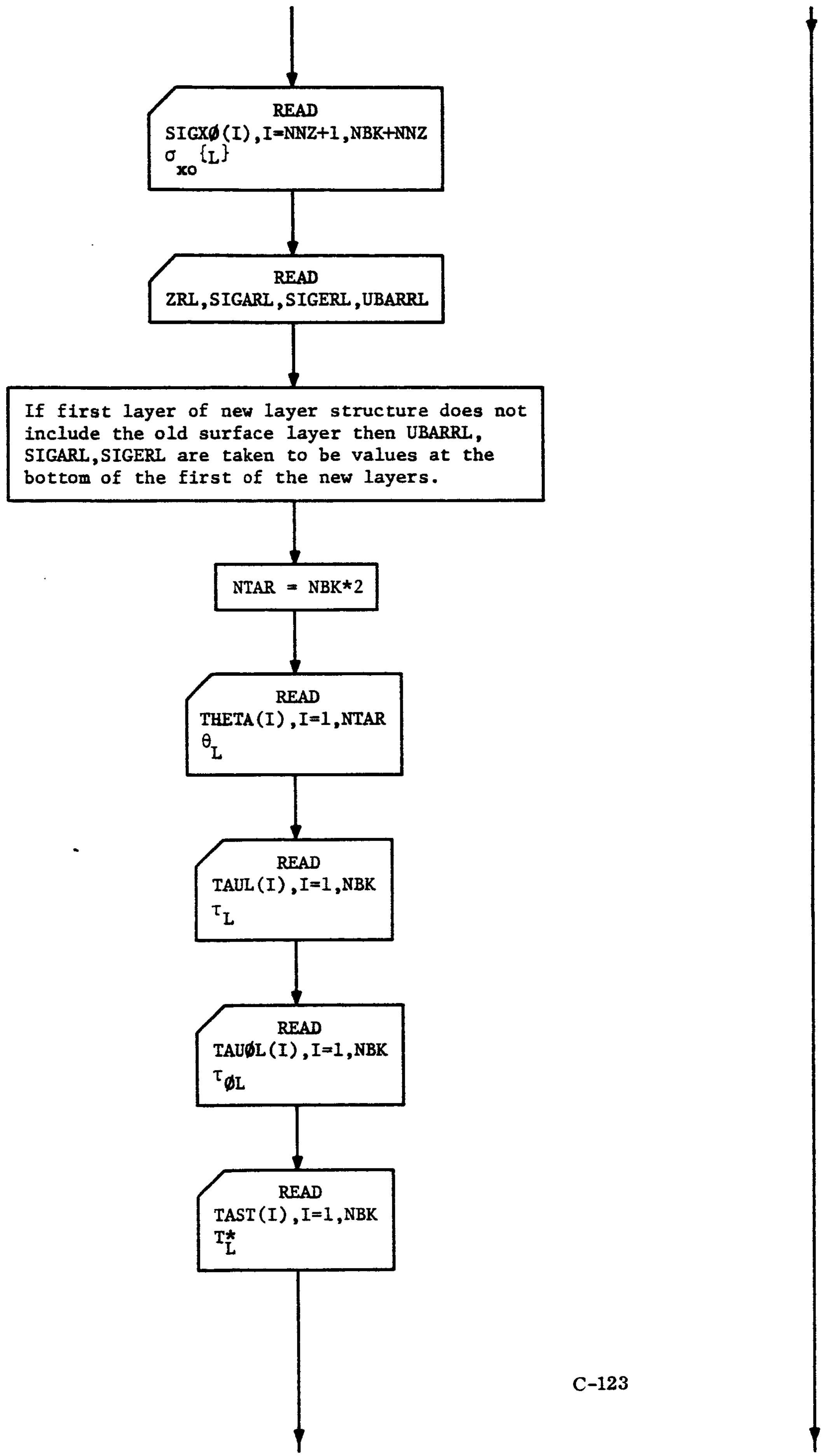

READ
ZRK,SIGARK,SIGERK,
UBARRK,DELPHI
NTAR = 2*NNZ
READ
THETAK(I),I=1,NTAR
θ_K
READ
TAUK(I),I=1,NNZ
τ_K
READ
TAUØK(I),I=1,NNZ
τ_{oK}
READ
T(I),I=1,NNZ
t_K
READ
H(I),I=1,NNZ
H_K
DØ 34 I=1,NNZ

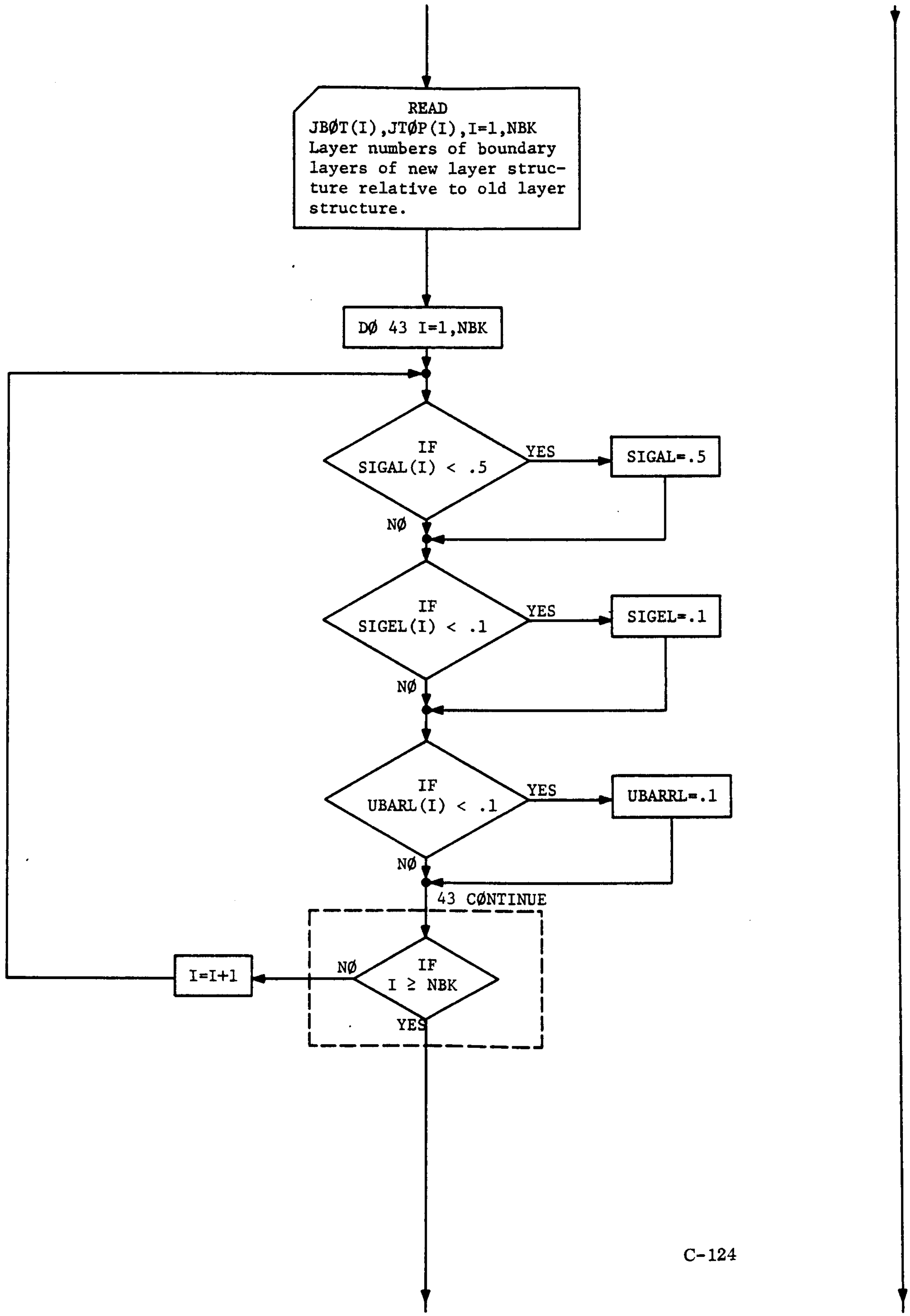

IF
SIGAK(I) < .5
YES
SIGAK(I)-.5
NØ
IF
SIGEK(I) < .1
YES
SIGEK(I)=.1
NØ
IF
UBARK(I) < .1
YES
UBARK(I)=.1
NØ
34 CØNTINUE
IF
I ≥ NNZ
NØ
I=I+1
YES

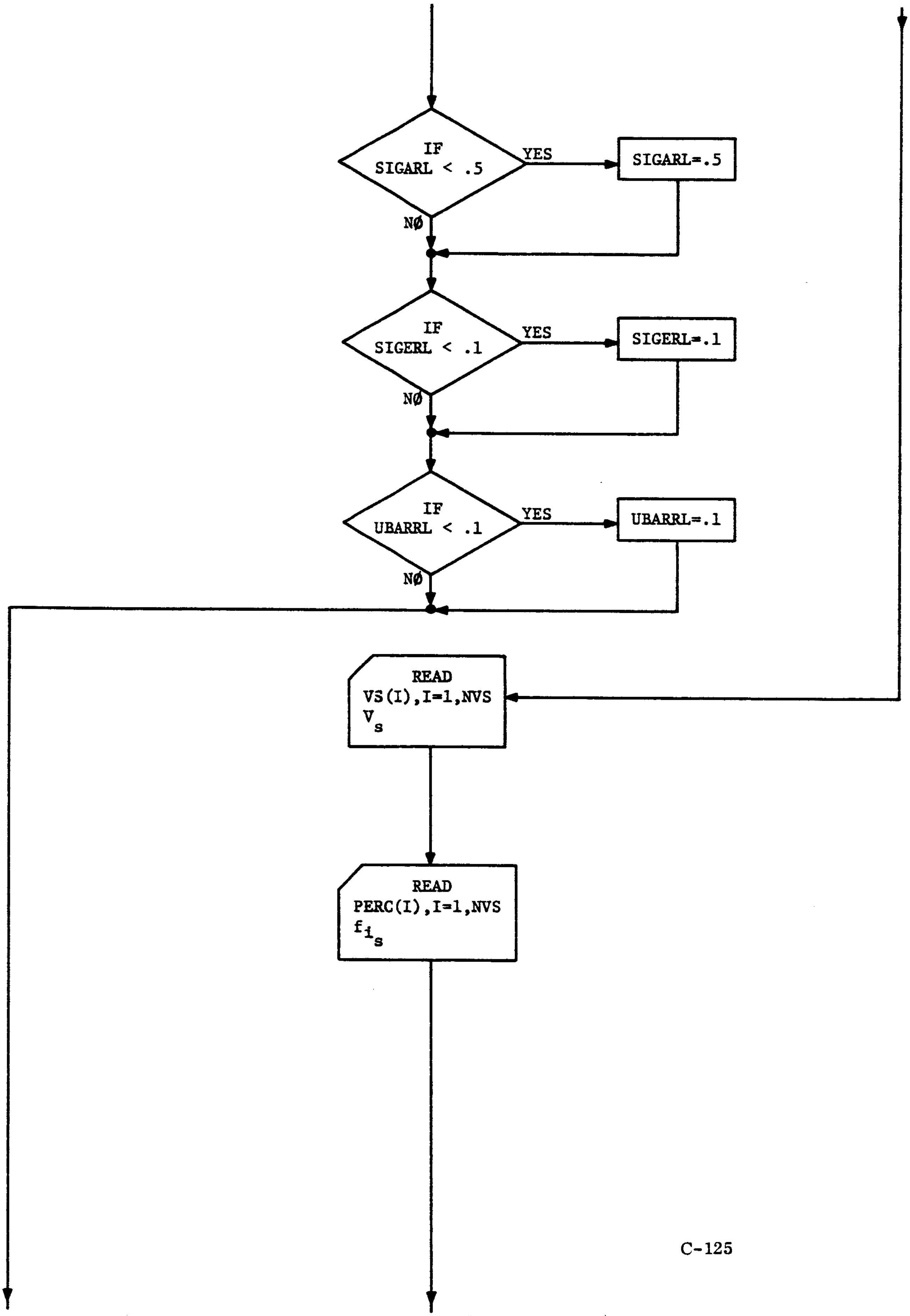

IF
SIGARK < .5
YES
SIGARK=.5
NØ
IF
SIGERK < .1
YES
SIGERK=.1
NØ
IF
UBARRK < .1
YES
UBARRK=.1
NØ
IF
ISKIP(1) = 2
YES
GRAVITATIØNAL
DEPØSITIØN MØDEL
NØ
READ
IZMØD(I),I=1,NNZ
Model Number

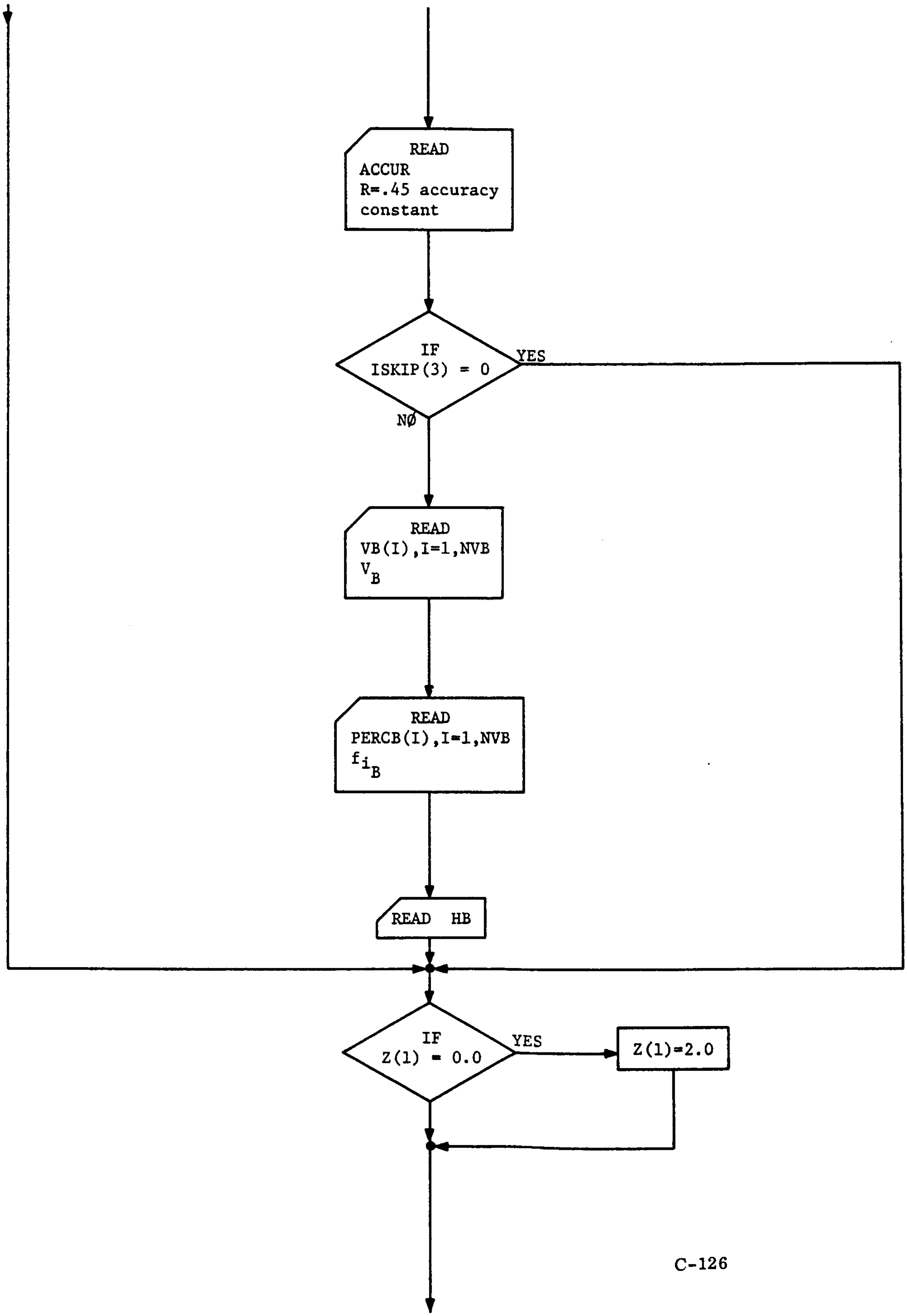

READ
NPT(I),I=1,NNZ
Number of cal-
culation heights
in layer
READ
DECAY,ZLIM,TIM1,
LAMBDA
READ
DXR(I),I=1,NDXR
Radial distances
along cloud axis
READ
IFLAG(I),I=1,NDXR
Flag to indicate
which distances
DXR to calculate
vertical isopleths
READ
DI(I),I=1,NDI
Desired dosage
isopleth levels
READ
CI(I),I=1,NCI
Desired concen-
tration isopleth
levels
IF
ISKIP(13) = 0
YES
LAYER STRUCTURE
DØES NØT CHANGE
NØ

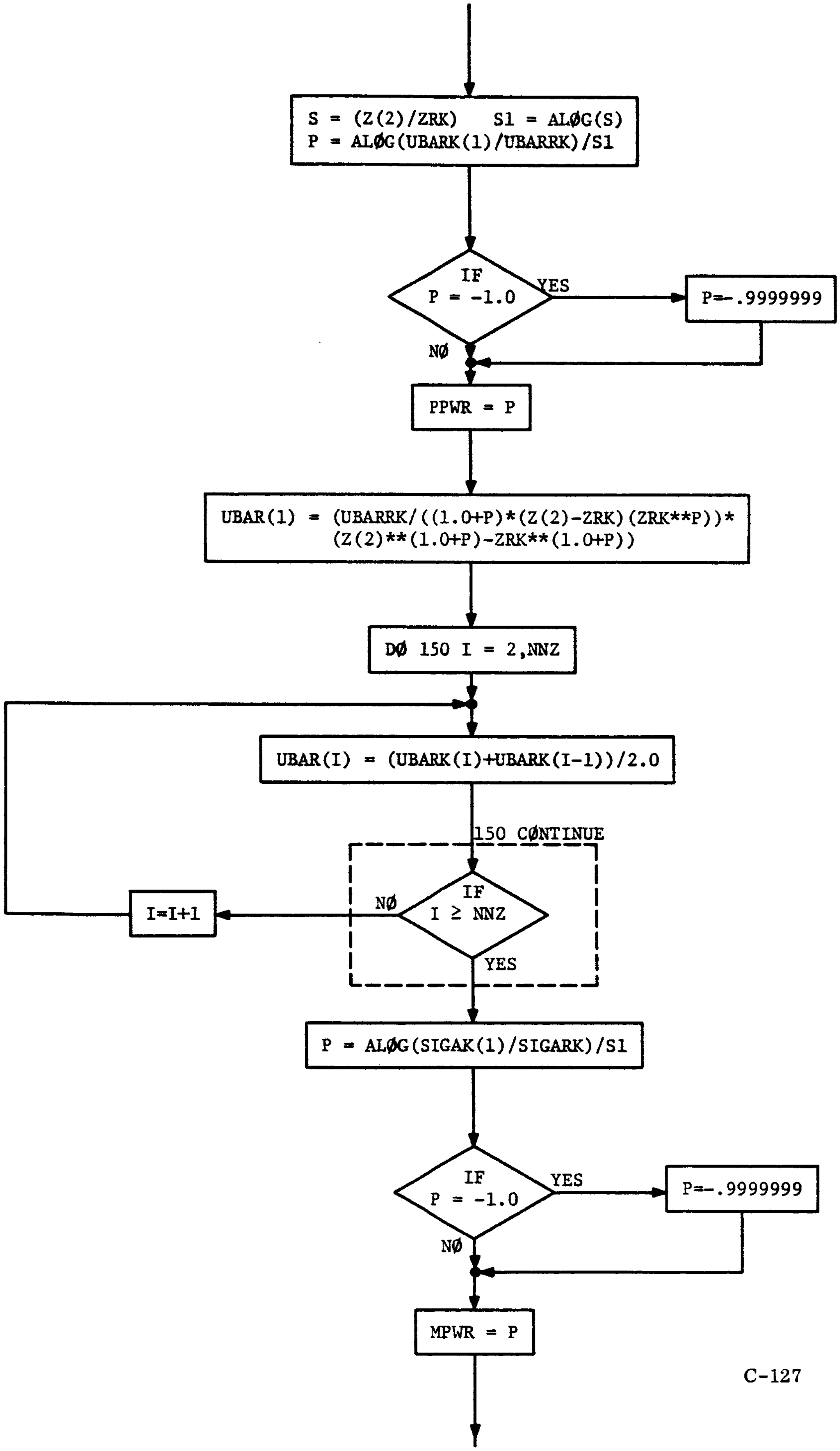

READ
UBARL(I),I=1,NBK
ū TL (Top of each layer)
SIGAL(I),I=1,NBK
σ ATL (top of each layer)
READ
SIGYØ(I),I=NNZ+1,NBK+NNZ
σ yo{L}
READ
SIGEL(I),I=1,NBK
σ ETL (Top of each layer)
READ
ALPHA(I),I=NNZ+1,NNZ+NBK
α L
READ
BETA(I),I=NNZ+1,NNZ+NBK
β L
READ
SIGZØ(I),I=NNZ+1,NBK+NNZ
σ zo{L}

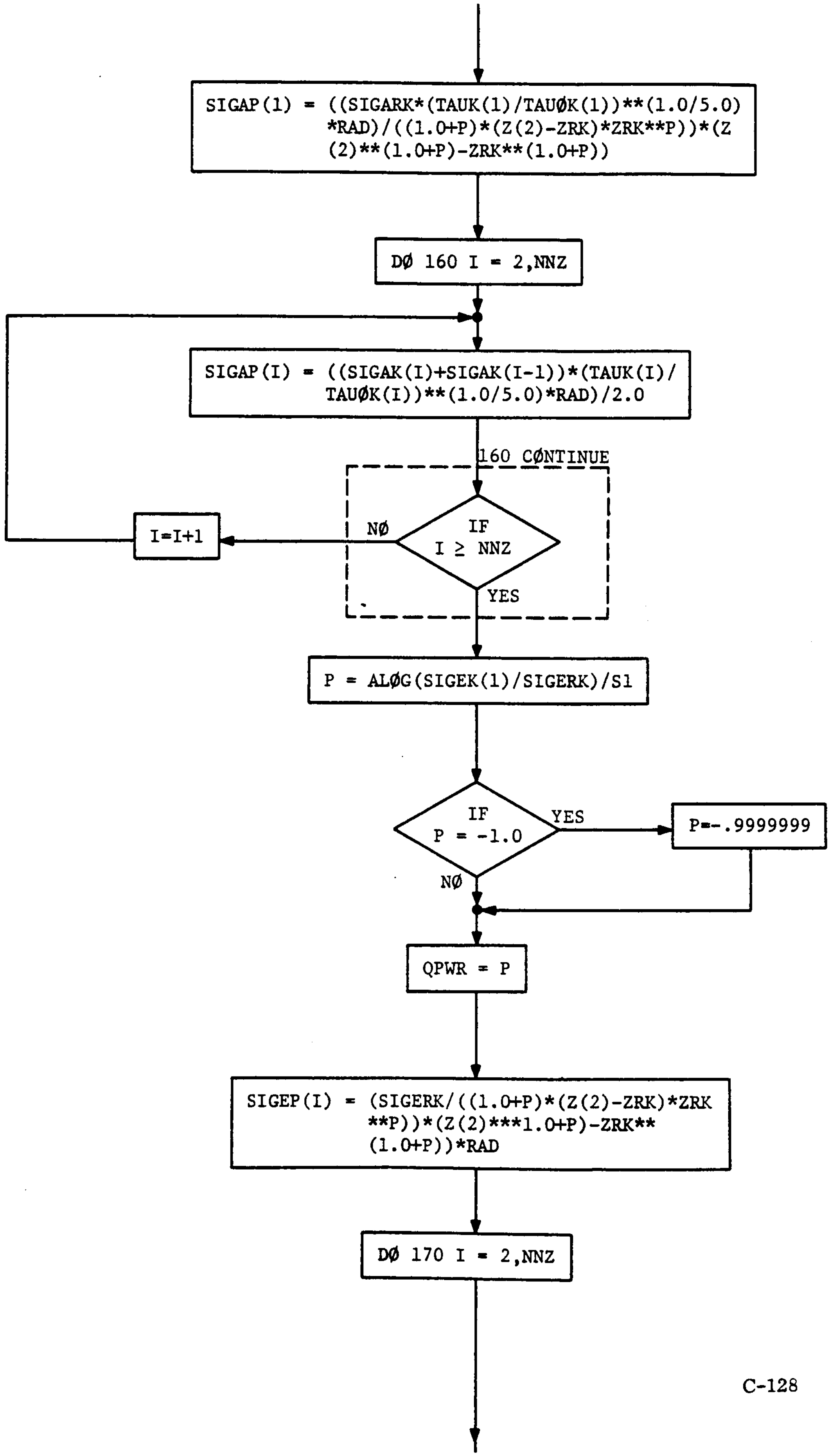

READ
SIGXØ(I),I=NNZ+1,NBK+NNZ
σxo{L}
READ
ZRL,SIGARL,SIGERL,UBARRL
If first layer of new layer structure does not include the old surface layer then UBARRL, SIGARL,SIGERL are taken to be values at the bottom of the first of the new layers.
NTAR = NBK*2
READ
THETA(I),I=1,NTAR
θL
READ
TAUL(I),I=1,NBK
τL
READ
TAUØL(I),I=1,NBK
τØL
READ
TAST(I),I=1,NBK
τ*L

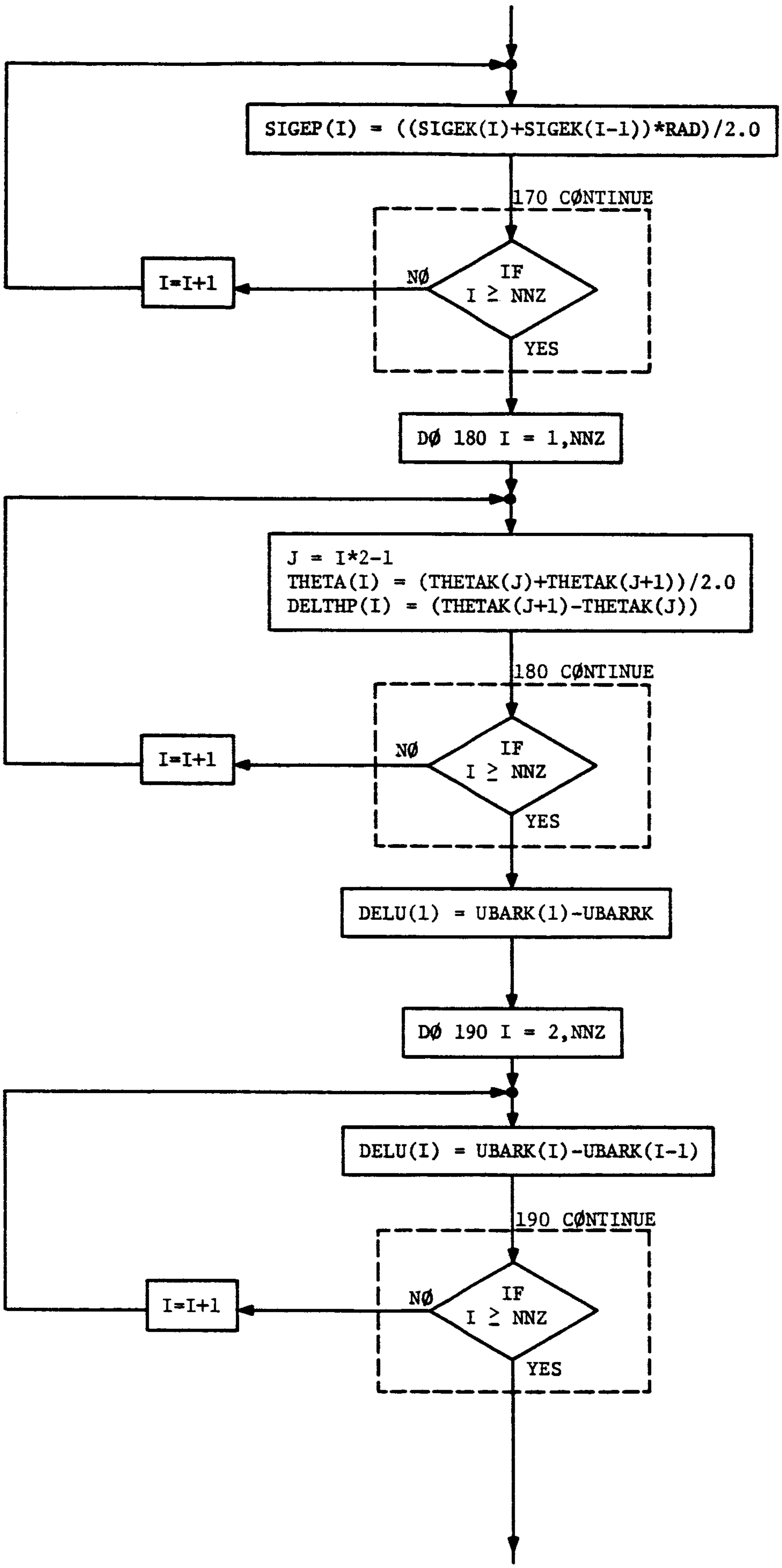

READ
JBØT(I),JTØP(I),I=1,NBK
Layer numbers of boundary layers of new layer structure relative to old layer structure.
DØ 43 I=1,NBK
IF
SIGAL(I) < .5
YES
SIGAL=.5
NØ
IF
SIGEL(I) < .1
YES
SIGEL=.1
NØ
IF
UBARL(I) < .1
YES
UBARRL=.1
NØ
43 CØNTINUE
NØ
IF
I ≥ NBK
YES
I=I+1

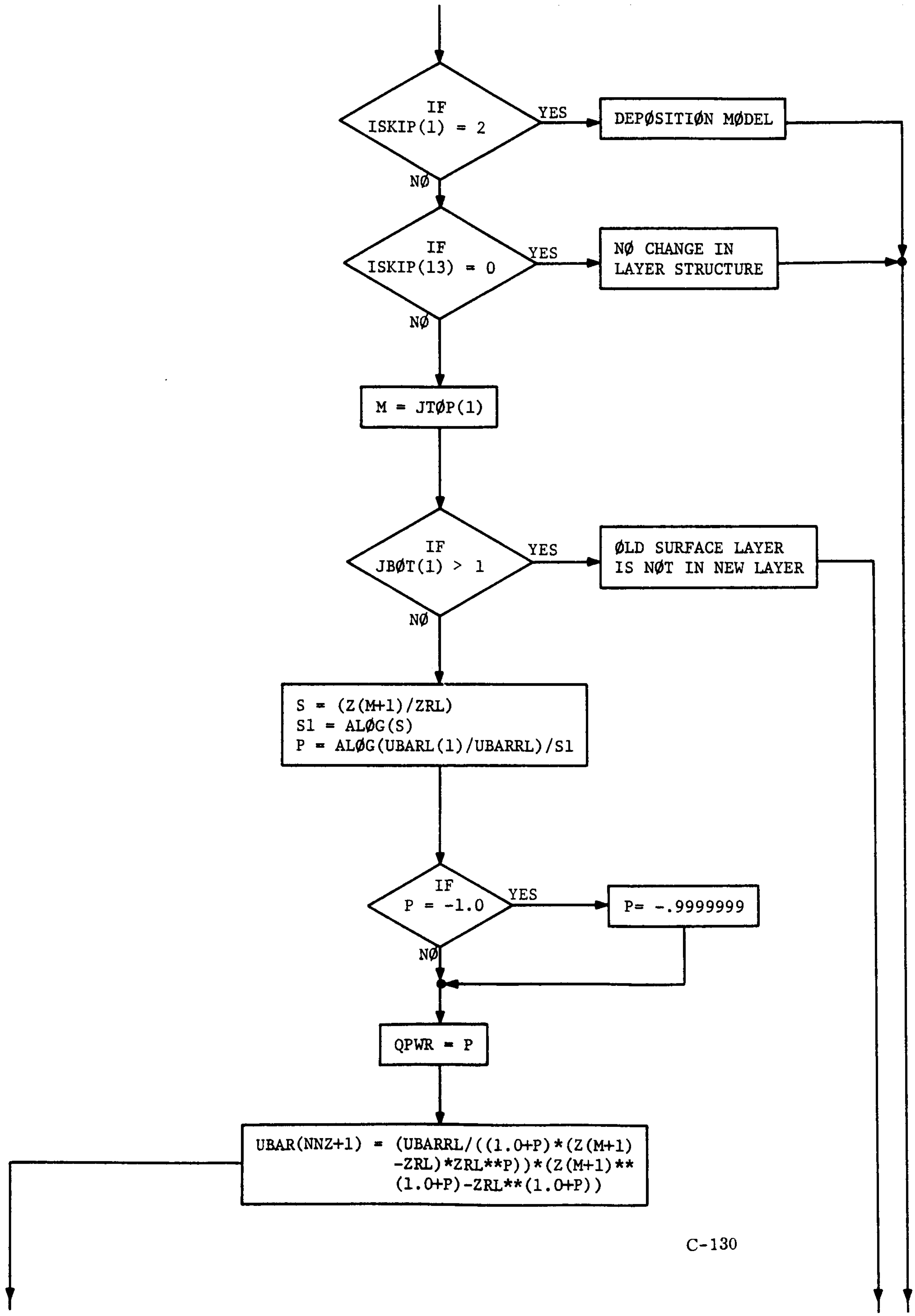

IF SIGARL < .5
YES
SIGARL=.5
NØ
IF SIGERL < .1
YES
SIGERL=.1
NØ
IF UBARRL < .1
YES
UBARRL=.1
NØ
READ VS(I),I=1,NVS V_s
READ PERC(I),I=1,NVS f_{i_s}


READ
ACCUR
R=.45 accuracy
constant
IF
ISKIP(3) = 0
YES
NØ
READ
VB(I),I=1,NVB
V_B
READ
PERCB(I),I=1,NVB
f_{i_B}
READ HB
IF
Z(1) = 0.0
YES
Z(1)=2.0

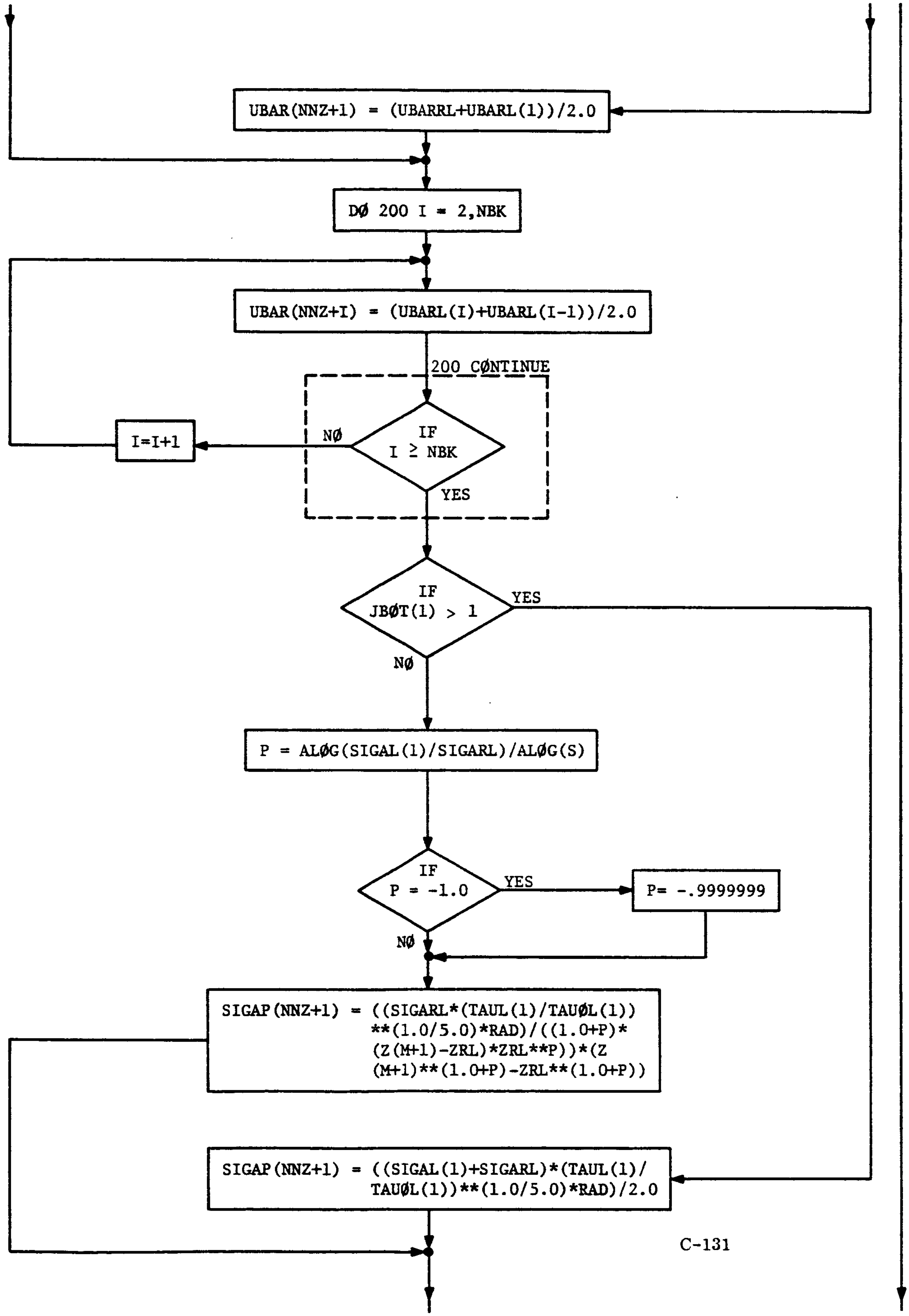

S = (Z(2)/ZRK)   S1 = ALØG(S)
P = ALØG(UBARK(1)/UBARRK)/S1
IF
P = -1.0
YES
P=-.9999999
NØ
PPWR = P
UBAR(1) = (UBARRK/((1.0+P)*(Z(2)-ZRK)(ZRK**P))*
(Z(2)**(1.0+P)-ZRK**(1.0+P))
DØ 150 I = 2,NNZ
UBAR(I) = (UBARK(I)+UBARK(I-1))/2.0
150 CØNTINUE
IF
I ≥ NNZ
NØ
I=I+1
YES
P = ALØG(SIGAK(1)/SIGARK)/S1
IF
P = -1.0
YES
P=-.9999999
NØ
MPWR = P

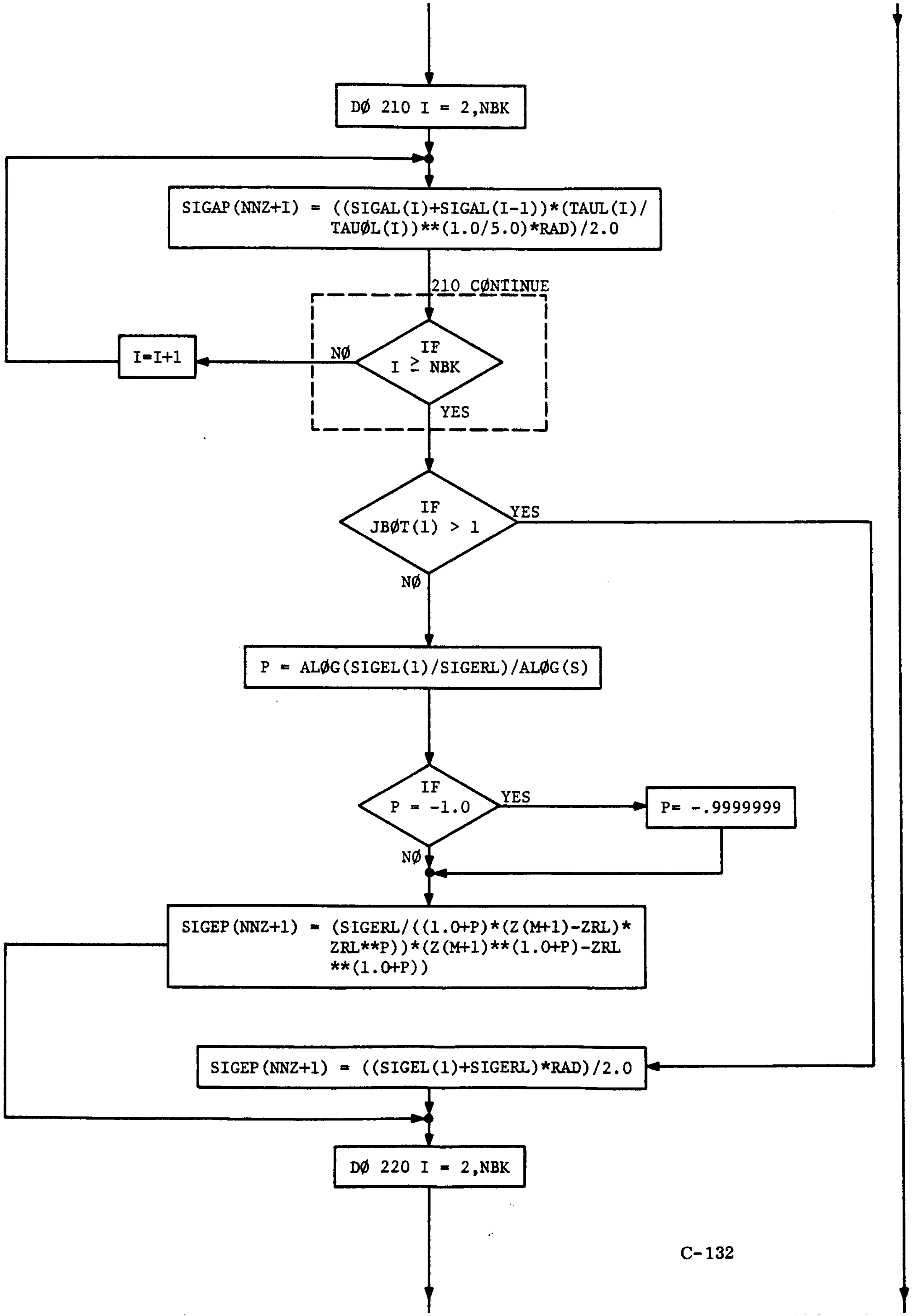

SIGAP(1) = ((SIGARK*(TAUK(1)/TAUØK(1))**(1.0/5.0) *RAD)/((1.0+P)*(Z(2)-ZRK)*ZRK**P))*(Z (2)**(1.0+P)-ZRK**(1.0+P))
DØ 160 I = 2,NNZ
SIGAP(I) = ((SIGAK(I)+SIGAK(I-1))*(TAUK(I)/ TAUØK(I))**(1.0/5.0)*RAD)/2.0
160 CØNTINUE
IF I ≥ NNZ
NØ
YES
I=I+1
P = ALØG(SIGEK(1)/SIGERK)/S1
IF P = -1.0
YES
NØ
P=-.9999999
QPWR = P
SIGEP(I) = (SIGERK/((1.0+P)*(Z(2)-ZRK)*ZRK **P))*(Z(2)***1.0+P)-ZRK** (1.0+P))*RAD
DØ 170 I = 2,NNZ

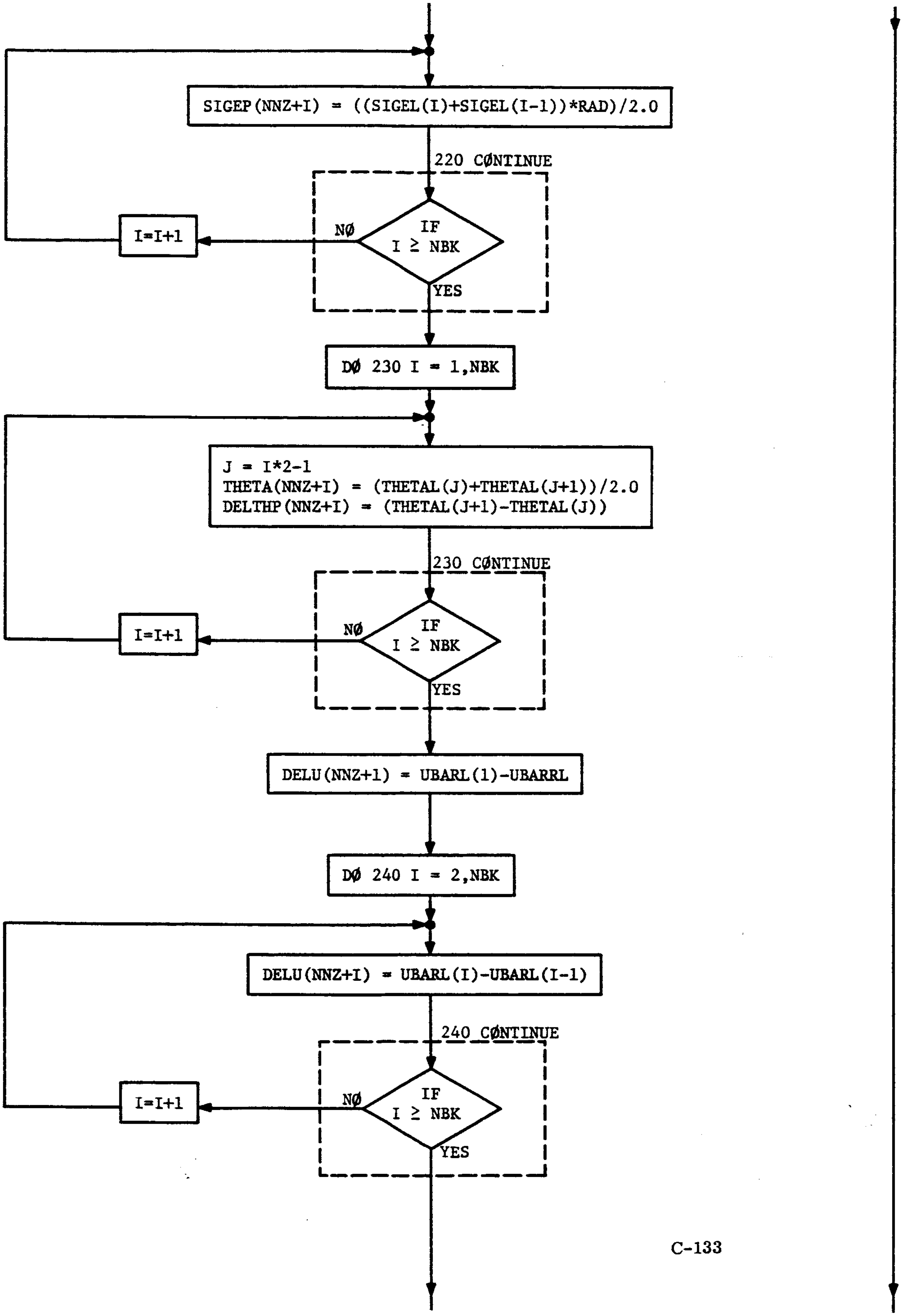

SIGEP(I) = ((SIGEK(I)+SIGEK(I-1))*RAD)/2.0
170 CØNTINUE
IF
I ≥ NNZ
NØ
YES
I=I+1
DØ 180 I = 1,NNZ
J = I*2-1
THETA(I) = (THETAK(J)+THETAK(J+1))/2.0
DELTHP(I) = (THETAK(J+1)-THETAK(J))
180 CØNTINUE
IF
I ≥ NNZ
NØ
YES
I=I+1
DELU(1) = UBARK(1)-UBARRK
DØ 190 I = 2,NNZ
DELU(I) = UBARK(I)-UBARK(I-1)
190 CØNTINUE
IF
I ≥ NNZ
NØ
YES
I=I+1



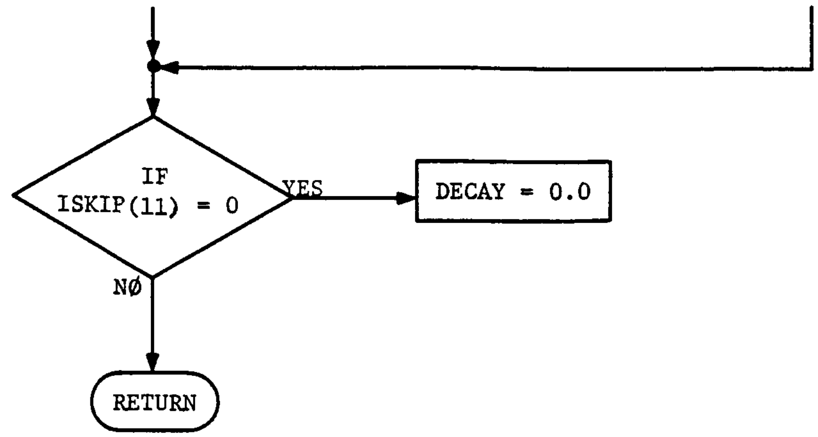
IF
ISKIP(1) = 2
YES
DEPØSITIØN MØDEL
NØ
IF
ISKIP(13) = 0
YES
NØ CHANGE IN
LAYER STRUCTURE
NØ
M = JTØP(1)
IF
JBØT(1) > 1
YES
ØLD SURFACE LAYER
IS NØT IN NEW LAYER
NØ
S = (Z(M+1)/ZRL)
S1 = ALØG(S)
P = ALØG(UBARL(1)/UBARRL)/S1
IF
P = -1.0
YES
P= -.9999999
NØ
QPWR = P
UBAR(NNZ+1) = (UBARRL/((1.0+P)*(Z(M+1)
-ZRL)*ZRL**P))*(Z(M+1)**
(1.0+P)-ZRL**(1.0+P))


UBAR(NNZ+1) = (UBARRL+UBARL(1))/2.0
DØ 200 I = 2,NBK
UBAR(NNZ+I) = (UBARL(I)+UBARL(I-1))/2.0
200 CØNTINUE
IF
I ≥ NBK
NØ
YES
I=I+1
IF
JBØT(1) > 1
YES
NØ
P = ALØG(SIGAL(1)/SIGARL)/ALØG(S)
IF
P = -1.0
YES
NØ
P= -.9999999
SIGAP(NNZ+1) = ((SIGARL*(TAUL(1)/TAUØL(1))
**(1.0/5.0)*RAD)/((1.0+P)*
(Z(M+1)-ZRL)*ZRL**P))*(Z
(M+1)**(1.0+P)-ZRL**(1.0+P))
SIGAP(NNZ+1) = ((SIGAL(1)+SIGARL)*(TAUL(1)/
TAUØL(1))**(1.0/5.0)*RAD)/2.0


DØ 210 I = 2,NBK
SIGAP(NNZ+I) = ((SIGAL(I)+SIGAL(I-1))*(TAUL(I)/TAUØL(I))**(1.0/5.0)*RAD)/2.0
210 CØNTINUE
IF I ≥ NBK
NØ
I=I+1
YES
IF JBØT(1) > 1
YES
NØ
P = ALØG(SIGEL(1)/SIGERL)/ALØG(S)
IF P = -1.0
YES
P= -.9999999
NØ
SIGEP(NNZ+1) = (SIGERL/((1.0+P)*(Z(M+1)-ZRL)*ZRL**P))*(Z(M+1)**(1.0+P)-ZRL**(1.0+P))
SIGEP(NNZ+1) = ((SIGEL(1)+SIGERL)*RAD)/2.0
DØ 220 I = 2,NBK



SIGEP(NNZ+I) = ((SIGEL(I)+SIGEL(I-1))*RAD)/2.0
220 CØNTINUE
IF I ≥ NBK
NØ
YES
I=I+1
DØ 230 I = 1,NBK
J = I*2-1
THETA(NNZ+I) = (THETAL(J)+THETAL(J+1))/2.0
DELTHP(NNZ+I) = (THETAL(J+1)-THETAL(J))
230 CØNTINUE
IF I ≥ NBK
NØ
YES
I=I+1
DELU(NNZ+1) = UBARL(1)-UBARRL
DØ 240 I = 2,NBK
DELU(NNZ+I) = UBARL(I)-UBARL(I-1)
240 CØNTINUE
IF I ≥ NBK
NØ
YES
I=I+1


IF
ISKIP(11) = 0
YES
DECAY = 0.0
NØ
RETURN

APPENDIX D

COMPUTER OUTPUT FOR SAMPLE PROBLEM

The sample problem refers to calculations of concentration and dosage fields downwind from a normal launch, using meteorological input information for the pre-cold front weather regime of 27 November 1966. A description of the synoptic weather situation and the meteorological inputs is contained in Appendix E, Section E. 1. Source inputs for this example are discussed in Section E. 2, Appendix E. For convenience, these inputs are repeated here in Table D-1. The completed program card input for this problem, as specified in Figure A-2 of Appendix A, is shown in Figure D-1.

A partial listing of the computer output for the example problem is given in Figure D-2. The output listing begins with the input parameters for the first layer. Calculated values for the mean layer wind speed and wind direction angle are then shown. These are followed by the values of the wind shear angle in the layer, the wind speed shear, and the mean layer values of σ_A and σ_E in radians. At this point, the program lists the dosage, peak concentration, and concentration at the first input receptor distance of 100 meters, at the base of the first layer, for each radial specified in the input. For convenience, the contribution of the vertical and vertical reflection terms in Equation (3-15) in the main body of text are listed at each receptor position. Calculated values of both the alongwind and lateral terms are also given. This output sequence continues until the concentration and dosage at each receptor position in each layer are specified. In Figure D-2, the sample listing is limited to the first two distances at the base of the first layer. This sequence is followed by a listing of the peak dosage and maximum peak concentration at the heights specified in the input. Finally, the output listing shows the crosswind distance from the cloud axis to input dosage and concentration isopleths. In Figure D-2, only the crosswind distances to dosage isopleths are shown.

TABLE D-1

PROGRAM INPUTS

Example Problem: Normal Launch for the Pre-Cold Front Situation, 2315 GMT, 27 November 1966

MODEL NO. 1				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Source Inputs			
Q_K (g m^{-1})	1.479×10^4	5.382×10^3	3.793×10^3	2.818×10^3
$\sigma_{yo}\{K\}$ (m)	290	150	100	75
$\sigma_{zo}\{K\}$ (m)	-	-	-	-
$\sigma_{xo}\{K\}$ (m)	290	150	100	75
τ_K (sec)	25	11	10	11
H_K (m)	-			
k	-			

TABLE D-1 (Continued)

MODEL NO. 1				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	8			
σ_{ER} (deg)	4.5			
$\bar{u}_R$ (m sec^{-1})	4.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	5	0	0	0
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		5	0	0
τ_{oK} (sec)	600	600	600	600
σ_{ETK} (deg)	4	0	0	0
σ_{EBK} (deg)		4	0	0
α_K	1	1	1	1
β_K	1	1	1	1
$\bar{u}_{TK}$ (m sec^{-1})	6.70	7.73	10.82	20.60
$\bar{u}_{BK}$ (m sec^{-1})		6.70	7.73	10.82
θ_{TK} (deg)	231	258	229	256
θ_{BK} (deg)	160	231	258	229
z_{TK} (m)	853.4	1828.8	3048	5000
z_{BK} (m)	2	853.4	1828.8	3048
Λ (sec^{-1})	-			
z_{lim} (m)	-			
t_1 (sec)	-			
t^* (sec)	-			

FIGURE D-1. Sample problem input.

REQUESTED BY | DEPARTMENT | JOB NO. & CODE | DATE | PAGE OF

A NORMAL L	AUNCH 11-2	7-66 2315Z	PRE-COLD	FRONT			
1 1	1 3 8						
23 25 5	10 10 23						
100.0	200.0	300.0	500.0	700.0	1000.0	1500.0	2000.0
2500.0	5000.0	7500.0	10000.0	15000.0	20000.0	25000.0	30000.0
40000.0	50000.0	60000.0	70000.0	80000.0	90000.0	100000.0	
280.0	290.0	300.0	310.0	320.0	330.0	340.0	350.0
0.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0
80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
160.0							
2.0	853.4	1828.8	3048.0	5000.0			
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.479 E+	045.382	E+033.793	E+032.81	8 E+03			
6.7	7.73	10.82	20.6				
5.0	0.0	0.0	0.0				
290.0	150.0	100.0	75.0				
4.0	0.0	0.0	0.0				
1.0	1.0	1.0	1.0				
1.0	1.0	1.0	1.0				
0.0	0.0	0.0	0.0				
290.0	150.0	100.0	75.0				
18.0	8.0	4.5	4.1	180.0			
160.0	231.0	231.0	258.0	258.0	229.0	229.0	256.0
25.0	11.0	10.0	11.0				
600.0	600.0	600.0	600.0				

FIGURE D-1. (Continued)

REQUESTED BY		DEPARTMENT		JOB NO. & CODE		DATE	PAGE OF	
1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	
0.0	0.0	0.0	0.0					1
0.0	0.0	0.0	0.0					2
1 1 1 1								3
0 0 0 0								4
0.0	0.0	0.0	0.0					5
100.0	200.0	300.0	500.0	700.0	1000.0	1500.0	2000.0	6
2500.0	5000.0	7500.0	10000.0	15000.0	20000.0	25000.0	30000.0	7
40000.0	50000.0	60000.0	70000.0	80000.0	90000.0	100000.0		8
0 0 0								9
0.5 E+	000.1	E+000.5	E-010.1	E-010.	5 E-02	0.1 E-	02	10
0.5 E+	030.1	E-030.5	E-040.1	E-04				11
0.5 E+	020.1	E-020.5	E-030.1	E-030.	5 E-04	0.1 E-	04	12
0.5 E+	050.1	E-050.5	E-060.1	E-06				13
								14
								15
								16
								17
								18
								19
								20
								21
								22
								23
								24
								25

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MULTILAYER DIFFUSION MODEL GCA CORP BJORKLUND                    DATE  121269  PAGE    66

***** THE TEST IS  NORMAL LAUNCH 11-27-66 2315Z PRE-COLD FRONT                                   *****


                              X IS RADIAL DISTANCE     , Y IS ANGLE IN DEGREES

                                         ***** LAYER 1 *****

                                          ** INPUT DATA **

Q=  .147900+05, ZRK=   18.00000, UBARRK=   4.10000, SIGARK=   8.00000, TAUDK= 60.00000, TAUK=  25.00000
SIGAK AT TOP=   5.00000, ALPHA=   1.00000, SIGYO= 290.00000, Z=    2.000, UBARK AT TOP=   6.70000, THETAK AT BOTTO = 160.00000
THETAK AT TOP= 231.00000, SIGERK=   4.50000, SIGEK AT TOP=   4.00000, BETA=   1.00000, SIGZO=    .00000, T=     .0000
H=     .0000, DELX=     .00000, DELY=     .00000, DELPHI= 180.00000, MODEL=  1, TI,1=      .0000, ZLIM=       .000
LAMBDA=    .00000, SIGXO= 290.00000

CALCULATED INPUT PARAMETERS FOR MODELS 1,2,3 **** UBAR =   5.99325, THETA = 195.50000, DELTHP =  71.00000, DELU =   2.60000
, SIGAF =    .05195, SIGEP =    .07182
      ---------------------------------------------------------------------------------------------------------


                                   ** CALCULATION HEIGHT Z =     2.000 **

                                           * X=     100.00 *
**** Y=    280.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=    290.00, DOSAGE=  .61792113+01, PEAK CON=  .26350050-01, CONCENTRATION=  .26350050-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .94278431+00
**** Y=    300.00, DOSAGE=  .61815308+01, PEAK CON=  .26359871-01, CONCENTRATION=  .26359871-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .94630009+00
**** Y=    310.00, DOSAGE=  .62020620+01, PEAK CON=  .26447285-01, CONCENTRATION=  .26447285-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .95272923+00
**** Y=    320.00, DOSAGE=  .62366827+01, PEAK CON=  .26594729-01, CONCENTRATION=  .26594729-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .96131802+00
**** Y=    330.00, DOSAGE=  .62798420+01, PEAK CON=  .26778554-01, CONCENTRATION=  .26778554-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .97106586+00
**** Y=    340.00, DOSAGE=  .63252091+01, PEAK CON=  .26971790-01, CONCENTRATION=  .26971790-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .98083280+00
**** Y=    350.00, DOSAGE=  .63664097+01, PEAK CON=  .27147281-01, CONCENTRATION=  .27147281-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .98946718+00
**** Y=       .00, DOSAGE=  .63977799+01, PEAK CON=  .27280900-01, CONCENTRATION=  .27280900-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .99594124+00
**** Y=     10.00, DOSAGE=  .64150552+01, PEAK CON=  .27354483-01, CONCENTRATION=  .27354483-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .99947787+00
**** Y=     20.00, DOSAGE=  .64158987+01, PEAK CON=  .27358076-01, CONCENTRATION=  .27358076-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .99965011+00
**** Y=     30.00, DOSAGE=  .64001967+01, PEAK CON=  .27291194-01, CONCENTRATION=  .27291194-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .99643714+00
**** Y=     40.00, DOSAGE=  .63700725+01, PEAK CON=  .27162882-01, CONCENTRATION=  .27162882-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .99022498+00
**** Y=     50.00, DOSAGE=  .63296182+01, PEAK CON=  .26990570-01, CONCENTRATION=  .26990570-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .98176558+00
**** Y=     60.00, DOSAGE=  .62843866+01, PEAK CON=  .26797911-01, CONCENTRATION=  .26797911-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .97206105+00
**** Y=     70.00, DOSAGE=  .62407150+01, PEAK CON=  .26611903-01, CONCENTRATION=  .26611903-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .96225876+00
**** Y=     80.00, DOSAGE=  .62049723+01, PEAK CON=  .26459678-01, CONCENTRATION=  .26459678-01, VERTICAL=  .00000000
                   REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .95350581+00
**** Y=     90.00, DOSAGE=  .61826187+01, PEAK CON=  .26365352-01, CONCENTRATION=  .26365352-01, VERTICAL=  .00000000
```

FIGURE D-2. Partial listing of computer output for sample problem.

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                MULTILAYER DIFFUSION MODEL GCA CORP BJORKLUND            DATE  121269  PAGE    67

                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .94682200+00
**** Y=   100.00, DOSAGE=  .61785446+01, PEAK CON=  .26347204-01, CONCENTRATION=  .26347204-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .94298979+00
**** Y=   110.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   120.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   130.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   140.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   150.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   160.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI

                                        * X=    200.00 *

**** Y=   280.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   290.00, DOSAGE=  .51740051+01, PEAK CON=  .22063524-01, CONCENTRATION=  .22063524-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .79059590+00
**** Y=   300.00, DOSAGE=  .52224767+01, PEAK CON=  .22269982-01, CONCENTRATION=  .22269982-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .80378244+00
**** Y=   310.00, DOSAGE=  .53311626+01, PEAK CON=  .22732976-01, CONCENTRATION=  .22732976-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .82700907+00
**** Y=   320.00, DOSAGE=  .54855274+01, PEAK CON=  .23390552-01, CONCENTRATION=  .23390552-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .85787968+00
**** Y=   330.00, DOSAGE=  .56664022+01, PEAK CON=  .24161030-01, CONCENTRATION=  .24161030-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .89311539+00
**** Y=   340.00, DOSAGE=  .58515063+01, PEAK CON=  .24949485-01, CONCENTRATION=  .24949485-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .92877678+00
**** Y=   350.00, DOSAGE=  .60176657+01, PEAK CON=  .25657212-01, CONCENTRATION=  .25657212-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .96064922+00
**** Y=      .00, DOSAGE=  .61436007+01, PEAK CON=  .26193588-01, CONCENTRATION=  .26193588-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .98477387+00
**** Y=    10.00, DOSAGE=  .62128477+01, PEAK CON=  .26488519-01, CONCENTRATION=  .26488519-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .99803684+00
**** Y=    20.00, DOSAGE=  .62162282+01, PEAK CON=  .26502911-01, CONCENTRATION=  .26502911-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .99868433+00
**** Y=    30.00, DOSAGE=  .61532916+01, PEAK CON=  .26234863-01, CONCENTRATION=  .26234863-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .98662996+00
**** Y=    40.00, DOSAGE=  .60323882+01, PEAK CON=  .25719918-01, CONCENTRATION=  .25719918-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .96347027+00
**** Y=    50.00, DOSAGE=  .58693505+01, PEAK CON=  .25025491-01, CONCENTRATION=  .25025491-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .93220378+00
**** Y=    60.00, DOSAGE=  .56851060+01, PEAK CON=  .24240701-01, CONCENTRATION=  .24240701-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .89673132+00
**** Y=    70.00, DOSAGE=  .55027712+01, PEAK CON=  .23464008-01, CONCENTRATION=  .23464008-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .86126768+00
**** Y=    80.00, DOSAGE=  .53448275+01, PEAK CON=  .22791187-01, CONCENTRATION=  .22791187-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .82979983+00
**** Y=    90.00, DOSAGE=  .52308342+01, PEAK CON=  .22305584-01, CONCENTRATION=  .22305584-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .80568532+00
**** Y=   100.00, DOSAGE=  .51758408+01, PEAK CON=  .22071339-01, CONCENTRATION=  .22071339-01, VERTICAL=  .00000000
                REFLECTION=  .10000000+01, ALONG WIND=  .10000000+01, LATERAL=  .79141457+00
**** Y=   110.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   120.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   130.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   140.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   150.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   160.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI

                                        * X=    300.00 *

**** Y=   280.00, RECEPTOR OUTSIDE OF SECTOR DELTA PHI
**** Y=   290.00, DOSAGE=  .38575146+01, PEAK CON=  .16449586-01, CONCENTRATION=  .16449586-01, VERTICAL=  .00000000
```

FIGURE D-2. (Continued)

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MULTILAYER DIFFUSION MODEL GCA CORP BJORKLUND                DATE  121269  PAGE   139

                    **** MAXIMUM PEAK DOSAGE AND/OR CONCENTRATION ****

------------------------** MAX PEAK CONCENTRATION AND,OR PEAK DOSAGE IN LAYER  1 AT HEIGHT      2.00 **-----------------------
                         ** DOSAGE, CLOUD AXIS IS AT  15.500 DEGREES RELATIVE TO SOURCE **
**R=    100.00,  DOS=  .64176130+01      **R=    200.00,  DOS=  .62230970+01      **R=    300.00,  DOS=  .59936926+01
**R=    500.00,  DOS=  .54810716+01      **R=    700.00,  DOS=  .49610998+01      **R=   1000.00,  DOS=  .42564945+01
**R=   1500.00,  DOS=  .33532173+01      **R=   2000.00,  DOS=  .27266036+01      **R=   2500.00,  DOS=  .22826622+01
**R=   5000.00,  DOS=  .12342305+01      **R=   7500.00,  DOS=  .84011874+00      **R=  10000.00,  DOS=  .63589392+00
**R=  15000.00,  DOS=  .42745353+00      **R=  20000.00,  DOS=  .32180782+00      **R=  25000.00,  DOS=  .25800287+00
**R=  30000.00,  DOS=  .21530172+00      **R=  40000.00,  DOS=  .16174890+00      **R=  50000.00,  DOS=  .12952566+00
**R=  60000.00,  DOS=  .10800728+00      **R=  70000.00,  DOS=  .92619515-01      **R=  80000.00,  DOS=  .81069273-01
**R=  90000.00,  DOS=  .72080242-01      **R= 100000.00,  DOS=  .64885576-01      **R=
                      ** CONCENTRATION, CLOUD AXIS IS AT  15.500 DEGREES RELATIVE TO SOURCE **
**R=    100.00,  CON=  .27365378-01      **R=    200.00,  CON=  .26532165-01      **R=    300.00,  CON=  .25547829-01
**R=    500.00,  CON=  .23345303-01      **R=    700.00,  CON=  .21106496-01      **R=   1000.00,  CON=  .18068496-01
**R=   1500.00,  CON=  .14148912-01      **R=   2000.00,  CON=  .11412515-01      **R=   2500.00,  CON=  .94875762-02
**R=   5000.00,  CON=  .47317521-02      **R=   7500.00,  CON=  .28927692-02      **R=  10000.00,  CON=  .19424197-02
**R=  15000.00,  CON=  .10294905-02      **R=  20000.00,  CON=  .62665706-03      **R=  25000.00,  CON=  .41792049-03
**R=  30000.00,  CON=  .29725329-03      **R=  40000.00,  CON=  .17196462-03      **R=  50000.00,  CON=  .11108765-03
**R=  60000.00,  CON=  .77675203-04      **R=  70000.00,  CON=  .57309925-04      **R=  80000.00,  CON=  .44001348-04
**R=  90000.00,  CON=  .34834767-04      **R= 100000.00,  CON=  .28256470-04      **R=

------------------------** MAX PEAK CONCENTRATION AND,OR PEAK DOSAGE IN LAYER  2 AT HEIGHT    853.40 **-----------------------
                         ** DOSAGE, CLOUD AXIS IS AT  64.500 DEGREES RELATIVE TO SOURCE **
**R=    100.00,  DOS=  .21006968+01      **R=    200.00,  DOS=  .20560623+01      **R=    300.00,  DOS=  .20093039+01
**R=    500.00,  DOS=  .18865702+01      **R=    700.00,  DOS=  .17602931+01      **R=   1000.00,  DOS=  .15741109+01
**R=   1500.00,  DOS=  .13052869+01      **R=   2000.00,  DOS=  .10969666+01      **R=   2500.00,  DOS=  .93829408+00
**R=   5000.00,  DOS=  .52917614+00      **R=   7500.00,  DOS=  .36454686+00      **R=  10000.00,  DOS=  .27738289+00
**R=  15000.00,  DOS=  .18732823+00      **R=  20000.00,  DOS=  .14132218+00      **R=  25000.00,  DOS=  .11343328+00
**R=  30000.00,  DOS=  .94728701-01      **R=  40000.00,  DOS=  .71228429-01      **R=  50000.00,  DOS=  .57067194-01
**R=  60000.00,  DOS=  .47601908-01      **R=  70000.00,  DOS=  .40829318-01      **R=  80000.00,  DOS=  .35743614-01
**R=  90000.00,  DOS=  .31784909-01      **R= 100000.00,  DOS=  .28619768-01      **R=
                      ** CONCENTRATION, CLOUD AXIS IS AT  64.500 DEGREES RELATIVE TO SOURCE **
**R=    100.00,  CON=  .37432484-01      **R=    200.00,  CON=  .36635028-01      **R=    300.00,  CON=  .35709366-01
**R=    500.00,  CON=  .33601963-01      **R=    700.00,  CON=  .31337932-01      **R=   1000.00,  CON=  .27996029-01
**R=   1500.00,  CON=  .23159609-01      **R=   2000.00,  CON=  .19398873-01      **R=   2500.00,  CON=  .16822731-01
**R=   5000.00,  CON=  .90071138-02      **R=   7500.00,  CON=  .58907993-02      **R=  10000.00,  CON=  .42014182-02
**R=  15000.00,  CON=  .24448843-02      **R=  20000.00,  CON=  .15812807-02      **R=  25000.00,  CON=  .10961816-02
**R=  30000.00,  CON=  .79960693-03      **R=  40000.00,  CON=  .47489003-03      **R=  50000.00,  CON=  .31231782-03
**R=  60000.00,  CON=  .22029464-03      **R=  70000.00,  CON=  .16342776-03      **R=  80000.00,  CON=  .12593419-03
**R=  90000.00,  CON=  .99952952-04      **R= 100000.00,  CON=  .81227482-04      **R=

------------------------** MAX PEAK CONCENTRATION AND,OR PEAK DOSAGE IN LAYER  3 AT HEIGHT   1828.80 **-----------------------
                         ** DOSAGE, CLOUD AXIS IS AT  63.500 DEGREES RELATIVE TO SOURCE **
**R=    100.00,  DOS=  .19367799+01      **R=    200.00,  DOS=  .18916673+01      **R=    300.00,  DOS=  .18270823+01
**R=    500.00,  DOS=  .16632310+01      **R=    700.00,  DOS=  .14867957+01      **R=   1000.00,  DOS=  .12470869+01
**R=   1500.00,  DOS=  .95109859+00      **R=   2000.00,  DOS=  .75615969+00      **R=   2500.00,  DOS=  .62337987+00
**R=   5000.00,  DOS=  .32598776+00      **R=   7500.00,  DOS=  .21991556+00      **R=  10000.00,  DOS=  .16816690+00
**R=  15000.00,  DOS=  .11093061+00      **R=  20000.00,  DOS=  .82918810-01      **R=  25000.00,  DOS=  .66374828-01
**R=  30000.00,  DOS=  .55332277-01      **R=  40000.00,  DOS=  .41516090-01      **R=  50000.00,  DOS=  .33220121-01
**R=  60000.00,  DOS=  .27687210-01      **R=  70000.00,  DOS=  .23734090-01      **R=  80000.00,  DOS=  .20768719-01
**R=  90000.00,  DOS=  .18462008-01      **R= 100000.00,  DOS=  .16616460-01      **R=
                      ** CONCENTRATION, CLOUD AXIS IS AT  63.500 DEGREES RELATIVE TO SOURCE **
**R=    100.00,  CON=  .59712831-01      **R=    200.00,  CON=  .58280856-01      **R=    300.00,  CON=  .56225059-01
**R=    500.00,  CON=  .50992021-01      **R=    700.00,  CON=  .45330473-01      **R=   1000.00,  CON=  .37583737-01
```

FIGURE D-2. (Continued)

```
MULTILAYER DIFFUSION MODEL GCA CORP BJORKLUND                DATE  121269  PAGE   140

**R=    1500.00,  CON=  .27890694-01      **R=   2000.00,  CON=  .21391917-01      **R=   2500.00,  CON=  .16898828-01
**R=    5000.00,  CON=  .68140783-02      **R=   7500.00,  CON=  .35430375-02      **R=  10000.00,  CON=  .21322527-02
**R=   15000.00,  CON=  .10063638-02      **R=  20000.00,  CON=  .57430055-03      **R=  25000.00,  CON=  .37118816-03
**R=   30000.00,  CON=  .25914662-03      **R=  40000.00,  CON=  .14657049-03      **R=  50000.00,  CON=  .94047839-04
**R=   60000.00,  CON=  .65404173-04      **R=  70000.00,  CON=  .48073943-04      **R=  80000.00,  CON=  .36843028-04
**R=   90000.00,  CON=  .29122120-04      **R= 100000.00,  CON=  .23595709-04      **R=

------------------------** MAX PEAK CONCENTRATION AND,OR PEAK DOSAGE IN LAYER  4 AT HEIGHT   3048.00 **----------------------
                          ** DOSAGE, CLOUD AXIS IS AT  62.500 DEGREES RELATIVE TO SOURCE **
**R=     100.00,  DOS=  .13638199+01      **R=    200.00,  DOS=  .13170443+01      **R=    300.00,  DOS=  .12523060+01
**R=     500.00,  DOS=  .10997841+01      **R=    700.00,  DOS=  .95129877+00      **R=   1000.00,  DOS=  .76935453+00
**R=    1500.00,  DOS=  .56712992+00      **R=   2000.00,  DOS=  .44342929+00      **R=   2500.00,  DOS=  .36227919+00
**R=    5000.00,  DOS=  .18685394+00      **R=   7500.00,  DOS=  .12540461+00      **R=  10000.00,  DOS=  .94298567-01
**R=   15000.00,  DOS=  .62997805-01      **R=  20000.00,  DOS=  .47288938-01      **R=  25000.00,  DOS=  .37848317-01
**R=   30000.00,  DOS=  .31548993-01      **R=  40000.00,  DOS=  .23669246-01      **R=  50000.00,  DOS=  .18938708-01
**R=   60000.00,  DOS=  .15783990-01      **R=  70000.00,  DOS=  .13530155-01      **R=  80000.00,  DOS=  .11839534-01
**R=   90000.00,  DOS=  .10524469-01      **R= 100000.00,  DOS=  .94723309-02      **R=
                      ** CONCENTRATION, CLOUD AXIS IS AT  62.500 DEGREES RELATIVE TO SOURCE **
**R=     100.00,  CON=  .78378987-01      **R=    200.00,  CON=  .76362224-01      **R=    300.00,  CON=  .71146093-01
**R=     500.00,  CON=  .61105018-01      **R=    700.00,  CON=  .51208520-01      **R=   1000.00,  CON=  .38953709-01
**R=    1500.00,  CON=  .25354666-01      **R=   2000.00,  CON=  .17330743-01      **R=   2500.00,  CON=  .12403546-01
**R=    5000.00,  CON=  .37320867-02      **R=   7500.00,  CON=  .17286591-02      **R=  10000.00,  CON=  .98737341-03
**R=   15000.00,  CON=  .44385438-03      **R=  20000.00,  CON=  .25070574-03      **R=  25000.00,  CON=  .16077022-03
**R=   30000.00,  CON=  .11176994-03      **R=  40000.00,  CON=  .62942710-04      **R=  50000.00,  CON=  .40308864-04
**R=   60000.00,  CON=  .27999113-04      **R=  70000.00,  CON=  .20574920-04      **R=  80000.00,  CON=  .15754826-04
**R=   90000.00,  CON=  .12449474-04      **R= 100000.00,  CON=  .10084808-04      **R=
    ---------------------------------------------------------------------------------------------------------
```

FIGURE D-2. (Continued)

```
***** ISOPLETHS HORIZONTAL PLANE AROUND CLOUD AXIS *****
** Y IS LATERAL DISTANCE FROM CLOUD AXIS **

** ANGLE TO CLOUD AXIS=  15.500 DEGREES RELATIVE TO SOURCE **
                          * HEIGHT =       2.00 *
                          * DOSAGE ISOPLETHS *
                         RADIAL DISTANCE R=    100.00
* DOSAGE= .50000000+00, Y=    670.10 * DOSAGE= .10000000+00, Y=   855.69 * DOSAGE= .50000000-01, Y=    924.20
* DOSAGE= .10000000-01, Y=   1066.95 * DOSAGE= .50000000-02, Y=  1122.17 * DOSAGE= .10000000-02, Y=   1241.95
* DOSAGE= .50000000-03, Y=   1290.11 * DOSAGE= .10000000-03, Y=  1395.55 * DOSAGE= .50000000-04, Y=   1438.58
* DOSAGE= .10000000-04, Y=   1533.84 * DOSAGE=
                         RADIAL DISTANCE R=    200.00
* DOSAGE= .50000000+00, Y=    686.67 * DOSAGE= .10000000+00, Y=   879.16 * DOSAGE= .50000000-01, Y=    950.07
* DOSAGE= .10000000-01, Y=   1097.16 * DOSAGE= .50000000-02, Y=  1154.76 * DOSAGE= .10000000-02, Y=   1278.52
* DOSAGE= .50000000-03, Y=   1328.27 * DOSAGE= .10000000-03, Y=  1437.17 * DOSAGE= .50000000-04, Y=   1481.60
* DOSAGE= .10000000-04, Y=   1579.97 * DOSAGE=
                         RADIAL DISTANCE R=    300.00
* DOSAGE= .50000000+00, Y=    707.83 * DOSAGE= .10000000+00, Y=   908.66 * DOSAGE= .50000000-01, Y=    982.59
* DOSAGE= .10000000-01, Y=   1135.84 * DOSAGE= .50000000-02, Y=  1195.80 * DOSAGE= .10000000-02, Y=   1329.61
* DOSAGE= .50000000-03, Y=   1376.37 * DOSAGE= .10000000-03, Y=  1489.65 * DOSAGE= .50000000-04, Y=   1535.86
* DOSAGE= .10000000-04, Y=   1638.19 * DOSAGE=
                         RADIAL DISTANCE R=    500.00
* DOSAGE= .50000000+00, Y=    759.97 * DOSAGE= .10000000+00, Y=   982.73 * DOSAGE= .50000000-01, Y=   1069.90
* DOSAGE= .10000000-01, Y=   1233.34 * DOSAGE= .50000000-02, Y=  1299.36 * DOSAGE= .10000000-02, Y=   1441.02
* DOSAGE= .50000000-03, Y=   1497.90 * DOSAGE= .10000000-03, Y=  1622.32 * DOSAGE= .50000000-04, Y=   1673.05
* DOSAGE= .10000000-04, Y=   1765.30 * DOSAGE=
                         RADIAL DISTANCE R=    700.00
* DOSAGE= .50000000+00, Y=    821.96 * DOSAGE= .10000000+00, Y=  1072.13 * DOSAGE= .50000000-01, Y=   1163.41
* DOSAGE= .10000000-01, Y=   1351.80 * DOSAGE= .50000000-02, Y=  1425.28 * DOSAGE= .10000000-02, Y=   1582.81
* DOSAGE= .50000000-03, Y=   1646.01 * DOSAGE= .10000000-03, Y=  1784.15 * DOSAGE= .50000000-04, Y=   1840.45
* DOSAGE= .10000000-04, Y=   1964.97 * DOSAGE=
                         RADIAL DISTANCE R=   1000.00
* DOSAGE= .50000000+00, Y=    925.49 * DOSAGE= .10000000+00, Y=  1224.84 * DOSAGE= .50000000-01, Y=   1333.22
* DOSAGE= .10000000-01, Y=   1556.01 * DOSAGE= .50000000-02, Y=  1692.68 * DOSAGE= .10000000-02, Y=   1828.19
* DOSAGE= .50000000-03, Y=   1902.45 * DOSAGE= .10000000-03, Y=  2064.71 * DOSAGE= .50000000-04, Y=   2130.79
* DOSAGE= .10000000-04, Y=   2276.83 * DOSAGE=
                         RADIAL DISTANCE R=   1500.00
* DOSAGE= .50000000+00, Y=   1107.45 * DOSAGE= .10000000+00, Y=  1504.54 * DOSAGE= .50000000-01, Y=   1646.31
* DOSAGE= .10000000-01, Y=   1935.86 * DOSAGE= .50000000-02, Y=  2047.99 * DOSAGE= .10000000-02, Y=   2287.24
* DOSAGE= .50000000-03, Y=   2382.89 * DOSAGE= .10000000-03, Y=  2591.40 * DOSAGE= .50000000-04, Y=   2676.20
* DOSAGE= .10000000-04, Y=   2663.43 * DOSAGE=
                         RADIAL DISTANCE R=   2000.00
* DOSAGE= .50000000+00, Y=   1285.80 * DOSAGE= .10000000+00, Y=  1794.99 * DOSAGE= .50000000-01, Y=   1974.24
* DOSAGE= .10000000-01, Y=   2338.02 * DOSAGE= .50000000-02, Y=  2478.29 * DOSAGE= .10000000-02, Y=   2776.80
* DOSAGE= .50000000-03, Y=   2895.90 * DOSAGE= .10000000-03, Y=  3155.15 * DOSAGE= .50000000-04, Y=   3260.46
* DOSAGE= .10000000-04, Y=   3492.75 * DOSAGE=
                         RADIAL DISTANCE R=   2500.00
* DOSAGE= .50000000+00, Y=   1453.19 * DOSAGE= .10000000+00, Y=  2085.66 * DOSAGE= .50000000-01, Y=   2305.20
* DOSAGE= .10000000-01, Y=   2746.12 * DOSAGE= .50000000-02, Y=  2918.24 * DOSAGE= .10000000-02, Y=   3279.38
* DOSAGE= .50000000-03, Y=   3423.20 * DOSAGE= .10000000-03, Y=  3735.84 * DOSAGE= .50000000-04, Y=   3862.70
* DOSAGE= .10000000-04, Y=   4142.31 * DOSAGE=
                         RADIAL DISTANCE R=   5000.00
* DOSAGE= .50000000+00, Y=   2073.23 * DOSAGE= .10000000+00, Y=  3457.48 * DOSAGE= .50000000-01, Y=   3905.30
* DOSAGE= .10000000-01, Y=   4764.15 * DOSAGE= .50000000-02, Y=  5119.03 * DOSAGE= .10000000-02, Y=   5818.96
* DOSAGE= .50000000-03, Y=   6095.70 * DOSAGE= .10000000-03, Y=  6694.28 * DOSAGE= .50000000-04, Y=   6936.18
* DOSAGE= .10000000-04, Y=   7467.70 * DOSAGE=
```

FIGURE D-2. (Continued)

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M LTILAYER DIFFUSION MODEL GCA CORP BJORKLUND                 DATE  121269  PAGE   193

 • DOSAGE=  .50000000-03, Y=  83264.38 • DOSAGE=  .10000000-03, Y=  95800.01 • DOSAGE=  .50000000-04, Y= 100719.28
 • DOSAGE=  .10000000-04, Y= 111306.15 • DOSAGE=
                                              RADIAL DISTANCE R= 100000.00
 • DOSAGE=  .50000000+00, Y=       .00 • DOSAGE=  .10000000+00, Y=       .00 • DOSAGE=  .50000000-01, Y=  21178.63
 • DOSAGE=  .10000000-01, Y=  56732.78 • DOSAGE=  .50000000-02, Y=  66419.99 • DOSAGE=  .10000000-02, Y=  84744.85
 • DOSAGE=  .50000000-03, Y=  91513.36 • DOSAGE=  .10000000-03, Y= 105568.79 • DOSAGE=  .50000000-04, Y= 111075.54
 • DOSAGE=  .10000000-04, Y= 122914.00 • DOSAGE=
                                          • CONCENTRATION ISOPLETHS •
                                              RADIAL DISTANCE R=    100.00
•CONCENTRATION=  .50000000-02, Y=    546.87 •CONCENTRATION=  .10000000-02, Y=    763.04 •CONCENTRATION=  .50000000-03, Y=    839.16
•CONCENTRATION=  .10000000-03, Y=    993.66 •CONCENTRATION=  .50000000-04, Y=   1053.24 •CONCENTRATION=  .10000000-04, Y=   1180.03
•CONCENTRATION=  .50000000-05, Y=   1230.62 •CONCENTRATION=  .10000000-05, Y=   1340.74 •CONCENTRATION=  .50000000-06, Y=   1368.48
•CONCENTRATION=  .10000000-06, Y=   1484.15 •CONCENTRATION=
                                              RADIAL DISTANCE R=    200.00
•CONCENTRATION=  .50000000-02, Y=    558.81 •CONCENTRATION=  .10000000-02, Y=    783.21 •CONCENTRATION=  .50000000-03, Y=    862.04
•CONCENTRATION=  .10000000-03, Y=   1021.89 •CONCENTRATION=  .50000000-04, Y=   1083.49 •CONCENTRATION=  .10000000-04, Y=   1214.54
•CONCENTRATION=  .50000000-05, Y=   1266.80 •CONCENTRATION=  .10000000-05, Y=   1380.56 •CONCENTRATION=  .50000000-06, Y=   1426.76
•CONCENTRATION=  .10000000-06, Y=   1528.65 •CONCENTRATION=
                                              RADIAL DISTANCE R=    300.00
•CONCENTRATION=  .50000000-02, Y=    573.60 •CONCENTRATION=  .10000000-02, Y=    808.49 •CONCENTRATION=  .50000000-03, Y=    890.77
•CONCENTRATION=  .10000000-03, Y=   1057.41 •CONCENTRATION=  .50000000-04, Y=   1121.58 •CONCENTRATION=  .10000000-04, Y=   1258.01
•CONCENTRATION=  .50000000-05, Y=   1312.40 •CONCENTRATION=  .10000000-05, Y=   1430.78 •CONCENTRATION=  .50000000-06, Y=   1478.80
•CONCENTRATION=  .10000000-06, Y=   1584.77 •CONCENTRATION=
                                              RADIAL DISTANCE R=    500.00
•CONCENTRATION=  .50000000-02, Y=    609.66 •CONCENTRATION=  .10000000-02, Y=    871.71 •CONCENTRATION=  .50000000-03, Y=    962.85
•CONCENTRATION=  .10000000-03, Y=   1146.85 •CONCENTRATION=  .50000000-04, Y=   1217.56 •CONCENTRATION=  .10000000-04, Y=   1367.72
•CONCENTRATION=  .50000000-05, Y=   1427.53 •CONCENTRATION=  .10000000-05, Y=   1557.58 •CONCENTRATION=  .50000000-06, Y=   1610.36
•CONCENTRATION=  .10000000-06, Y=   1726.69 •CONCENTRATION=
                                              RADIAL DISTANCE R=    700.00
•CONCENTRATION=  .50000000-02, Y=    651.15 •CONCENTRATION=  .10000000-02, Y=    947.54 •CONCENTRATION=  .50000000-03, Y=   1049.72
•CONCENTRATION=  .10000000-03, Y=   1255.29 •CONCENTRATION=  .50000000-04, Y=   1334.10 •CONCENTRATION=  .10000000-04, Y=   1501.22
•CONCENTRATION=  .50000000-05, Y=   1567.72 •CONCENTRATION=  .10000000-05, Y=   1712.18 •CONCENTRATION=  .50000000-06, Y=   1770.78
•CONCENTRATION=  .10000000-06, Y=   1899.87 •CONCENTRATION=
                                              RADIAL DISTANCE R=   1000.00
•CONCENTRATION=  .50000000-02, Y=    716.78 •CONCENTRATION=  .10000000-02, Y=   1075.86 •CONCENTRATION=  .50000000-03, Y=   1197.79
•CONCENTRATION=  .10000000-03, Y=   1441.66 •CONCENTRATION=  .50000000-04, Y=   1534.80 •CONCENTRATION=  .10000000-04, Y=   1731.88
•CONCENTRATION=  .50000000-05, Y=   1810.12 •CONCENTRATION=  .10000000-05, Y=   1979.96 •CONCENTRATION=  .50000000-06, Y=   2048.77
•CONCENTRATION=  .10000000-06, Y=   2200.27 •CONCENTRATION=
                                              RADIAL DISTANCE R=   1500.00
•CONCENTRATION=  .50000000-02, Y=    818.75 •CONCENTRATION=  .10000000-02, Y=   1306.74 •CONCENTRATION=  .50000000-03, Y=   1467.74
•CONCENTRATION=  .10000000-03, Y=   1786.47 •CONCENTRATION=  .50000000-04, Y=   1907.40 •CONCENTRATION=  .10000000-04, Y=   2162.26
•CONCENTRATION=  .50000000-05, Y=   2263.20 •CONCENTRATION=  .10000000-05, Y=   2481.79 •CONCENTRATION=  .50000000-06, Y=   2570.21
•CONCENTRATION=  .10000000-06, Y=   2764.63 •CONCENTRATION=
                                              RADIAL DISTANCE R=   2000.00
•CONCENTRATION=  .50000000-02, Y=    896.88 •CONCENTRATION=  .10000000-02, Y=   1540.49 •CONCENTRATION=  .50000000-03, Y=   1746.06
•CONCENTRATION=  .10000000-03, Y=   2148.82 •CONCENTRATION=  .50000000-04, Y=   2300.66 •CONCENTRATION=  .10000000-04, Y=   2619.49
•CONCENTRATION=  .50000000-05, Y=   2745.42 •CONCENTRATION=  .10000000-05, Y=   3017.63 •CONCENTRATION=  .50000000-06, Y=   3127.57
•CONCENTRATION=  .10000000-06, Y=   3369.03 •CONCENTRATION=
                                              RADIAL DISTANCE R=   2500.00
•CONCENTRATION=  .50000000-02, Y=    941.49 •CONCENTRATION=  .10000000-02, Y=   1767.66 •CONCENTRATION=  .50000000-03, Y=   2022.02
•CONCENTRATION=  .10000000-03, Y=   2515.31 •CONCENTRATION=  .50000000-04, Y=   2700.14 •CONCENTRATION=  .10000000-04, Y=   3086.91
•CONCENTRATION=  .50000000-05, Y=   3239.28 •CONCENTRATION=  .10000000-05, Y=   3568.08 •CONCENTRATION=  .50000000-06, Y=   3700.69
•CONCENTRATION=  .10000000-06, Y=   3991.66 •CONCENTRATION=
                                              RADIAL DISTANCE R=   5000.00
•CONCENTRATION=  .50000000-02, Y=       .00 •CONCENTRATION=  .10000000-02, Y=   2719.11 •CONCENTRATION=  .50000000-03, Y=   3269.68
•CONCENTRATION=  .10000000-03, Y=   4283.30 •CONCENTRATION=  .50000000-04, Y=   4652.30 •CONCENTRATION=  .10000000-04, Y=   5412.93
•CONCENTRATION=  .50000000-05, Y=   5709.38 •CONCENTRATION=  .10000000-05, Y=   6344.51 •CONCENTRATION=  .50000000-06, Y=   6599.25
•CONCENTRATION=  .10000000-06, Y=   7155.83 •CONCENTRATION=
```

FIGURE D-2. (Continued)

APPENDIX E

EXAMPLE CALCULATIONS EMPLOYING THE MULTI-LAYER DIFFUSION PROGRAM

This Appendix contains example calculations that illustrate the use of the multi-layer diffusion program discussed in Section 4 for the following modes of release of toxic fuels:

- Normal launch
- Vehicle destruct at the surface
- Vehicle destruct aloft
- Cold surface spill

The example calculations were carried out for two meteorological situations that occur frequently at Cape Kennedy:

- A pre-cold front regime typical of wintertime conditions
- An extension of the Bermuda High into the Gulf of Mexico typical of summertime conditions

The model layer boundaries and meteorological inputs for each situation were defined from vertical profile measurements taken at Cape Kennedy on two days selected as representative of these conditions under Contract NAS8-30503 (Record, et al., 1970).

The example calculations consist principally of concentration and dosage fields at the base of each layer. Surface deposition patterns due to gravitational settling and precipitation scavenging were also calculated. In the example calculation of surface deposition due to precipitation scavenging, the layer structure is assumed to change at the onset of precipitation to illustrate the program's capability for handling changes in layer structure.

Results of all program calculations are presented in figures showing the concentration, dosage and deposition fields plotted on a reference polar-coordinate grid with the origin at the launch site. The grid consisted of 828 receptor positions located at 23 distances downwind from the origin on radials at an angular separation of 10 degrees. In any specific calculation, however, computation time was conserved by not requesting results for receptors that were clearly upwind from the source. If results had been requested for these positions, the program would have automatically rejected the positions as being outside the angular sectors of interest, but more computation time would have been consumed. All the figures except those showing deposition due to gravitational settling and and precipitation scavenging and changes in layer structure were originally plotted on the GERBER 622 plotter at the University of Utah.

E.1 SELECTION OF METEOROLOGICAL INPUT PARAMETERS

The discussion below of the synoptic maps, vertical profiles, and meteorological inputs for the pre-cold front and Bermuda-high example cases, is taken from Sections 3.3.1 and 3.4.3, respectively, of the Final Report prepared under Contract NAS8-30503 (Record, et al., 1970). The required meteorological inputs for the multi-layer computer program are listed in Table 4-1 and the procedures followed in selecting these inputs for the example calculations are summarized in Section 4.2 of the present report.

E.1.1 Southwesterly Flow in Advance of a Cold Front - 2315 GMT, 27 November 1966

Figures E-1, E-2 and E-3 show the synoptic-scale circulation pattern and the vertical structure at Cape Kennedy during the approach of a

SLC302038

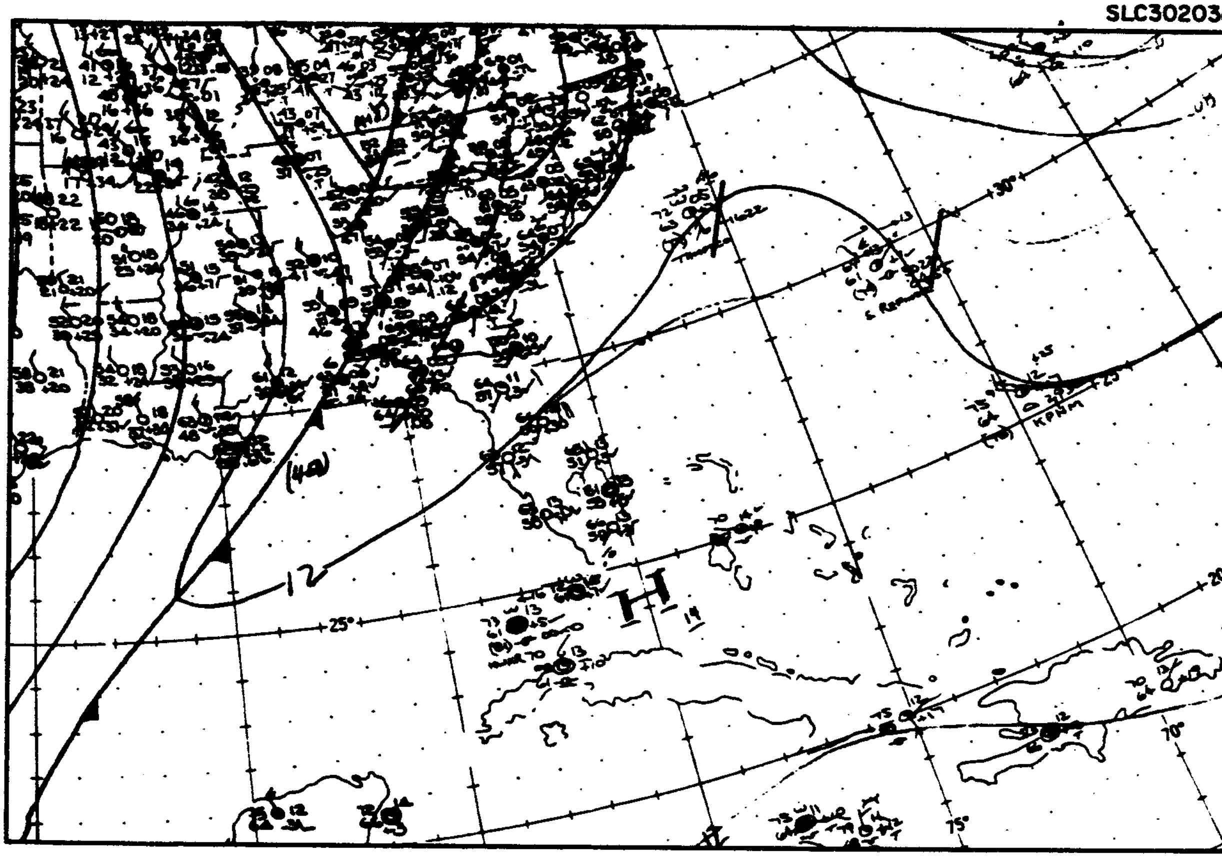

FIGURE E-1 Surface map for 0000 GMT, 28 November 1966.

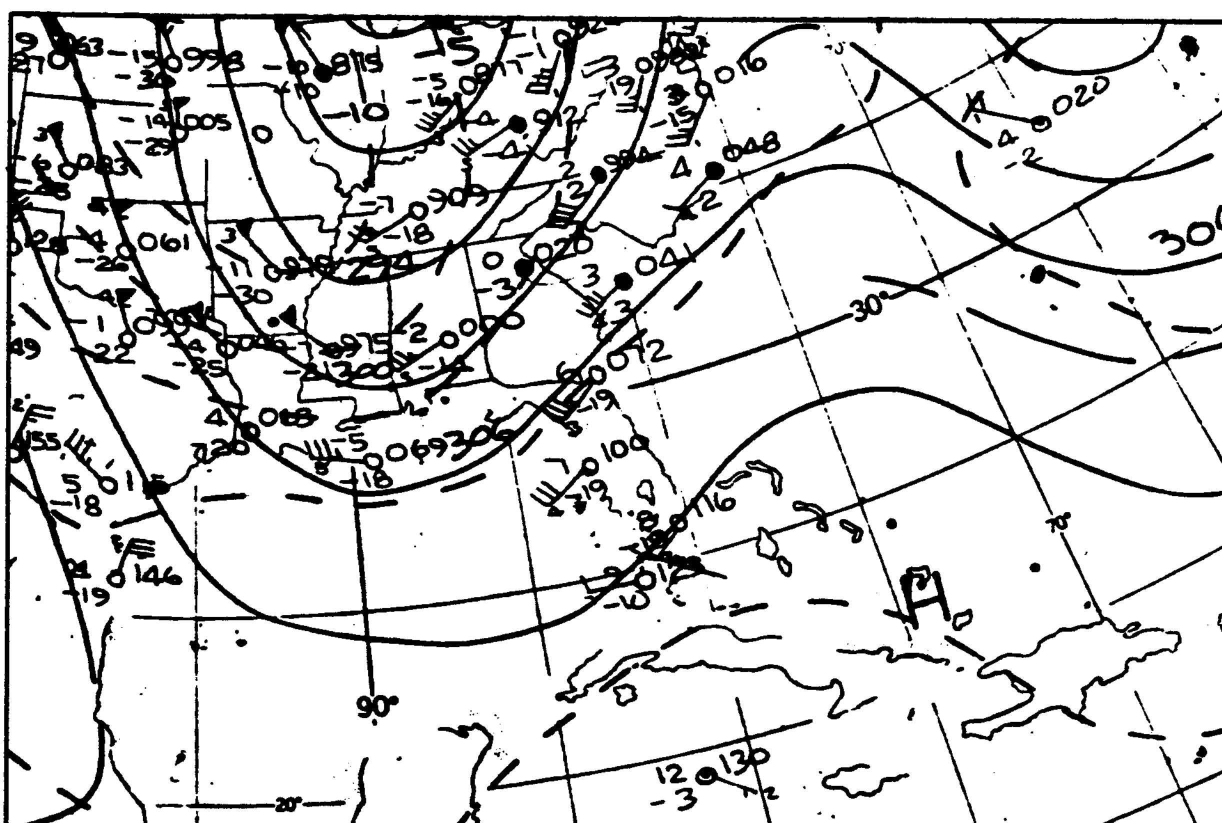

FIGURE E-2 700-mb map for 0000 GMT, 28 November 1966.

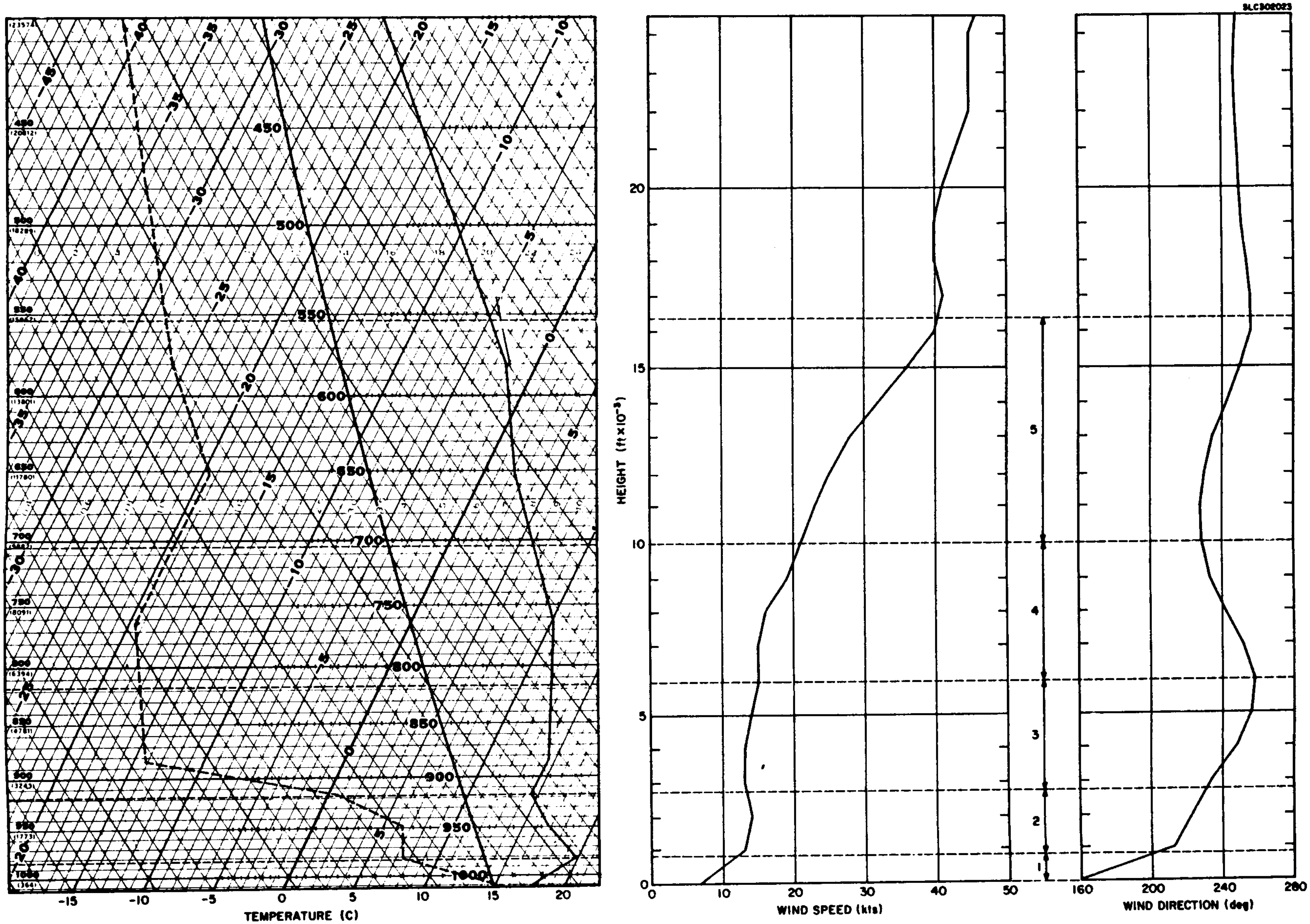

FIGURE E-3. Vertical profiles for 27 November 1966, 2315 GMT. Solid line on Skew T, Log P diagram is air temperature; dashed line is dew point temperature. Assignment of layers for diffusion model is indicated between wind speed and wind direction profiles.

major, rapidly-moving cold front. Figures E-1 and E-2 show the surface and 700-millibar maps, respectively, when the cold front was approximately 300 miles to the northwest of Cape Kennedy. Temperature and dewpoint values at the significant levels of the 2315 GMT Cape Kennedy sounding are plotted on a section of a USAF Modified Skew T, Log P Diagram at the left in Figure E-3. Wind speed and direction are plotted at 1000-foot intervals at the right in Figure E-3. The dashed horizontal lines indicate the division of the lowest 5 kilometers into five layers for multi-layer model calculations. Layer 1 comprises the surface inversion, and extends to about 900 feet. Layer 2 is approximately dry adiabatic and extends to about 2800 feet. Layer 3 is a· isothermal layer within which the dewpoint decreases rapidly. The top of Layer 3 is at 6000 feet where the wind direction begins to back with height. The lapse rate between 6000 and 16,400 feet is approximately moist adiabatic and the wind speed increases steadily with height. However, this height interval has been divided into two layers on the basis of the wind direction shear. Table E-1 lists meteorological inputs to the diffusion model at the surface reference height and at the five layer boundaries obtained from the profiles in Figure E-3. The values of σ_A and σ_E given in Table E-1 were determined by the procedures outlined in Section 4.2 Within the surface inversion, $p = 0.14$ and σ_A and σ_E are assumed to vary as $z^{-0.14}$. The temperature and wind speed profiles indicate a lapse rate close to the dry adiabatic in Layer 2 and $p = 0.06$. According to the guidelines in Section 4.2, if Layer 2 is unstable, σ_A and σ_E may be assumed to vary, respectively, as $z^{-0.06}$ and $z^{0.24}$. However, Layer 2, which is the upper part of the daytime mixing layer, is becoming decoupled from the surface by the developing ground-level inversion and it would probably be equally valid either to let σ_E vary as z^{-p}, or to assign minimal values to both σ_A and σ_E at the 2800-foot boundary.

The wind direction in Layers 1 and 2 would cause a toxic cloud generated in these layers to be transported over the ocean to the north of Launch Complex 39 at KSC. In the calculations, it has been assumed that the

TABLE E-1

METEOROLOGICAL MODEL INPUTS FOR 2315 GMT
27 NOVEMBER 1966

Layer No.	Height (ft)	Wind Speed (knot)	Wind Direction (deg)	Potential Temperature (C)	σ_A (deg)	σ_E (deg)
	59	8	160	17	8	4.5
1						
	870	12	206	22	6	3
2						
	2,800	13	231	22	5	4
3						
	6,000	15	258	29	0	0
4						
	10,000	21	229	36	0	0
5						
	16,400	40	256	45	0	0

ground-based inversion would not be present over the water surface. Layers 1 and 2 have therefore been treated as a single layer in which the wind field is defined by the winds at the bottom of Layer 1 and the top of Layer 2.

E.1.2 Extension of the Bermuda High into the Gulf of Mexico – 0515 GMT, 12 May 1967

On 12 May 1967, the Bermuda High extended westward to the Gulf of Mexico and a weak surface pressure gradient existed over Florida. Figure E-4 shows the surface map for 0600 GMT and Figure E-5 shows the 700-millibar map for 0000 GMT on this date. The lowest 16,400 feet have been divided into the five layers shown in Figure E-6 for use in the multi-layer diffusion model. Layer 1 extends to the top of the weak ground-level inversion at 850 feet. Layer 2 extends from 850 feet to the base of the subsidence inversion at 3500 feet. Layer 3 contains the subsidence inversion and extends from 3500 to 5300 feet. The height interval from 5300 to 16,400 feet has been divided at 10,000 feet into Layers 4 and 5 on the basis of the wind speed profile. The wind speed decreases with height slightly between 5300 and 10,000 feet, and increases between 10,000 and 16,400 feet.

The meteorological inputs for this example are listed in Table E-2. Both σ_A and σ_E are assumed to vary as z^{-p} in Layers 1 and 2. The p values for Layers 1 and 2 are 0.20 and 0.27, respectively.

As in the previous case, the wind trajectory in the surface layer will transport toxic clouds generated in Layers 1 and 2 to the northeast of Launch Complex 39. It has been assumed that the weak ground-based inversion will not persist over the ocean. Layers 1 and 2 were treated as a single layer in the example calculations.

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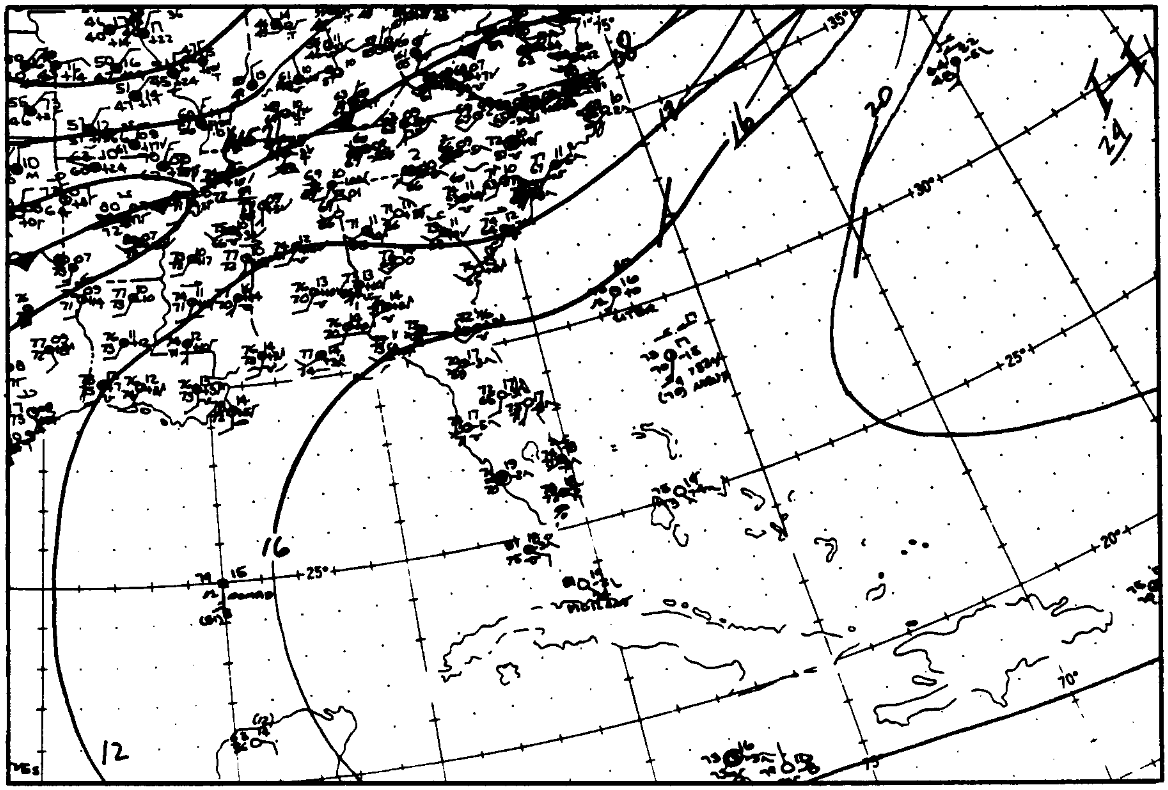

FIGURE E-4 Surface map for 0600 GMT, 12 May 1967.

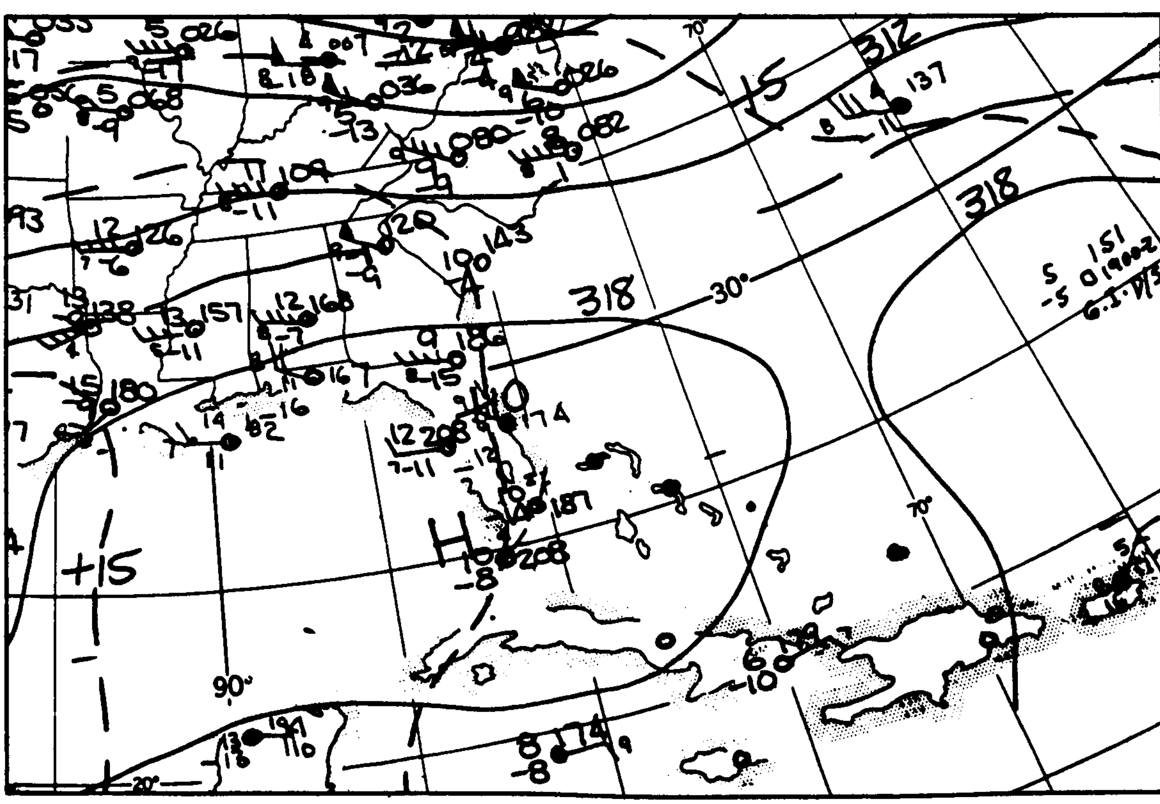

FIGURE E-5 700-mb map for 0000 GMT, 12 May 1967.

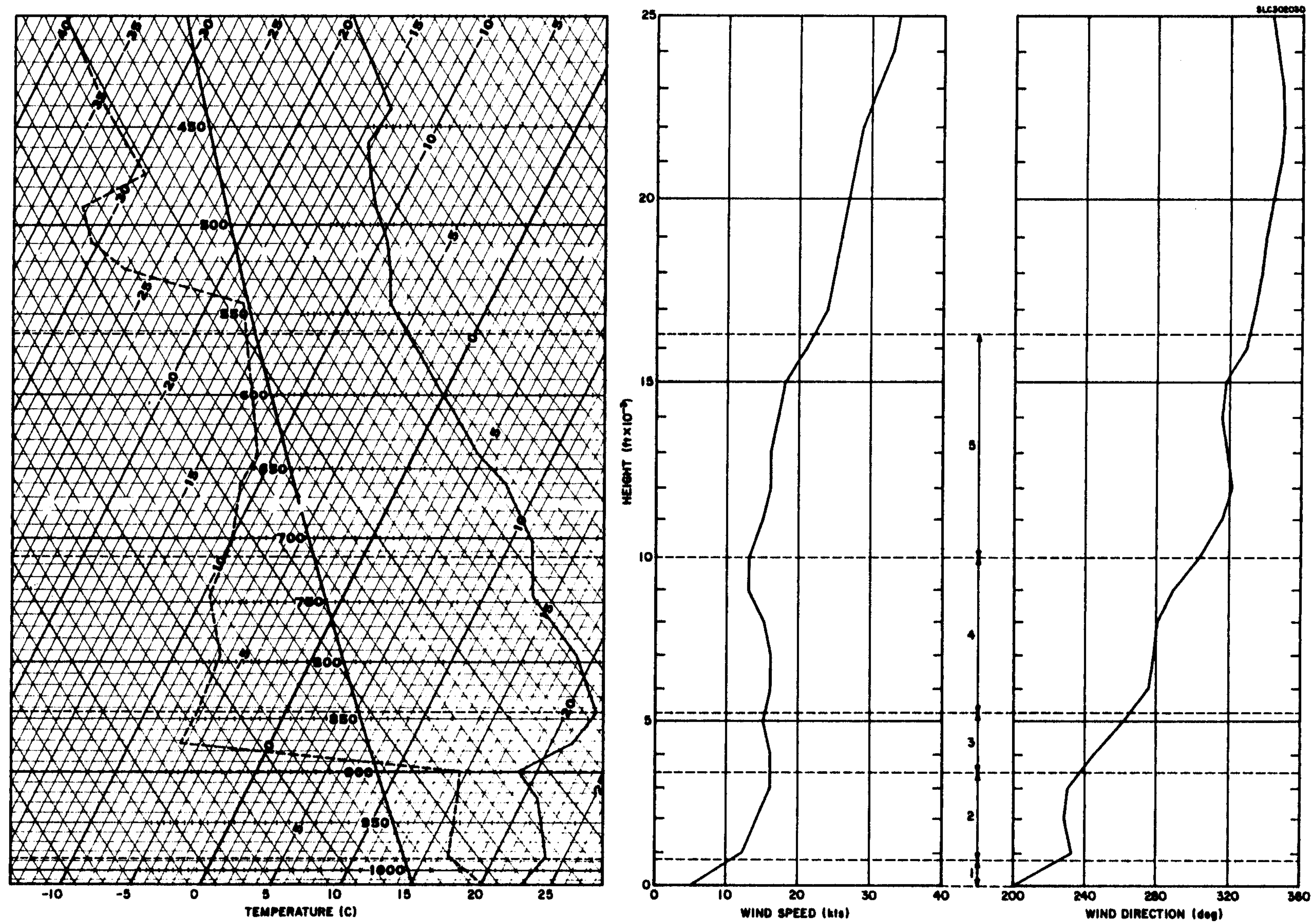

FIGURE E-6. Vertical profiles for 12 May 1967, 0515 GMT. Solid line on Skew T, Log P diagram is air temperature; dashed line is dew point temperature. Assignment of layers for diffusion model is indicated between wind speed and wind direction profiles.

TABLE E-2

METEOROLOGICAL MODEL INPUTS FOR 0515 GMT
12 MAY 1967

Layer No.	Height (ft)	Wind Speed (knot)	Wind Direction (deg)	Potential Temperature (C)	σ_A (deg)	σ_E (deg)
	59	6	200	22	6	3
1						
	850	11	230	25	4	2
2						
	3,500	16	237	28	3	1
3						
	5,300	15	263	37	0	0
4						
	10,000	13	303	41	0	0
5						
	16,400	22	328	44	0	0

E.2 SELECTION OF SOURCE INPUT PARAMETERS

Source inputs required for the multi-layer models are specified in Table 4-3. These inputs are clearly dependent on the type of vehicle and the physical properties of the toxic material comprising the source. The design features of the deflector in the base of the launch pad also affect the source dimensions and cloud rise in the surface layer. Because of these factors and because little information is available regarding the properties of toxic clouds formed during normal launches and vehicle destructs, the source inputs selected for the example calculations are somewhat arbitrary. Insofar as possible, information available from launches of Saturn V vehicles was used in specifying the source parameters.

E.2.1 Q_K - Source Strength

In the case of normal launches, model Equation (3-1) requires that source strength be stated in terms of mass per unit depth of layer. For the example problems, the emission rate of toxic material was arbitrarily set equal to 5×10^5 grams per second. The residence time of the Saturn vehicle in each layer was selected from Figure E-7, which shows vehicle height as a function of elapsed time after launch as given by Adelfang, Ashburn, and Court (1968). The source strength in the layer was determined through multiplication of the emission rate by the residence time of the vehicle in the layer and division of this product by the depth of the layer.

In examples where vehicle destruct occurs, the total amount of toxic material assumed available for atmospheric dispersal was 10^8 grams. This total mass was distributed approximately in the vertical according to the distribution shown in Figure E-8 which is taken from Hage, Bowne, and Hilst (1965).

In using Figure E-8, the radius r of the cloud in the plane of the horizon at the effective source height H_K was arbitrarily set equal to 305 meters. In the example calculations where vehicle destruct occurs at the surface, the amount of material in each layer was determined directly from Figure E-8. Where vehicle destruct occurs aloft, the source strength in the layers below the level of destruct was assumed equivalent to that produced by a normal launch. In the layers between the effective source height H_K and the destruct height h, the remaining material was distributed according to the distribution shown in Figure E-8.

In the examples of cold spills in the surface layer the source strength was assigned a value of 10^2 grams per second.

E.2.2 H_K - Effective Source Height

The effective source height was calculated using Equation (4-15) and the potential temperatures given in Tables E-1 and E-2. The value of Q', the energy released in vehicle destruct situations, was arbitrarily set equal to 3.5×10^7 kilocalories.

E.2.3 τ_K - Cloud Stabilization Time

For example cases of normal launches, the cloud stabilization time τ_K was set equal to the residence time of the vehicle in the layer given by Figure E-7. The time τ_K was set equal to 10 seconds in the layers affected by vehicle destruct situations. In example cases of cold spills in the surface layer, τ_K was set equal to 10 minutes.

E.2.4 $\sigma_{xo}\{K\}$, $\sigma_{yo}\{K\}$, $\sigma_{zo}\{K\}$ - Source Dimensions

In the example calculations for normal launches, alongwind and lateral source dimensions in the surface layer $\sigma_{xo}\{K=1\}$, $\sigma_{yo}\{K=1\}$ were based on photographs supplied by NASA of the launch of Apollo 10. The photographs show the vehicle exhaust plume in the vicinity of the launch pad taken from a fixed camera position on the NASA 150-meter Meteorological Tower every 2 seconds. Beyond an elapsed time of about 30 seconds, the exhaust plume cannot be distinguished from the background. Figure E-9 shows estimates of the height of two portions of the plume issuing from the exhaust deflector and the total width of the exhaust plume as a function of elapsed time. Inspection of Figure E-9 shows the width of the cloud to be about 1250 meters 25 seconds after launch; in the example cases, this is the time the vehicle leaves the first layer. At this time, the two portions of the cloud from the exhaust deflector appear nearly merged in the photographs. The alongwind and crosswind dimensions were assumed equal to the width, 1250 meters, divided by 4.3 (see Section 4.3). In the layers aloft, the dimensions were arbitrarily decreased.

As mentioned earlier, the cloud radius at the height H_K for examples of vehicle destruct was assigned a value of 305 meters in the plane of the horizon and the alongwind and crosswind dimensions were assumed equal to 305 meters divided by 4.3. The vertical source dimension in the layer containing H_K was arbitrarily set equal to the height difference between H_K and the lower boundary of this layer divided by 2.15.

In the examples of cold spills in the surface layer, the spill was assumed to have dimensions of 50 meters in diameter; the alongwind and lateral dimensions were set equal to 50 meters divided by 4.3, or 11.6 meters. The vertical source dimension was set equal to unity.

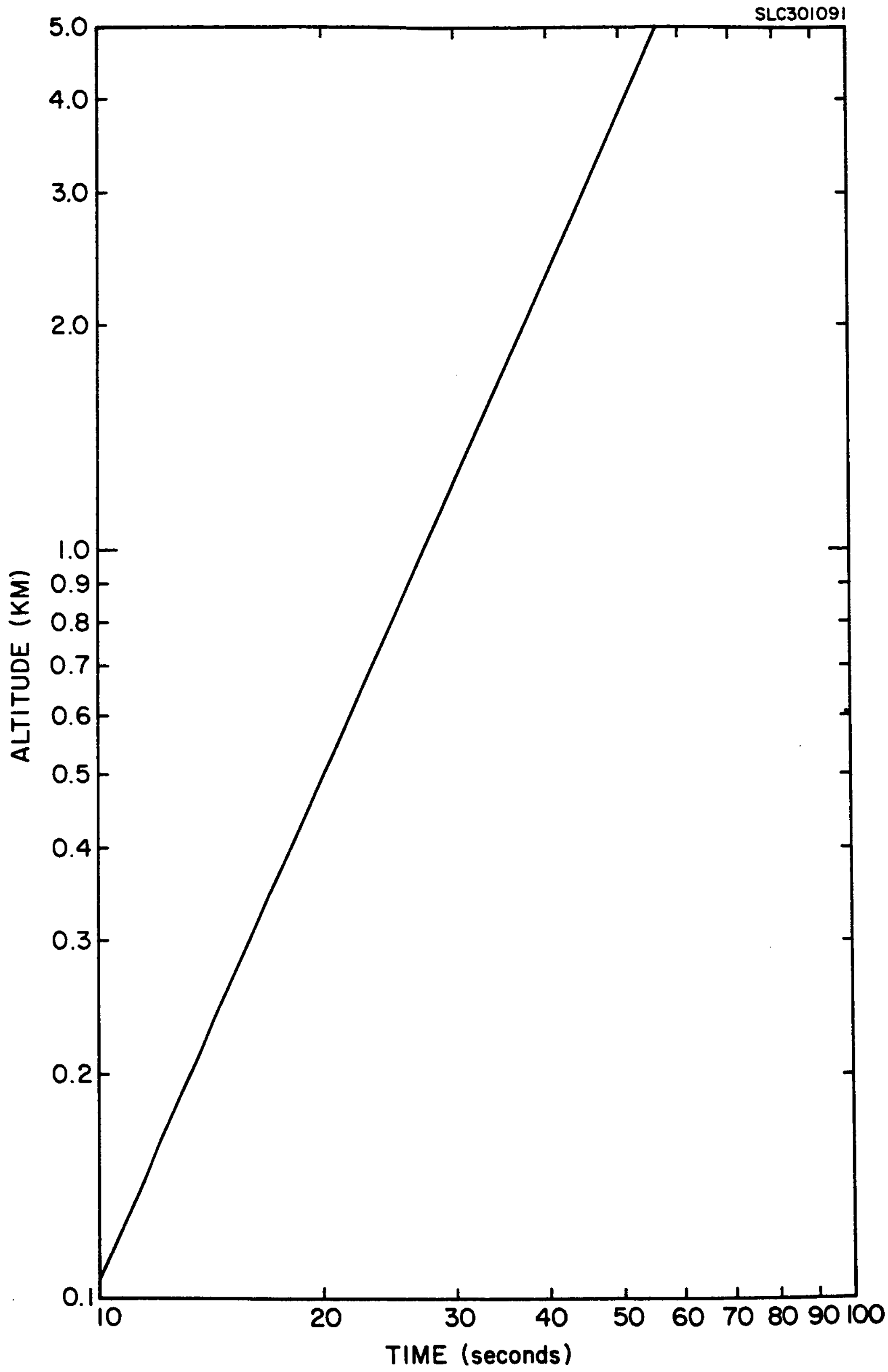

FIGURE E-7. Altitude of the SATURN AS-504 vehicle as a function of flight time (after Adelfang, Ashburn, and Court, 1968).

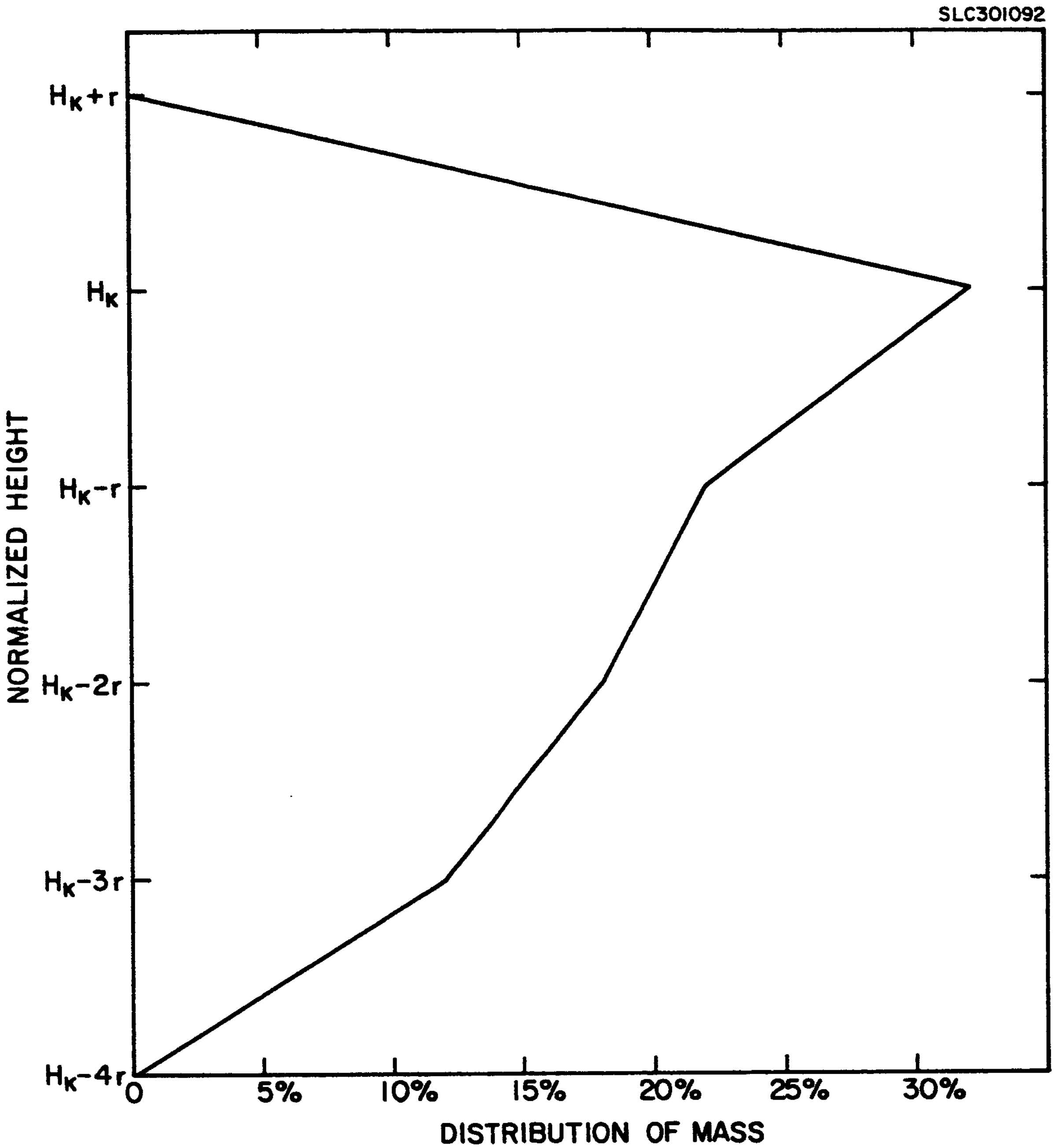

FIGURE E-8. Assumed distribution of mass in the cloud resulting from a vehicle destruct after Hage, K. D., N. E. Bowne, and G. R. Hilst (1965). In the figure, H_K is the effective release height and r is the radius in the plane of the horizon of the source at H_K.

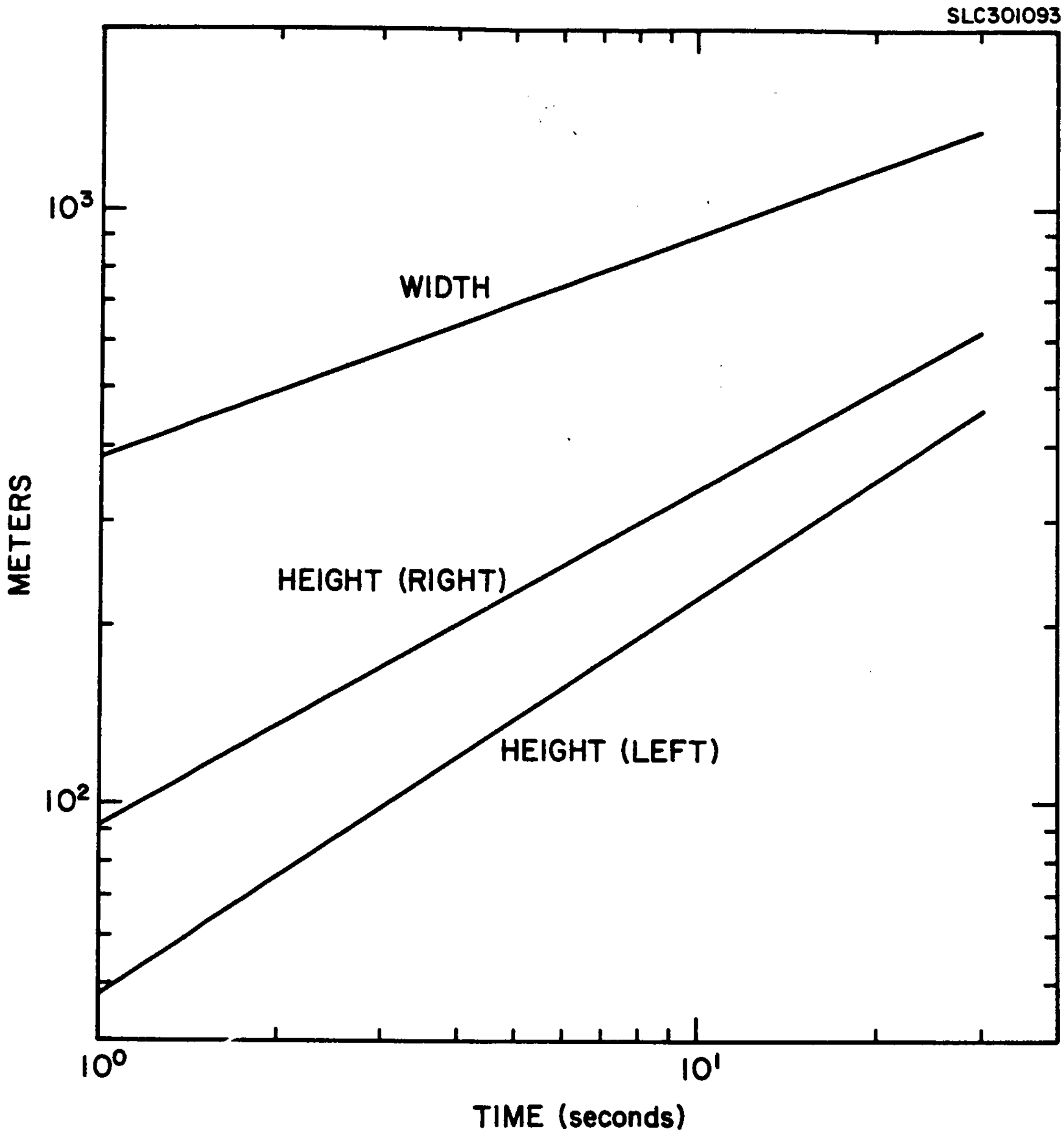

FIGURE E-9. Increase in height and width of plume formed by launch of Apollo 10 as a function of elapsed time. Lower curves represent height of the two portions of the plume formed by the deflector at the base of the launch pad.

E.2.5 V_s, f_i - Settling Velocity and Fraction of Material with Settling Velocity V_s

Table E-3 presents the median particle diameter of each particle size category of an assumed distribution used for the example in Section E.5 of ground-level deposition due to gravitational settling. Table E-3 shows the fraction of material assigned each particle size category and the settling velocities for droplets or particles having these median diameters and unit density (after Johnson, 1954).

E.3 CONCENTRATION AND DOSAGE PATTERNS FOR THE PRE-COLD FRONT SITUATION - 2315 GMT, 27 NOVEMBER 1966

This section contains the results of the example calculations for the various source modes for the pre-cold front regime discussed in Section E.1.1.

E.3.1 Normal Launch

The source and meteorological inputs for the normal launch calculation are given in Table E-4. Figures E-10 and E-11 respectively show the maximum ground-level concentrations and dosages downwind from the launch pad. Figures E-12 and E-13 show the corresponding ground-level concentration and dosage isopleths. Figures E-14 through E-19 contain the concentration and dosage isopleths at the base of the three layers above the surface layer.

E.3.2 Vehicle Destruct at the Surface

The source and meteorological inputs for a vehicle destruct at the surface are given in Table E-5. Figures E-20 and E-21 respectively show maximum ground-level concentrations and dosages downwind from the launch pad.

TABLE E-3

ASSUMED MEDIAN PARTICLE DIAMETERS, FRACTION OF MATERIAL WITH SETTLING VELOCITY V_s, AND V_s

Particle Diameter (micrometers)	f_i	V_s (m sec^{-1})
37	1/10	0.043
53.5	1/10	0.090
67	1/10	0.140
84	1/10	0.209
100	1/10	0.275
120	1/10	0.355
150	1/10	0.485
190	1/10	0.660
270	1/10	1.000
660	1/10	2.700

TABLE E-4

PROGRAM INPUTS

Example Problem: Normal Launch for Pre-Cold Front Situation, 2315 GMT, 27 November 1966

MODEL NO. 1				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Source Inputs			
Q_K (gm^{-1})	1.48×10^4	5.38×10^3	3.79×10^3	2.82×10^3
$\sigma_{yo}\{K\}$ (m)	290	150	100	75
$\sigma_{zo}\{K\}$ (m)	-	-	-	-
$\sigma_{xo}\{K\}$ (m)	290	150	100	75
τ_K (sec)	25	11	10	11
H_K (m)				
k				

TABLE E-4 (Continued)

MODEL NO. 1				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	8			
σ_{ER} (deg)	4.5			
$\bar{u}_R$ (m sec^{-1})	4.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	5	0	0	0
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		5	0	0
τ_{oK} (sec)	600	600	600	600
σ_{ETK} (deg)	4	0	0	0
σ_{EBK} (deg)		4	0	0
α_K	1	1	1	1
β_K	1	1	1	1
$\bar{u}_{TK}$ (m sec^{-1})	6.70	7.73	10.8	20.6
$\bar{u}_{BK}$ (m sec^{-1})		6.70	7.73	10.8
θ_{TK} (deg)	231	258	229	256
θ_{BK} (deg)	160	231	258	229
z_{TK} (m)	853	1829	3048	5000
z_{BK} (m)	2	853	1829	3048
Λ (sec^{-1})				
z_{lim} (m)				
t_1 (sec)				
t^* (sec)				

TABLE E-5

PROGRAM INPUTS

Example Problem: Vehicle Destruct at Surface for Pre-Cold Front Situation, 2315 GMT, 27 November 1966

MODEL NO. 1 (Layer 1), 3 (Layer 2)				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Source Inputs			
Q_K (g m^{-1})	4.45×10^4			
Q_K (g)		6.2×10^7		
$\sigma_{yo}\{K\}$ (m)	35	142		
$\sigma_{zo}\{K\}$ (m)	-	142		
$\sigma_{xo}\{K\}$ (m)	35	142		
τ_K (sec)	10	10		
H_K (m)		1285		
k	-			

TABLE E-5 (Continued)

MODEL NO. 1 (Layer 1), 3 (Layer 2)				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	8			
σ_{ER} (deg)	4.5			
$\bar{u}_R$ (m sec^{-1})	4.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	5	0		
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)				
τ_{oK} (sec)	600	600		
σ_{ETK} (deg)	4	0		
σ_{EBK} (deg)		4		
α_K	1	1		
β_K	1	1		
$\bar{u}_{TK}$ (m sec^{-1})	6.70	7.73		
$\bar{u}_{BK}$ (m sec^{-1})		6.70		
θ_{TK} (deg)		258		
θ_{BK} (deg)	160	231		
z_{TK} (m)	853	1829		
z_{BK} (m)	2	853		
Λ (sec^{-1})				
z_{lim} (m)				
t_1 (min)				
t* (min)				

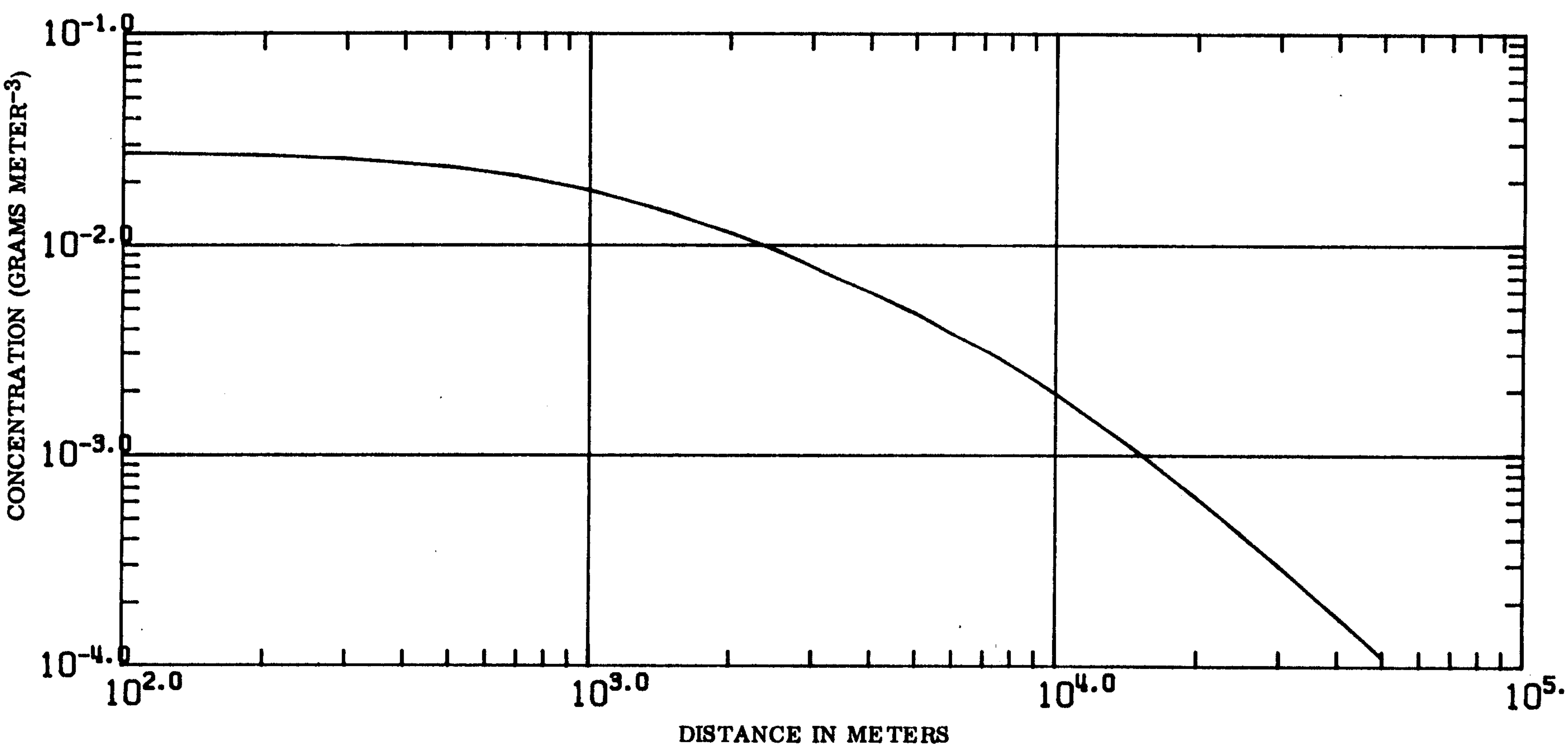

FIGURE E-10. Maximum ground-level concentration for a normal launch, 2315 GMT, 27 November 1966.

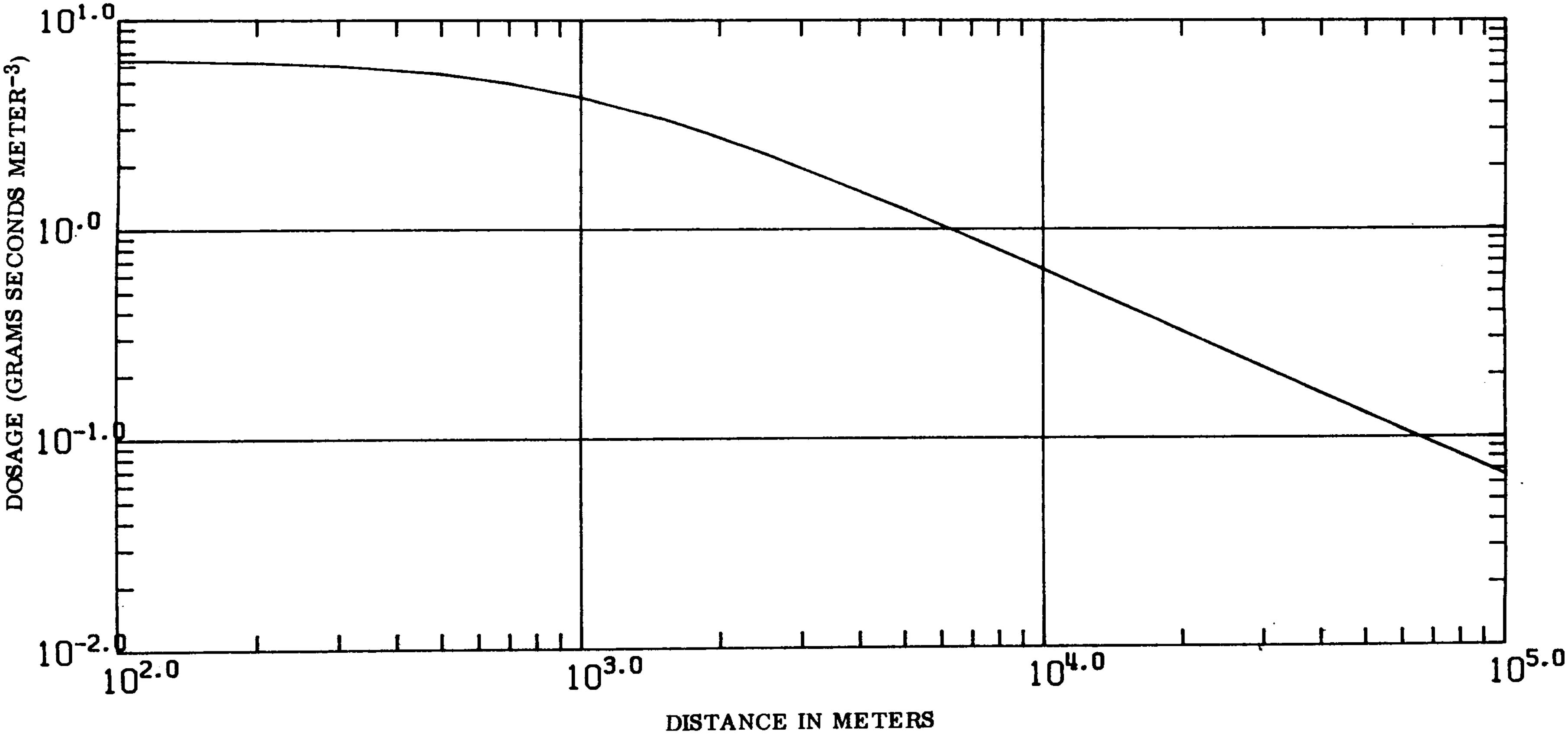

FIGURE E-11. Maximum ground-level dosage for a normal launch, 2315 GMT, 27 November 1966.

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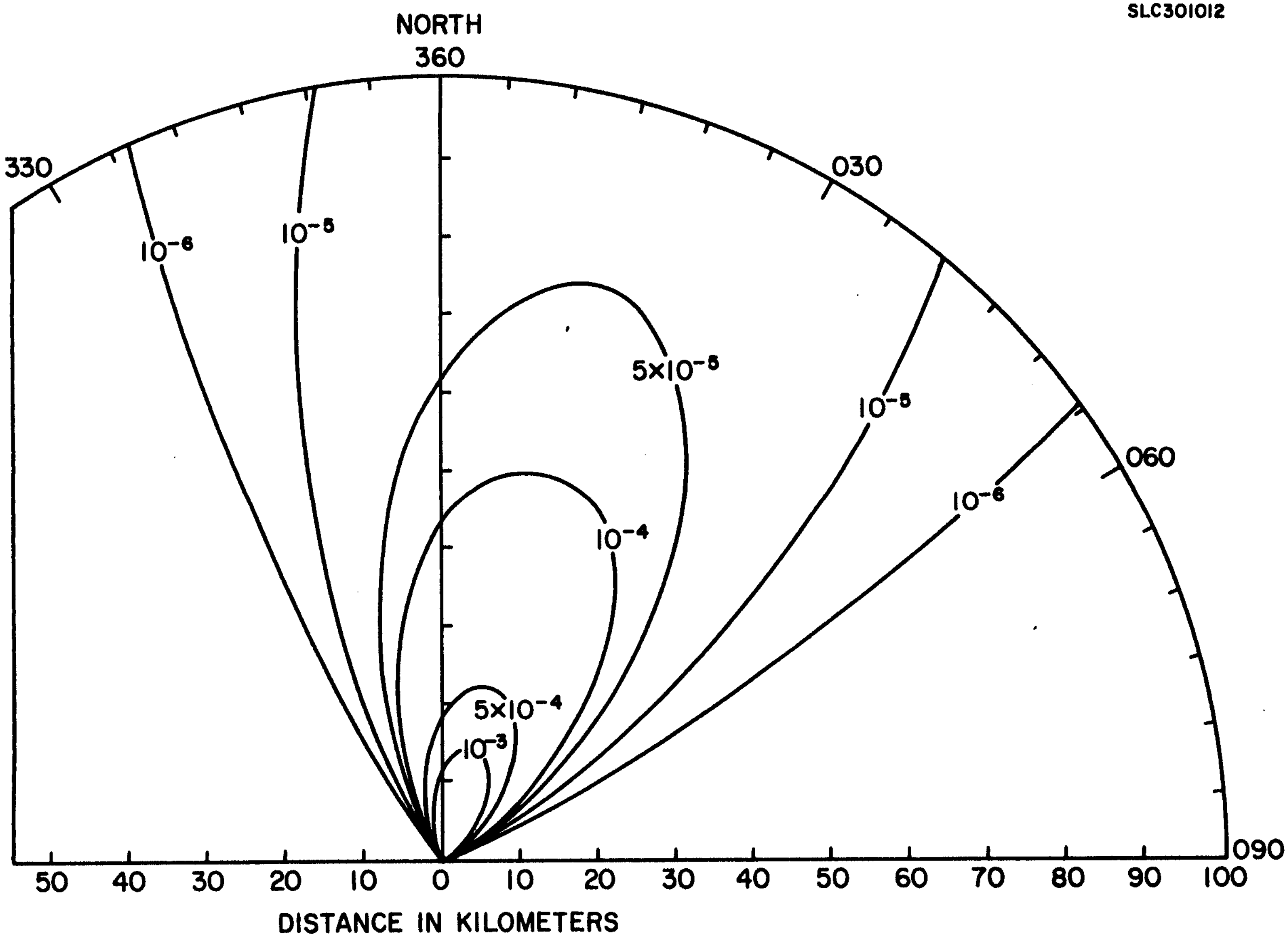

FIGURE E-12. Ground-level concentration isopleths in grams per cubic meter for a normal launch, 2315 GMT, 27 November 1966.

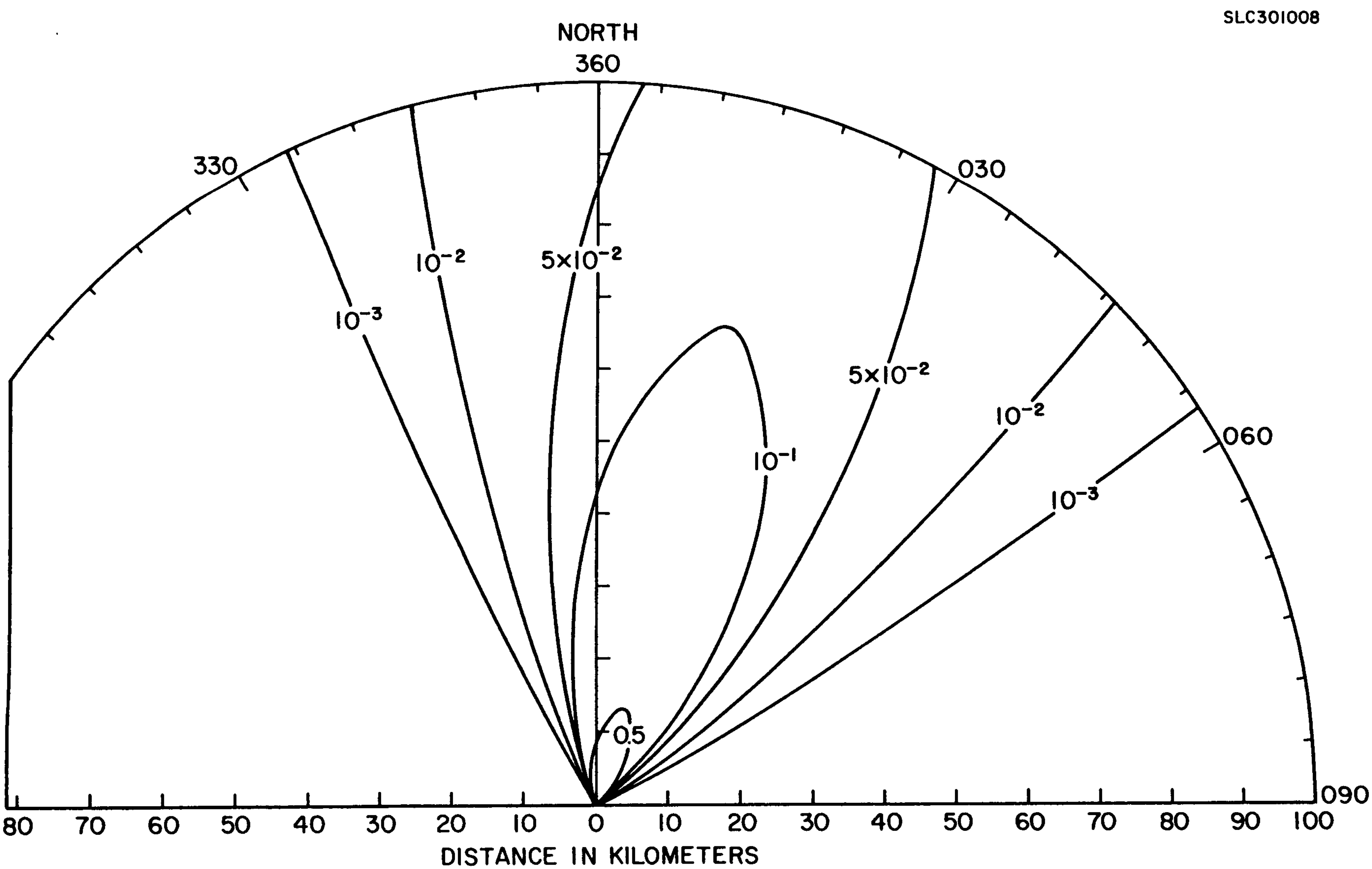

FIGURE E-13. Ground-level dosage isopleths in grams seconds per cubic meter for a normal launch, 2315 GMT, 27 November 1966.

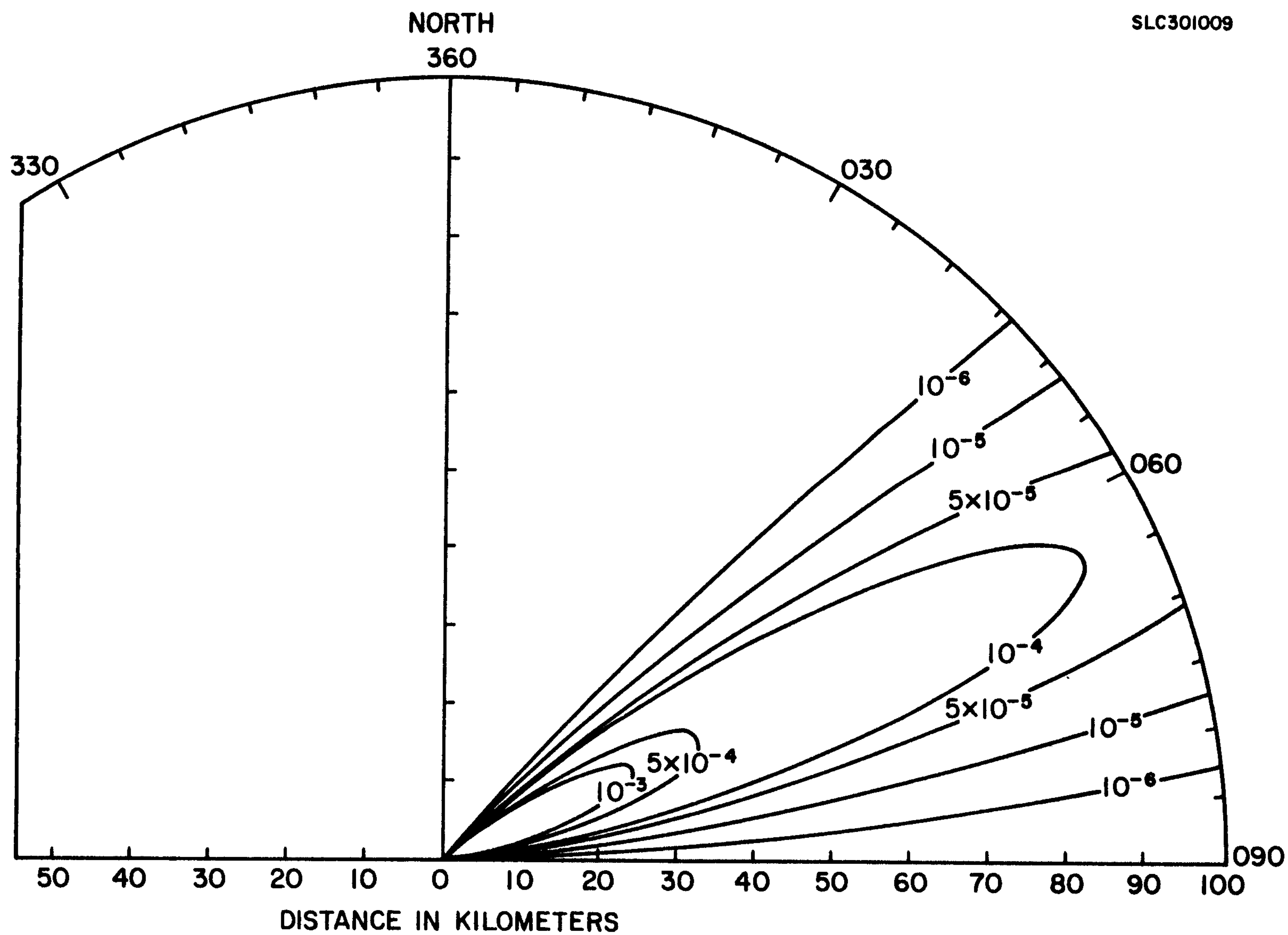

FIGURE E-14. Concentration isopleths in grams per cubic meter at a height of 853 meters for a normal launch, 2315 GMT, 27 November 1966.

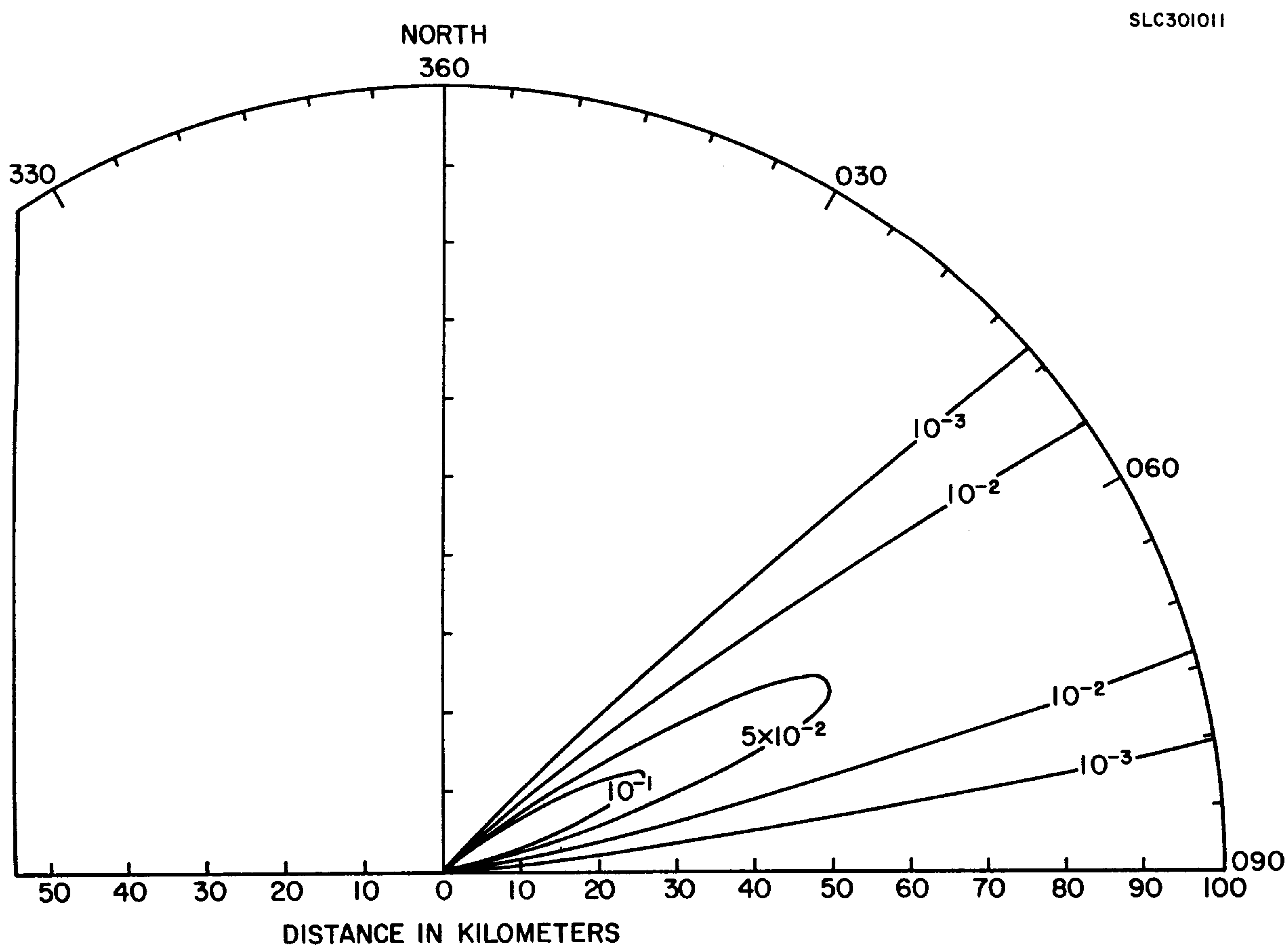

FIGURE E-15. Dosage isopleths in grams seconds per cubic meter at a height of 853 meters for a normal launch, 2315 GMT, 27 November 1966.

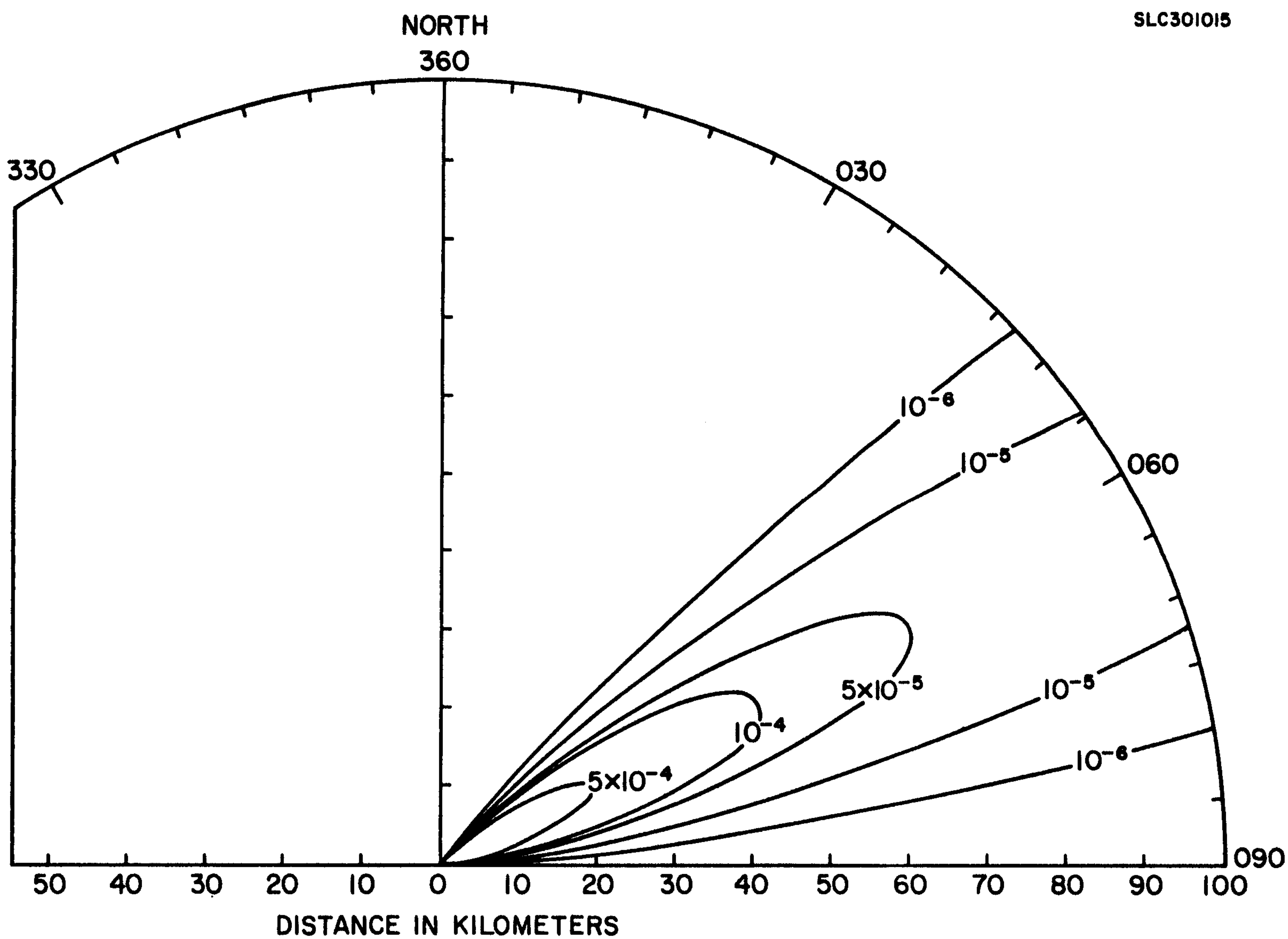

FIGURE E-16. Concentration isopleths in grams per cubic meter at a height of 1829 meters for a normal launch, 2315 GMT, 27 November 1966.

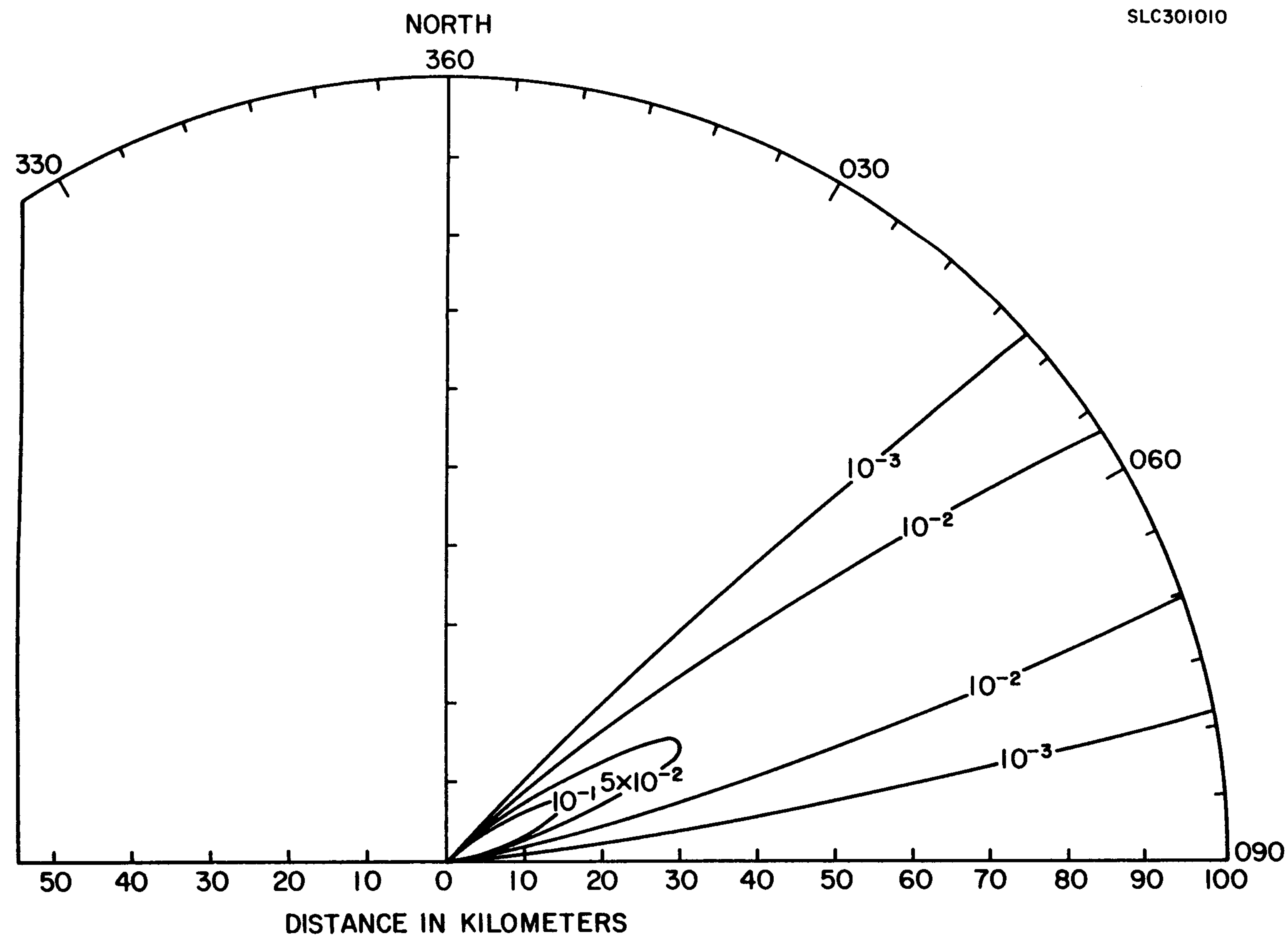

FIGURE E-17. Dosage isopleths in grams seconds per cubic meter at a height of 1829 meters for a normal launch, 2315 GMT, 27 November 1966.

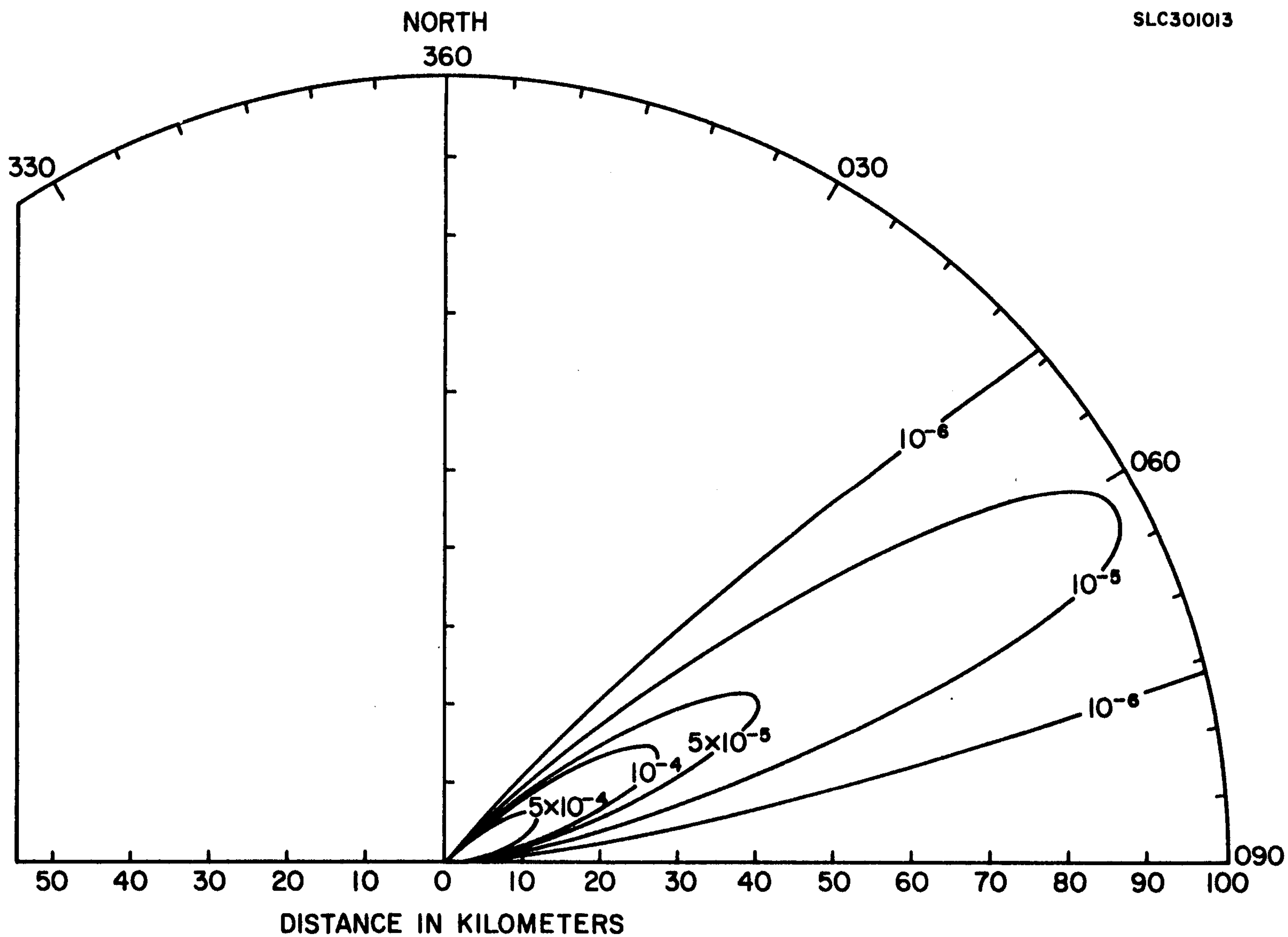

FIGURE E-18. Concentration isopleths in grams per cubic meter at a height of 3048 meters for a normal launch, 2315 GMT, 27 November 1966.

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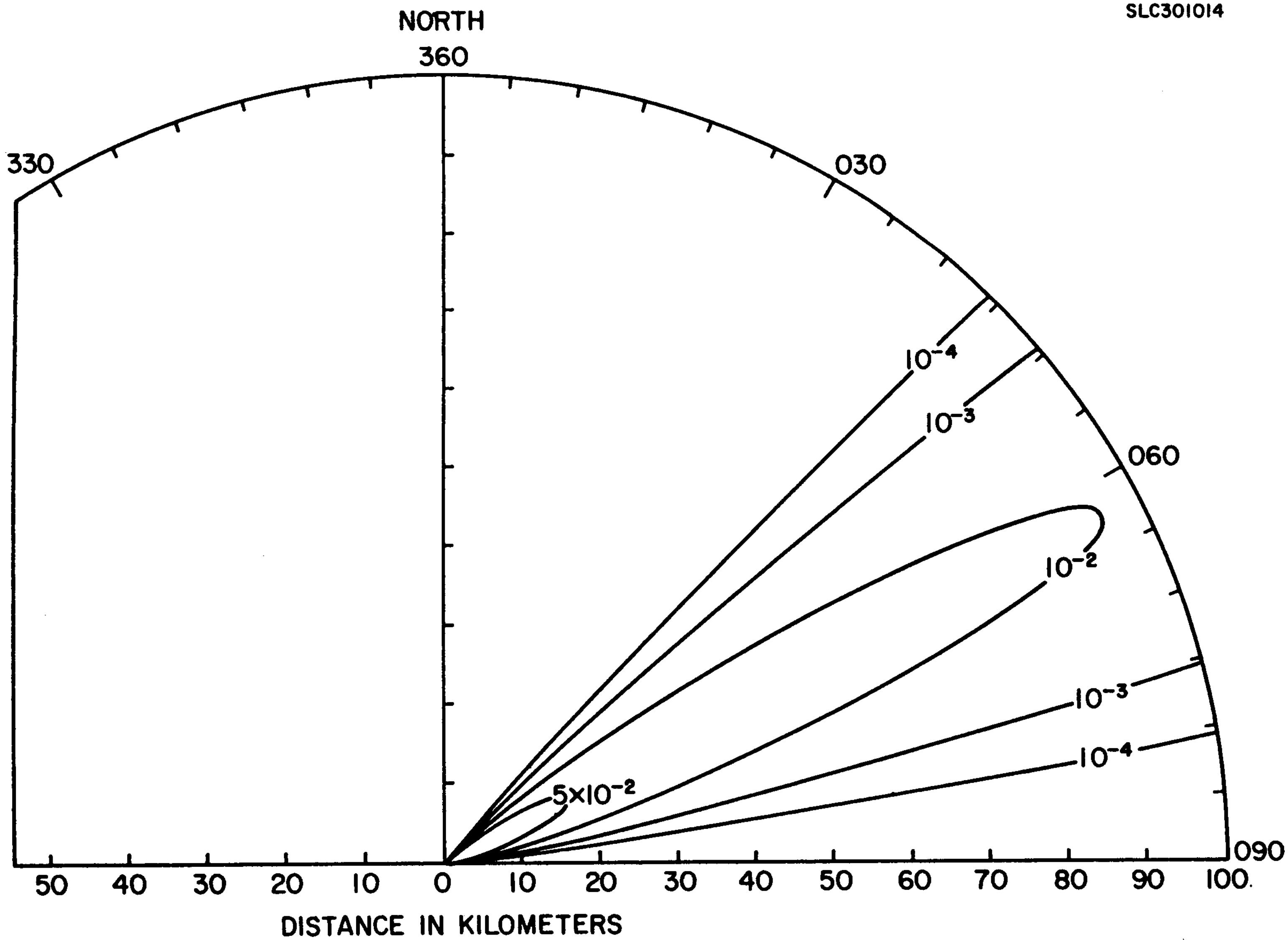

FIGURE E-19. Dosage isopleths in grams seconds per cubic meter at a height of 3048 meters for a normal launch, 2315 GMT, 27 November 1966.

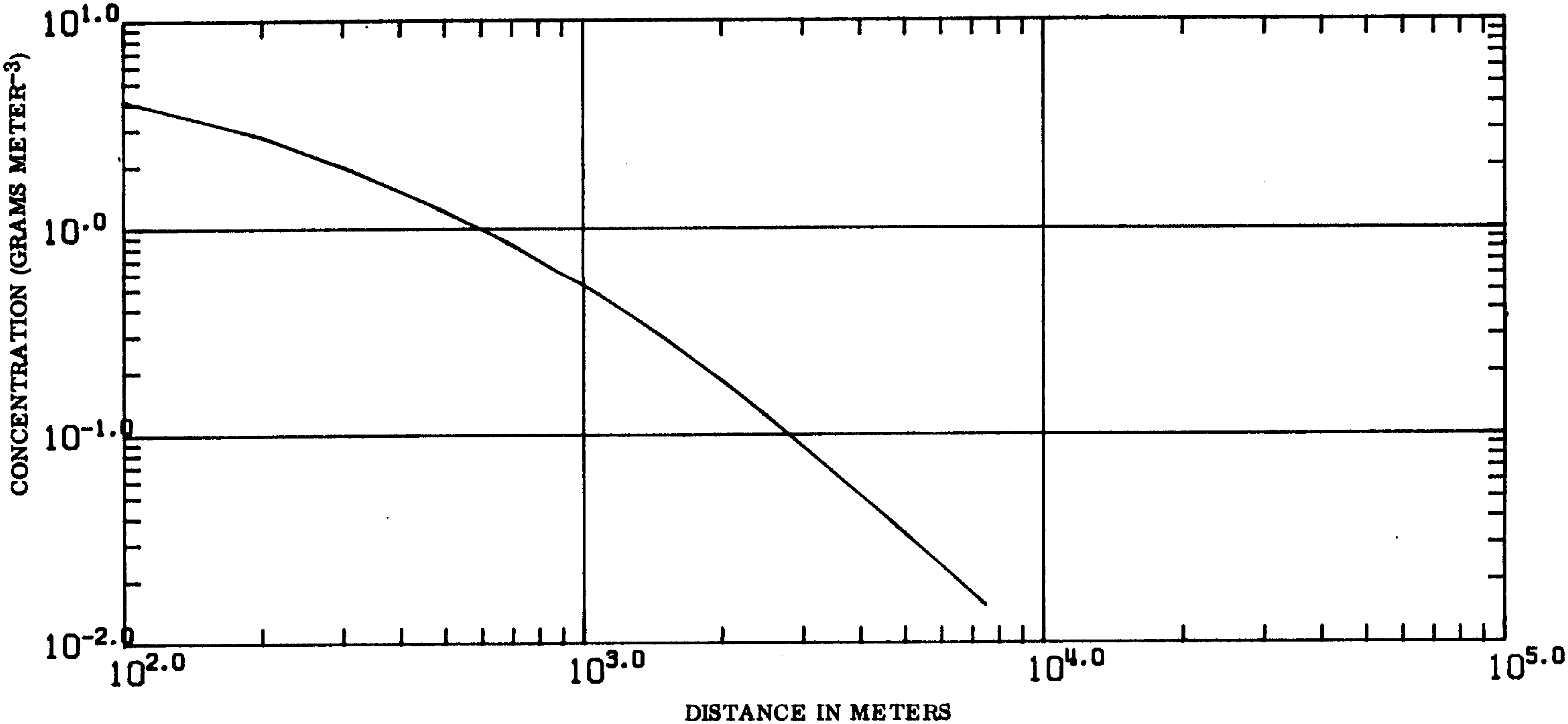

FIGURE E-20. Maximum ground-level concentration for a vehicle destruct on pad, 2315 GMT, 27 November 1966.

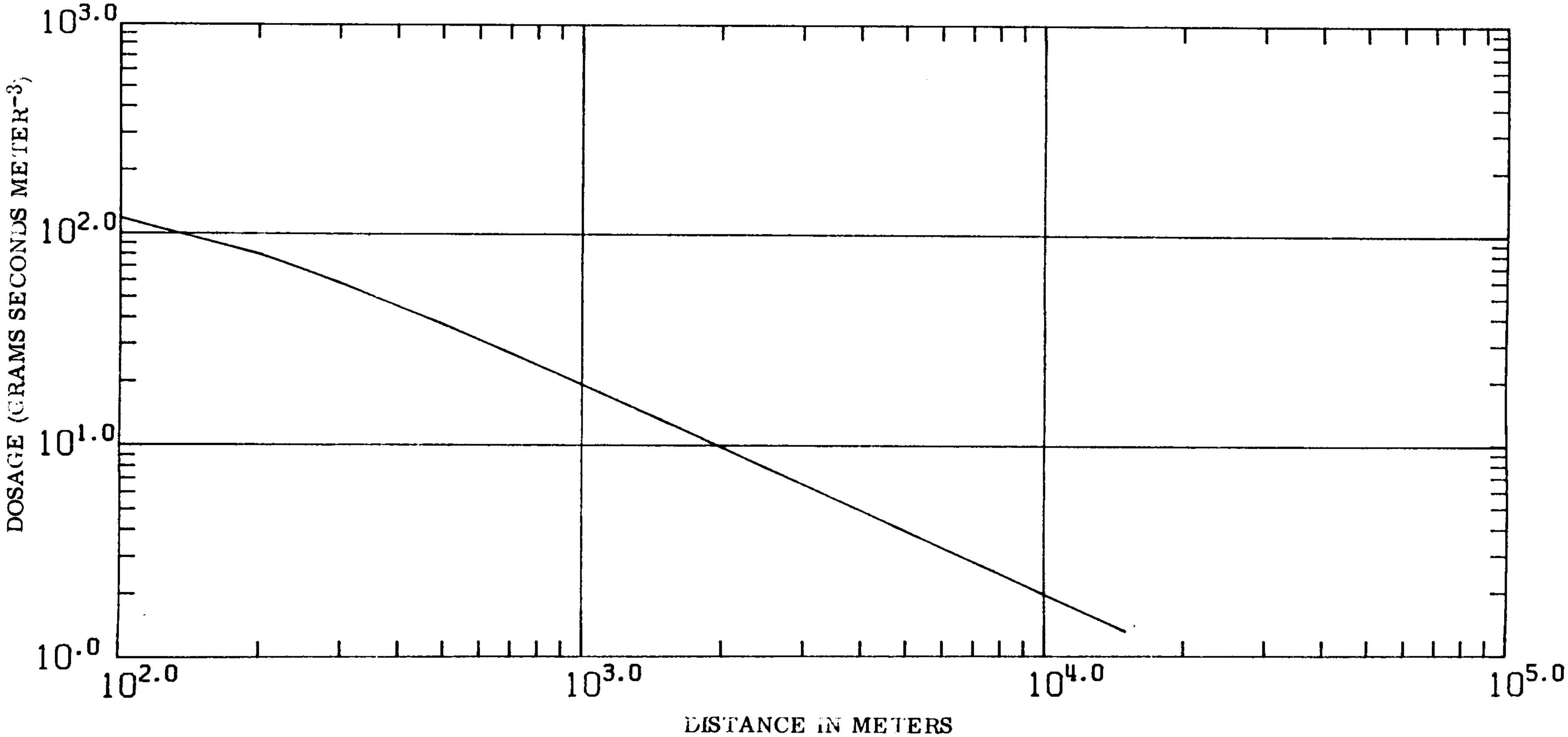

FIGURE E-21. Maximum ground-level dosage for a vehicle destruct on pad, 2315 GMT, 27 November 1966.

Figures E-22 and E-23 respectively show ground-level concentration and dosage isopleths. Figures E-24 and E-25 respectively show concentration and dosage isopleths at the base of the second layer. As expected, dosages and concentrations in the second layer are much higher than those in the surface layer, because of the buoyant rise of material.

E.3.3 Vehicle Destruct Aloft

The source and meteorological inputs for this example are given in Table E-6. Figures E-26 and E-27 respectively show maximum ground-level concentrations and dosages downwind from the launch pad. Because the vehicle destruct occurs at a height of 1350 meters, these results, as well as those for ground-level concentration and dosage isopleths shown in Figures E-28 and E-29, are the same as those for the normal launch case. Figures E-30 and E-31 respectively show concentration and dosage isopleths at the base of the second layer, the layer in which the vehicle is assumed to have been destructed. Finally, Figures E-32 and E-33 respectively show isopleths of concentration and dosage at the base of the third layer. The effective height of the volume source H_K from the destruct is in the third layer at a height of 2593 meters.

E.3.4 Cold Spill in the Surface Layer

The source and meteorological inputs for this example are given in Table E-7. Figure E-34 shows ground-level concentration isopleths for a spill 50 meters in diameter in the surface layer calculated using the multi-layer diffusion program.

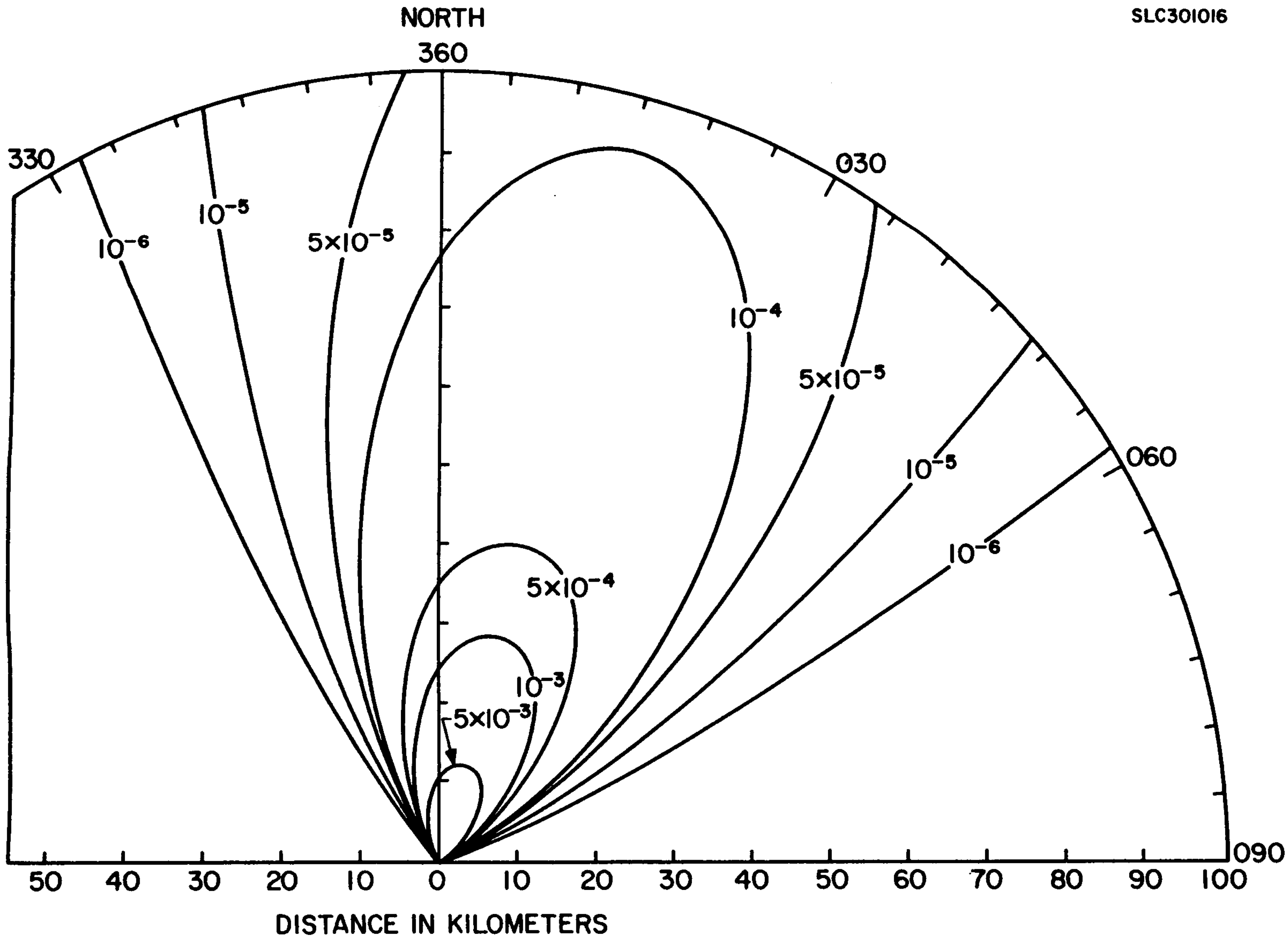

FIGURE E-22. Ground-level concentration isopleths in grams per cubic meter for a vehicle destruct on the pad, 2315 GMT, 27 November 1966.

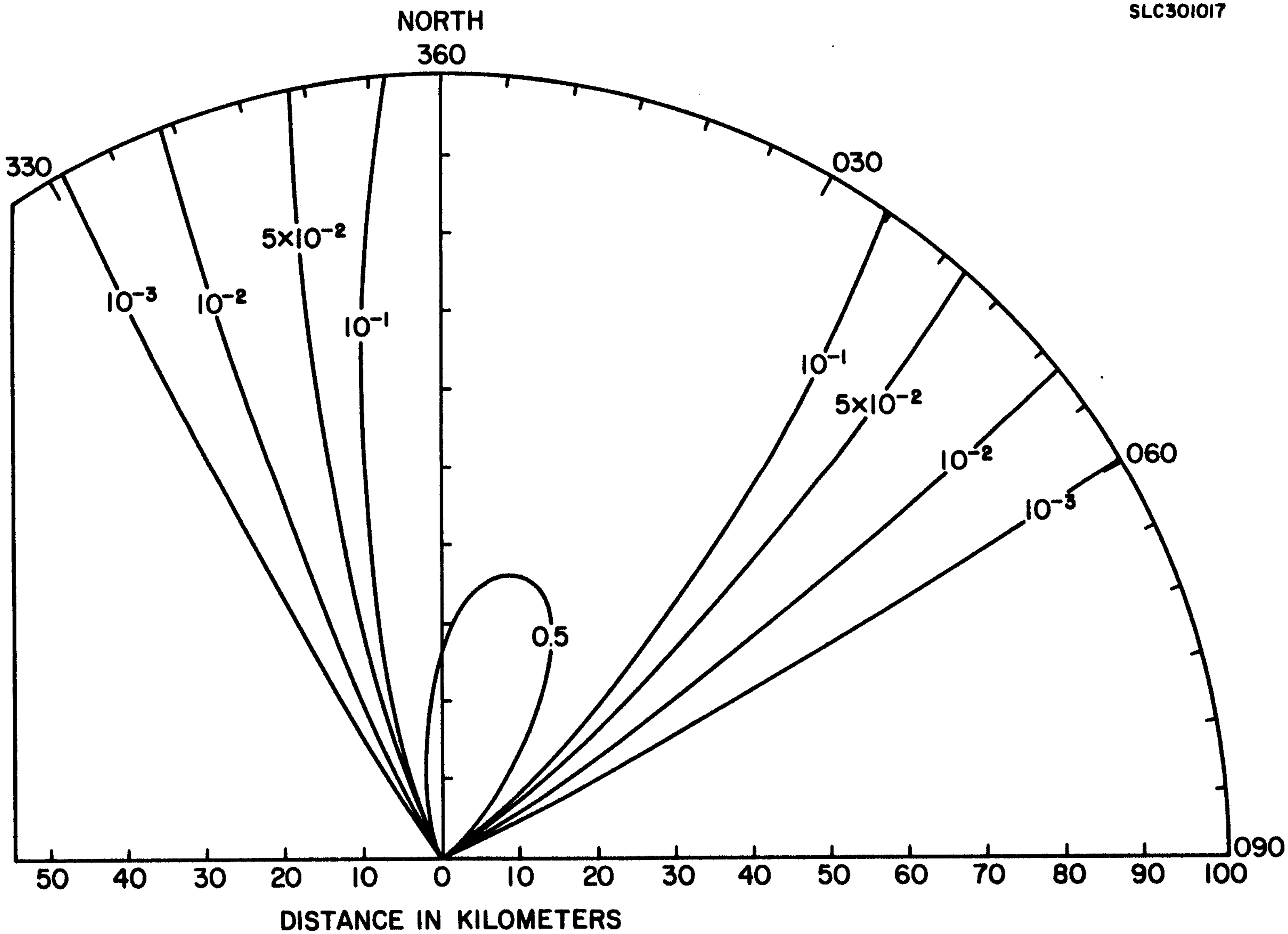

FIGURE E-23. Ground-level dosage isopleths in grams seconds per cubic meter for a vehicle destruct on the pad, 2315 GMT, 27 November 1966.

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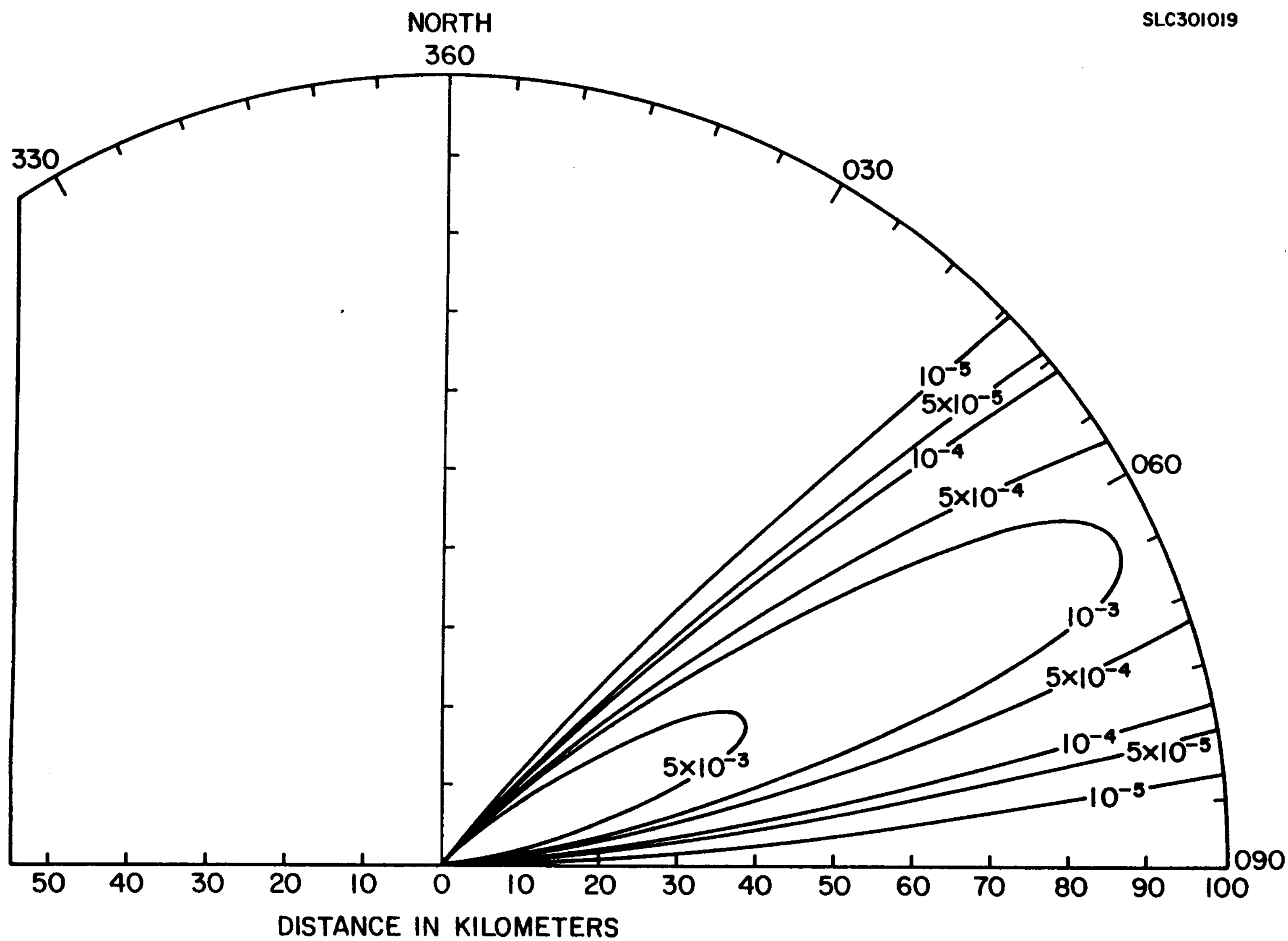

FIGURE E-24. Concentration isopleths in grams per cubic meter at a height of 853 meters for a vehicle destruct on the pad, 2315 GMT, 27 November 1966.

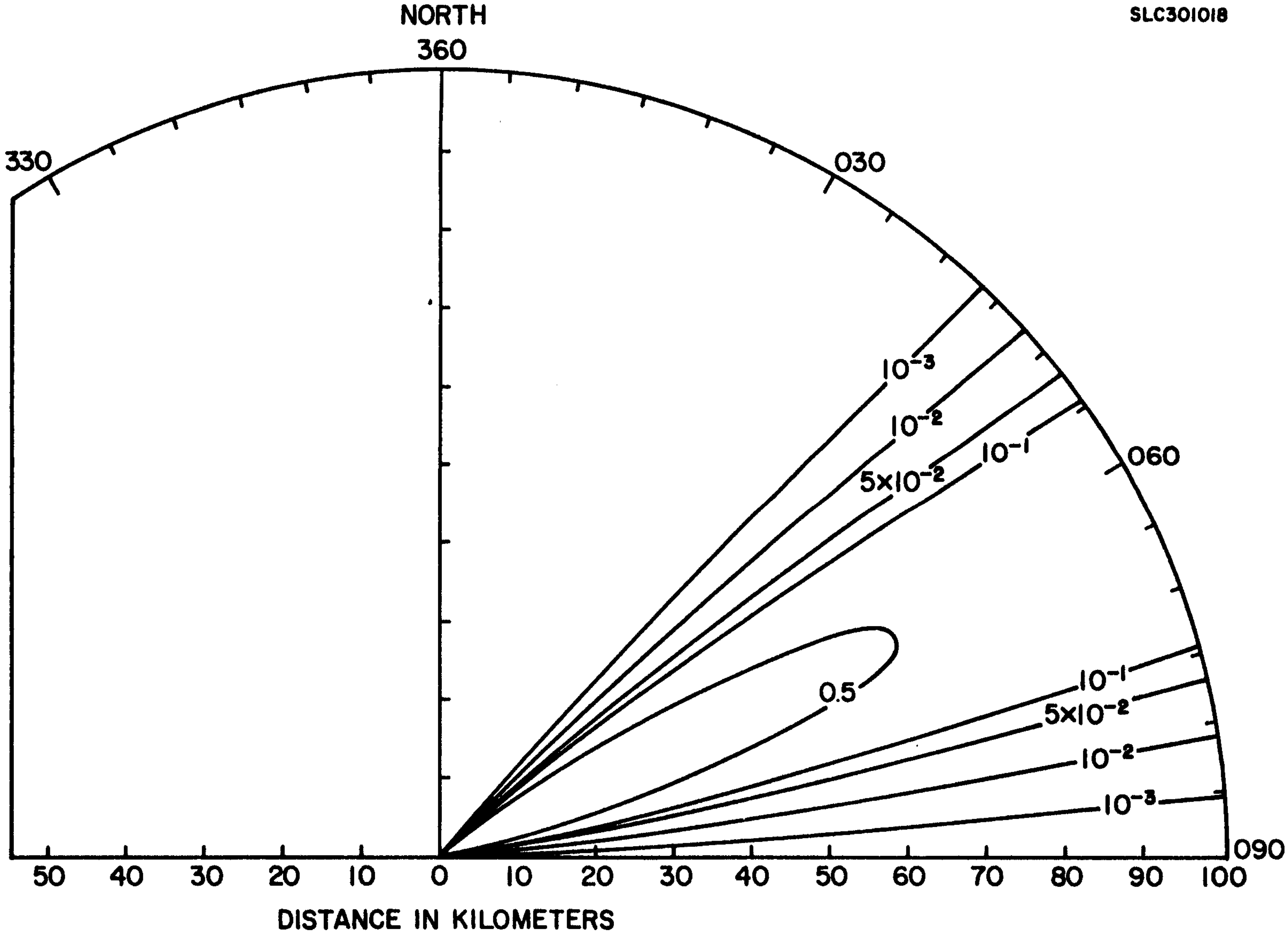

FIGURE E-25. Dosage isopleths in grams seconds per cubic meter at a height of 853 meters for a vehicle destruct on the pad. 2315 GMT, 27 November 1966.

TABLE E-6

PROGRAM INPUTS

Example Problem: Vehicle Destruct Aloft for Pre-Cold Front Situation, 2315 GMT, 27 November 1966

MODEL NO. 1 (Layer 1), 1 (Layer 2), 3 (Layer 3)				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Source Inputs			
Q_K $(g\ m^{-1})$	1.48×10^4	1.34×10^4		
Q_K (g)			7.43×10^7	
$\sigma_{yo}\{K\}$ (m)	290	100	142	
$\sigma_{zo}\{K\}$ (m)	-	-	355	
$\sigma_{xo}\{K\}$ (m)	290	100	142	
τ_K (sec)	25	10	10	
H_K (m)			2593	
k				

TABLE E-6 (Continued)

MODEL NO. 1 (Layer 1), 1 (Layer 2), 3 (Layer 3)				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	8			
σ_{ER} (deg)	4.5			
$\bar{u}_R$ (m sec^{-1})	4.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	5	0	0	
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		5	0	
τ_{oK} (sec)	600	600	600	
σ_{ETK} (deg)	4	0	0	
σ_{EBK} (deg)		4	0	
α_K	1	1	1	
β_K	1	1	1	
$\bar{u}_{TK}$ (m sec^{-1})	6.70	7.73	10.8	
$\bar{u}_{BK}$ (m sec^{-1})		6.70	7.73	
θ_{TK} (deg)	231	258	229	
θ_{BK} (deg)	160	231	258	
z_{TK} (m)	853	1829	3048	
z_{BK} (m)	2	853	1829	
Λ (sec^{-1})				
z_{lim} (m)				
t_1 (min)				
t^* (min)				

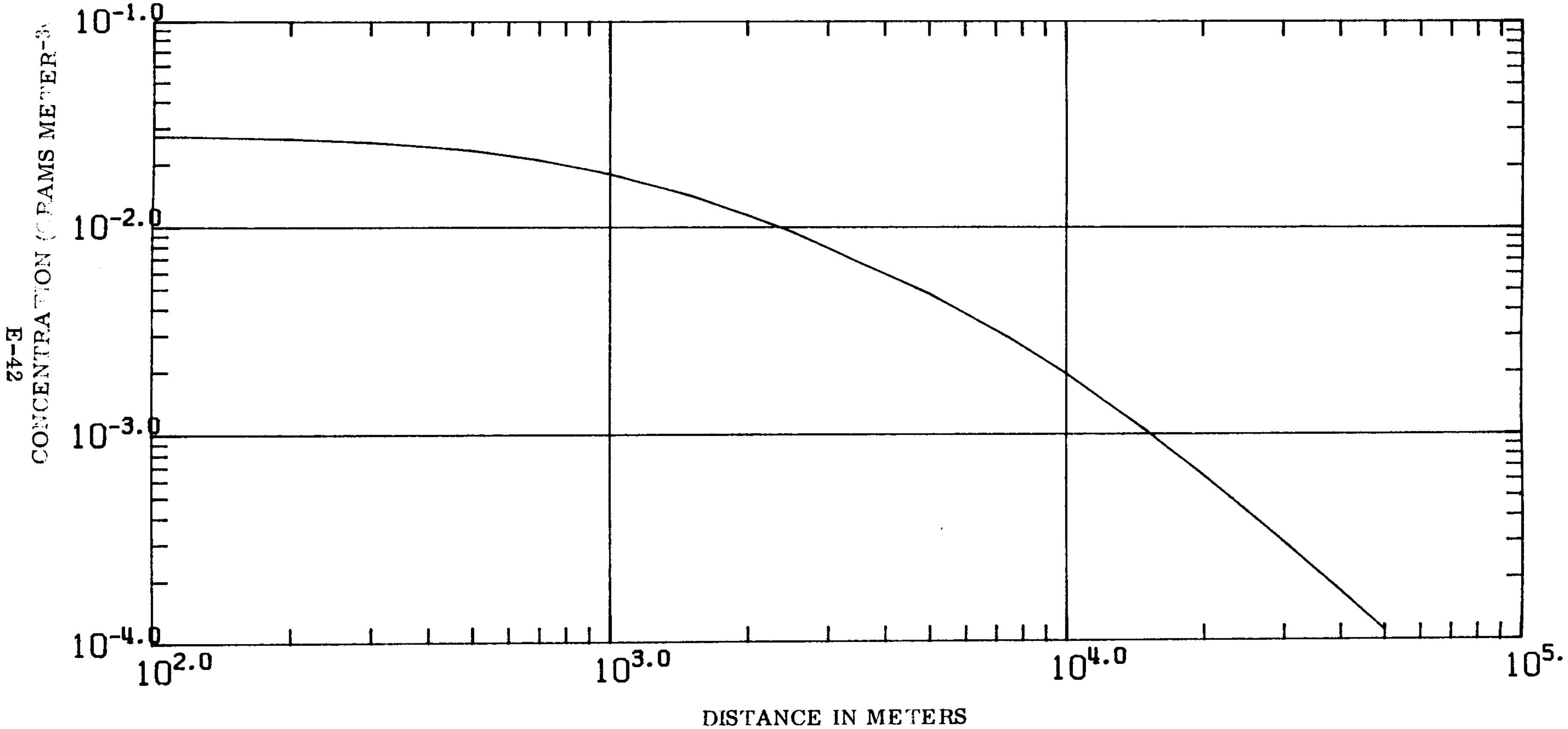

FIGURE E-26. Maximum ground-level concentration for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

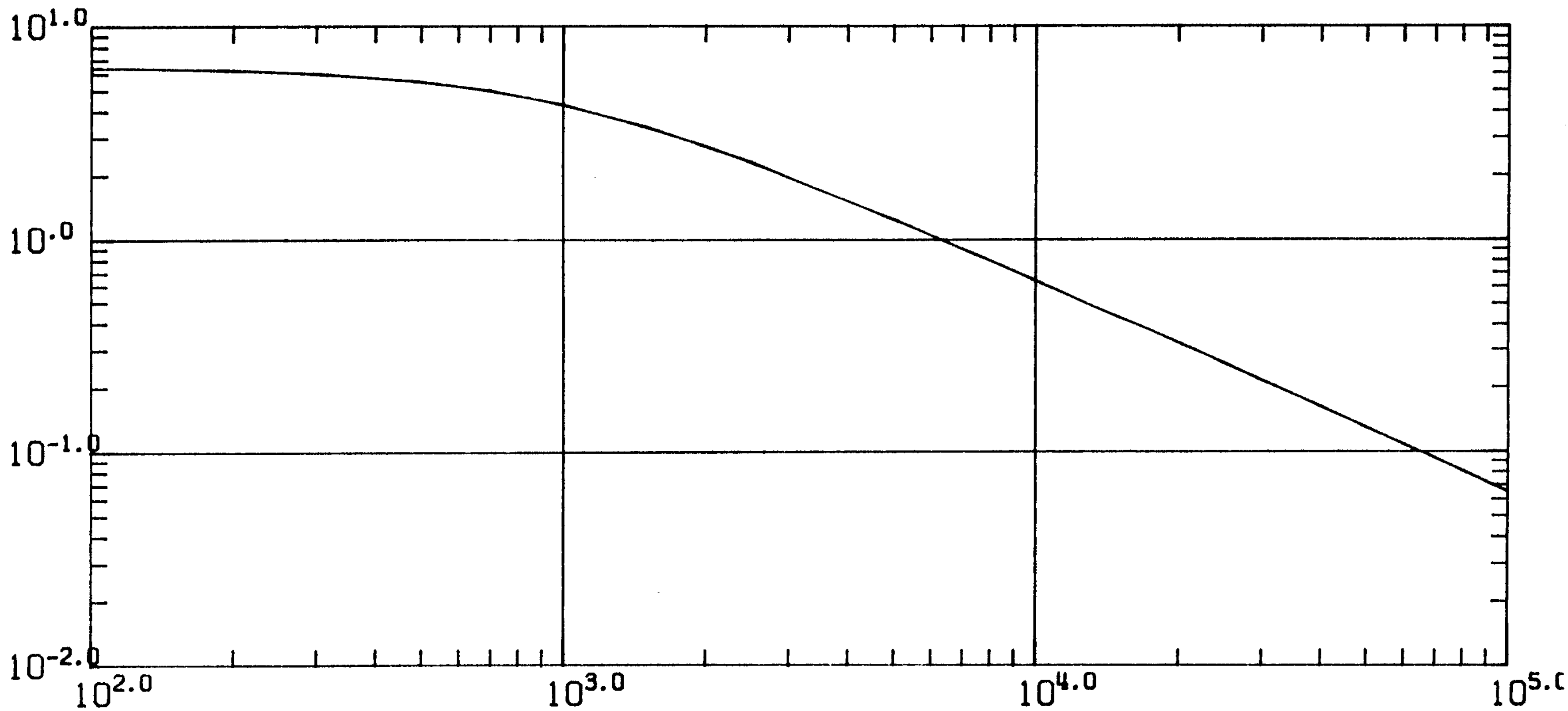

FIGURE E-27. Maximum ground-level dosage for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

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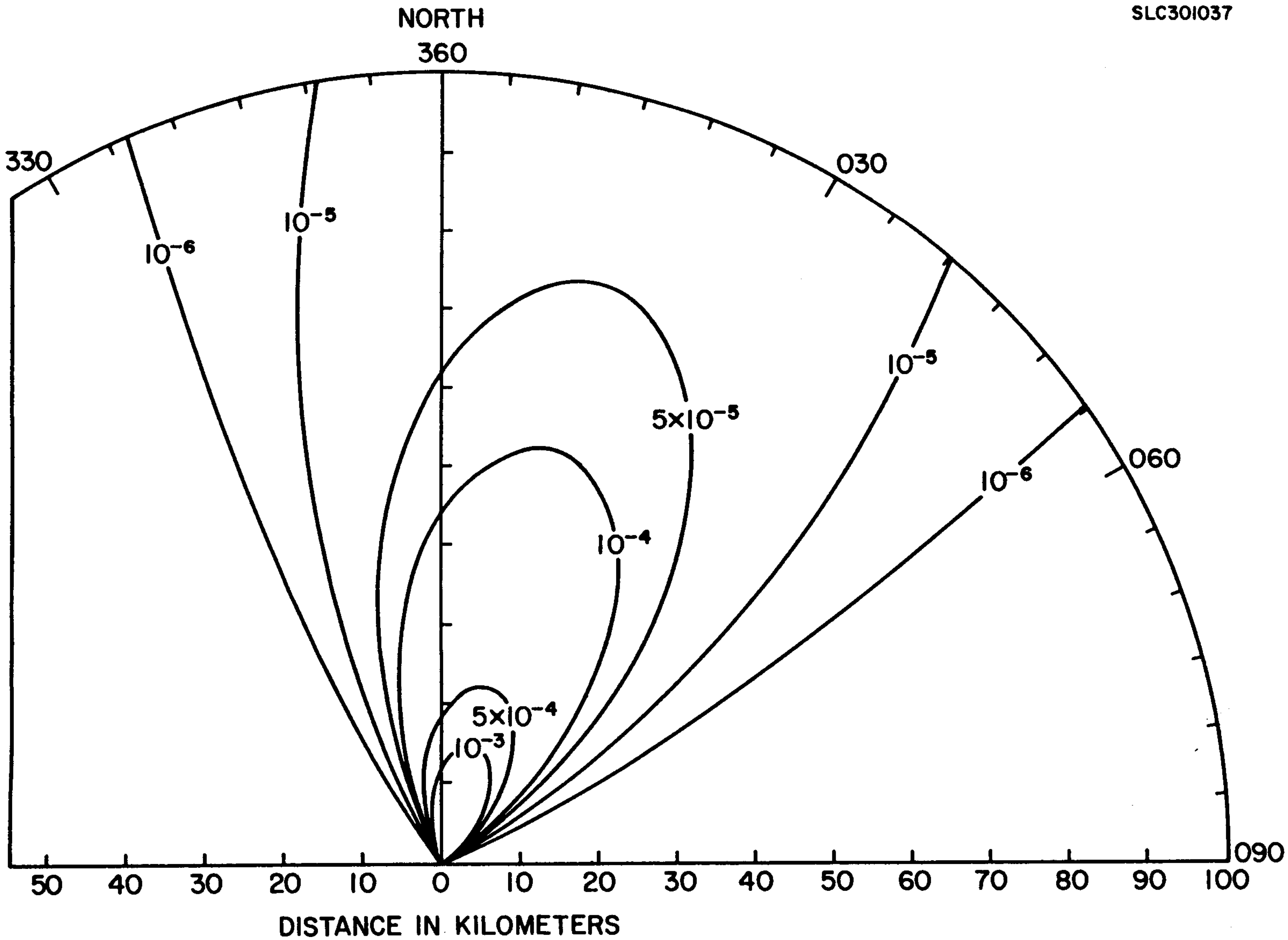

FIGURE E-28. Ground-level concentration isopleths in grams per cubic meter for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

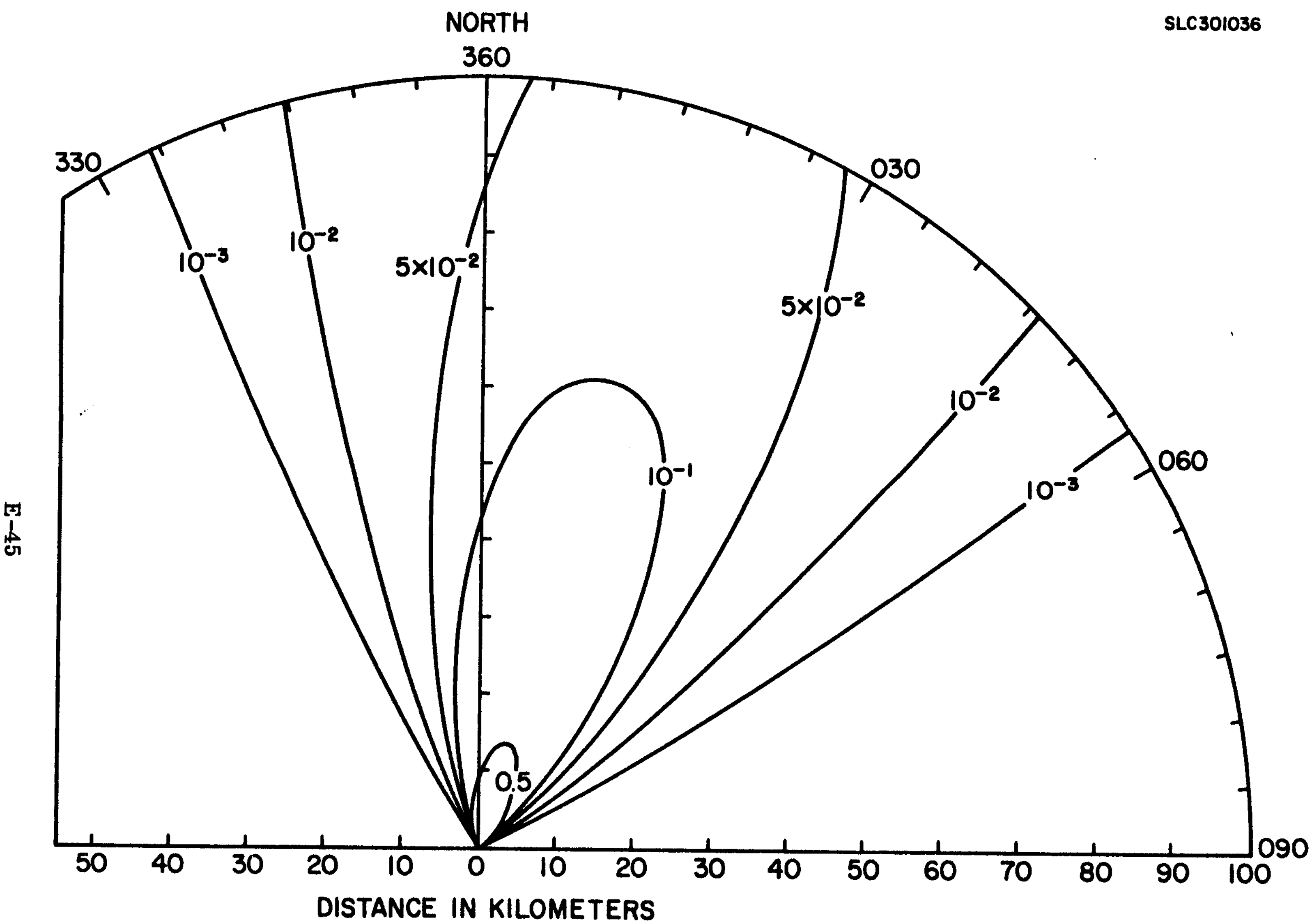

FIGURE E-29. Ground-level dosage isopleths in grams seconds per cubic meter for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

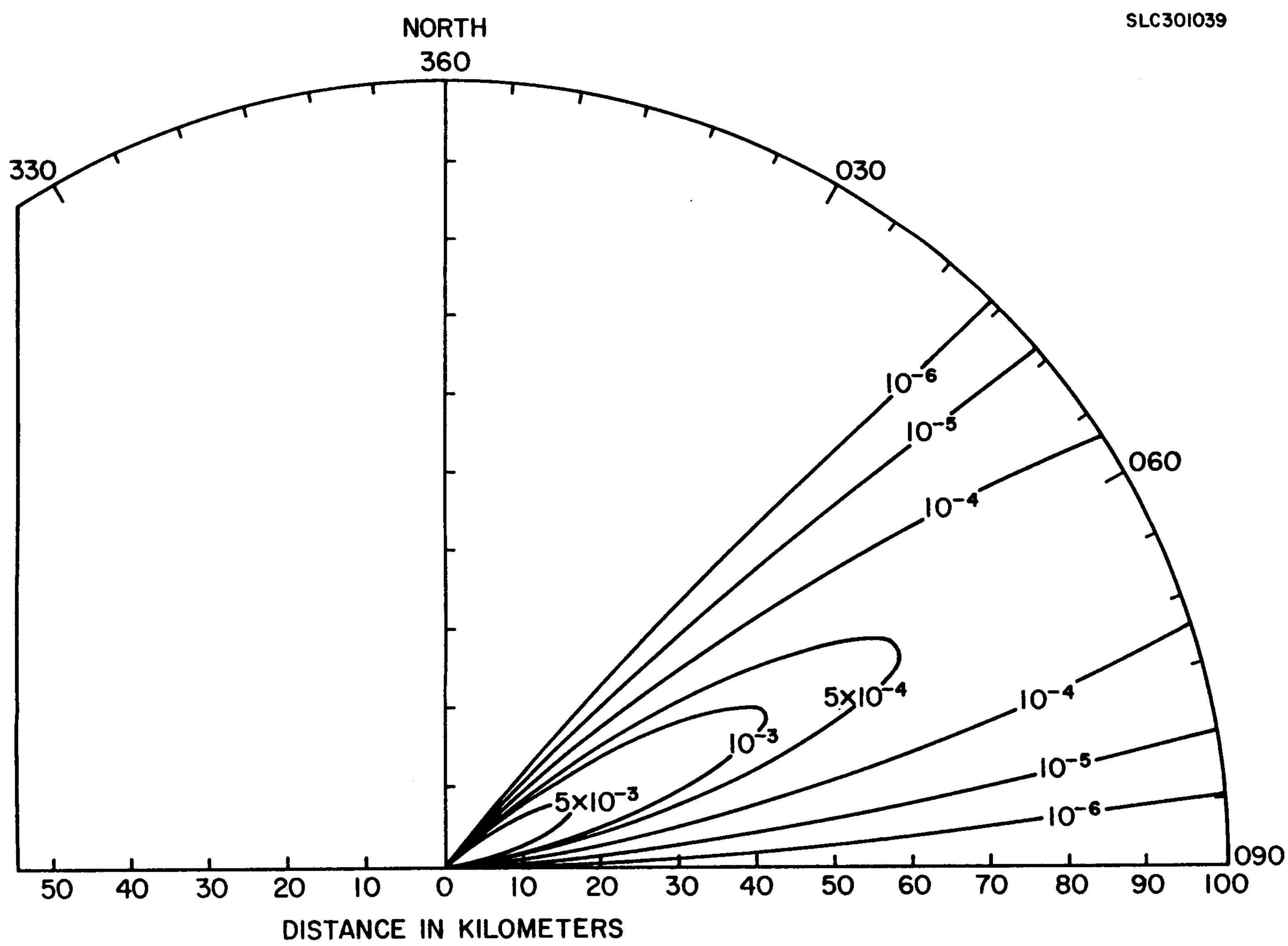

FIGURE E-30. Concentration isopleths in grams per cubic meter at a height of 853 meters for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

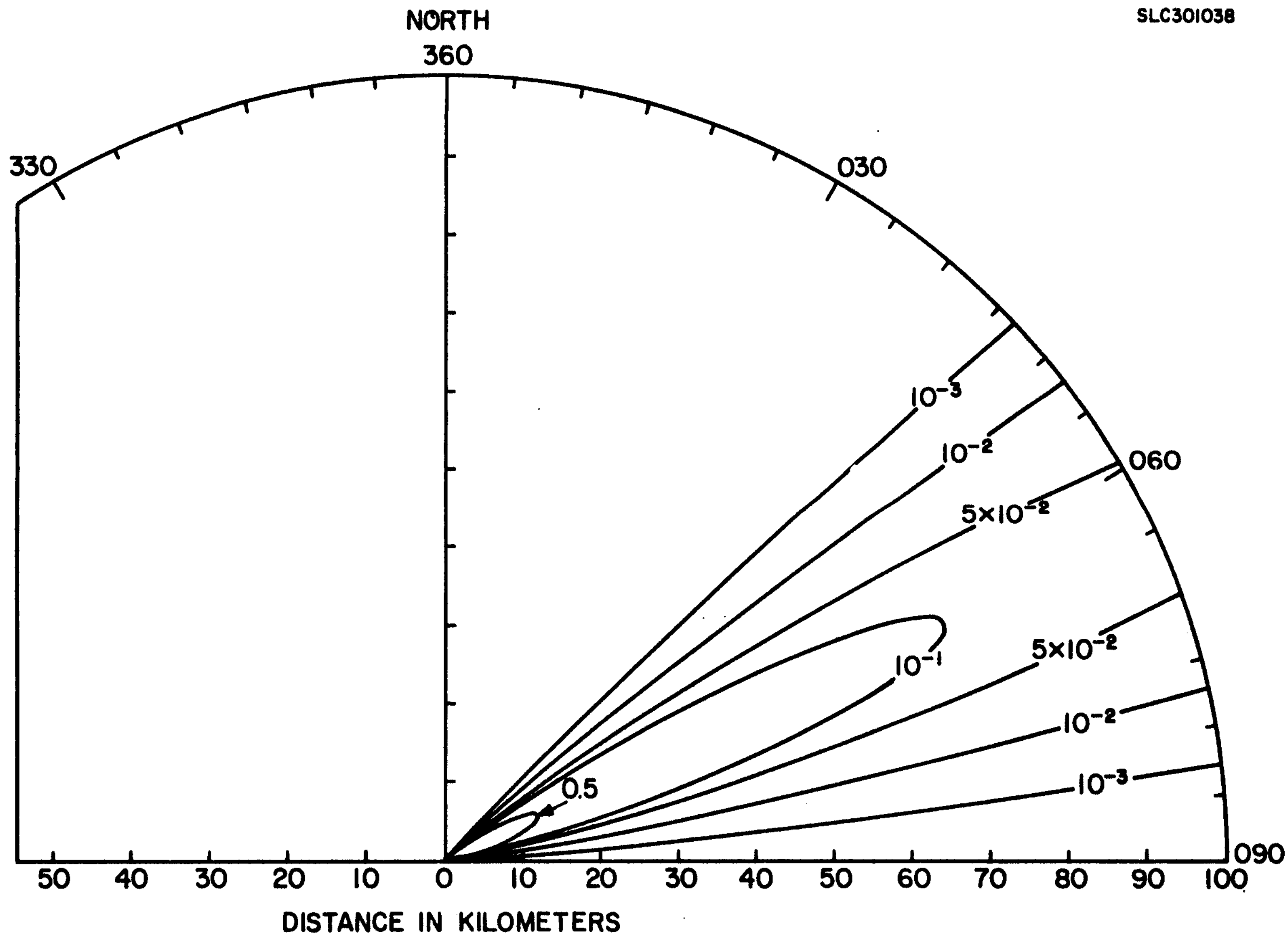

FIGURE E-31. Dosage isopleths in grams seconds per cubic meter at a height of 853 meters for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

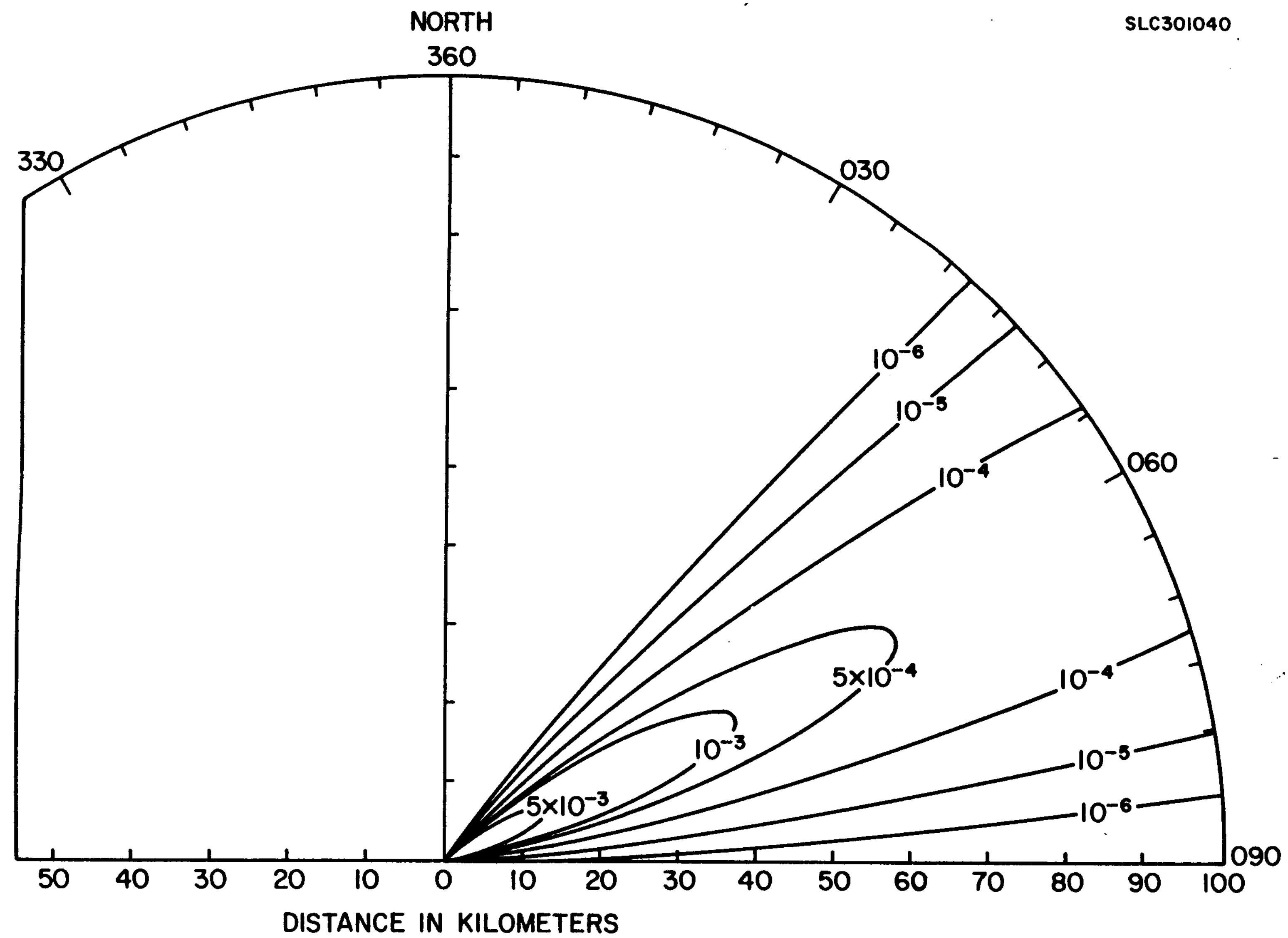

FIGURE E-32. Concentration isopleths in grams per cubic meter at a height of 1829 meters for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

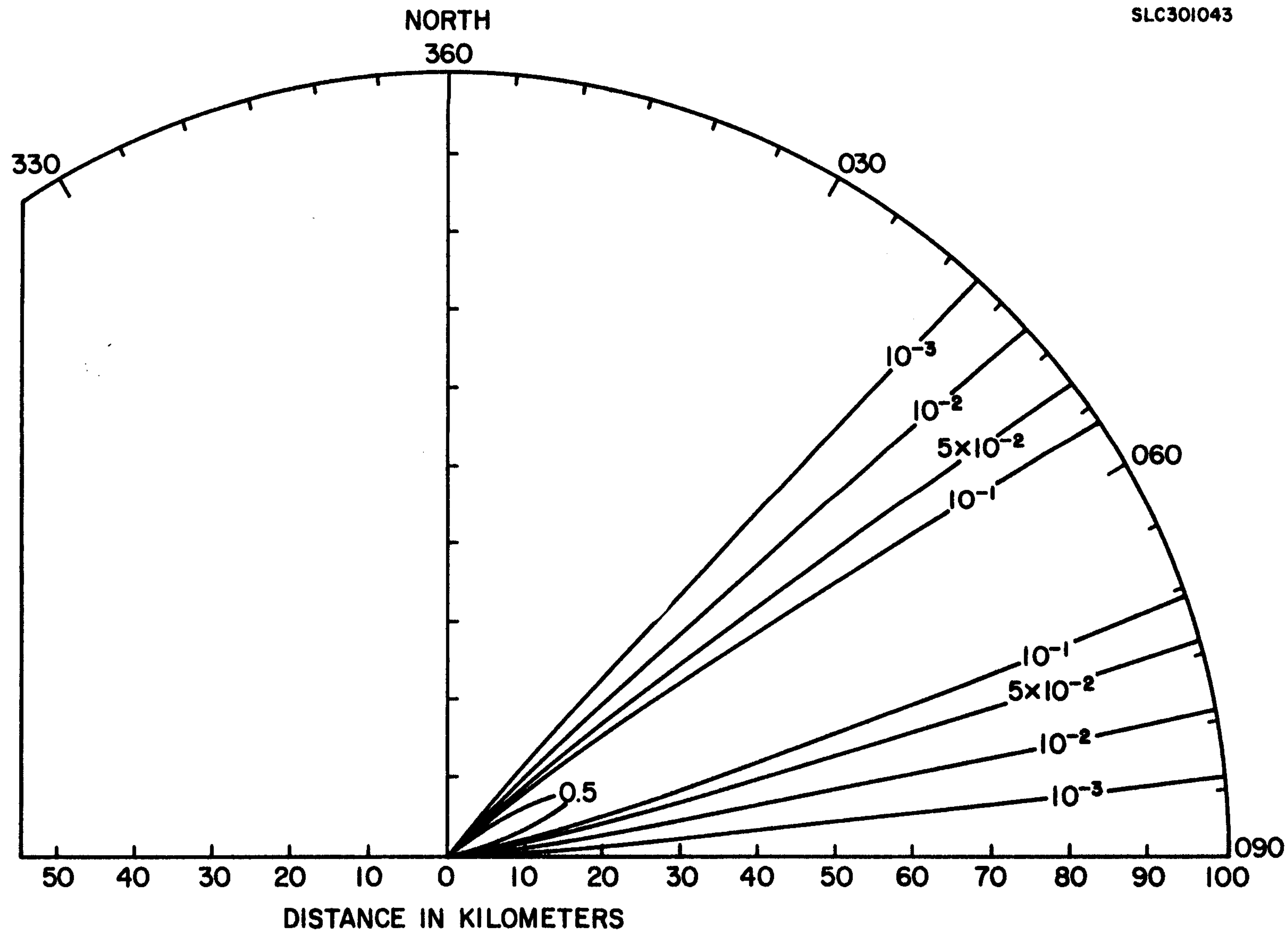

FIGURE E-33. Dosage isopleths in grams seconds per cubic meter at a height of 1829 meters for a vehicle destruct at 1350 meters, 2315 GMT, 27 November 1966.

TABLE E-7

PROGRAM INPUTS

Example Problem: Cold Spill in the Surface Layer for Pre-Cold Front Situation, 2315 GMT, 27 November 1966

MODEL NO. 3				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Source Inputs			
Q_K (g sec^{-1})	100			
$\sigma_{yo}\{K\}$ (m)	11.6			
$\sigma_{zo}\{K\}$ (m)	1			
$\sigma_{xo}\{K\}$ (m)	11.6			
τ_K (sec)	600			
H_K (m)	-			
k	-			

TABLE E-7 (Continued)

MODEL NO. 3				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	8			
σ_{ER} (deg)	4.5			
$\bar{u}_R$ (m sec^{-1})	4.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$				
$\sigma_{ABK}\{\tau_{oK}\}$				
τ_{oK} (sec)	600			
σ_{ETK} (deg)	4.5			
σ_{EBK} (deg)				
α_K	1			
β_K	1			
$\bar{u}_{TK}$ (m sec^{-1})	6.7			
$\bar{u}_{BK}$ (m sec^{-1})				
θ_{TK} (deg)	231			
θ_{BK} (deg)	160			
z_{TK} (m)	853			
z_{BK} (m)	2			
Λ (sec^{-1})				
z_{lim} (m)				
t_1 (sec)				
t^* (sec)				

SLC301108

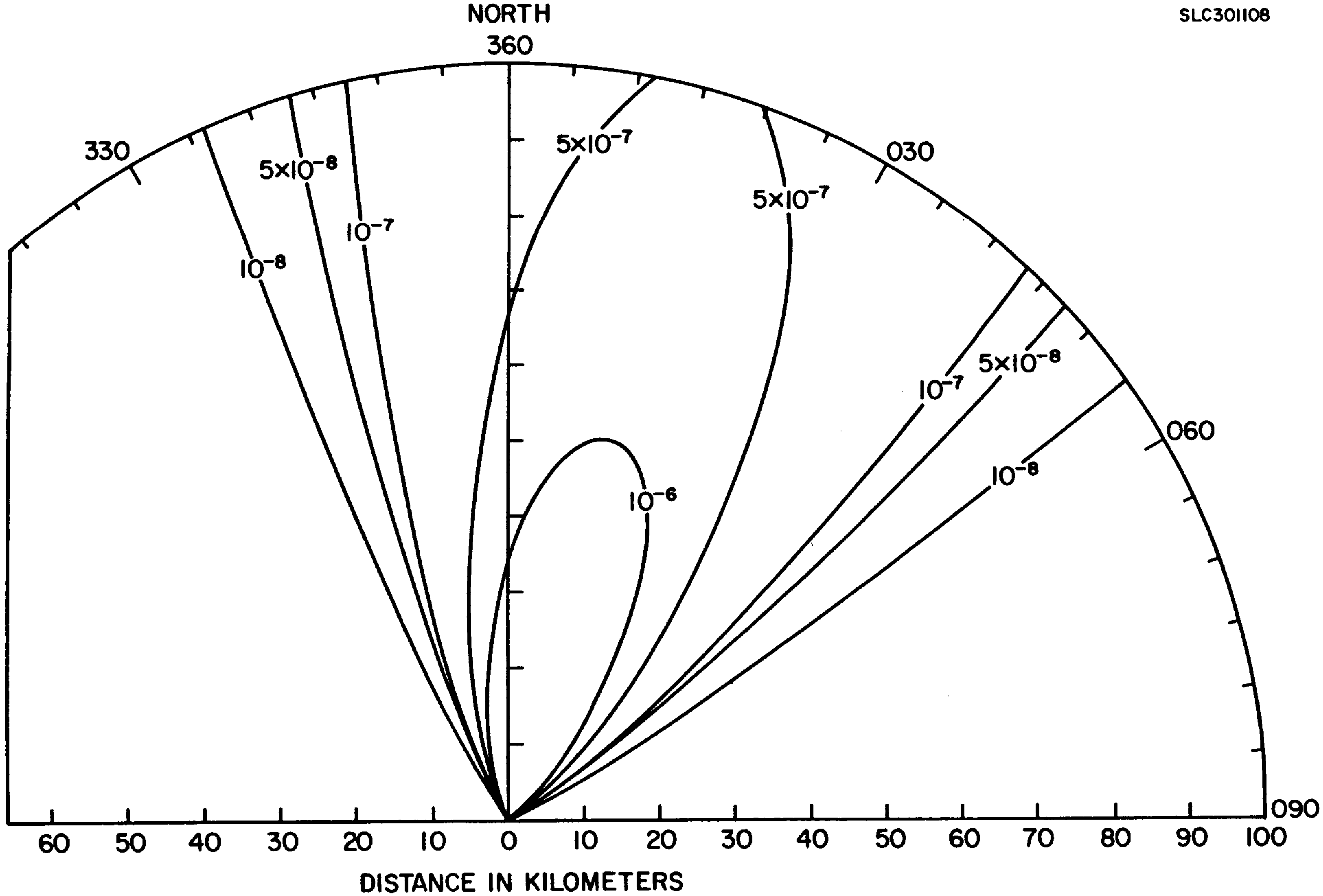

FIGURE E-34. Ground-level concentration isopleths in grams per cubic meter for a large surface spill, 2315 GMT, 27 November 1966.

E.4 CONCENTRATION AND DOSAGE PATTERNS FOR THE SUMMERTIME BERMUDA HIGH SITUATION - 0515 GMT, 12 MAY 1967

This section contains the results of the example calculations for the various source modes for the summertime Bermuda High regime discussed in Section E.1.2.

E.4.1 Normal Launch

The source and meteorological inputs for the normal launch calculations are given in Table E-8. Figures E-35 and E-36 respectively show the maximum ground-level concentrations and dosages downwind from the launch pad. Figures E-37 and E-38 show ground-level concentration and dosage isopleths. Concentration and dosage isopleths at the bases of the three layers above the surface layer are shown in Figures E-39 through E-44.

E.4.2 Vehicle Destruct at the Surface

The source and meteorological inputs for the surface vehicle destruct example are given in Table E-9. Figures E-45 and E-46 respectively show the maximum ground-level concentrations and dosages downwind from the launch pad. Isopleths of ground-level concentration and dosage, respectively, are shown in Figures E-47 and E-48. Figures E-49 and E-50 show concentration and dosage isopleths at the base of the second layer. Since the bulk of the material released in the surface destruct ascended to the second layer due to buoyancy, the concentrations and dosages in the second layer are much higher than at the surface.

E.4.3 Vehicle Destruct Aloft

The source and meteorological inputs for the vehicle destruct aloft example are given in Table E-10. Maximum ground-level concentrations and

TABLE E-8

PROGRAM INPUTS

Example Problem: Normal Launch for Summertime Bermuda High Situation, 0515 GMT, 12 May 1967

MODEL NO. 1				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Source Inputs			
Q_K $(g\ m^{-1})$	1.32×10^4	5.24×10^3	3.84×10^3	2.82×10^3
$\sigma_{yo}\{K\}$ (m)	290	150	100	75
$\sigma_{zo}\{K\}$ (m)	-	-	-	-
$\sigma_{xo}\{K\}$ (m)	290	150	100	75
τ_K (sec)	28	6	11	11
H_K (m)	-			
k	-			

TABLE E-8 (Continued)

MODEL NO. 1				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oK}\}$ (deg)	6			
σ_{ER} (deg)	3			
$\bar{u}_R$ (m sec^{-1})	3.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	3	0	0	0
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		3	0	0
τ_{oK} (sec)	600	600	600	600
σ_{ETK} (deg)	1	0	0	0
σ_{EBK} (deg)		1	0	0
α_K	1	1	1	1
β_K	1	1	1	1
$\bar{u}_{TK}$ (m sec^{-1})	8.24	7.73	6.70	11.3
$\bar{u}_{BK}$ (m sec^{-1})		8.24	7.73	6.70
θ_{TK} (deg)	237	263	303	328
θ_{BK} (deg)	200	237	263	303
z_{TK} (m)	1067	1615	3048	5000
z_{BK} (m)	2	1067	1615	3048
Λ (sec^{-1})	-			
z_{lim} (m)	-			
t_1 (sec)	-			
t* (sec)	-			

TABLE E-9

PROGRAM INPUTS

Example Problem: Vehicle Destruct at Surface for Summertime Bermuda High Situation, 0515 GMT, 12 May 1967

MODEL NO: 1 (Layer 1), 3 (Layer 2)				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Source Inputs			
Q_K (g m^{-1})	5.63×10^4			
Q_K (g)		4×10^7		
$\sigma_{yo}\{K\}$ (m)	35	142		
$\sigma_{zo}\{K\}$ (m)	-	142		
$\sigma_{xo}\{K\}$ (m)	35	142		
τ_K (sec)	10	10		
H_K (m)		1127		
k	-			

TABLE E-9 (Continued)

MODEL NO: 1 (Layer 1), 3 (Layer 2)				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oK}\}$ (deg)	6			
σ_{ER} (deg)	3			
$\bar{u}_R$ (m sec^{-1})	3.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	3	0		
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		3		
τ_{oK} (sec)	600	600		
σ_{ETK} (deg)	1	0		
σ_{EBK} (deg)		1		
α_K	1	1		
β_K	1	1		
$\bar{u}_{TK}$ (m sec^{-1})	8.24	7.73		
$\bar{u}_{BK}$ (m sec$^{-1}\theta$		8.24		
θ_{TK} (deg)	237	263		
θ_{BK} (deg)	200	237		
z_{TK} (m)	1067	1615		
z_{BK} (m)	2	1067		
Λ (sec^{-1})	-			
z_{lim} (m)	-			
t_1 (sec)	-			
t* (sec)	-			

TABLE E-10

PROGRAM INPUTS

Example Problem: Vehicle Destruct Aloft for Summertime Bermuda High Situation, 0515 GMT, 12 May 1967

MODEL NO. 1 (Layer 1), 1 (Layer 2), 3 (Layer 3)				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Source Inputs			
Q_K (g m^{-1})	1.32×10^4	1.72×10^4		
Q_K (g)			7.64×10^7	
$\sigma_{yo}\{K\}$ (m)	290	100	142	
$\sigma_{zo}\{K\}$ (m)	-	-	400	
$\sigma_{xo}\{K\}$ (m)	290	100	142	
τ_K (sec)	28	10	10	
H_K (m)			2473	
k	-			

TABLE E-10 (Continued)

MODEL NO. 1 (Layer 1), 1 (Layer 2), 3 (Layer 3)				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	6			
σ_{ER} (deg)	3			
$\bar{u}_R$ (m sec^{-1})	3.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	3	0	0	
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		3	0	
τ_{oK} (sec)	600	600	600	
σ_{ETK} (deg)	1	0	0	
σ_{EBK} (deg)		1	0	
α_K	1	1	1	
β_K	1	1	1	
$\bar{u}_{TK}$ (m sec^{-1})	8.24	7.73	6.70	
$\bar{u}_{BK}$ (m sec^{-1})		8.24	7.73	
θ_{TK} (deg)	237	263	303	
θ_{BK} (deg)	200	237	263	
z_{TK} (m)	1067	1615	3048	
z_{BK} (m)	2	1067	1615	
Λ (sec^{-1})	-			
z_{lim} (m)	-			
t_1 (sec)	-			
t* (sec)	-			

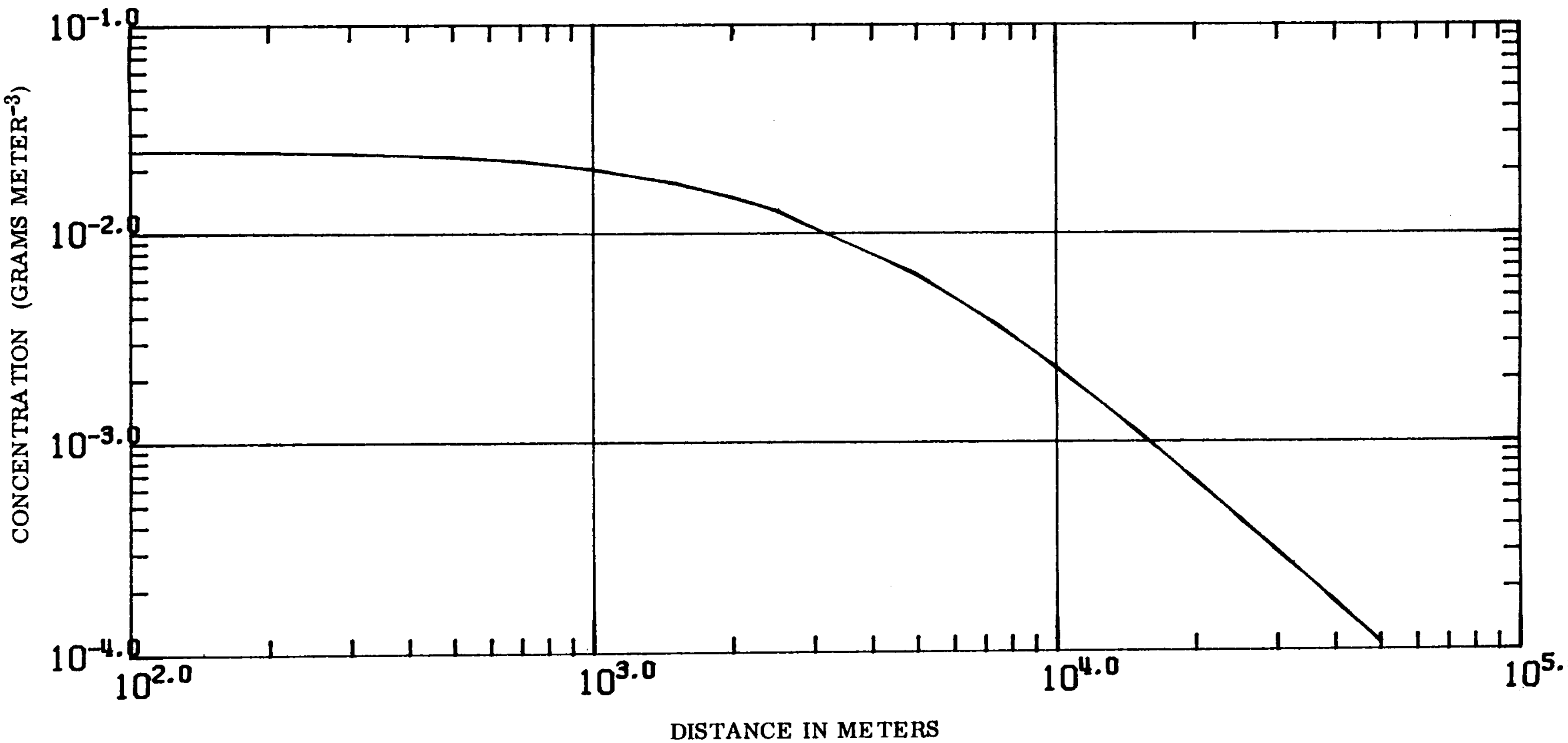

FIGURE E-35. Maximum ground-level concentration for a normal launch, 0515 GMT, 12 May 1967.

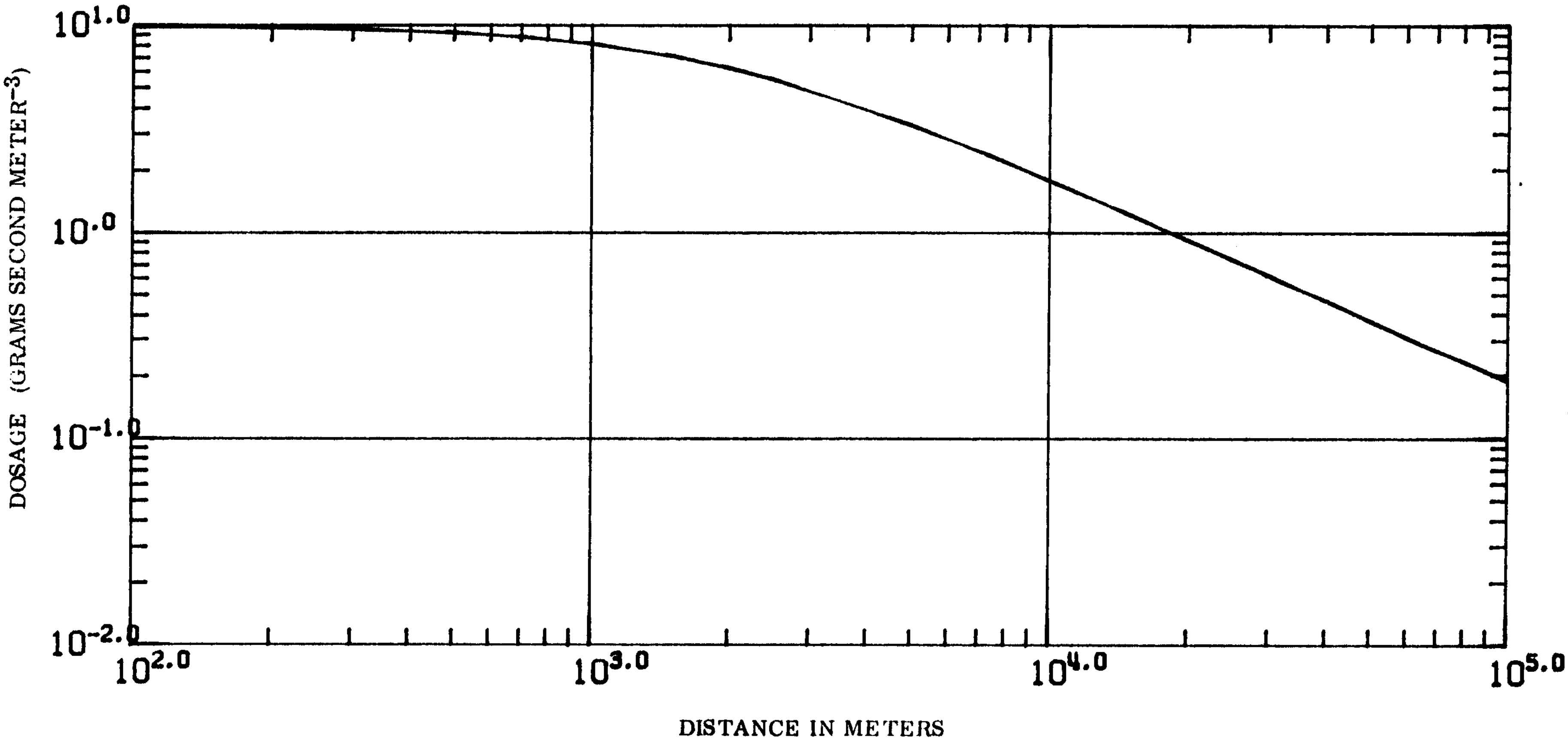

FIGURE E-36. Maximum ground-level dosage for a normal launch, 0515 GMT, 12 May 1967.

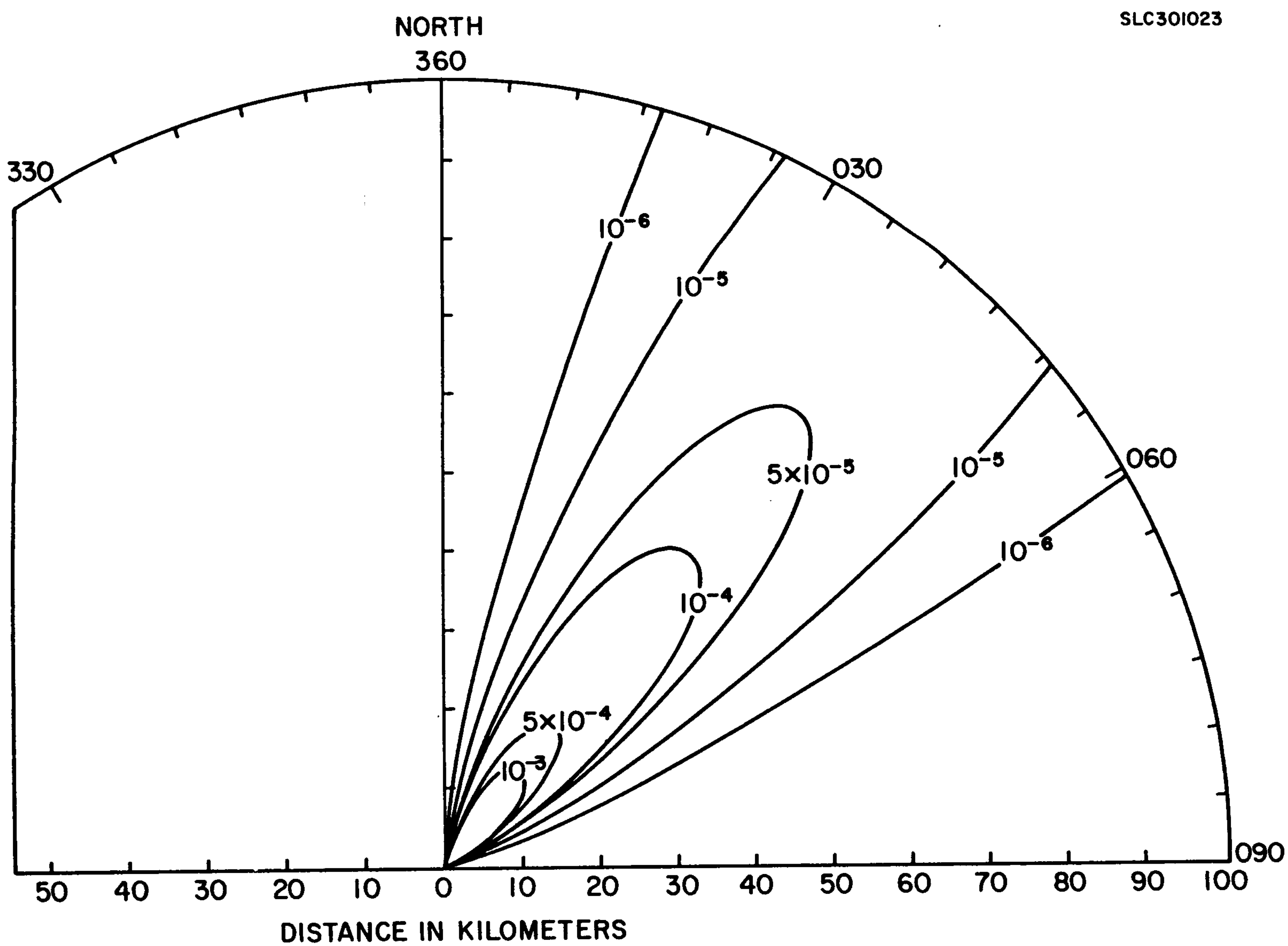

FIGURE E-37. Ground-level concentration isopleths in grams per cubic meter for a normal launch, 0515 GMT, 12 May 1967.

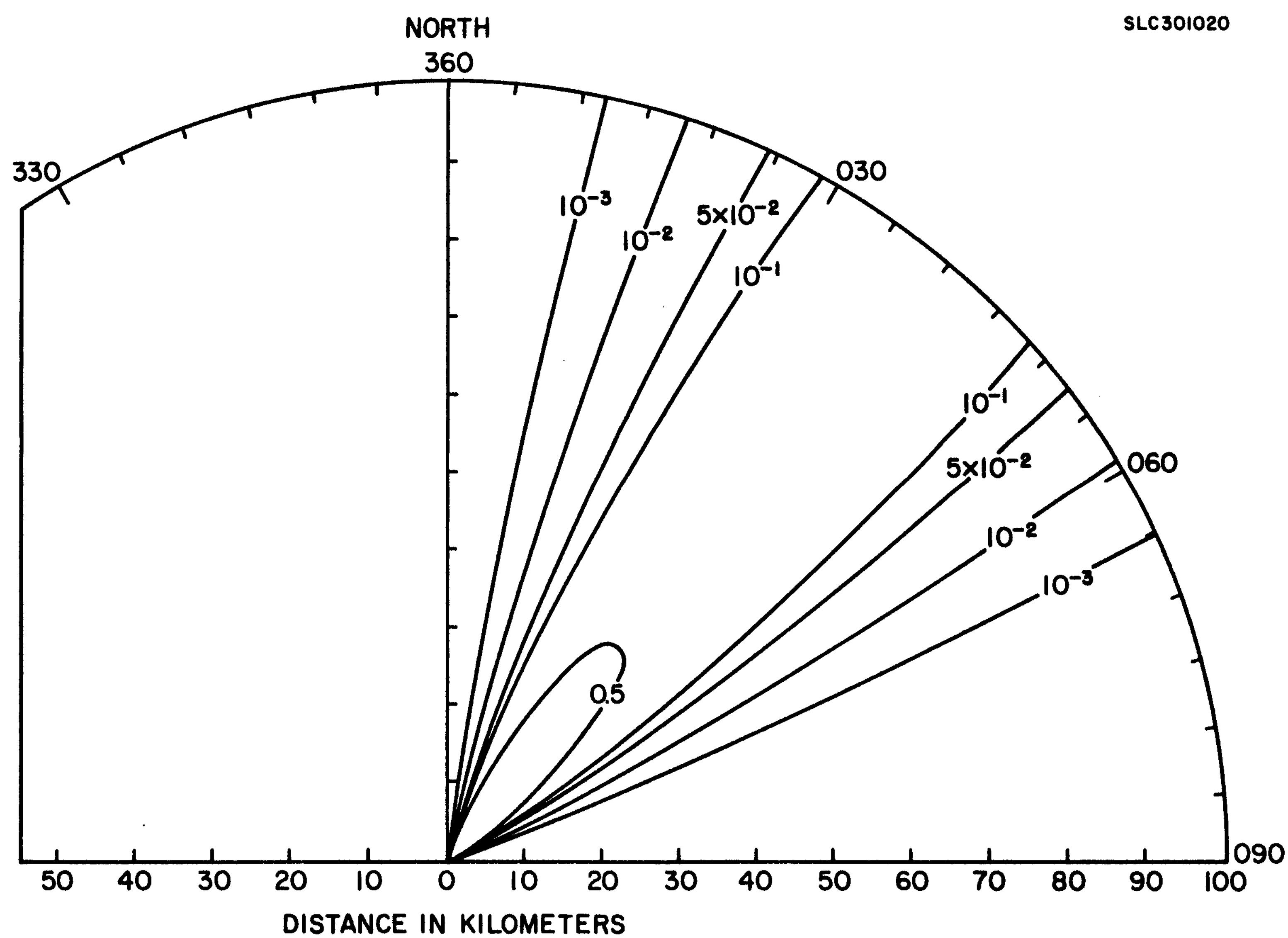

FIGURE E-38. Ground-level dosage isopleths in grams seconds per cubic meter for a normal launch, 0515 GMT, 12 May 1967.

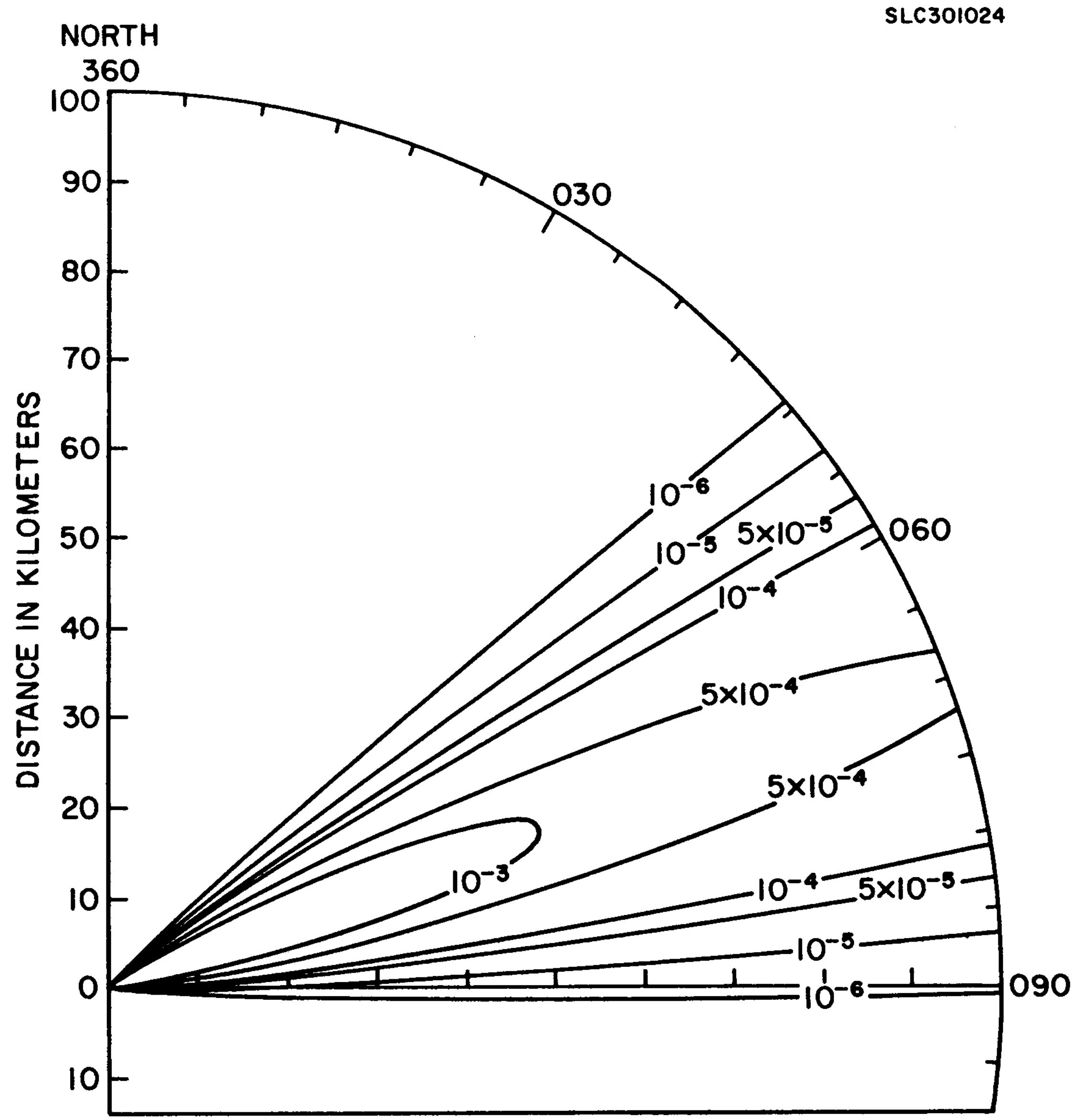

FIGURE E-39. Concentration isopleths in grams per cubic meter at a height of 1067 meters for a normal launch, 0515 GMT, 12 May 1967.

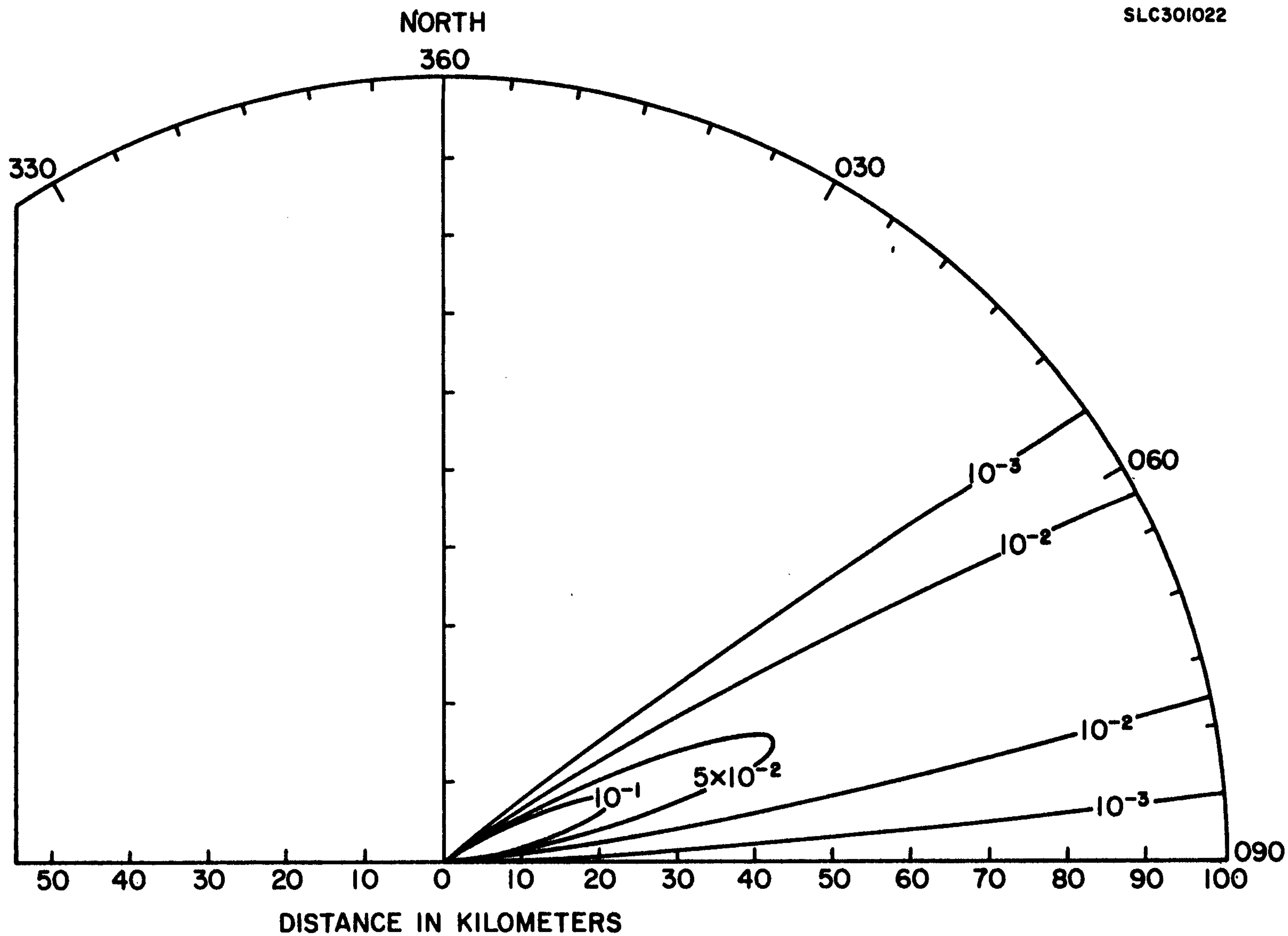

FIGURE E-40. Dosage isopleths in grams seconds per cubic meter at a height of 1067 meters for a normal launch, 0515 GMT, 12 May 1967.

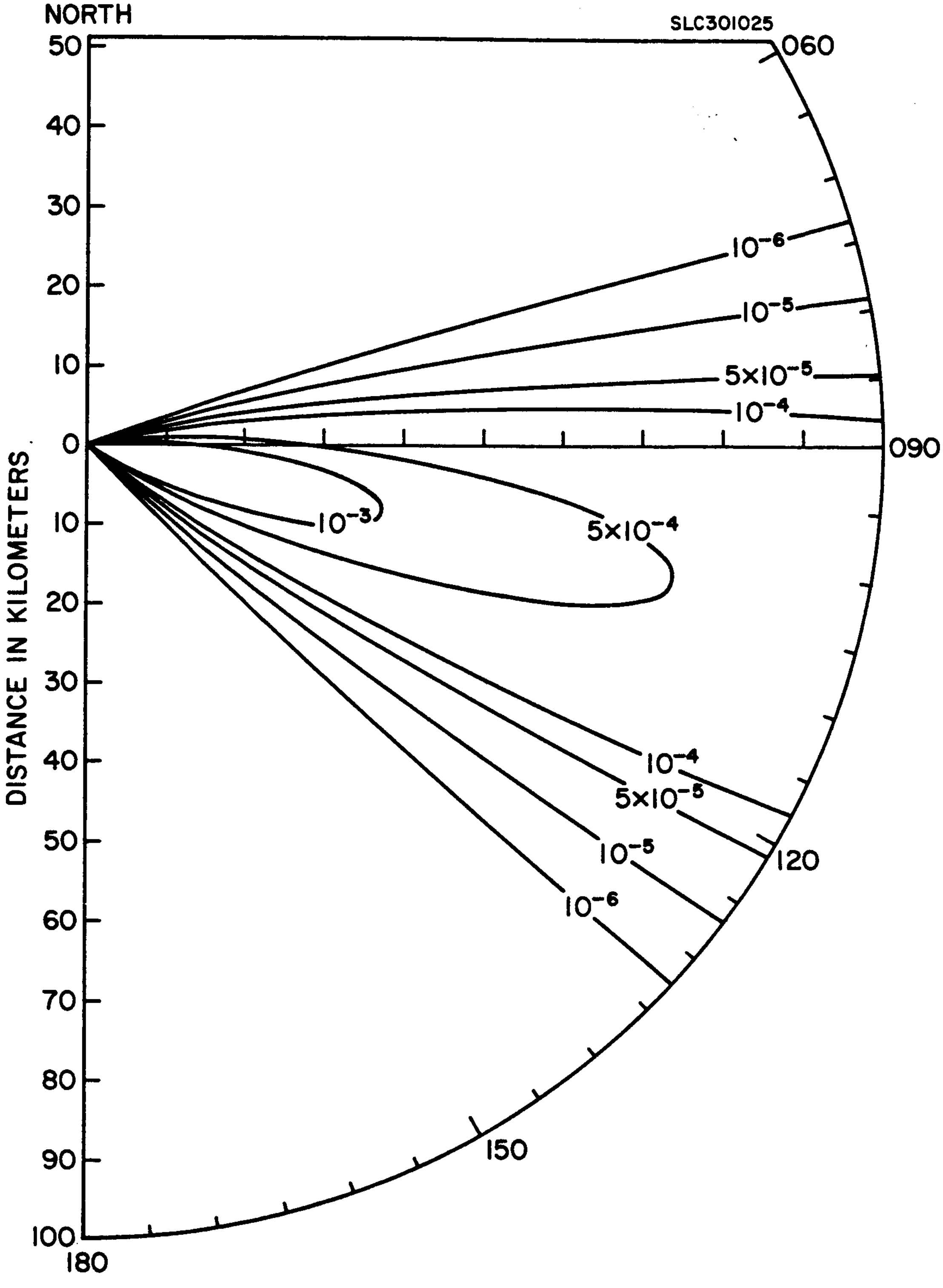

FIGURE E-41. Concentration isopleths in grams per cubic meter at a height of 1615 meters for a normal launch, 0515 GMT, 12 May 1967.

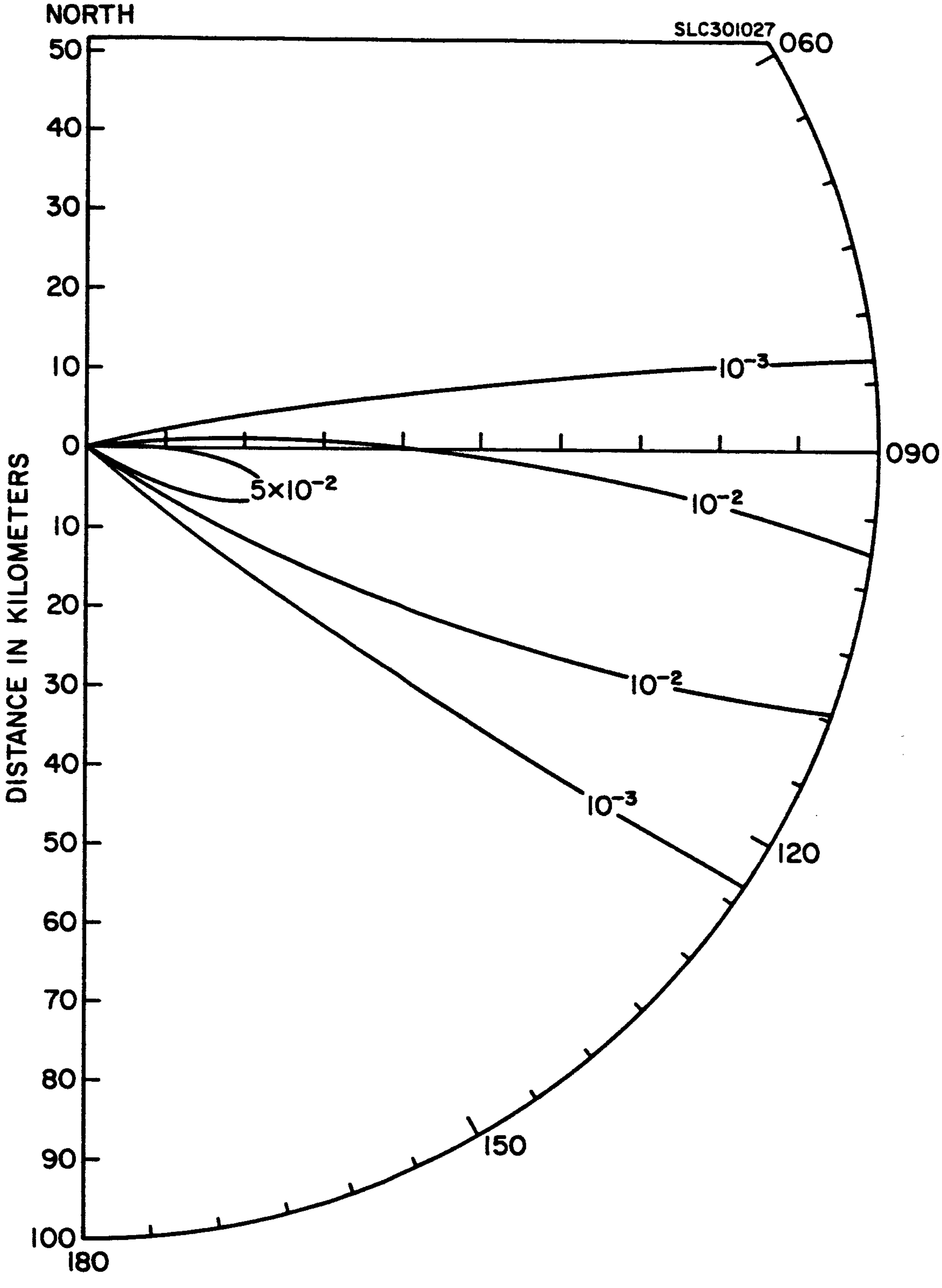

FIGURE E-42. Dosage isopleths in grams seconds per cubic meter at a height of 1615 meters for a normal launch, 0515 GMT, 12 May 1967.

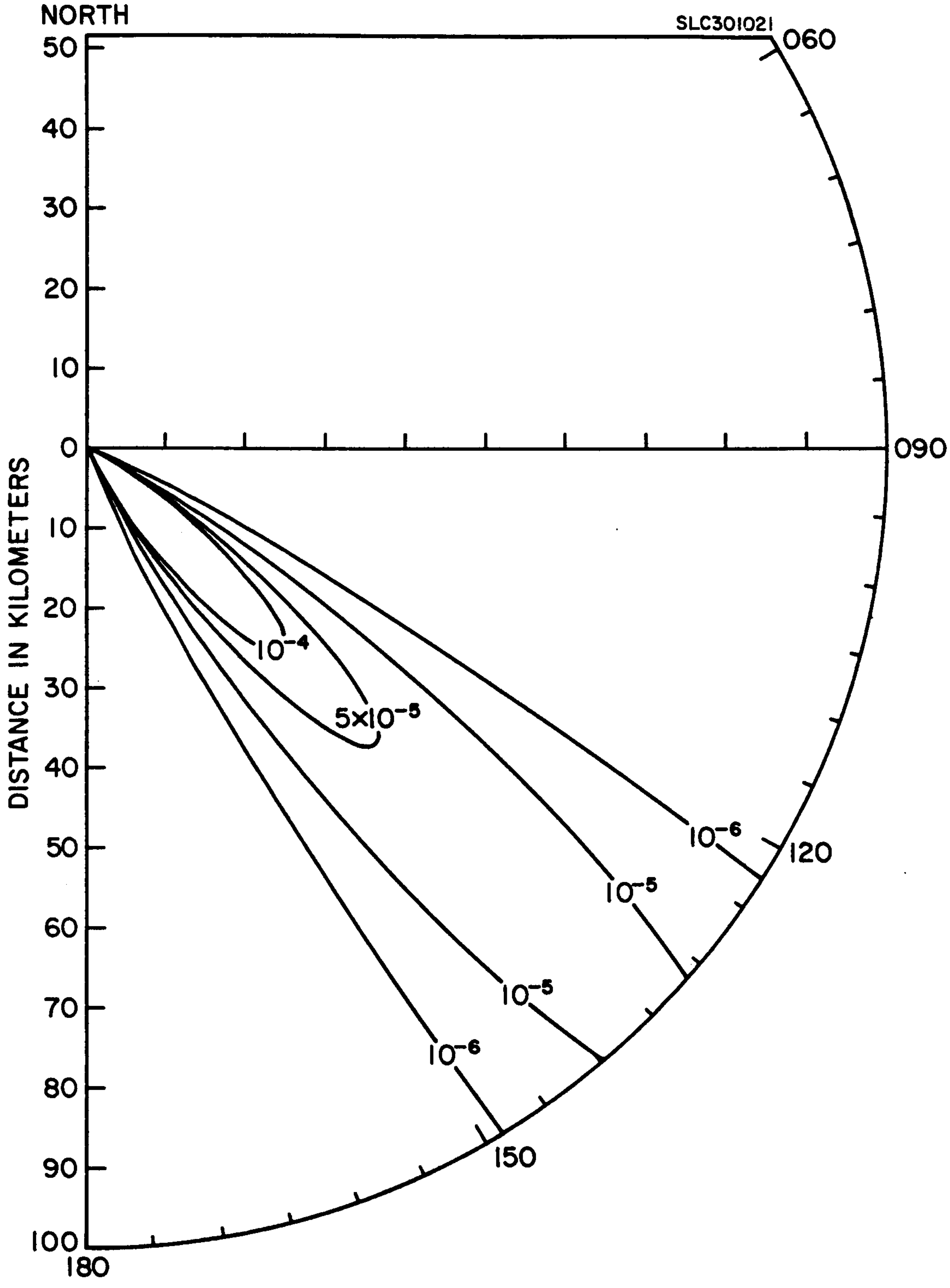

FIGURE E-43. Concentration isopleths in grams per cubic meter at a height of 3048 meters for a normal launch, 0515 GMT, 12 May 1967.

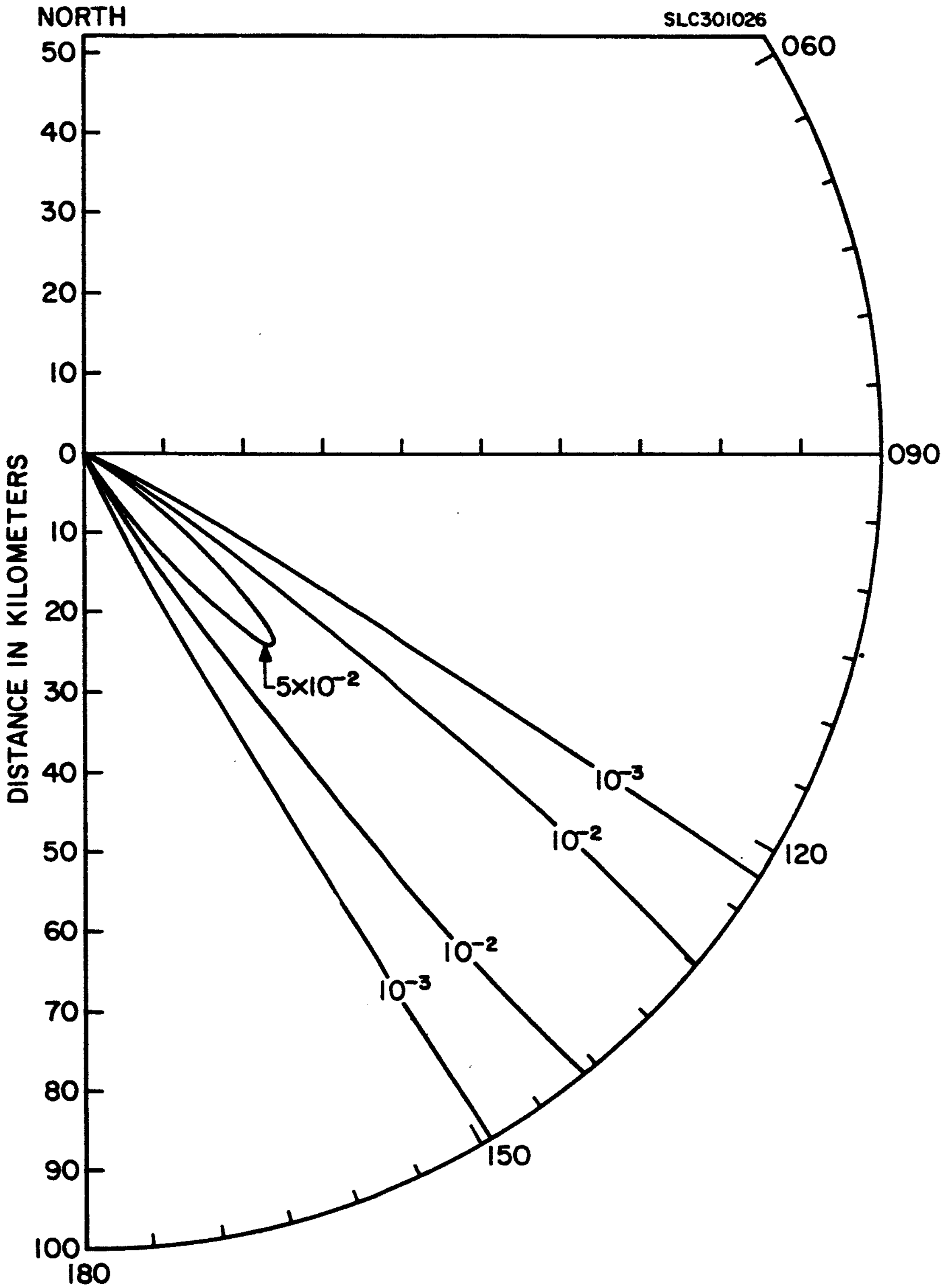

FIGURE E-44. Dosage isopleths in grams seconds per cubic meter at a height of 3048 meters for a normal launch, 0515 GMT, 12 May 1967.

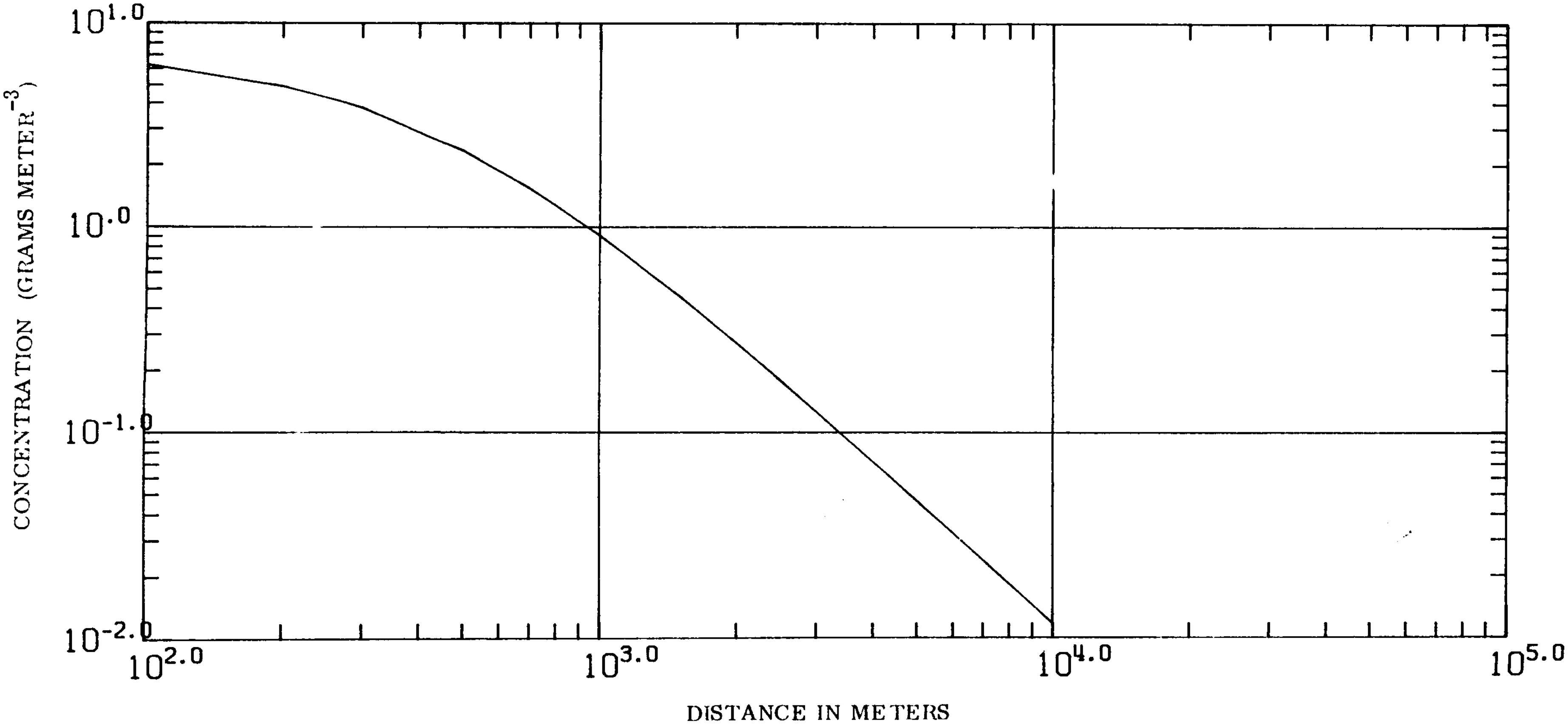

FIGURE E-45. Maximum ground-level concentration for a vehicle destruct on pad, 0515 GMT, 12 May 1967.

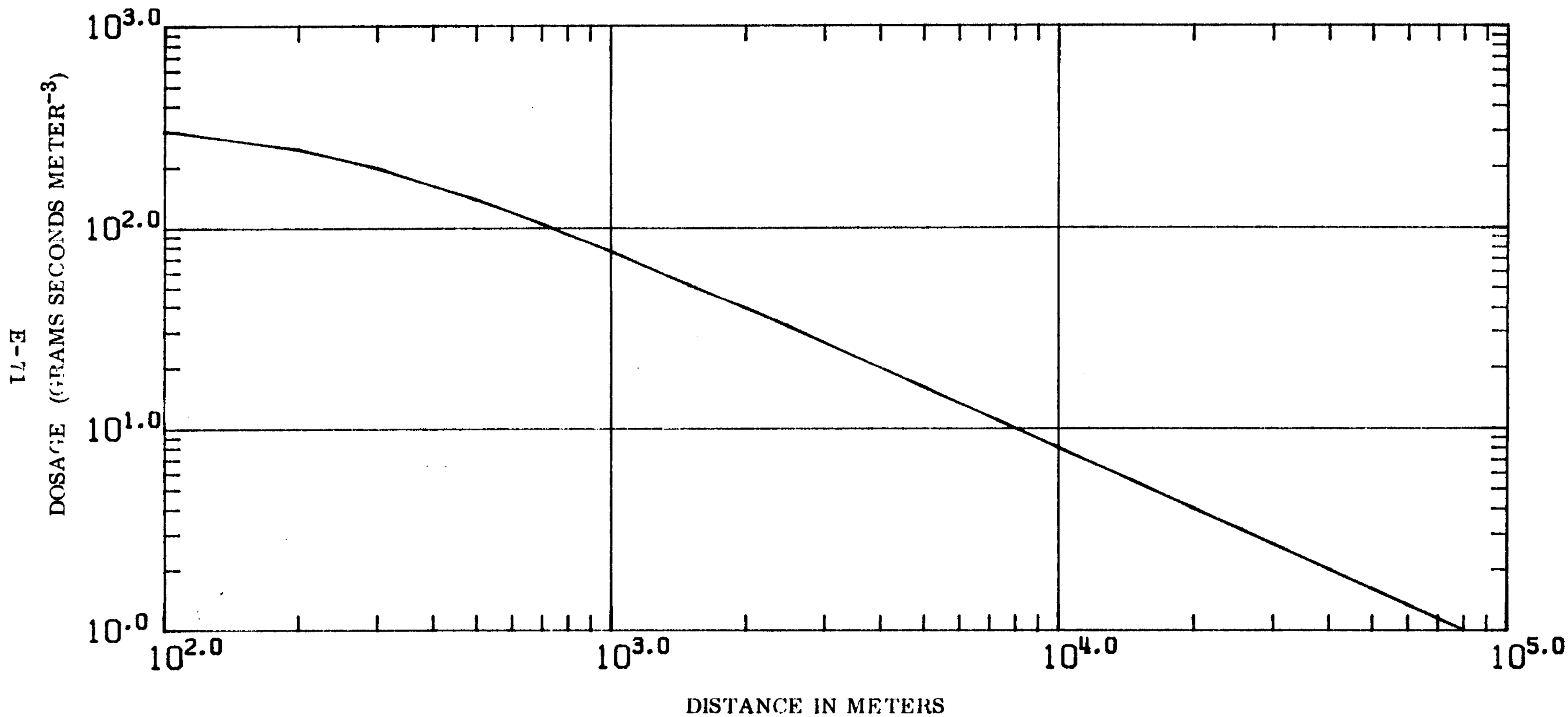

FIGURE E-46. Maximum ground-level dosage for a vehicle destruct on pad, 0515 GMT, 12 May 1967.

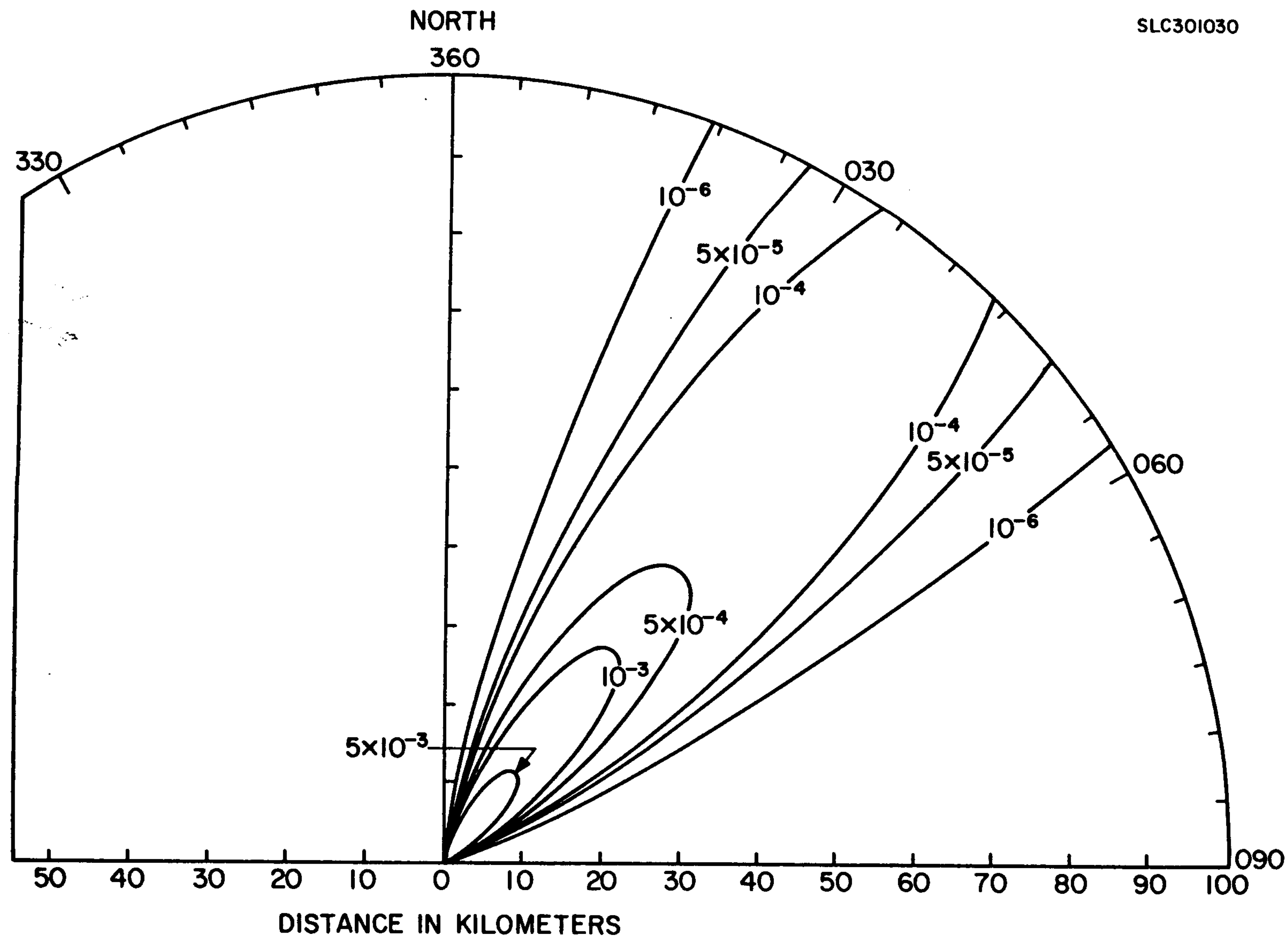

FIGURE E-47. Ground-level concentration isopleths in grams per cubic meter for a vehicle destruct on the pad, 0515 GMT, 12 May 1967.

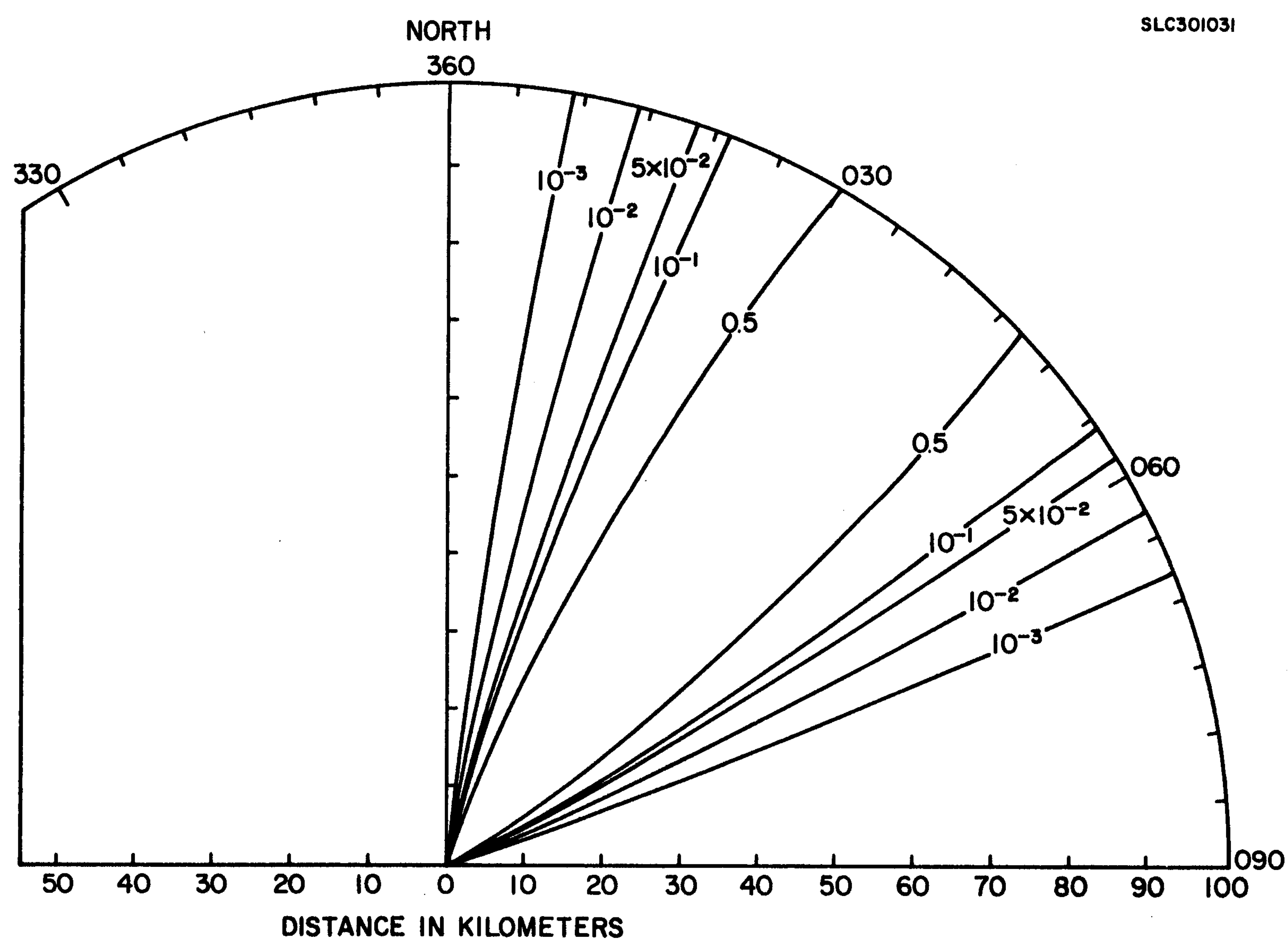

FIGURE E-48. Ground-level dosage isopleths in grams seconds per cubic meter for a vehicle destruct on the pad, 0515 GMT, 12 May 1967.

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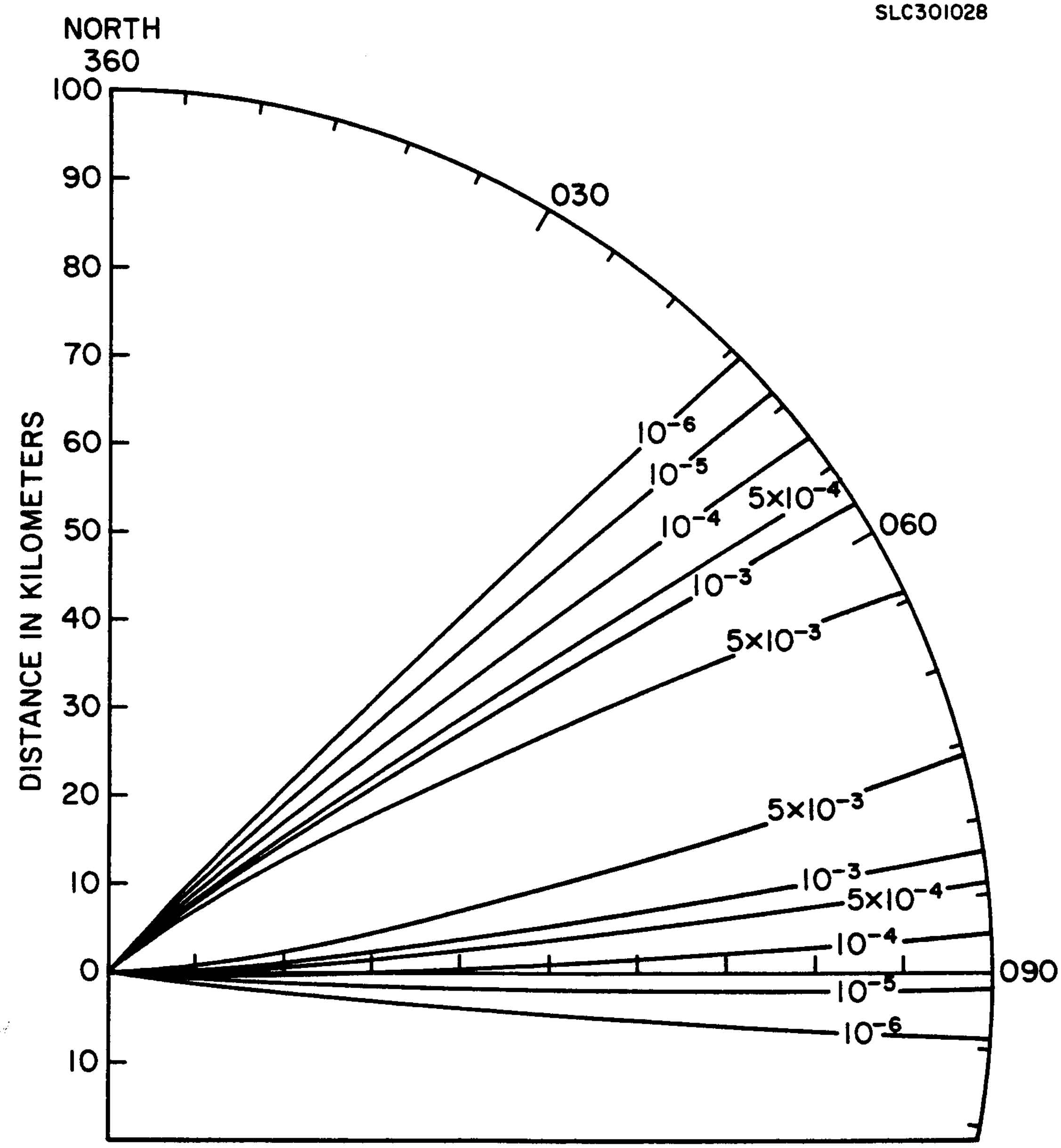

FIGURE E-49. Concentration isopleths in grams per cubic meter at a height of 1067 meters for a vehicle destruct on the pad, 0515 GMT, 12 May 1967.

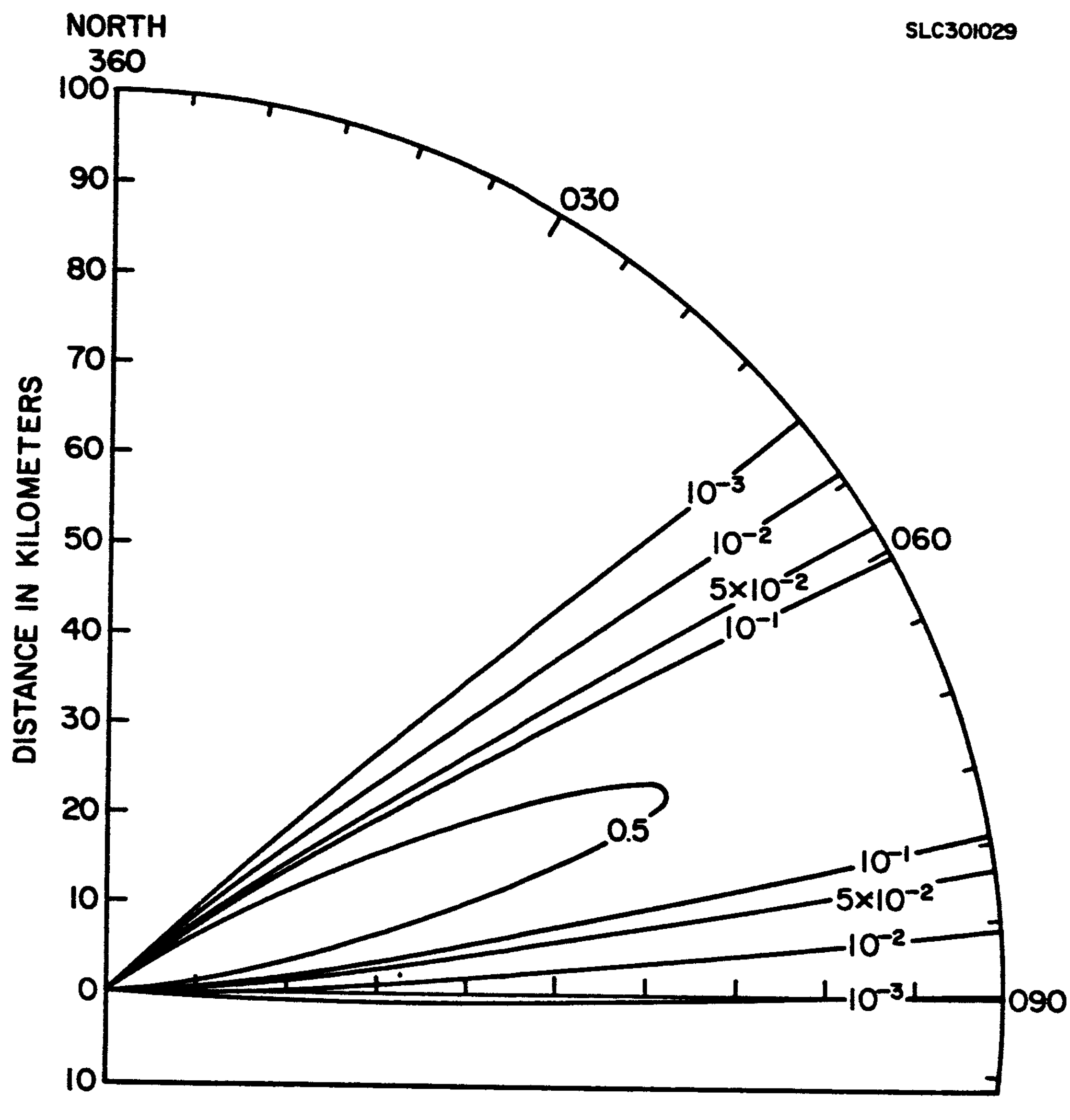

FIGURE E-50. Dosage isopleths in grams seconds per cubic meter at a height of 1067 meters for a vehicle destruct on the pad, 0515 GMT, 12 May 1967.

and dosages are shown, respectively, in Figures E-51 and E-52. Figures E-53 and E-54 respectively show ground-level isopleths of concentration and dosage. The curves in Figures E-51 through E-54 are similar to the corresponding curves in Figures E-35 through E-38, because only the normal launch mode contributed to the toxic fuel hazard in the surface layer. Figures E-55 and E-56 respectively show concentration and dosage isopleths at the base of the second layer. Concentration and dosage isopleths at the base of the third layer are shown in Figures E-57 and E-58.

E.4.4 Cold Spill in the Surface Layer

The source and meteorological inputs for the surface cold spill are given in Table E-11. Ground-level concentration isopleths for the spill at the surface are shown in Figure E-59.

E.5 EXAMPLE CALCULATION OF GROUND-LEVEL DEPOSITION DUE TO GRAVITATIONAL SETTLING

The computer program for the multi-layer diffusion model was used to estimate the ground-level deposition pattern due to gravitational settling for a normal launch assumed to occur at 2315 GMT on 27 November 1966. The particle size distribution of material released as exhaust products and the settling velocities for various particle-size categories are given in Table E-3. The remaining source parameters and the meteorological parameters used in the example problem are given in Table E-12.

The calculated isopleths of ground-level deposition are given in Figure E-60. Inspection of Figure E-60 shows the isopleths are spread through a 180-degree sector north of the launch site, with the major ground-level deposition occurring along an east-northeast axis after the first 15 kilometers of cloud travel.

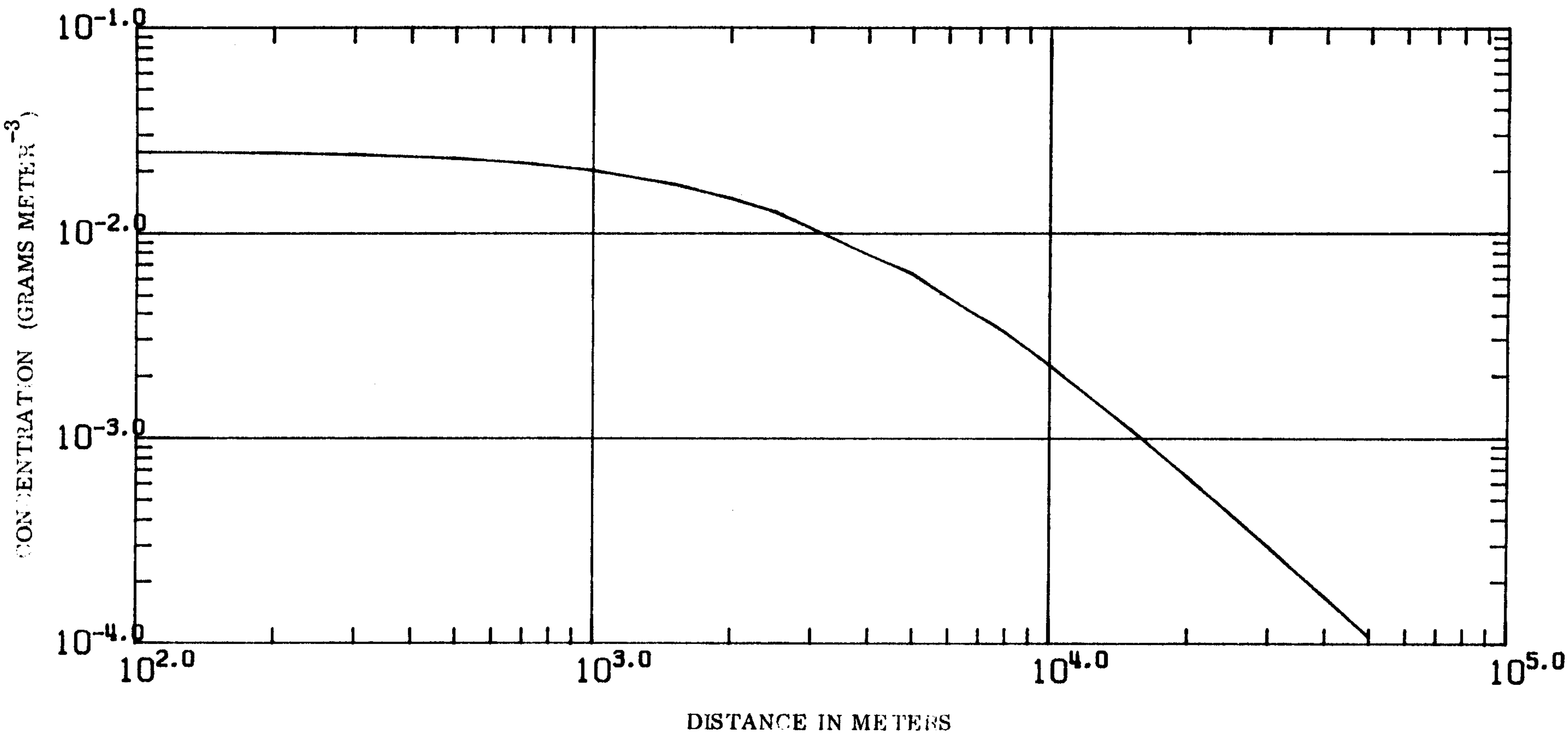

FIGURE E-51. Maximum ground-level concentration for a vehicle destruct at 1350 meters, 0515 GMT, 12 May 1967.

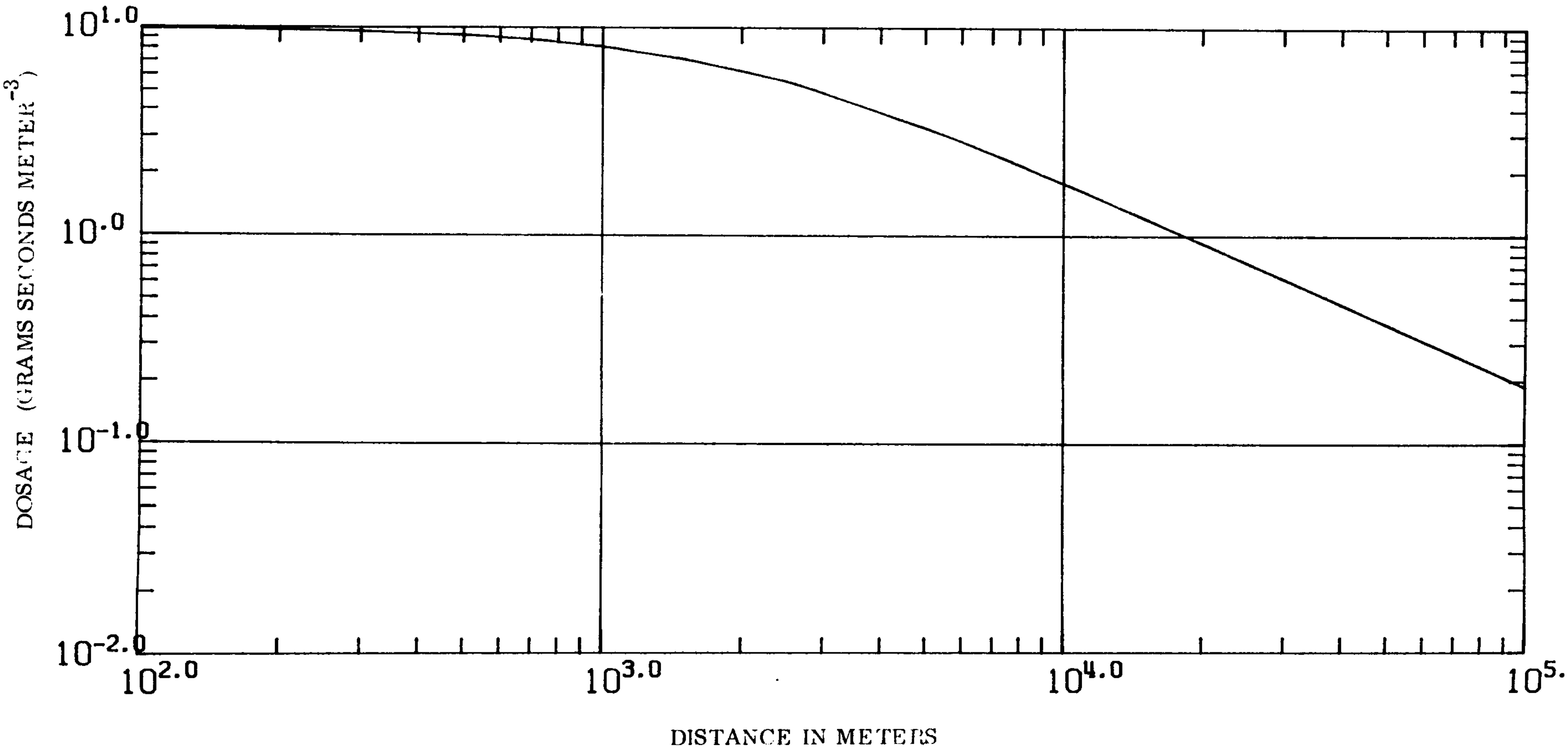

FIGURE E-52. Maximum ground-level dosage for a vehicle destruct at 1350 meters, 0515 GMT, 12 May 1967.

SLC301033

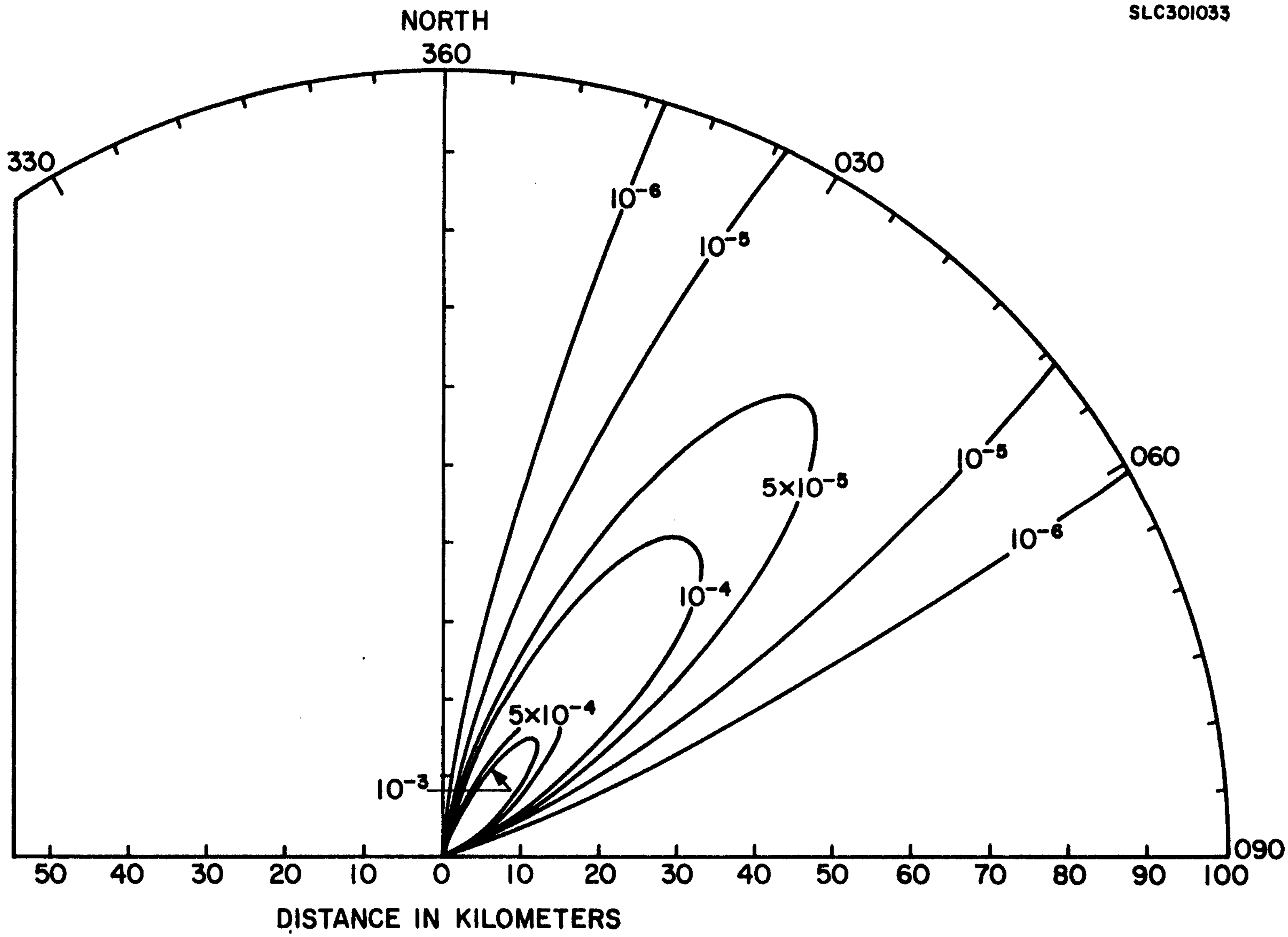

FIGURE E-53. Ground-level concentration isopleths in grams per cubic meter for a vehicle destruct at 1350 meters, 0515 GMT, 12 May 1967.

SLC301032

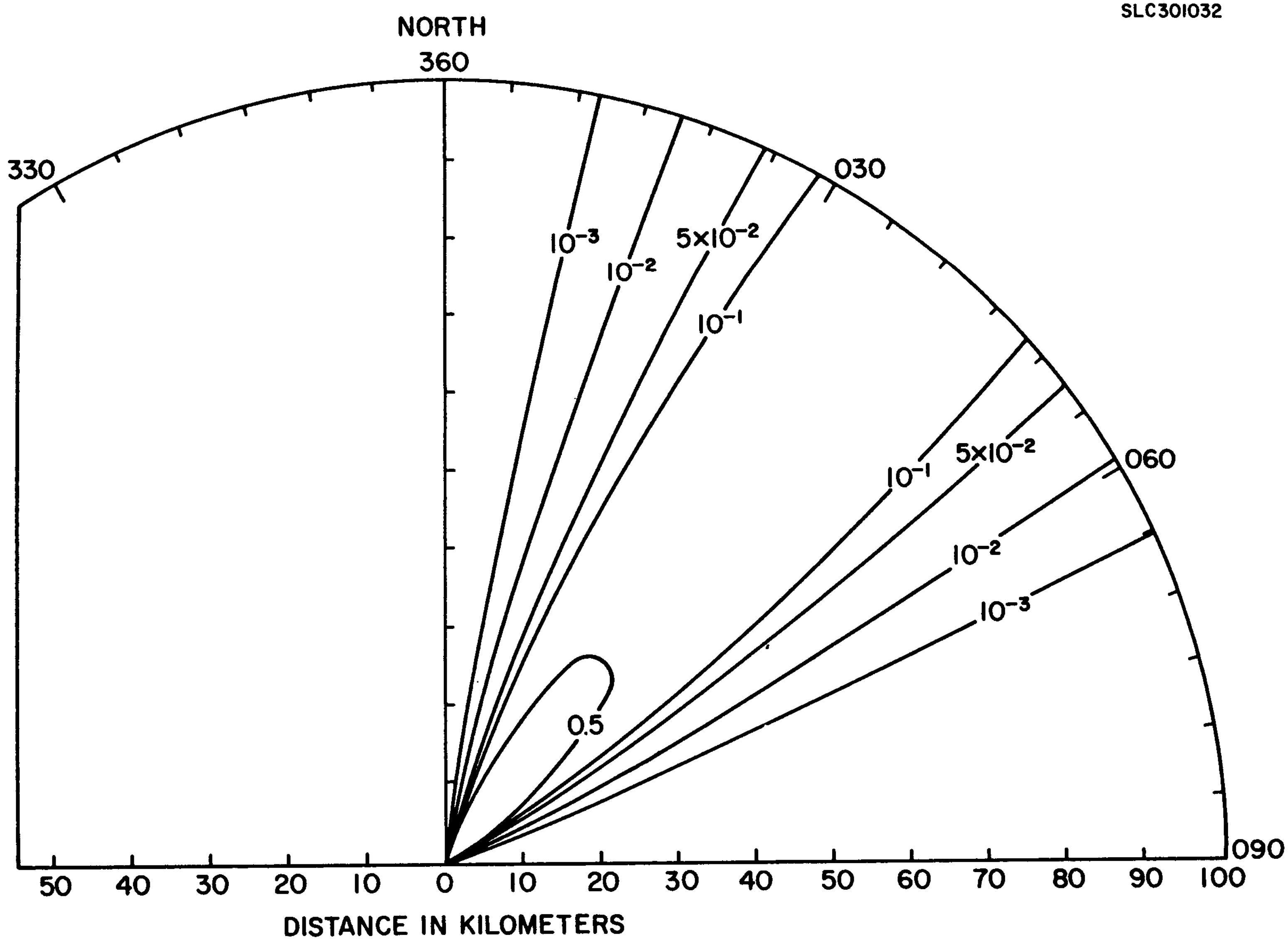

FIGURE E-54. Ground-level dosage isopleths in grams seconds per cubic meter for a vehicle destruct at 1350 meters, 0515 GMT, 12 May 1967.

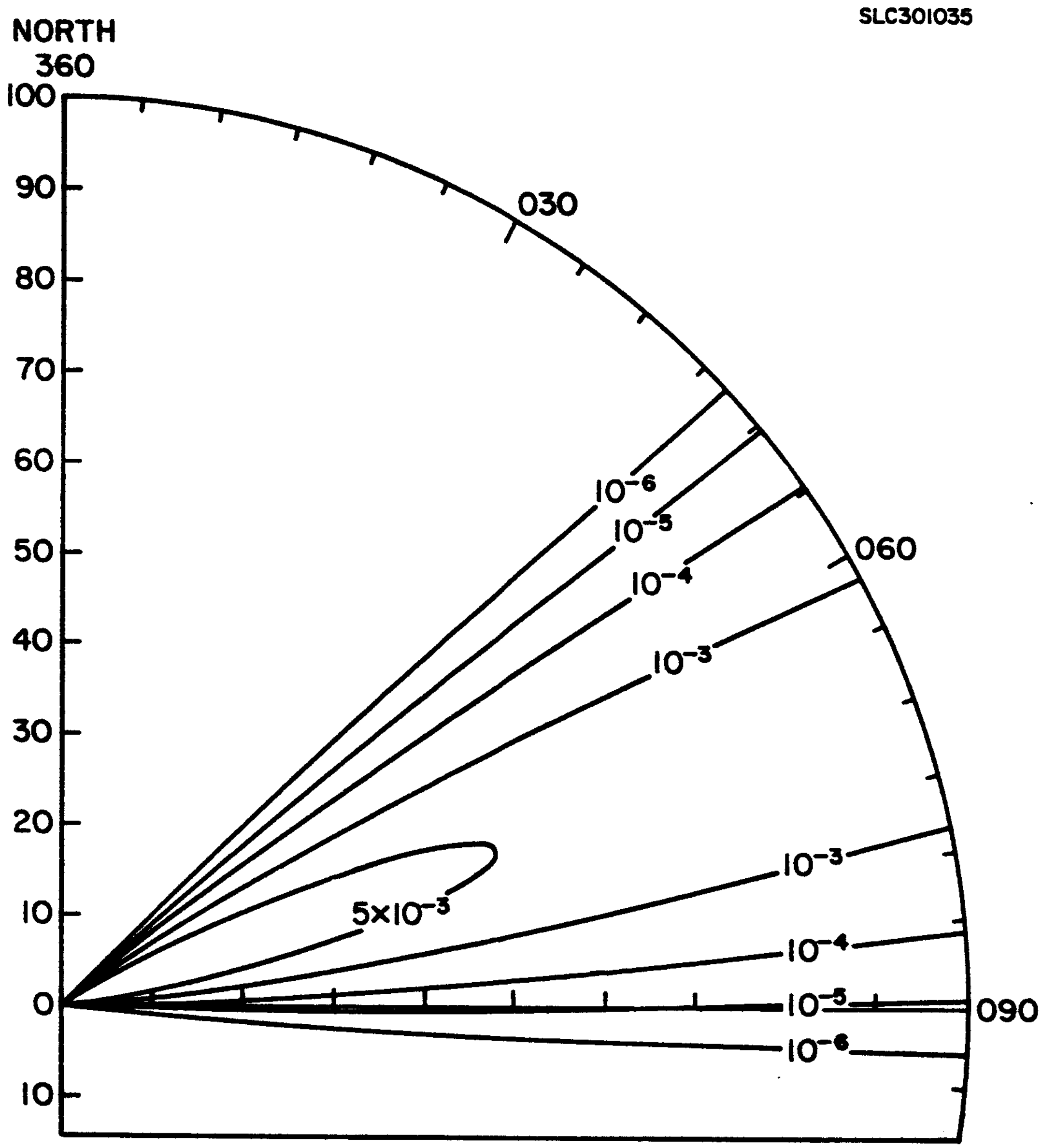

FIGURE E-55. Concentration isopleths in grams per cubic meter at a height of 1067 meters for a vehicle destruct at 1350 meters, 0515 GMT, 12 May, 1967.

SLC301034

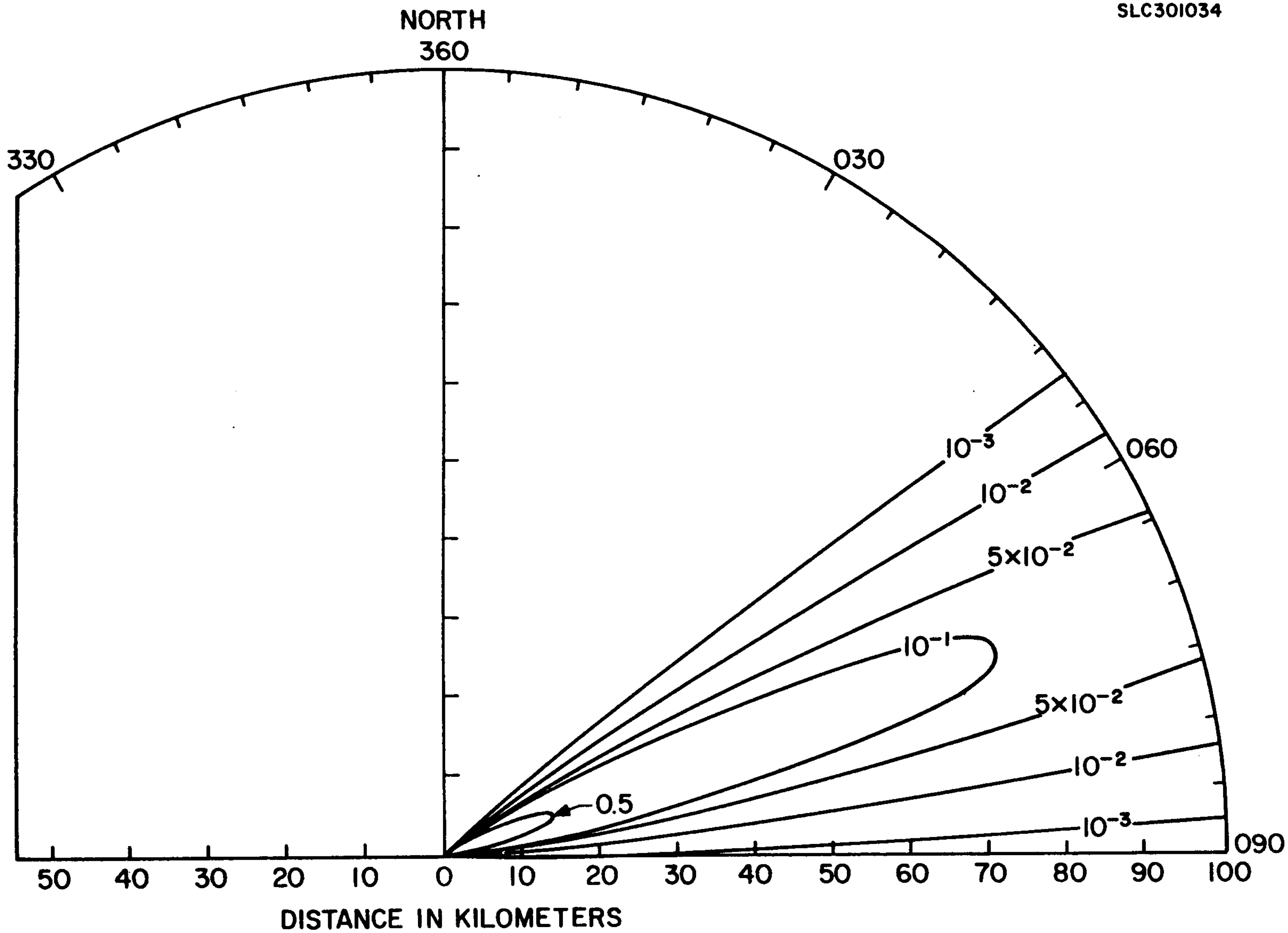

FIGURE E-56. Dosage isopleths in grams seconds per cubic meter at a height of 1067 meters for a vehicle destruct at 1350 meters, 0515 GMT, 12 May 1967.

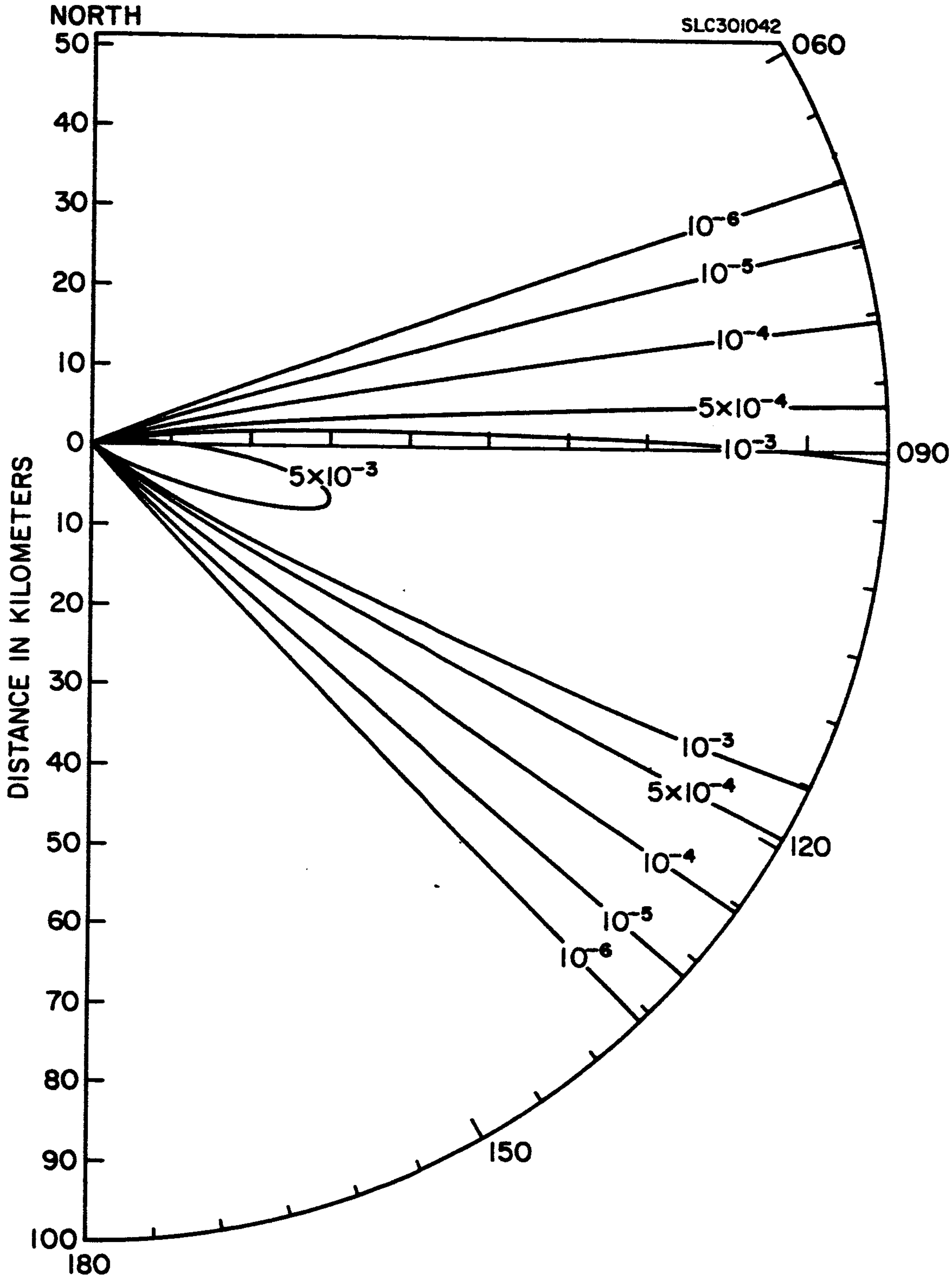

FIGURE E-57. Concentration isopleths in grams per cubic meter at a height of 1615 meters for a vehicle destruct at 1350 meters, 0515 GMT, 12 May 1967.

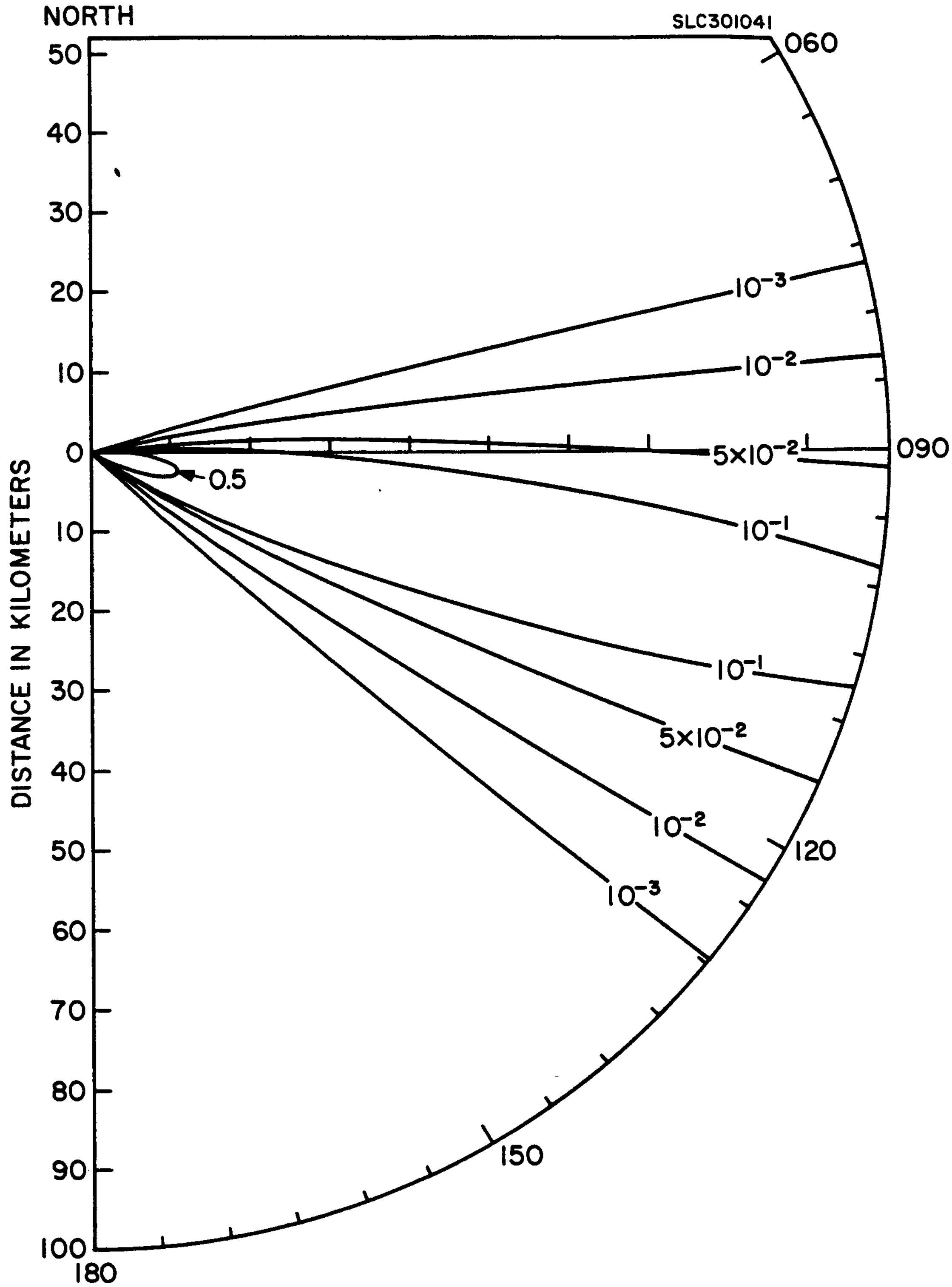

FIGURE E-58. Dosage isopleths in grams seconds per cubic meter at a height of 1615 meters for a vehicle destruct at 1350 meters, 0515 GMT, 12 May 1967.

TABLE E-11

PROGRAM INPUTS

Example Problem: Surface Cold Spill for Summertime Bermuda High Situation, 0515 GMT, 12 May 1967

MODEL NO. 3				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Source Inputs			
Q_K (g sec^{-1})	100			
$\sigma_{yo}\{K\}$ (m)	11.6			
$\sigma_{zo}\{K\}$ (m)	1			
$\sigma_{xo}\{K\}$ (m)				
τ_K (sec)	600			
H_K (m)	-			
k	-			

TABLE E-11 (Continued)

MODEL NO. 3				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	6			
σ_{ER} (deg)	3			
$\bar{u}_R$ (m sec^{-1})	3.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	6			
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)				
τ_{oK} (sec)	600			
σ_{ETK} (deg)	3			
σ_{EBK} (deg)				
α_K	1			
β_K	1			
$\bar{u}_{TK}$ (m sec^{-1})	8.24			
$\bar{u}_{BK}$ (m sec^{-1})				
θ_{TK} (deg)	237			
θ_{BK} (deg)	200			
z_{TK} (m)	1067			
z_{BK} (m)	2			
Λ (sec^{-1})	-			
z_{lim} (m)	-			
t_1 (sec)	-			
t^* (sec)	-			

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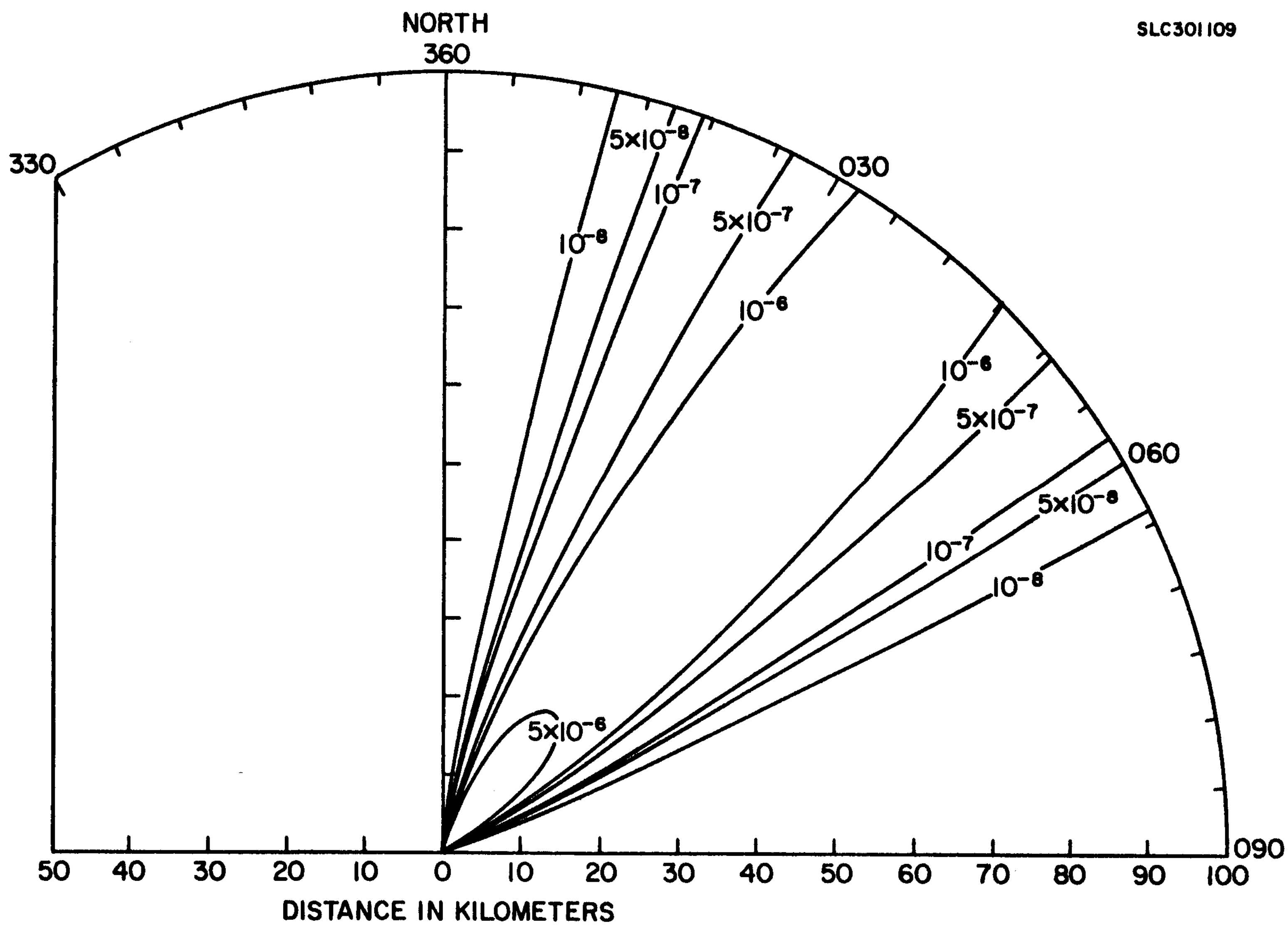

FIGURE E-59. Ground-level concentration isopleths in grams per cubic meter for a large surface spill, 0515 GMT, 12 May 1967.

TABLE E-12

PROGRAM INPUTS

Example Problem: Deposition by Gravitational Settling for Pre-Cold Front Situation, 2315GMT, 27 November 1966

MODEL NO. 7				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Source Inputs			
Q_K (g sec^{-1})	5×10^5	5×10^5	5×10^5	5×10^5
$\sigma_{yo}\{K\}$ (m)	290	150	100	75
$\sigma_{zo}\{K\}$ (m)	-	-	-	-
$\sigma_{xo}\{K\}$ (m)	-	-	-	-
$\tau_K = T_K$ (sec)	25	11	9.3	9.0
H_K (m)	-			
k	-			

TABLE E-12 (Continued)

MODEL NO. 7				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	8			
σ_{ER} (deg)	4.5			
$\bar{u}_R$ (m sec^{-1})	4.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	5	0	0	0
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		5	0	0
τ_{oK} (sec)	600	600	600	600
σ_{ETK} (deg)	4	0	0	0
σ_{EBK} (deg)		4	0	0
α_K	1	1	1	1
β_K	1	1	1	1
$\bar{u}_{TK}$ (m sec^{-1})	6.70	7.73	10.8	20.6
$\bar{u}_{BK}$ (m sec^{-1})		6.70	7.73	10.8
θ_{TK} (deg)	231	258	229	256
θ_{BK} (deg)	160	231	258	229
z_{TK} (m)	853	1829	3048	5000
z_{BK} (m)	2	853	1829	3048
Λ (sec^{-1})	-			
z_{lim} (m)	-			
t_1 (sec)	-			
t^* (sec)	-			

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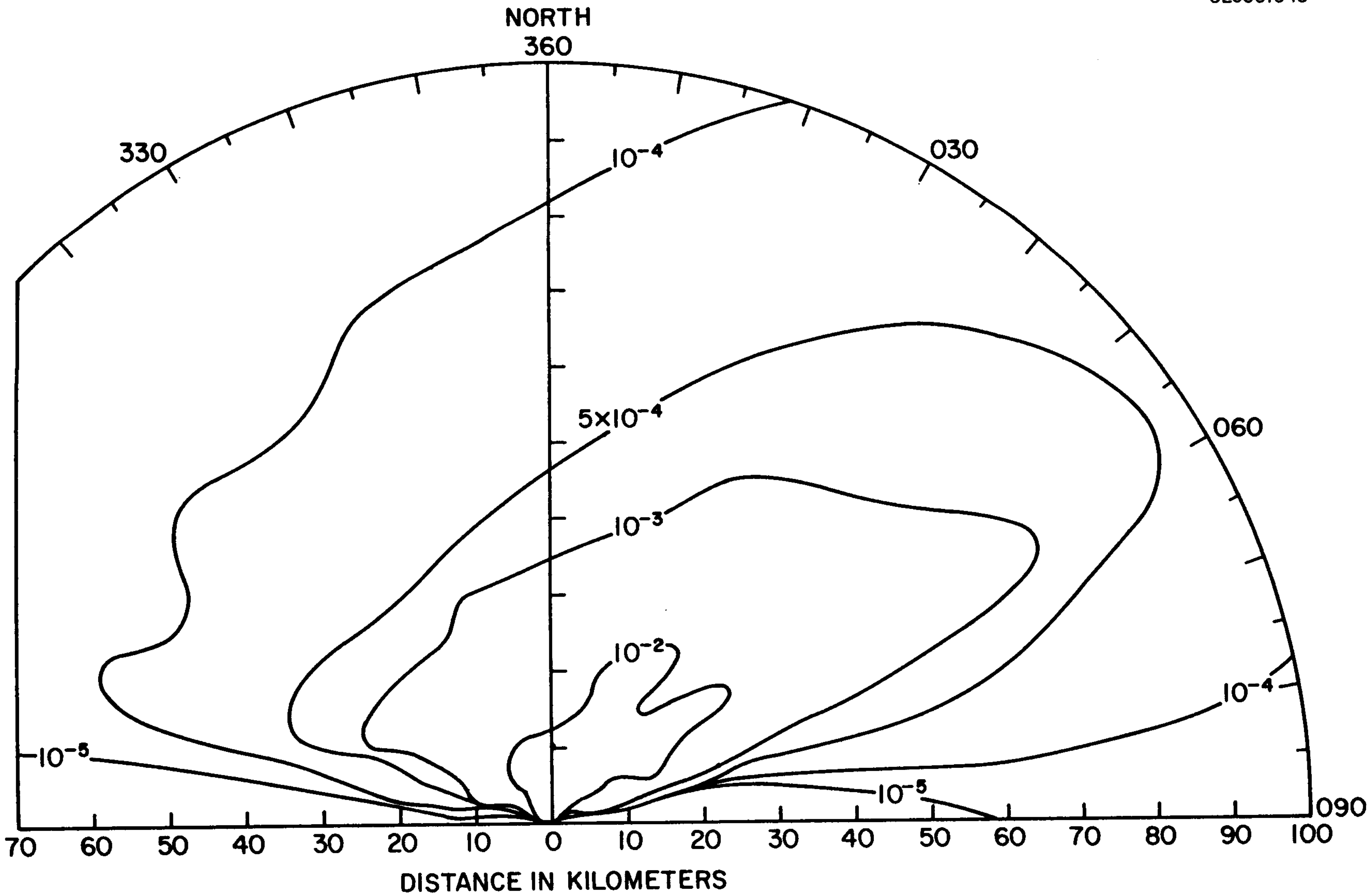

FIGURE E-60. Isopleths of ground-level deposition in grams per square meter due to gravitational settling for a normal launch, 2315 GMT, 27 November 1966.

This orientation of the axis of maximum deposition is due to the veering of the azimuth wind direction from south-southeast to west-southwest between the surface and higher layers. Thus, material emitted in the higher layers is transported by the wind in those layers to the east-northeast and is deposited at long downwind distances. Material emitted in the surface layers is deposited nearer the source along a more north-northwesterly axis.

E.6 EXAMPLE OF A CHANGE IN LAYER STRUCTURE AND DEPOSITION DUE TO PRECIPITATION SCAVENGING

This example illustrates the use of the computer program for the multi-layer diffusion model to calculate ground-level deposition due to precipitation scavenging after a change in layer structure occurs. The time of change in layer structure t* is set equal to 3000 seconds after launch. The meteorological and source inputs for the calculation of the concentration and dosage fields prior to the change in layer structure are given in Table E-4.

At time t*, the wind direction near the surface becomes southwesterly and the lowest two layers are combined in a single layer as a cold front approaches Kennedy Space Center. Also, at the same time as the change in layer structure occurs, rain is assumed to begin falling through the new layer in the general area surrounding Kennedy Space Center. The turbulence structure in Layer 3 (Table E-4) is also changed and clouds are assumed to have formed in the layer. The source and meteorological inputs, reflecting the above changes in layer structure, that must be supplied to the computer program are given in Table E-13. With the exception of τ_K, the source parameters for the calculation of concentration, dosage, and deposition due to precipitation scavenging under the new structure regime are calculated internally in the program. In the new surface layer (Layer 1 in Table E-13), τ_K has been assigned the average of the values of τ_K in Layers 1 and 2 in Table E-4. In the new Layer 2 (Table E-13), the value of τ_K is the same as for Layer 3 in Table E-4.

TABLE E-13

PROGRAM INPUTS

Example Problem: Deposition by Precipitation Scavenging with Change in Layer Structure for Pre-Cold Front Situation, 2315 GMT, 27 November 1966

MODEL NO. 5, 6				
	Layer 1	Layer 2	Layer 3	Layer 4
Parameter	Source Inputs			
Q_K				
$\sigma_{yo}\{K\}$ (m)				
$\sigma_{zo}\{K\}$ (m)				
$\sigma_{xo}\{K\}$ (m)				
τ_K (sec)	18	10		
H_K (m)				
k				

TABLE E-13 (Continued)

MODEL NO. 5, 6				
Parameter	Layer 1	Layer 2	Layer 3	Layer 4
	Meteorological Inputs			
$\sigma_{AR}\{\tau_{oR}\}$ (deg)	8			
σ_{ER} (deg)	4.5			
$\bar{u}_R$ (m sec^{-1})	4.1			
z_R (m)	18			
$\sigma_{ATK}\{\tau_{oK}\}$ (deg)	4	0		
$\sigma_{ABK}\{\tau_{oK}\}$ (deg)		4		
τ_{oK} (sec)	600	600		
σ_{ETK} (deg)	2	0		
σ_{EBK} (deg)		2		
α_K	1	1		
β_K	1	1		
$\bar{u}_{TK}$ (m sec^{-1})	7.73	10.8		
$\bar{u}_{BK}$ (m sec^{-1})		7.73		
θ_{TK} (deg)	258	229		
θ_{BK} (deg)	230	258		
z_{TK} (m)	1829	3048		
z_{BK} (m)	2	1829		
Λ (sec^{-1})	10^{-3}			
z_{lim} (m)	1829			
t_1 (sec)	3000			
t* (sec)	3000			

Ground-level dosage isopleths calculated by the program are shown in Figure E-61. The isopleth pattern reflects the change in wind direction in the surface layer from southerly to southwesterly. Figure E-62 shows ground-level deposition isopleths due to precipitation scavenging. The lobe of the pattern at distances between 20 and 40 kilometers east of the source is due to washout of material contained in the second layer prior to the change in layer structure. The isopleth for 10^{-1} grams per square meter indicates the approximate location, just after precipitation started, of material originally contained in the surface layer.

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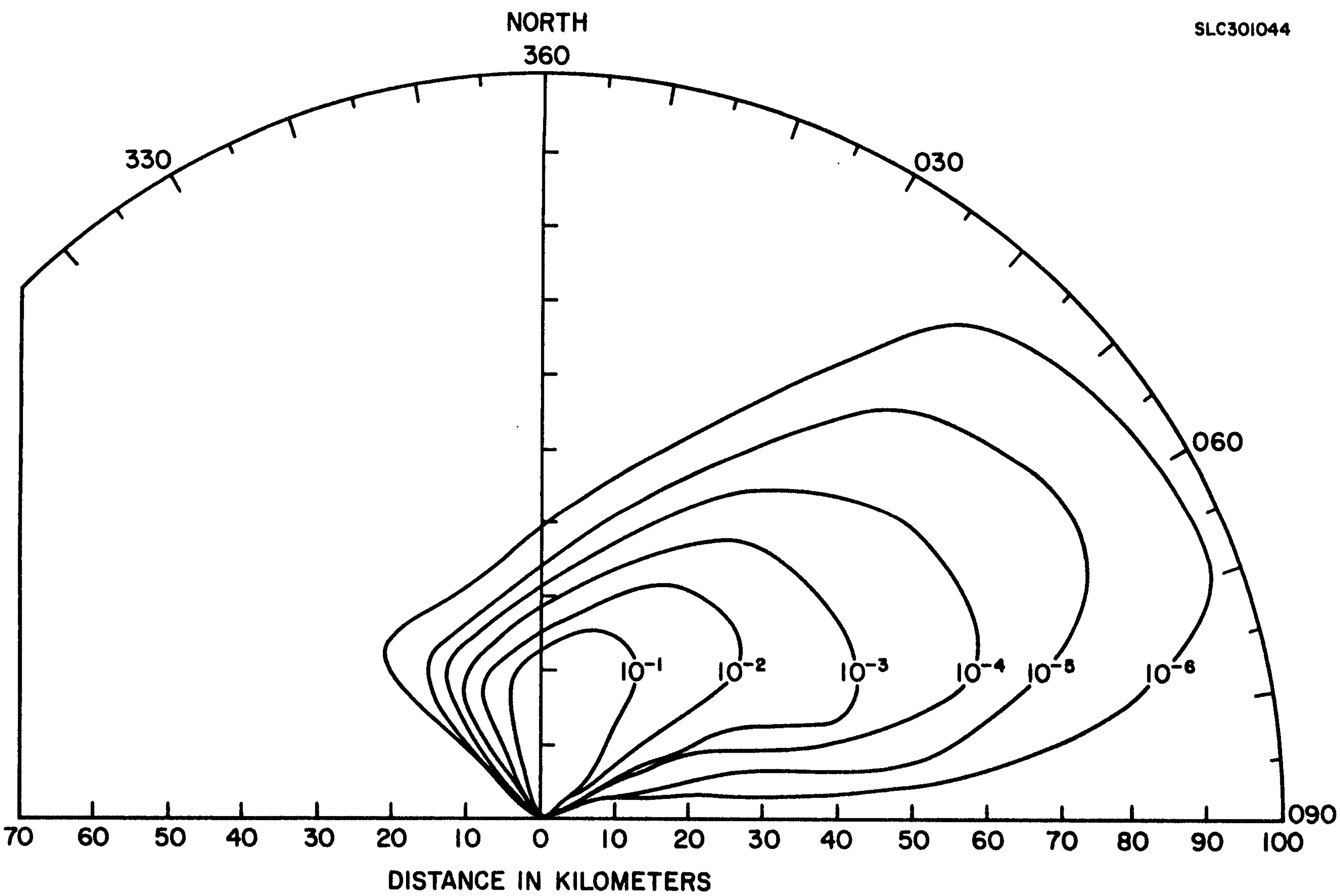

FIGURE E-61. Ground-level dosage isopleths in grams seconds per cubic meter for a normal launch, 2315 GMT, 27 November 1966, with a change in layer structure and the start of precipitation occurring 50 minutes after launch.

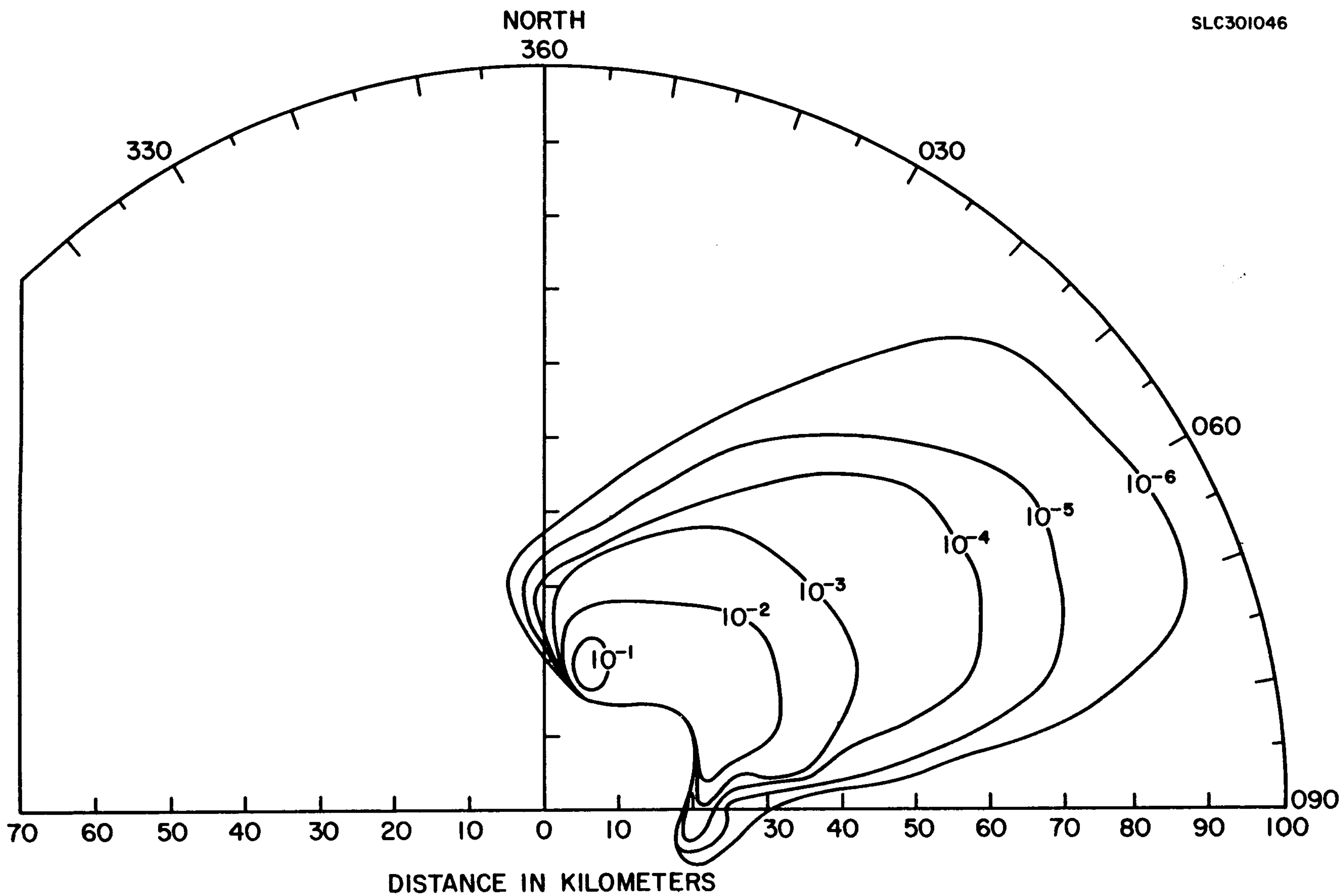

FIGURE E-62. Ground-level deposition isopleths in grams per square meter due to precipitation scavenging, 2315 GMT, 27 November 1966; precipitation starts 50 minutes after launch.

APPENDIX F

NOMOGRAMS FOR CALCULATING σ_A, σ_E AND p AND EXAMPLE CALCULATIONS

F.1 NOMOGRAMS FOR CALCULATING σ_A, σ_E AND p

Three nomograms for calculating the meteorological inputs σ_E, σ_A and p to the multi-layer diffusion model from values of σ_A and σ_E at a reference height and from wind speeds at layer boundaries are presented in Figures F-1 through F-3.

Figure F-1 is used to calculate ratios or products.

Figure F-2 is used for calculations based on the wind speed power-law relationship.

$$\frac{\bar{U}\ (\text{upper})}{\bar{U}\ (\text{lower})} = \left\{\frac{Z\ (\text{upper})}{Z\ (\text{lower})}\right\}^{p}$$

Figure F-3 is used for the calculation of σ_E under unstable thermal stratification from the expression

$$\frac{\sigma_E\ (\text{upper})}{\sigma_E\ (\text{lower})} = \left\{\frac{Z\ (\text{upper})}{Z\ (\text{lower})}\right\}^{0.3-p} \qquad o<p<0.3$$

The use of these nomograms is illustrated below by calculating model input values for Layers 1 and 2 of the example case described in Section E.1.1 for 27 November 1966, 2315 GMT.

F.2 EXAMPLE CALCULATIONS

F.2.1 Selection of Nomogram Inputs

The wind speed at the reference height of 18 meters is interpolated from a log-log plot of the radiosonde data as 8.4 knots. Figure 4-4 shows that the sounding was taken about 45 minutes after transition time, and slightly stable conditions are postulated near the ground. The temperature profile indicates an adiabatic lapse rate between 870 and 2,800 feet (Layer 2) and that a surface inversion is being established below 870 feet (Layer 1). It is postulated that vertical mixing is still taking place in Layer 2. For a wind speed of 8.4 knots (4.3 meters per second) and slight stability ($\Delta T \approx 0.4C$), Figures 4-2 and 4-3 give values of about 8 and 4.5 degrees, respectively, for σ_A and σ_E at the reference height of 18 meters. Wind speeds at 870 and 2,800 feet are 12 and 13 knots, respectively. According to the relationships given in Section 4.2, σ_A and σ_E are assumed to vary as Z^{-p} within Layer 1. For illustrative purposes it is assumed that σ_E varies as $Z^{0.3-p}$ within Layer 2, although Layer 2 is in the process of becoming decoupled from the surface as the surface temperature inversion in Layer 1 develops.

F.2.2 Use of the Nomograms

The use of the nomograms to determine model inputs is illustrated by Figures F-4, F-5, and F-6. Figure F-4 uses the wind speeds at 59 feet (18 meters) and 870 feet to calculate $\sigma_A = 5.6$ degrees and $\sigma_E = 3.2$ degrees at 870 feet from the reference values at 18 meters. Figure F-5 uses the wind speed and height ratios at the upper and lower boundaries of Layer 2 to calculate p for the layer. Figure F-6 uses the value of p determined for Layer 2, the height ratio of the boundaries, and the value of σ_E at the lower boundary to calculate σ_E at the upper boundary.

In Figures F-4 through F-6, the number in parentheses is the height in feet to which the quantity refers. The symbol $\bar{U}$ refers to the wind speed. The symbol R denotes one of the ratio scales shown as ordinates in Figures F-2 and F-3; the subscript used with R indicates the specific scale to which reference is made:

- $R_{\overline{U}}$ = ratio of wind speeds
- R_{σ} = ratio of standard deviations of elevation
- R_{Z} = ratio of heights

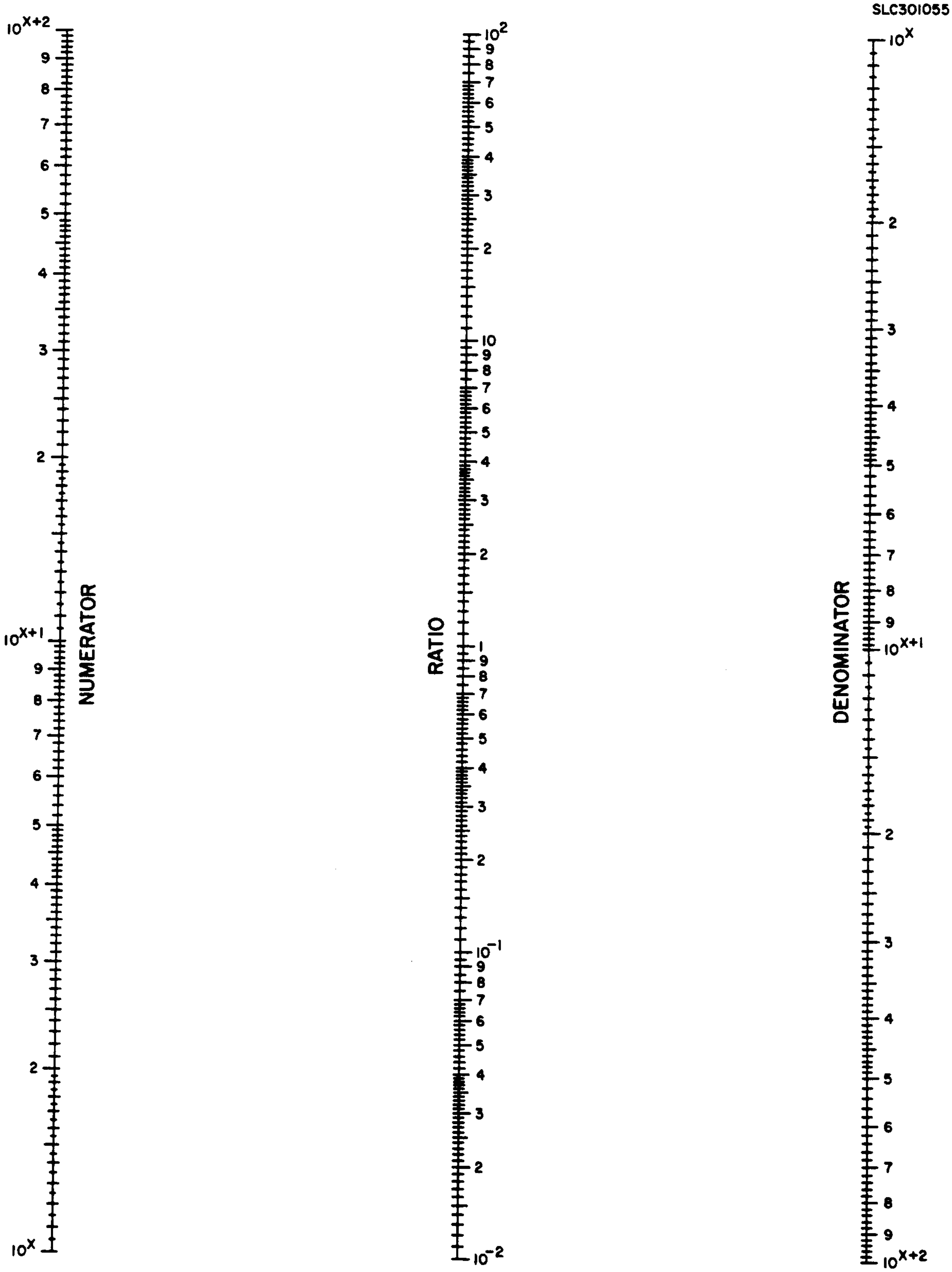

FIGURE F-1. Nomogram for calculating ratios or products.

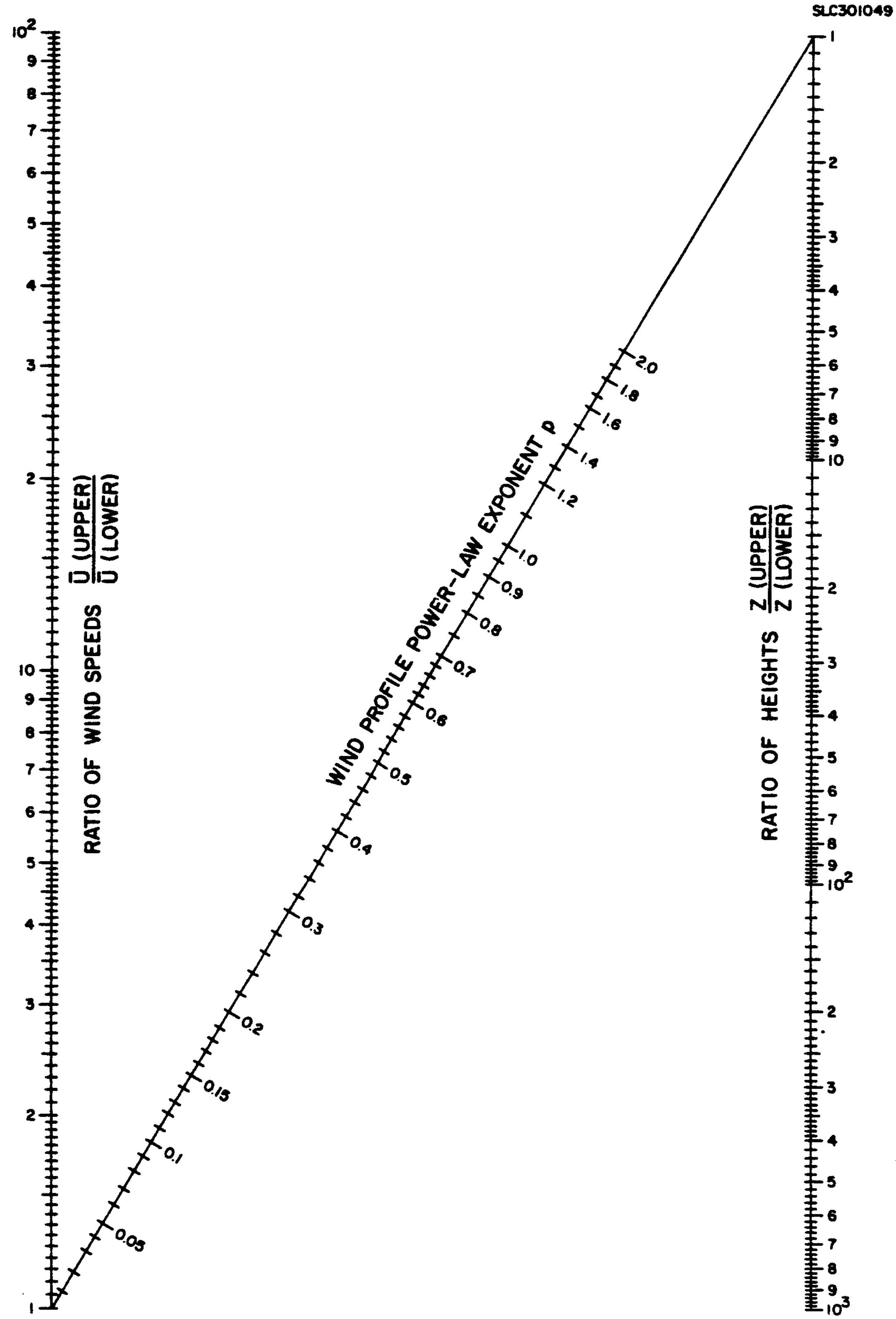

FIGURE F-2. Nomogram for calculating the wind-profile exponent p.

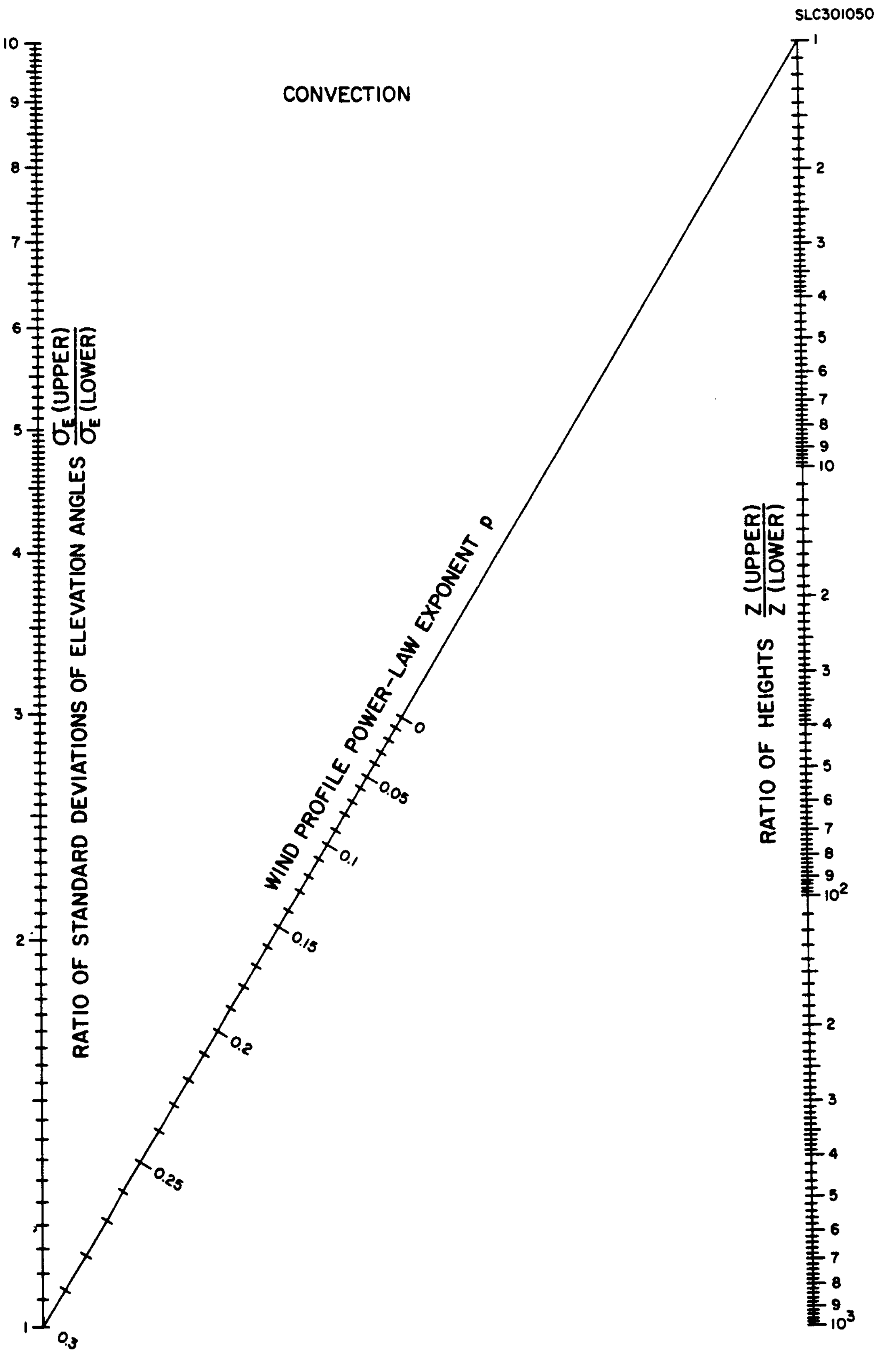

FIGURE F-3. Nomogram for calculating σ_E under unstable thermal stratification.

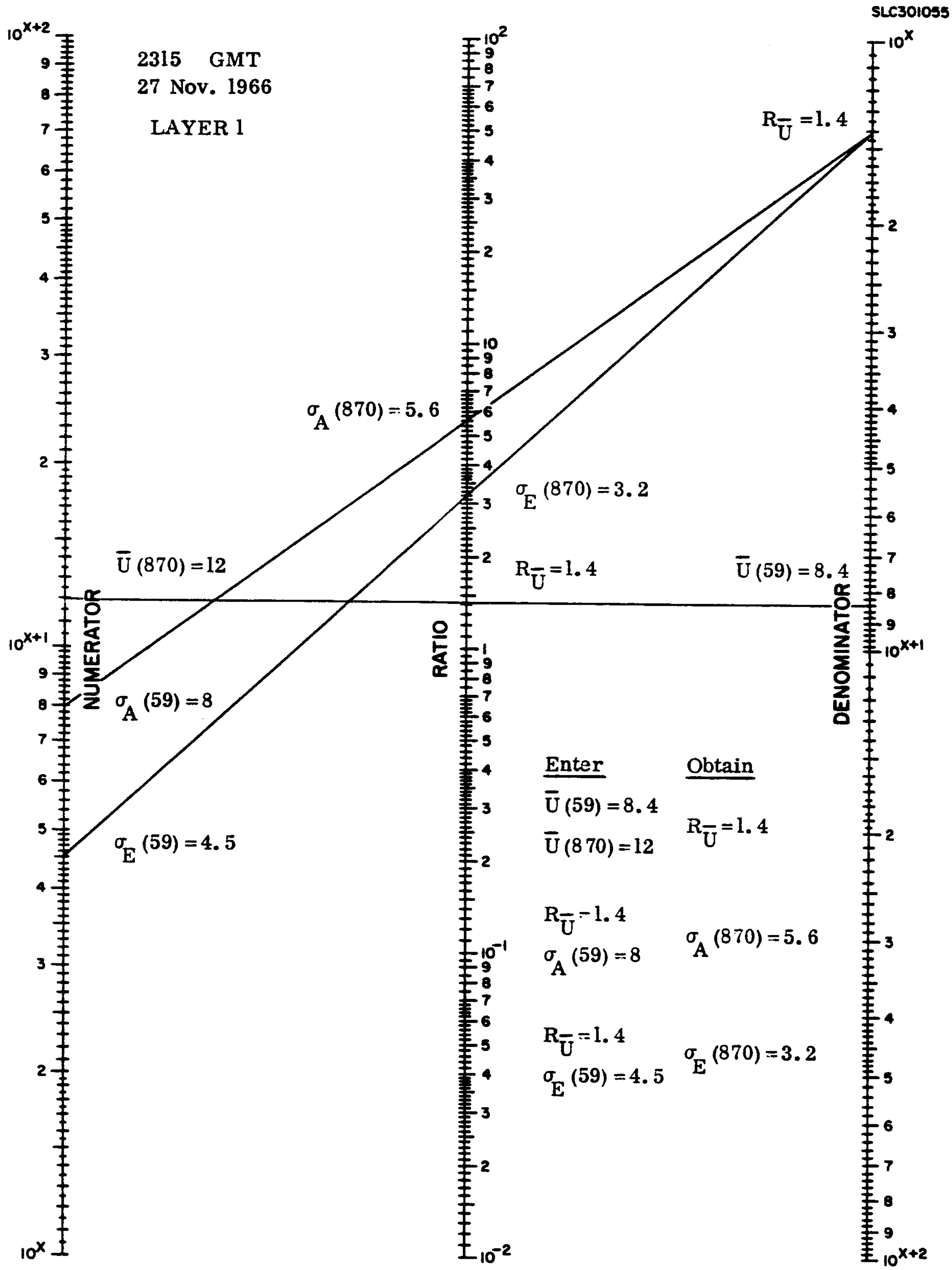

FIGURE F-4. Use of Figure F-1 to calculate σ_A and σ_E from the wind speed ratio when σ_A and σ_E are assumed to vary as Z^{-p}.

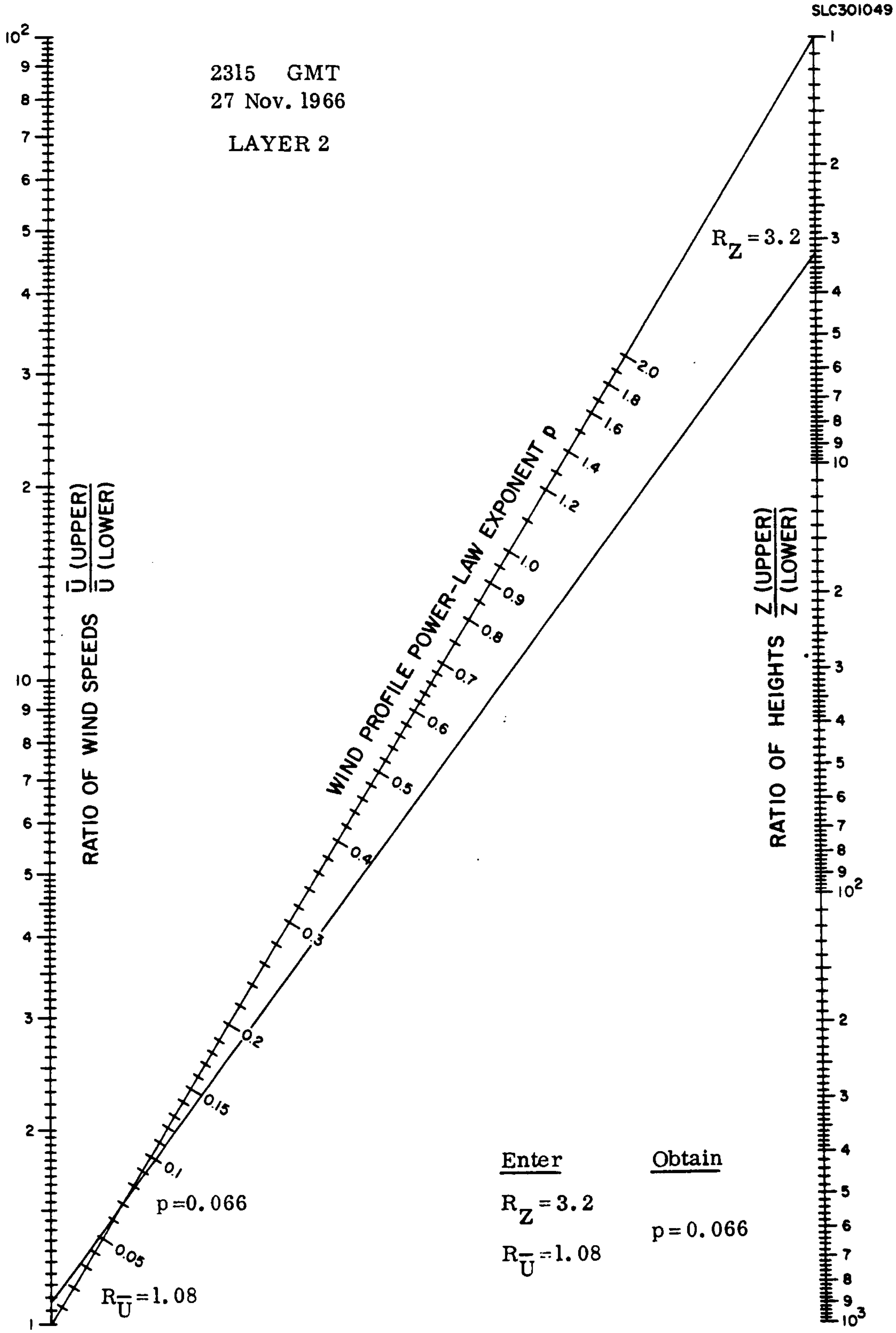

FIGURE F-5. Use of Figure F-2 to calculate the power-law exponent p.

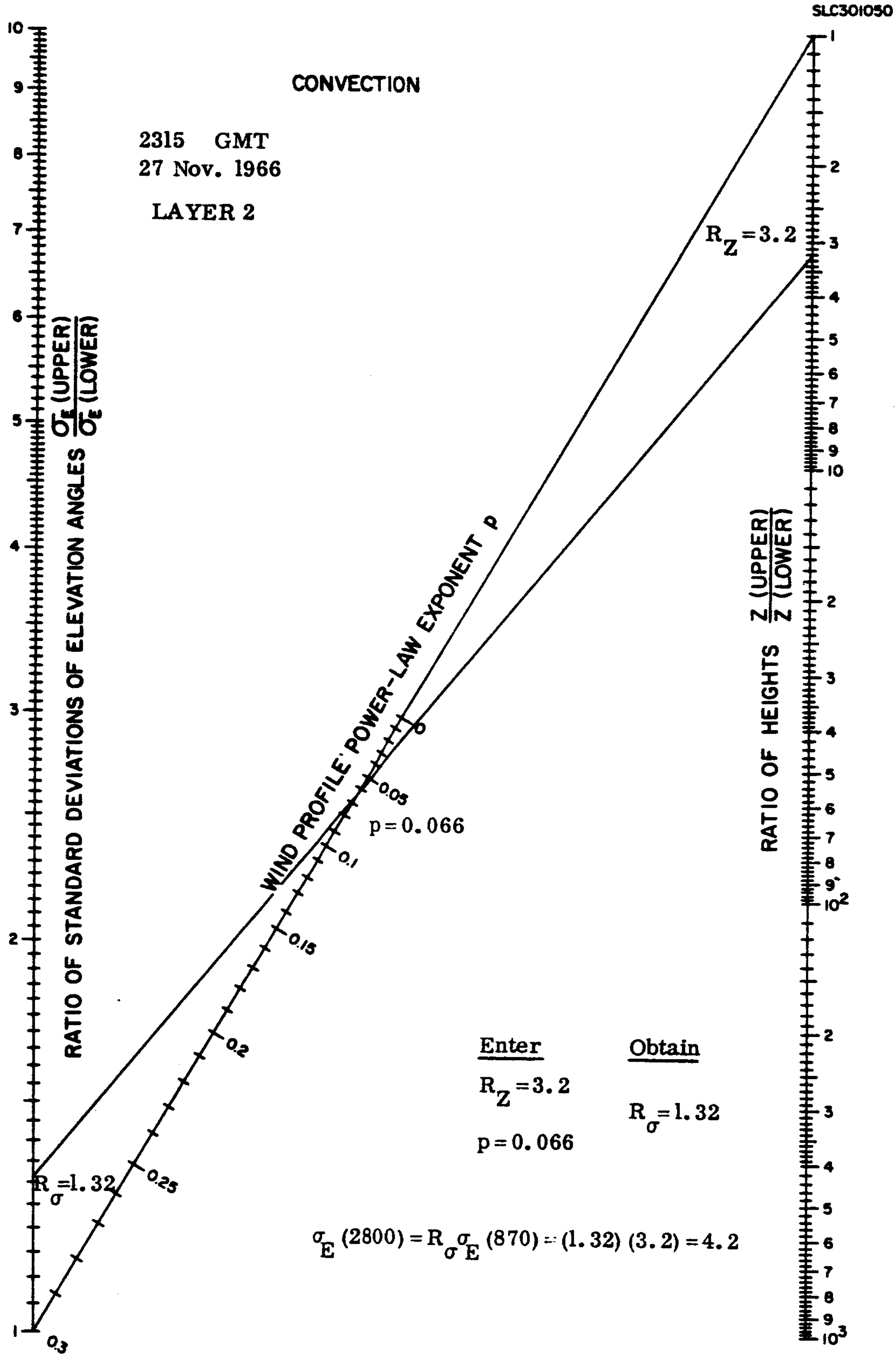

FIGURE F-6. Use of Figure F-3 to calculate σ_E when σ_E is assumed to vary as $Z^{0.3-p}$.

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