NIOSH Technical Report

A MODEL FOR THE IDENTIFICATION OF HIGH RISK OCCUPATIONAL GROUPS USING RTECS AND NOHS DATA

David H. Pedersen, Randy O. Young, and David S. Sundin

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Surveillance, Hazard Evaluations and Field Studies
Cincinnati, Ohio 45226

October, 1983

DISCLAIMER

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGEMENT

The mathematical model discussed in this technical report was developed by modifying an earlier model developed under NIOSH Contract Number 210-78-0076 (Tracor Jitco, Inc.).

DHHS (NIOSH) Publication No. 83-117

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

ABSTRACT

The National Institute for Occupational Safety and Health (NIOSH) has developed two data files, the Registry of Toxic Effects of Chemical Substances (RTECS) and the National Occupational Hazard Survey (NOHS), which contain data on chemical toxicity and potential worker exposure to chemical agents, respectively.

This report describes an attempt to combine data from these two files for the purpose of quantifying in a relative sense, potential health risks associated with industries and occupations covered in the NOHS. A model has been designed which permits the user to make certain decisions concerning which toxic effects or potential exposure conditions are to be emphasized in a given computational cycle of the algorithms. The model thus produces rank-ordered lists of exposure agents, industries, or occupations which reflect the particular interests of the user.

The indices of potential health risk derived from the various algorithms in this model are intended as an initial step in the identification and prioritization of subjects for occupational health research. The calculated indices do not provide absolute measures of occupational health risk.

Table of Contents

Figures

Tables

INTRODUCTION

The process of prioritizing and selecting a discrete number of occupational health research projects from the vast array of potentially rewarding subject areas has always been difficult, involving a variety of objective data and certain subjective values. Based on evidence that certain chemicals are known to cause specific illnesses or that certain agents are in widespread occupational use, decision-makers assign a priority to the study of a particular agent or occupational environment. These priorities are then considered in light of available resources, and decisions are made concerning which candidate projects should be funded.

The National Occupational Hazard Survey* (NOHS) conducted during 1972-1974 in approximately 5,000 industrial facilities by the National Institute for Occupational Safety and Health (NIOSH) has developed data which can be used to estimate the number of workers potentially exposed to particular compounds, and to describe the conditions of those exposures in the workplace.

Similarly, the initial publication of the NIOSH Toxic Substances List (now the Registry of Toxic Effects of Chemical Substances**) in 1971 proved to be of value as a readily accessible compendium of the (unevaluated) chemical-specific toxicity studies available in the published technical literature.

Both of these data collections contain information which can be used to identify potential occupational risk due to chemical exposure through combination in a risk-ranking system. The risk-ranking algorithms described herein are intended to provide decision-makers with a technique for the initial assessment of relative risk associated with potential occupational exposures to chemical agents. The algorithms in this model are designed (1) to rate and compare the relative potential health risk of exposure to specific chemicals, and (2) to provide a measure of the overall health risk faced by various occupational groups through the computation of a single risk index number for an industry or an occupation.

---

* National Occupational Hazard Survey, National Institute for Occupational Safety and Health, DHEW Publications No. (NIOSH) 74-127, May 1974; (NIOSH) 77-213, July 1977; and (NIOSH) 78-114, December 1977.

** Registry of Toxic Effects of Chemical Substances, 1980 edition, National Institute for Occupational Safety and Health, DHHS (NIOSH), Publication No. 81-116, February 1982.

The identification of high risk chemicals and occupational groups is accomplished by computer-based processing of the RTECS and NOHS files using computational algorithms designed to incorporate data from both sources simultaneously. The work, both in the developmental contract and in the succeeding in-house effort, is empirical, and uses only the data available from RTECS and NOHS as well as selected data from the Bureau of the Census.*

All the model algorithm have the ultimate function of producing an "index number" for the production of rank ordered indexes of potential chemical and occupational group "risk". Accordingly, RTECS toxicity data are accepted at face value, even though some toxic effects are not universally accepted as dose dependent, and the data is unevaluated.

The varying specialized interests of researchers were anticipated. The model algorithms were, therefore, designed to permit user emphasis and/or selection of specific toxicological outcomes corresponding to researchers concerns.

The output from this model should be viewed as a pilot effort. The algorithms provide indices of risk on the basis of potential risk due to chemical exposure utilizing a limited chemical list, and without considering actual environmental levels, since this data is not available in either RTECS or NOHS. In addition, animal study data is assumed to be an accurate predictor of human response. Nevertheless, it is felt that the use of these model indices as a surveillance mechanism for the identification of high risk chemicals and occupational groups will be a valuable addition to the process of determining occupational risk, and as input to the identification and prioritization of possible research efforts. Although both data collections used as the basis for these indices have significant limitations in their coverage and in the consistency of the data they contain, they appear to be the most comprehensive data collections of their kind in the world. Furthermore, the algorithms and software developed to make use of the available RTECS and NOHS data should continue to prove useful when better data are available for future algorithm development, and for the machine processing of large scale toxicological data bases.

The model produces four specific types of indices, which are:

- Hazard Risk Index (HRI), a listing of the chemicals common to both the RTECS and NOHS data bases ranked by the

---

* Census Bureau Publication CBP-73-1, U.S. Summary, Country Business Patterns, 1973.

toxicological risk they pose. The HRI algorithm calculates index numbers, indicative of the relative toxicological risk posed by each chemical, and uses these numbers to sequence the chemicals in the index. The HRI is based entirely on the unevaluated animal study toxicological data available in the RTECS data base and does not include any consideration of the extent of worker exposure.

- Adjusted Hazard Risk Index (AHRI), a listing of the chemicals common to both the RTECS and NOHS data bases ranked by the toxicological risk they pose and the extent of worker exposure. The algorithm that produces this index combines the risk index numbers from the HRI algorithm with data on worker exposure to chemical hazards from the NOHS data file to produce "adjusted" risk index numbers which are used to sequence the chemicals in the AHRI.

- Industry Risk Index (IRI), a listing of industries at the 2-, 3-, and 4-digit Standard Industrial Classification (SIC) levels which are included in the NOHS data base, ranked by the potential risk due to chemical exposure of workers in each industry. The algorithm that produces this index calculates the incremental risk posed by each chemical to which workers in an industry are potentially exposed, and cumulates these incremental risks for all the potential exposures in the industry to form an index number for each industry, listing the industries in order by these index numbers. 1973 Census Bureau data on worker populations by industry are used in the algorithm.

- Occupational Risk Index (ORI), a listing of the occupations which are included in the NOHS data base, ranked by the potential chemical risk to workers in each occupation. The algorithm that produces this index calculates the incremental risk posed by each chemical to which workers in an occupation are potentially exposed, cumulates these incremental risks for all the potential exposures in the occupation to form an index number for each occupation, and lists the occupations in order by these index numbers. 1973 Census Bureau data on worker population by occupation are used in this algorithm.

MODEL OVERVIEW

The goal of the occupational health community is to eliminate adverse health effects suffered by the worker as a consequence of employment. However, a combination of finite resource commitment, continual identification of new problem areas, and technological change prevents the attainment of this goal.

What can be done is to continually and systematically examine the work place, and attempt to eliminate or control those situations identifiable as high risk.

In order to label any occupational group as "high risk" due to chemical exposure and to prioritize efforts to reduce the adverse health effects associated with employment in such groups, it has always been necessary to: (1) assess the toxicological effects of individual chemicals known to be in the work place, (2) determine the incidence of exposure to these individual chemicals, and (3) estimate the aggregate risk due to the influence of multiple chemical exposures.

In assessing current NIOSH computerized data base capabilities, the authors decided that these three levels of necessary information could be at least partially met with a modeling technique. The model reported here, therefore, is divided into three major areas: (1) an assessment of the relative toxicity of chemicals based only on RTECS data, (2) an assessment of potential work force health effect based upon the calculated toxic potential of a chemical and its incidence in the work place as reported in NOHS*, and (3) an assessment of the health risk of occupational groups which considers the chemical exposures specific to that group, the relative incidence and conditions of exposure to each specific chemical within that group, and the potential toxicity of these chemicals to derive an estimate of aggregate risk.

The data flow resulting in the four risk indexes produced by this model is shown in Figure 1.

---

* Any NOHS data relating to occupational exposure must be considered to be "potential" due to the lack of environmental level data associated with the observed chemical exposures.

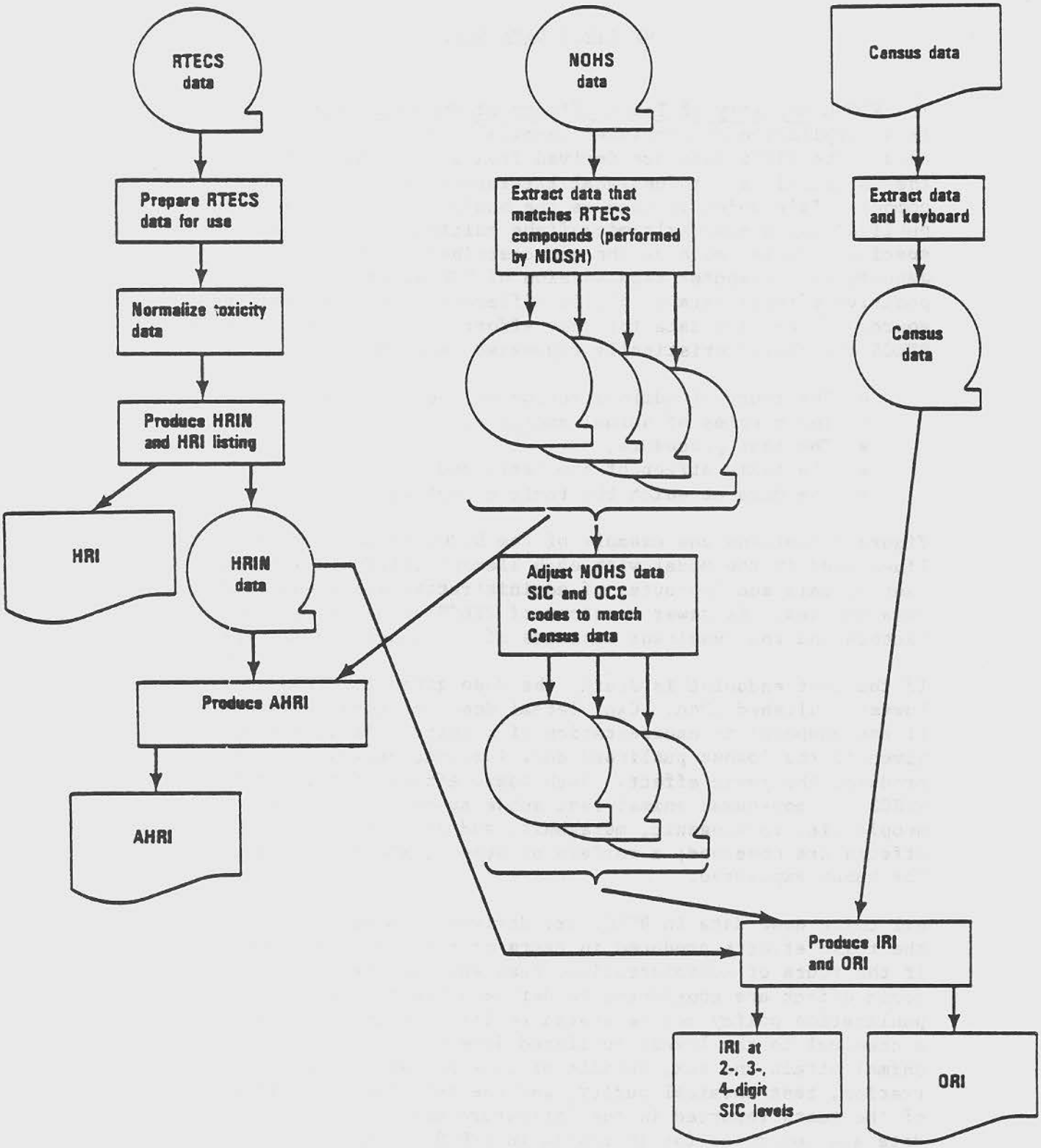


FIGURE 1. Index Production Data Flow

THE RTECS DATA SOURCE

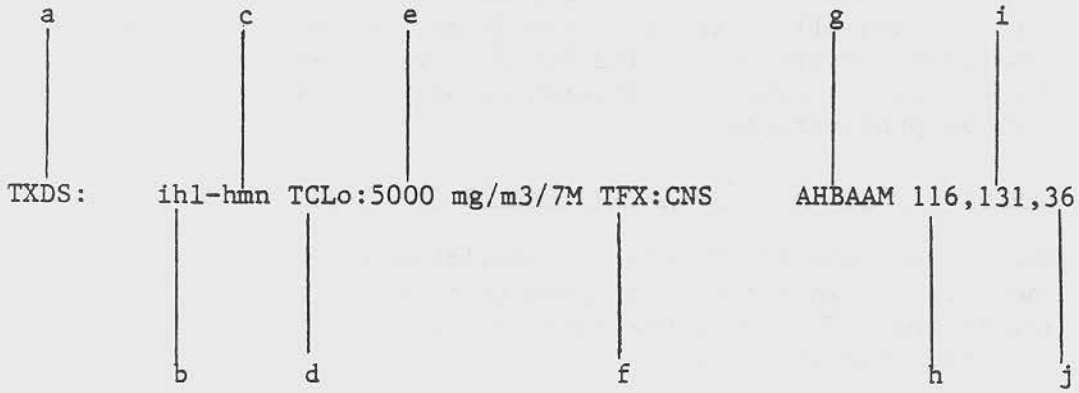
The NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) is a compilation of published chemical toxicological and related data. The RTECS data are derived from a comprehensive review of the international professional literature, and are input to a computer file which is used as the basis for the annual RTECS publication, a quarterly microfiche edition of RTECS, and for special purposes such as the one described in this report. The January 1981 computer tape version of RTECS, which contains positive effects data on 45,156 different chemicals, was the source of toxicity data for this effort. The toxicity data in RTECS are characteristically expressed in terms of:

- The route of administration of the test chemical,
- The species of animal and/or cell type used in the test,
- The test procedure,
- The toxic effect of the test, and
- The dose at which the toxic effect was noted.

Figure 2 contains one example of the RTECS toxicity data entry lines used in the model with each element defined. A total of 31 test animals and 26 routes of administration are found in RTECS data entries. As newer versions of RTECS are accessed these factors and the resultant outcomes of the model indices will change.

If the test endpoint is death, the dose given in RTECS is the lowest published LD_{50}, LC_{50}, lethal dose, or lethal concentration. If the endpoint is manifestation of a toxic effect, the dose given in the lowest published dose (or concentration) that produced the toxic effect. Such toxic effects are recorded in RTECS for non-human animal test subjects only if carcinogenic, neoplastic, teratogenic, mutagenic, and skin and eye irritation effects are observed; a variety of other toxic effects are recorded for human exposures.

All toxic dose data in RTECS are derived from published reports of the toxic effects produced in tests of the individual substances. If the route of administration, test species, test procedure and toxic effect are considered to define a "test class", RTECS general publication policy can be stated as limiting the RTECS entries for a chemical to the lowest published dose for each test class. Test animal strain and sex, details of dose preparation and administration, test chemical purity, and the relative scientific merit of the tests reported in the literature are not considered when data are assembled for inclusion in RTECS. Thus, the toxicity data available for use in this project are made up of the unevaluated



Abbreviations used in RTECS are listed in Appendix B.

a. An acronym which stands for "Toxic Dose".
b. This is an abbreviation for the route of administration or entry.
c. This is an abbreviation for the species.
d. This is the test procedure reported.
e. This is the dose which caused the toxic effect, including period of administration (if applicable).
f. The first part of this notation, "TFX", is an acronym which stands for "Toxic Effect". The last part of this notation refers to the organ system affected by the dose administered, and is the toxic effect portion of the test class.
g. This is a code denoting the reference from which the toxic data was derived.
h. Volume number of the reference.
i. Page number of the reference.
j. These two digits stand for the year of publication, i.e. 1936.

FIGURE 2. A Typical Toxic Dose Entry From RTECS

lowest doses producing a specific effect reported for a wide variety of test animals and regimens.

In spite of these limitations, RTECS is an unequaled resource for toxicity data. The January 1981 computer tape version of RTECS used in this model contains 75,357 toxicity data measurements on 45,156 different chemical compounds. Each test is systematically reported and all of the data are in machine-readable form and are separately addressable. The RTECS file is reasonably current with respect to the published literature and covers both domestic and foreign publications.

Preparation of RTECS Data for Use in the Model

Even though the RTECS data are available in computer-readable form, they are not in a form that permits their direct use in computer algorithms. The available data are variable in format and subject content. For example,

- The RTECS doses are expressed in a number of different units.
- RTECS presents data on tests using many different test animals and routes of administration, and with many different test endpoints.
- RTECS presents both acute and chronic test results, as well as the results of skin and eye irritation tests.

In addition, problems related to machine processing of the data base emerged. Primarily, these problems arose from the fact that the majority of data in any given record is position and length variable, requiring a character by character search of each record to determine the presence of required data. This would probably be true of any large scale toxicological data base. However, it meant that the program to access selected RTECS data for the model had to be designed to accomodate all the possible combinations of data position and length.

General decisions defining the data to be extracted from the RTECS file for use in model computer programs were:

- Model data needs are met with chemical name, molecular weight, toxic effect (acute or chronic), and skin/eye irritation data lines. (Defined by RTECS as of January 1981 as the "A", "H", "R", "S", and "T" lines.)

- In-vivo test procedures resulting in a mutagenic outcome must be performed on specified mammalian species, utilizing specified tests, and utilizing any route of dose administration except "unknown", "multiple", or "rectal". This

was done to restrict data to mammalian species tests which were comparable to other RTECS data and to approximate general mammalian response and exposure.

- In-vitro test procedures resulting in a mutagenic outcome must have been performed on specified types of cells originating from the same mammals specified for in-vivo procedures, and performed utilizing specified test procedures. Such restriction was mandated for the same reasons indicated for in-vivo mutagen studies.

- Skin and eye irritation data was restricted to rabbit studies, with eye or skin routes in an effort to initially extract only those studies meeting "Draize test" criteria. This criteria was imposed for reasons of data comparability.

- In general toxicity studies, any route of administration except "unknown" was accepted. Additionally, intradermal, intramuscular and subcutaneous routes of administration were project defined as synonymous to increase the number of useable data lines which were considered directly comparable and on the assumption that under occupational conditions, any route of administration (other than absorption) penetrating the skin occurs as the result of an accident, involving all three routes simultaneously. All such lines were converted via computer program to the "subcutaneous" route of administration.

- As noted earlier, the RTECS data are reported in terms of test animal species, routes of administration, test procedures and toxic effects. The original developmental contract showed (1) that the bulk of the RTECS data relates to a relatively small number of test classes and (2) that combination of some test classes through redefinition of the aminal species vocabulary would produce a few additional test classes with useful data populations. In general, any animal species utilized in test procedures was acceptable, except citations of "unknown" species. Species originally termed "infant", "child", "man", "woman", and "human" were all converted to "human". Species originally cited as "bird", "chicken", "duck", "pigeon", "quail", "turkey", and "bird-wild bird" were all converted to "bird". These steps were taken to increase the number of directly comparable data lines.

These inital decisions on test class parameters resulted in the creation of 393 test classes across RTECS. These initial test classes contained a range of cited test results from 1 to 12,495 per test class.

For greater detail regarding the computer program to access RTECS data (including acceptable species, routes, tests and dose conversions), see Figure 3 and the discussion in Appendix A, "High Risk Model Computer Program Considerations"; CIORIEXT, CIORISTD, and CIORICAL programs.

Selection of Specific Test Classes for the Model

In addition to the species combination decisions discussed earlier, and based on the model approach to the HRIN algorithm, in which the algorithm would use data from the different test classes to compare and rank chemicals, it was obvious that test classes with small populations of data would be of far less use than those that have data on many chemicals. A threshold of 65 chemicals was selected empirically, and data records within the test classes that met this standard were extracted for use in the algorithm. It was found that essentially all of the test classes with acute toxicity endpoints were included, but that a significant part of the chronic data were excluded. To prevent this, the chronic test classes that were excluded by the 65-chemical threshold were combined by grouping all of the test species and routes into the "any" classification. This produced the 98 test classes listed in Table 1. This set of test classes was used in development of the HRIN algorithm.

Limitation of the RTECS data to these 98 test classes combined with program data requirements for selected chemicals reduced the number of matched chemicals to 1721 from the original NOHS-RTECS matched total of 2092. A listing of these 1721 chemicals in RTECS accession number order is attached in microfiche form. (See listings in Appendix E.)

Dose Unit Consideration

The RTECS data use a number of different units to report the doses that produced the stated toxic effect. In order to compare the data from chemical to chemical the reported units were standardized as follows:

a. All dose units on inhalation route were converted to parts per million.
b. All dose units on data other than the inhalation route were converted to milligrams per kilogram of unit body weight, and then to molar form (i.e. millimoles/kg).

Conversion of RTECS data from milligrams per cubic meter (mg/m^3) to parts per million (ppm) was accomplished using the following equation:

$$ppm = (mg/m^3)(24.45)/\text{molecular weight}$$

FIGURE 3. RTECS Processing Computer Programs Flow Chart

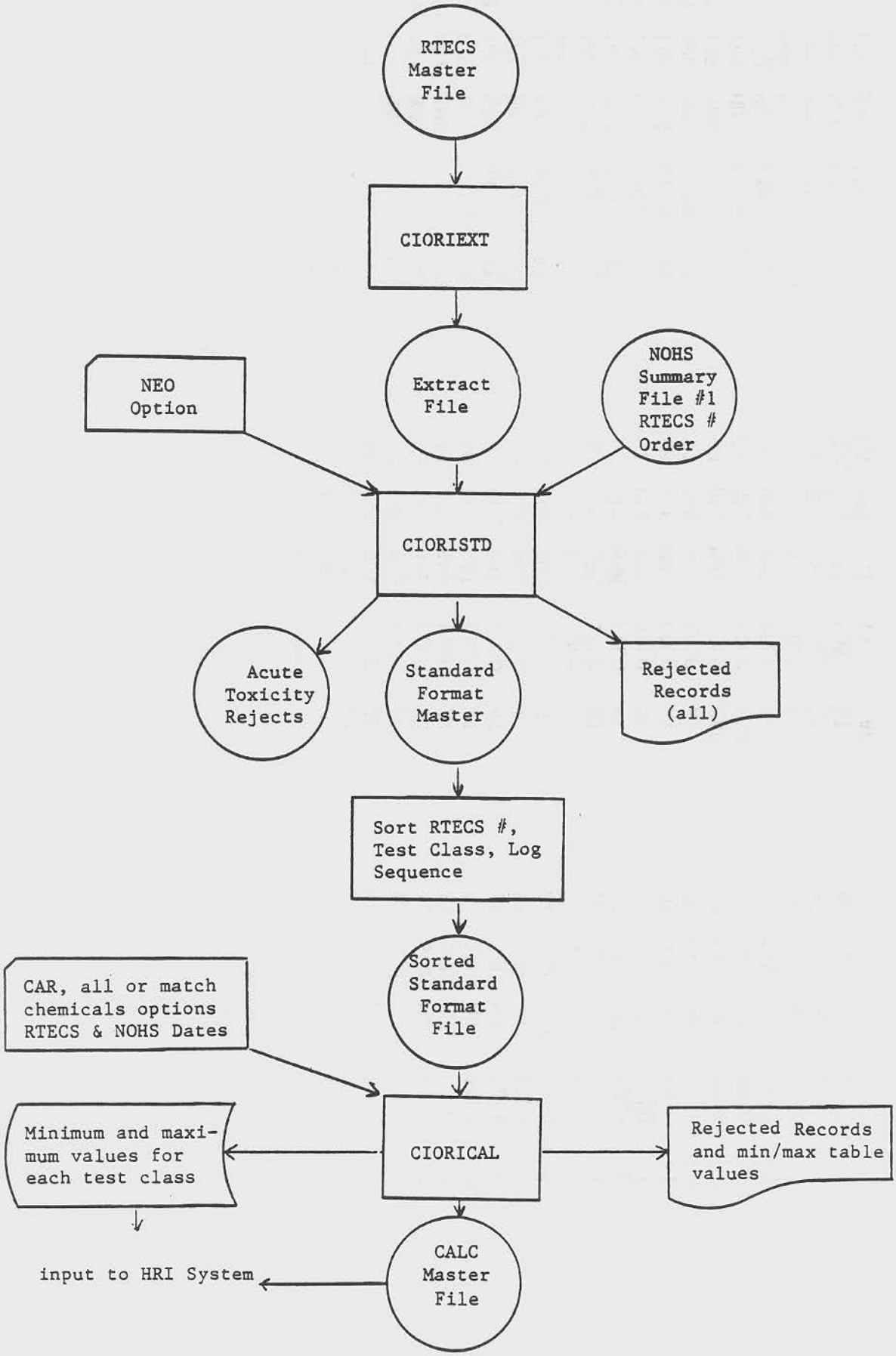


TABLE 1 - TEST CLASSES*

ROUTE/SPECIES/TEST/TOXIC EFFECT				ROUTE/SPECIES/TEST/TOXIC EFFECT				ROUTE/SPECIES/TEST/TOXIC EFFECT			
1. ANY	ANY	ANY	CAR	34. IPR	RAT	TDLO	TER	67. ORL	RAT	TD	ETA
2. ANY	ANY	ANY	ETA	35. IPR	RBT	LD50	AT	68. ORL	RAT	TDLO	CAR
3. ANY	ANY	ANY	NEO	36. IVN	CAT	LDLO	AT	69. ORL	RAT	TDLO	ETA
4. ANY	ANY	ANY	TER	37. IVN	CAT	LD50	AT	70. ORL	RAT	TDLO	NEO
5. ANY	ANY	ANY	TFX	38. IVN	DOG	LDLO	AT	71. ORL	RAT	TDLO	TER
6. ANY	ANY	CYT	MUT	39. IVN	DOG	LD50	AT	72. ORL	RBT	LDLO	AT
7. ANY	ANY	DLT	MUT	40. IVN	GPG	LDLO	AT	73. ORL	RBT	LD50	AT
8. ANY	ANY	DND	MUT	41. IVN	MUS	LDLO	AT	74. PAR	MUS	LDLO	AT
9. ANY	ANY	MSC	MUT	42. IVN	MUS	LD50	AT	75. SCU	CAT	LDLO	AT
10. ANY	ANY	OTR	MUT	43. IVN	RAT	LDLO	AT	76. SCU	DOG	LDLO	AT
11. ANY	ANY	SCE	MUT	44. IVN	RAT	LD50	AT	77. SCU	FRG	LDLO	AT
12. ANY	ANY	VIT	MUT	45. IVN	RBT	LDLO	AT	78. SCU	GPG	LDLO	AT
13. ANY	ANY	VIV	MUT	46. IVN	RBT	LD50	AT	79. SCU	GPG	LD50	AT
14. ANY	HAM	CYT	MUT	47. LYM	MUS	DND	MUT	80. SCU	MUS	LDLO	AT
15. ANY	HMN	CYT	MUT	48. ORL	BRD	LDLO	AT	81. SCU	MUS	LD50	AT
16. ANY	HMN	DNS	MUT	49. ORL	BRD	LD50	AT	82. SCU	MUS	TDLO	CAR
17. EYE	RBT	SSSS	PI	50. ORL	CAT	LDLO	AT	83. SCU	MUS	TDLO	ETA
18. IHL	GPG	LCLO	AT	51. ORL	CAT	LD50	AT	84. SCU	MUS	TDLO	NEO
19. IHL	HMN	TCLO	TFX	52. ORL	DOG	LDLO	AT	85. SCU	RAT	LDLO	AT
20. IHL	MUS	LCLO	AT	53. ORL	DOG	LD50	AT	86. SCU	RAT	LD50	AT
21. IHL	MUS	LC50	AT	54. ORL	GPG	LDLO	AT	87. SCU	RAT	TD	ETA
22. IHL	RAT	LCLO	AT	55. ORL	GPG	LD50	AT	88. SCU	RAT	TDLO	ETA
23. IHL	RAT	LC50	AT	56. ORL	HMN	LDLO	AT	89. SCU	RAT	TDLO	NEO
24. IPR	GPG	LDLO	AT	57. ORL	HMN	TDLO	TFX	90. SCU	RBT	LDLO	AT
25. IPR	GPG	LD50	AT	58. ORL	MUS	LDLO	AT	91. SCU	RBT	LD50	AT
26. IPR	MUS	LDLO	AT	59. ORL	MUS	LD50	AT	92. SKN	MUS	TD	ETA
27. IPR	MUS	LD10	AT	60. ORL	MUS	TDLO	CAR	93. SKN	MUS	TDLO	ETA
28. IPR	MUS	LD20	AT	61. ORL	MUS	TDLO	ETA	94. SKN	MUS	TDLO	NEO
29. IPR	MUS	LD50	AT	62. ORL	MUS	TDLO	NEO	95. SKN	RAT	LD50	AT
30. IPR	MUS	TDLO	NEO	63. ORL	MUS	TDLO	TER	96. SKN	RBT	LDLO	AT
31. IPR	MUS	TDLO	TER	64. ORL	RAT	LDLO	AT	97. SKN	RBT	LD50	AT
32. IPR	RAT	LDLO	AT	65. ORL	RAT	LD50	AT	98. SKN	RBT	SSSS	PI
33. IPR	RAT	LD50	AT	66. ORL	RAT	TD	CAR				

*RTECS Abbreviations - See Appendix B

where 24.45 is the number of liters occupied by one mole of an ideal gas at 25°C and 760 mm Hg. All other conversion of units followed standard metric system rules as specified in Appendix A.

The decision to use molar units was based on the way the data were to be used, i.e., for systematic comparison of chemicals. Doses expressed in moles per kilogram of body weight correspond directly to the numbers of molecules which produced the observed effect and were considered, therefore, more indicative of the toxicological activity of the chemical. For example, if compound X has a gram-molecular weight of 350 and compound Y has a gram-moleuclar weight of 50, then any equal weight samples of the two compounds will contain markedly different numbers of molecules, namely X will contain about one-seventh as many molecules as Y. If the two chemicals act similarly on the same target organ or cellular system, then a dose of a given weight of Y would provide seven times as many molecules to impact on receptor sites as would a dose of the same weight of X.

After the dose units were converted, the dose type (either ppm or moles/kg) was compared against the route of administration to assure that volumetric measurements (i.e., ppm) appear only in inhalation studies and that per kilogram measurements (i.e., moles/kg) appear only in non-inhalation studies. Any data record not conforming to these guidelines is rejected to avoid direct comparison of ppm and mole/kg dose units.

In certain cases, (in-vitro mutagenic studies and skin and eye irritation studies performed under the Draize procedure) a known volume is specified, and, with an assumption that the specific gravity of the liquids is equal to 1.0, most units can be converted to millimole notation, making more data useable. (See the computer program model criteria in Appendix A for specific lists of converted and rejected dose units.)

Chronic Data Considerations

Chronic effect data in RTECS are expressed in terms of the unit or daily dose administered and the frequency and/or duration of the administration, but the data often are incomplete. After a review of the RTECS data it was apparent that the only consistently available data entry was the unit or daily dose, and, for consistency in treatment, it was decided that this parameter should be used in this project without consideration of the frequency or duration of administration.

Primary Irritation Data Considerations

The primary irritation data in RTECS are recorded in much the same way as other toxicity data. The test animal, route of

administration, and toxic effect are identified, as is the dose that was administered. However, the duration of exposure, which is highly significant in tests of this type, and the degree of irritation observed are also usually reported. Consequently, the dose could not be used as the single indicator of activity. It was observed that the Draize procedure (J. Pharmacol. Exp. Ther., 82:277-419, 1944) is very widely used in primary irritation testing. In this test the amount of chemical (volume if liquid, weight if solid) applied and the duration of application are fixed, and the degree of irritation (if any) is expressed as mild, moderate, or severe in terms of defined standards. Since a high percentage of the RTECS primary irritation data records were from Draize tests, it was decided to limit use of the RTECS primary irritation data to results derived using this procedure. The doses were converted to molar form and standard units, and then modified as follows to correspond to the degree of irritation observed:

- doses with mild effects were multiplied by 1.0
- doses with moderate effects were multiplied by 0.5
- doses with severe effects were multiplied by 0.25
- doses with an irritant effect shown in other than Draize notation were treated as moderate since examination of the data indicated this to be the best approach

In this way the relatively complex primary irritation data were expressed in dose terms in a way that was analogous to the balance of the RTECS data used in the HRI algorithm.

Tumorigenic and Carcinogenic Data Considerations

RTECS differentiates between carcinogenic and neoplastic tumor formation citations as follows:

- A citation is coded "TFX:NEO" (neoplastic) when "the tumors consist of cells that closely resemble the tissue of origin that are not grossly abnormal cytologically, that may compress surrounding tissues, but that neither invade tissues nor metastasize or when the tumors produced cannot definitely be classified as either benign or malignant."

- A citation is coded "TFX:CAR" (carcinogenic) when "the tumors consist of autonomous populations of cells of abnormal cytology capable of invading and destroying normal tissues, or the tumors metastasize as confirmed by histopathology."

In working with the RTECS data, it was observed that many compounds

reported to be carcinogenic did not also have neoplastigen records. If the researcher studying a chemical observed a statistically significant increase in the number of tumors but did not report them as malignant or metastasized, the tumor-producing compound would have been reported as a neoplastigen in RTECS. The carcinogen category might then be regarded as a subset of the neoplastigen category, at least for the purposes of this model. If the data are considered in this light, then a neoplastigen record could be considered to exist for any chemical with a carcinogenic citation. Given this assumption, generation of a neoplastigen record using the dose data of the existing carcinogen record was made an option in the HRI algorithm computer programs. Exercise of this option expands the data available on those chemicals for which only a carcinogenic citation is present, and standardizes the reporting of toxic effects across all chemicals with carcinogenic properties. Under this option no record is generated if the compound has a neoplastigen record in RTECS in the same test class as the carcinogen record. In the HRIN algorithm computer programs, this option is identified as the "NEO OPTION" and is exercised if the "NEO OPTION" is set to "YES". The effect of utilizing the "NEO OPTION" is illustrated in Table 2. Comparison of the data shows, for example, that for the ORAL-RAT-TDLO-NEO test class, use of the "NEO OPTION" increases the number of chemical-specific neoplastic citations from 95 to 364 and identifies a different chemical as the one producing a neoplasm at the lowest dose level in the test class.

A second option was also developed in an effort to extend the RTECS data. This option applies when RTECS has a neoplastigen record for a compound but does not have a carcinogen record for the compound. Since the observation of any tumor may have carcinogenic significance, it was considered worthwhile to permit optional use of the calculated neoplasm sub-HRIN (as discussed in the HRI algorithm section) as an estimator of the carcinogen sub-HRIN. Note that this procedure does not directly use the dose data from a neoplastic citation for the estimate of a dose to produce a carcinogenic effect. This option is identified in the computer programs as the "CAR OPTION" and is exercised when the "CAR OPTION" is set to "YES" (See discussion on pages 26 and A-15).

Both of these options are controlled by the algorithm user through control codes introduced into the computer programs. The programs require the user to input codes for each option before the program can be run, so the options must be considered each time the HRI algorithm is used. It should be noted that when these options are exercised in the HRI algorithm their effects are introduced into all subsequent algorithms via use of the HRIN data produced by the HRI algorithm (See Figure 1).

TABLE 2 - NEOPLASTIC TEST CLASSES
SHOWING THE EFFECT OF THE "NEO OPTION"

	TEST CLASS	MINIMUM(+30.00) LOG VALUE	MINIMUM LOG VALUE RTECS ACCESSION NO.	MAXIMUM(+30.00) LOG VALUE	MAXIMUM LOG VALUE RTECS ACCESSION NO.	NO. OF TEST CITATIONS
			"NEO OPTION" OFF			
3.	ANY ANY ANY NEO	19.255035	HN2625000	37.786942	XU7350000	253
30.	IPR MUS TDLO NEO	25.502625	CW1795065	33.985306	MU7700000	82
62.	ORL MUS TDLO NEO	20.901321	HP3500000	38.378464	AJ0175000	95
70.	ORL RAT TDLO NEO	27.683380	WU7675000	39.131470	AB4025000	95
84.	SCU MUS TDLO NEO	21.820023	HN2625000	34.937149	RQ8050000	125
89.	SCU RAT TDLO NEO	19.291580	WJ5600000	36.089828	RQ8050000	132
94.	SKN MUS TDLO NEO	22.075012	CW1795050	39.639572	CY1400000	167
			"NEO OPTION" ON			
3	ANY ANY ANY NEO	19.255035	HN2625000	38.845291	KX4550000	425
30	IPR MUS TDLO NEO	23.042969	YQ8925000	33.985306	MU7700000	116
62	ORL MUS TDLO NEO	20.901321	HP3500000	40.013458	HO7030000	240
70	ORL RAT TDLO NEO	23.288483	GY1925000	39.131470	AB4025000	364
84	SCU MUS TDLO NEO	21.820023	HN2625000	34.937149	RQ8050000	200
89.	SCU RAT TDLO NEO	19.291580	WJ5600000	39.774017	DV4900000	194
94.	SKN MUS TDLO NEO	22.075012	CW1795050	39.639572	CY1400000	213

In addition, some RTECS tumorigenic data is classified as "equivocal tumorigenic agent" (ETA). This classification is utilized when "some evidence of tumorigenic activity is presented, but one or more of the criteria listed" for neoplastic or carcinogenic tumor formation is missing. This data is used in the model algorithms because of the potential for tumor formation indicated by existing data.

Normalization of Dose Data

If all of the chemicals in question had been tested in the same way, i.e., in one test class, the doses of these tests could be used directly to rank the chemicals. However, as noted previously, the chemicals have been tested in a number of ways and many individual chemicals have been tested in two or more test classes. Furthermore, the test classes span a number of toxic effects, including acute toxicity, primary irritation, carcinogenicity, mutagenicity, etc., which are of significance in the model algorithms. It was necessary, therefore, to devise a way to compare dose data across test classes as well as from chemical to chemical within a test class. The dose data had to be normalized in some manner so that the effects of using specific test animals and routes of administration would be removed.

To do this, one works with each of the test classes separately. Each dose in a specific four element test class (d_i) can be expressed as a function of some characteristic of the class, such as the lowest dose, the average dose, or the range of the doses in the class. Each dose in a test class can thereby be expressed as a function of the same base, and since each test class in treated in the same way, doses from the various test classes become more comparable.

The use of the range of doses within a test class was selected as the most effective for purposes of the HRI algorithm. In this approach the normalized dose is calculated as follows:

$$d_n = \frac{d_{max} - d_i}{d_{max} - d_{min}}$$

where: d_n = normalized dose

d_i = observed dose*

d_{max} = maximum observed dose in the test class*

d_{min} = minimum observed dose in the test class*

* All doses in this equation are expressed as the natural logarithm of the dose.

Thus, the difference between the observed dose in question and the highest dose in the test class is divided by the range of doses in the class. This normalization approach was selected because the result is a positive number that ranges from zero for the highest dose (i.e., the least toxic material) to 1.0 for the lowest dose (i.e., the most toxic chemical) in a test class, and that is directly proportional to the relative position of the observed dose between the highest and the lowest observed doses. These characteristics lend themselves to computer manipulation and to generation of an index number that corresponds to the relative risk resulting from exposure to specific chemicals.

The function shown above was used to produce normalized dose data in each of the 98 test classes.

It was found that the wide variation in doses from the most toxic chemicals to the least toxic within a specified test class involved calculations that required as much as fourteen significant figures and masked the small dose differences that exist in the more toxic chemicals. To bring the range of doses into more manageable terms, the doses were converted to logarithmic scale. This produced dose numerics that were all within two orders of magnitude and retained the capability to recognize small differences that exist at the low end of the dose scale. All algorithm calculations used data in these units (in millimoles per kilogram body weight or in ppm), to which a constant of 30.00 was added to assure that all values would be positive. Examples of the calculated log values can be seen in Table 3. In addition to displaying the minimum (most toxic dose) log values for each test class, Table 3 cites the RTECS assession number for the chemical where the minimum or maximum test class dose is found, as well as the number of test citations in each test class.

RTECS Work Record

Accomplishment of the steps outlined in the preceding sections produce a work record for each RTECS toxic data record that contained the following separately addressable data elements:

- RTECS accession number
- Indicator for occurence in NOHS file
- RTECS chemical name (first 94 positions)
- Route of administration, test species, test procedure, and toxic effect
- Dose in ppm or millimole/kg

TABLE 3 - TEST CLASSES SHOWING
DOSE LOG VALUES, RTECS CHEMICAL REFERENCE CITED, & NUMBER OF RECORDS PER TEST CLASS

TEST CLASS NO.*	MINIMUM(+30.00) LOG VALUE	MINIMUM LOG VALUE RTECS ACCESSION NO.	MAXIMUM(+30.00) LOG VALUE	MAXIMUM LOG VALUE RTECS ACCESSION NO.	NO. OF TEST CITATIONS
1.	22.566498	RP5950000	39.774017	DV4900000	299
2.	22.090057	KG2975000	39.483154	KI0175000	418
3.	19.255035	HN2625000	37.786942	XU7350000	253
4.	15.708064	HP3500000	34.117218	OJ5800000	300
5.	14.211206	TJ2800000	37.774139	ZC0110000	360
6.	20.531967	KE4100000	33.413162	EZ6475000	108
7.	18.636520	KE4390000	35.916260	LZ6500000	83
8.	13.820038	HB7875000	40.296600	MU7175000	189
9.	17.499817	FZ3675000	41.818069	BZ8580500	114
10.	17.499817	FZ3670000	31.169800	PB2100000	70
11.	10.375351	TP2450000	33.688873	IQ0525000	88
12.	19.724854	AV9800000	38.070892	KU9625000	102
13.	15.105679	AB1925000	33.493240	RC8965000	142
14.	17.754761	YY8050000	40.126617	RS2060000	150
15.	10.663040	DK7175000	35.562271	KQ6300000	139
16.	16.184479	UZ9850000	34.605164	QH4560000	72
17.	16.739517	EJ8225000	31.987122	KL5600000	1454
18.	27.723434	DT7000000	41.512924	PA8400000	102
19.	25.355911	RN1140000	41.091431	PC1400000	89
20.	27.271454	DT7000000	43.458832	KI1100000	375
21.	19.947906	LT8524000	43.764206	KU5340000	173
22.	27.812057	DT7000000	43.704575	FG4920000	424
23.	27.908203	TA0700000	48.927490	TE7000000	219
24.	20.140060	B08785750	34.463669	KQ6300000	110
25.	23.002609	WH6650000	34.479172	MA1575000	171
26.	20.081467	CB9459000	34.978333	ZF0800000	1760
27.	11.068497	VC3968770	30.315033	AF1710000	434
28.	22.160370	AU1490000	29.777191	TX7020000	83
29.	14.339328	RT6475000	36.516541	QL2975000	12495
30.	25.502625	CW1795065	33.985306	MU7700000	82
31.	20.898514	AU1575000	35.331802	LQ2100000	103
32.	20.939194	AR5950000	34.659348	MN9275000	865

*See Table 1 for test class titles

TABLE 3 (Continued)

TEST CLASS NO.	MINIMUM(+30.00) LOG VALUE	MINIMUM LOG VALUE RTECS ACCESSION NO.	MAXIMUM(+30.00) LOG VALUE	MAXIMUM LOG VALUE RTECS ACCESSION NO.	NO. OF TEST CITATIONS
33.	14.911523	RT6475000	35.695938	PC1400000	2289
34.	21.387405	OH6300000	34.891739	LQ0525000	119
35.	25.041641	XX9625000	32.641083	YU0875000	66
36.	20.983322	ED9770000	34.449814	KQ6300000	163
37.	20.779022	FH5090000	32.877502	DG6125000	218
38.	17.432083	BR7875000	34.444733	NT8050000	271
39.	11.841690	RT6475000	35.833664	TY2000000	217
40.	21.691162	GA0875000	33.907898	VZ4725000	87
41.	17.482758	VG4888000	33.647812	TS8750000	342
42.	13.354279	RT6475000	35.172318	MA1575000	10478
43.	18.488571	WR7940000	33.808945	KW2975000	269
44.	12.832092	RT6475000	34.492493	TY2000000	1125
45.	20.381500	UL2100000	35.445465	AC5960000	508
46.	11.473969	RT6475000	34.562103	LW5320000	539
47.	20.684296	AR9548200	30.405457	EV6475000	208
48.	25.739029	YD0160000	32.092285	OV9100000	77
49.	22.841568	TF3850000	35.034149	PV6210000	320
50.	21.930389	GH0700000	34.869125	KQ6300000	107
51.	21.166656	LZ0875000	34.841537	GE8050000	72
52.	21.930389	GH0700000	36.023804	AL3150000	167
53.	22.389542	AY4375000	35.666611	TY2000000	181
54.	24.332535	TB1700000	34,594391	OG4375000	116
55.	16.806671	HP3500000	35.520004	TY2000000	420
56.	20.899017	GH0520000	34.963333	NT8050000	152
57.	18.025192	ZG0700000	36.945023	TY2000000	148
58.	22.908752	JO6300000	35.062012	HE4375000	458
59.	19.546204	TM3170000	38.366623	TK7887000	6240
60.	23.071991	WJ5600000	40.013458	HO7030000	145
61.	25.839706	CW3850000	42.566772	SJ3325000	136
62.	20.901321	HP3500000	38.378464	AJ0175000	95
63.	20.719009	HP3500000	38.443344	KQ6300000	69
64.	22.436279	RQ2128000	35.189713	CZ0240000	824
65.	20.253891	TF2780000	36.122849	GU9625000	5118

TABLE 3 (Continued)

TEST CLASS NO.	MINIMUM(+30.00) LOG VALUE	MINIMUM LOG VALUE RTECS ACCESSION NO.	MAXIMUM(+30.00) LOG VALUE	MAXIMUM LOG VALUE RTECS ACCESSION NO.	NO. OF TEST CITATIONS
66.	21.608261	HP3500000	38.440323	JG8225000	68
67.	22.237793	HP3500000	38.776840	DE4550000	141
68.	23.288483	GY1925000	39.042648	PB2100000	269
69.	20.613647	HP3500000	41.909988	SJ3325000	395
70.	27.683380	WU7675000	39.131470	AB4025000	95
71.	19.802704	HP3500000	37.041656	MO6300000	145
72.	19.620377	HP3500000	35.571304	TY2000000	312
73.	23.052094	GY1925000	34.917923	KQ6300000	399
74.	23.871597	TC2275000	34.923645	YT7175000	155
75.	22.613174	AR5960000	33.701080	AI9100000	115
76.	21.676743	BO4900000	34.869125	KQ6300000	121
77.	20.835098	WL2275000	35.779846	KI5775000	180
78.	20.533722	AR5960000	35.316406	TY2000000	224
79.	19.200699	XW5500000	34.141830	OZ5075000	98
80.	18.078796	UL2100000	34.766266	UY5715000	724
81.	16.777252	CR5250000	35.722839	PC1400000	3581
82.	22.914780	CN0700000	34.172211	QL3675000	77
83.	21.591660	AU1575000	37.979706	OD9625000	409
84.	21.820023	HN2625000	34.937149	RQ8050000	125
85.	21.226883	AR5950000	35.389023	OZ4550000	338
86.	13.820038	RT6475000	35.571304	TY2000000	755
87.	23.572571	HN2625000	35.306015	FG4900000	67
88.	24.094467	MA1050000	36.906174	MN4725000	232
89.	19.291580	WJ5600000	36.089828	RQ8050000	132
90.	20.427887	BR7875000	34.484070	KW2975000	316
91.	20.334595	TB1090000	34.700317	SA0700000	108
92.	23.925781	CW3850000	37.517639	RN7700000	84
93.	21.699829	HP3500000	38.856308	EM7350000	307
94.	22.075012	CW1795050	39.639572	CY1400000	167
95.	25.204819	UX6825000	34.965195	FC1925000	253
96.	23.832809	MQ5270000	36.073105	KQ6300000	142
97.	22.934586	HP3500000	36.436188	PC1400000	890
98.	12.321259	VR3545000	32.704666	AS6920000	1265

- Dose in natural log (ln) millimole/kg or natural log (ln) ppm

The file of these records serves as the input used by the HRI algorithm computer programs discussed in the next section of this report.

THE HAZARD RISK INDEX

The Hazard Risk Index (HRI) represents accomplishment of the first major NIOSH goal in the development of this model - to provide a mechanism for the assessment of the toxicological effects of chemicals known to be in the workplace.

The HRI algorithm provides a rank-ordering of the chemicals common to both the RTECS and NOHS data sources ("linked" chemicals) based only on their potential toxicological risk. Only RTECS data is used, and without consideration of the conditions or extent of worker exposure.

An estimate of the relative toxicological risk posed by any linked chemical is provided in numerical form by the HRI algorithm. This number is used to rank-order all linked chemicals in descending order of toxicity. The resulting list provides the chemical toxicity priorities needed for an assessment of potential workplace hazard.

The HRI Algorithm

In producing an algorithm to assess the toxicological risk of a chemical based solely on RTECS data, NIOSH realizes that use of the results from this algorithm must be tempered by a recognition that:

a) The RTECS data are unevaluated; only the lowest dose producing a specific effect for a given test class is reported for any specific chemical, and coverage of chemicals and test classes is incomplete; and

b) The criteria for selection of RTECS data, as detailed in the preceding section, impose further data limitations.

Examination of the normalized dose and test class data derived in preparation of the RTECS data source indicated that all the selected data could be contained in the following eight categories:

- Acute toxicity (AT)
- Carcinogenicity (CAR)
- Equivocal tumorigenic agents (ETA)

- Mutagenicity (MUT)
- Neoplastigenicity (NEO)
- Primary irritation (PI)
- Teratogenicity (TER)
- Other toxic effects (TFX)

It was decided that the algorithm should consider each of these categories separately in the calculation of the overall Hazard Risk Index Number (HRIN) for any given chemical. Accordingly, these categories were designated sub-HRI's, and the numerical value arising from the examination of the normalized dose data within each sub-HRI became the sub-HRIN.

Calculation of the sub-HRIN is accomplished by averaging the normalized dose data (one citation per test class) falling within each sub-HRI for a given chemical. This results in the expression of from one to eight sub-HRIN values for each chemical. (See Appendix A and Figure 4 for computer program considerations.)

As expressed earlier, NIOSH intends that any of the algorithms in this model be responsive to user needs. It was therefore decided that the algorithm be designed so that any individual sub-HRIN could be suppressed or enhanced in the calculation of the final chemical-specific HRIN in accordance with user priorities (e.g. increased emphasis on carcinogenic test results).

Finally, experimentation with various methods for utilizing the sub-HRIN values to calculate the HRIN for each chemical indicated that the best procedure was to simply sum the sub-HRIN's. This decision was made on the basis of two observations:

a) Use of an averaging procedure for sub-HRIN's containing data was observed to result in the expression of a value biased toward chemicals with a single relatively high sub-HRIN. Examination of trial listings, and subsequent discussions with toxicologists confirmed that the averaging procedure tended to assign relatively low HRIN values to well-researched chemicals with broad spectrum toxicological properties in comparison to the values assigned to single-effect chemicals. This resulted in inappropriate ranking for many chemicals.

b) While summing procedure equates no data in a sub-HRI with no demonstrated toxic effect, this assumption is necessary because of the limited nature of our data source. Although it is not complete, we believe that the RTECS data source contains as complete a listing of toxicity effects as is currently available.

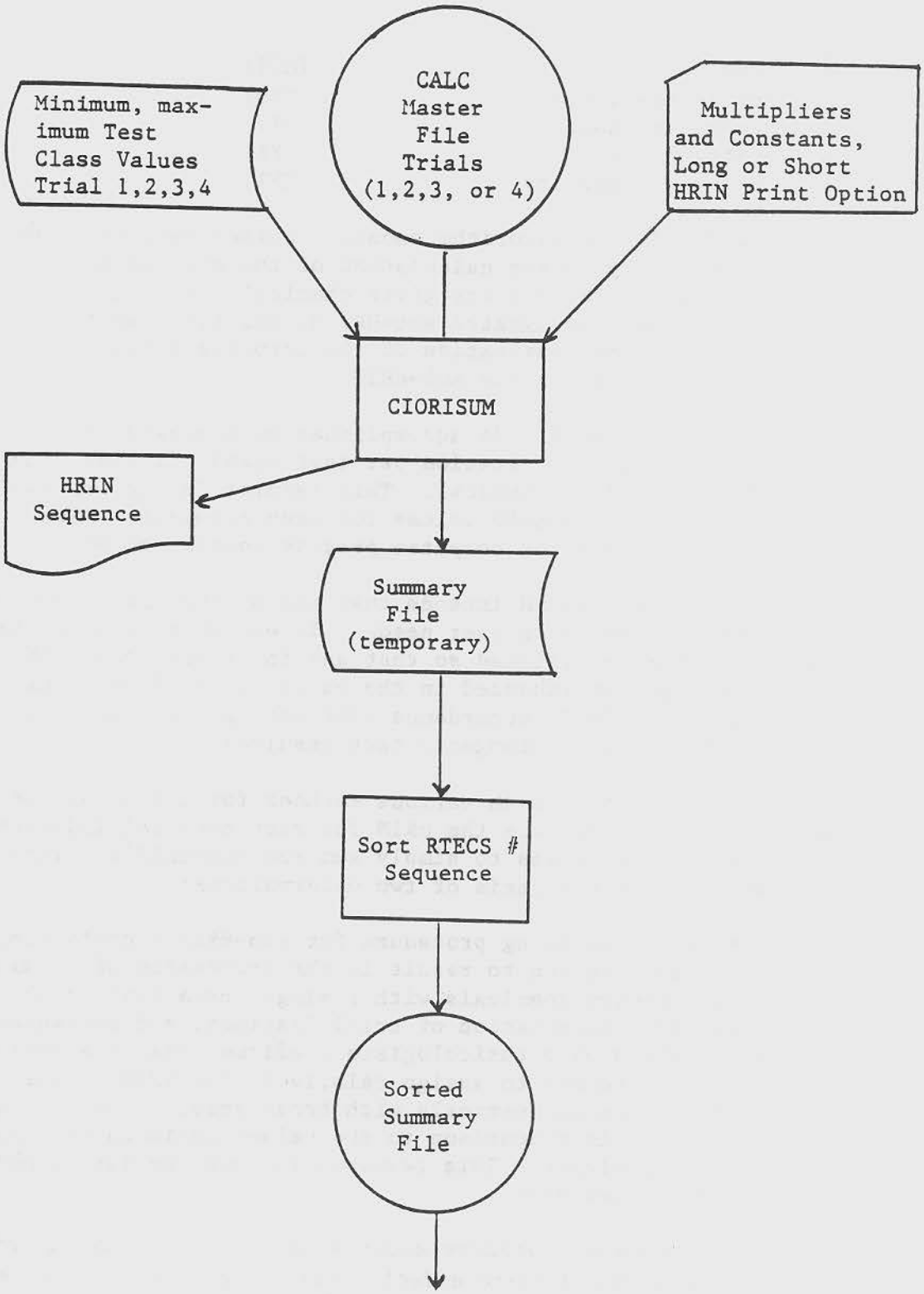


FIGURE 4. HRI Algorithm Computer Programs Flow Chart

On the basis of all these considerations, the final HRI algorithm is expressed as:

$$HRIN = (aAT \oplus b) + (cCAR \oplus d) + (eETA \oplus f) + (gMUT \oplus h) + (iNEO \oplus j) + (kPI \oplus I) + (mTER \oplus n) + (oTFX \oplus p)$$

where, for each test class within each chemical (See discussion on Pages 17 and 18):

AT = The average of all acute toxicity normalized doses.
CAR = The average of all carcinogenic normalized doses.
ETA = The average of all equivocal tumorigenic agent normalized doses.
MUT = The average of all mutagenic normalized doses.
NEO = The average of all neoplastigenic normalized doses.
PI = The average of all primary irritation normalized doses.
TER = The average of all teratogenic normalized doses.
TFX = The average of all other toxic effect normalized doses.

Lower case letters "a" through "p" indicate variable numerical factors (values 0 to 9) for the enhancement or suppression of individual sub-HRIN values.

$\oplus$ = an addition which is performed only if the associated sub-HRIN is not equal to zero.

The above HRI algorithm produces a hazard risk index number that has a direct relationship to the overall observed toxicity of the chemical; the higher the HRIN, the higher the toxicity. In addition, an algorithm in this form allows the user great flexibility in defining his toxicological priorities. He can increase the impact of any sub-HRIN by using a multiplier (a, c, e, g, i, k, m, and o in the equation), he can eliminate any sub-HRIN from the equation by using a zero multiplier, and he can cause chemicals with data in any area, such as carcinogenesis, to head the Hazard Risk Index by using sufficiently large constants (b, d, f, h, j, l, n and p in the equation). In short, he can adapt the algorithm to any toxicological priorities that apply in his/her situation.

It should be noted that the normalized dose for the least toxic chemical in each test class (i.e., the chemical for which $d_i = d_{max}$) produces a situation that must be handled separately by the computer program. If the sub-HRIN were derived from a single RTECS data entry of this type, the sub-HRIN would be zero and would not be included in the process used to calculate the HRIN. This situation is avoided, however, by a subroutine in the normalized dose calculation program which gives any normalized dose calculated

to be zero a nominal value of 0.0001. Consequently, a zero sub-HRIN is only encountered when there are no data in the sub-HRIN category, and all such zero sub-HRIN's properly have no effect on the final HRIN.

Computer programs to operate this algorithm and display the data in standard format were developed and tested. A sample page from a Hazard Risk Index is shown in Figure 5. As seen in Figure 5, the data display format for the HRIN is in several parts, as follows:

(1) The first line of the heading at the top of each page identifies the index, the date of the RTECS data used in its preparation, the date the index was run, and the sequential page number.

(2) The second and third lines of the heading at the top of each page identify the multiplier and constant values used in calculation of the HRIN. They also identify the setting of the "NEO OPTION" ("YES" indicating that RTECS carcinogenic dose data were used to produce neoplastic data citations in those cases where RTECS has a CAR citation but no NEO citation within the same chemical/test class), the setting of the "CAR OPTION" ("YES" indicating that NEO sub-HRIN values were used as estimators for the CAR sub-HRIN where RTECS has a NEO citation(s) but no CAR citation within the same chemical). (In this example, all multipliers are set at 1, all constants are set at 0, and the "NEO OPTION" and "CAR OPTION" set at "NO" - resulting in an HRIN value derived from considering all sub-HRIN's equal in toxicological importance; and with no estimate of CAR or NEO made.

(3) The entry for each chemical is made up of three types of lines. The first line gives the sequence number of the chemical (out of 1721), identifies it as a "linked" chemical ("H"), cites the RTECS accession number, and gives the RTECS primary name. The second line type gives the calculated value for each sub-HRIN for which there is data and the final HRIN. The third type of line presents the RTECS toxicity data for the chemical; lines of this type are entered in whatever number is needed to display all the RTECS data within the selected 98 test classes for the chemical. East test class is identified in terms of route, species, test and outcome (e.g. SCU MUS LD50 AT) using RTECS abbreviations. This is followed by a numeric entry showing the number of chemicals for

HRIN calculations based on RTECS data as of 01/81 DATE: 08/17/81 page 1

Multipliers for AT=1 CAR=1 ETA=1 MUT=1 NEO=1 PI=1 TER=1 TFX=1 NEO OPTION= NO
Constants for AT=0 CAR=0 ETA=0 MUT=0 NEO=0 PI=0 TER=0 TFX=0 CAR OPTION= NO

SEQ# 1 H AR1925000 Acetaldehyde
AT= .186 CAR= .000 ETA= .000 MUT= .440 NEO= .000 PI= .120 TER= .131 TFX= .393 HRIN= 1.271

ANY	ANY	ANY	TER	300	.131572
ANY	ANY	DND	MUT	189	.127994
ANY	ANY	SCE	MUT	88	.192107
ANY	ANY	VIV	MUT	142	1.000000
EYE	RBT	SSSS	PI	1454	.227582
IHL	HMN	TCLO	TFX	89	.393606
IHL	RAT	LCLO	AT	424	.340445
IPR	RAT	LDLO	AT	865	.162556
IVN	MUS	LD50	AT	10478	.165060
ORL	RAT	LD50	AT	5118	.147655
SCU	MUS	LD50	AT	3581	.167873
SCU	RAT	LD50	AT	755	.133114
SKN	RBT	SSSS	PI	1265	.013521

SEQ# 2 H AB2450000 Acetaldehyde, Chloro-
AT= .580 CAR= .000 ETA= .000 MUT= .000 NEO= .000 PI= .000 TER= .000 TFX= .000 HRIN= .580

IPR	GPG	LD50	AT	171	.809896
IPR	MUS	LD50	AT	12495	.459322
IPR	RAT	LD50	AT	2289	.450620
IPR	RBT	LD50	AT	66	.878338
ORL	MUS	LD50	AT	6240	.514611
ORL	RAT	LD50	AT	5118	.463197
SKN	RBT	LD50	AT	890	.488431

FIGURE 5. Example HRI

which there are data within that test class. Next is a number entry showing the normalized dose value for each test class (to six decimals) which is used in the calculation of the sub-HRIN.

Printing of the third type of line in the HRI is an option in the computer program, and is referred to as the "long form".

In Figure 5, it can be noted that acetaldehyde (sequence number 1) has RTECS data on acute toxicity, carcinogenicity, mutagenicity, primary irritation, teratogenicity, and other toxic effects. Its HRIN is derived from these six sub-HRIN's.

For details regarding the computer programs producing the HRI see Figure 4, "HRI Algorithm Computer Programs Flow Chart", and the HRI material in Appendix A.

For complete examples of the Hazard Risk Index, see the listing of HRI's in Appendix E (pages E-1, E-2, and E-3) and the corresponding microfiche copies of the computer printouts in the packet at the back of this publication.

THE NOHS DATA SOURCE

The National Occupational Hazard Survey (NOHS) is a two-year study conducted by the National Institute for Occupational Safety and Health, starting in 1972. The survey was intended to describe the health and safety conditions in the American work environment and, more specifically, to determine the extent of worker exposure to chemical and physical agents and the conditions under which such exposure occurs. The sample of businesses in the survey, selected by the Bureau of Labor Statistics, totaled approximately 5000 establishments in 67 metropolitan areas throughout the United States. The sample represents all non-agricultural businesses covered under the Occupational Safety and Health Act of 1970.

Survey data were collected by engineers specially trained in the recognition of industrial health hazards. Worker exposures to specific potential health hazards were recorded. Strong emphasis was placed on uniformity in the data collection.

The exposure data used in this model are derived from the NOHS raw data master files. Due to the design of this survey, in which certain SIC groups (e.g., manufacturing) and certain facility sizes (e.g., large) were oversampled, projections from the sample to the

national universe were found by NIOSH to be generally statistically reliable only at the 2-digit SIC or hazard-specific levels. Projections at lower levels (e.g., 4-digit SIC) are relatively unreliable due to the high variance associated with the estimates.

Because of this, it was decided that it was not possible to produce sufficiently accurate projected estimates of the number of persons exposed at the national level for all the various worker groups* under consideration. Data at the hazard level (i.e., data that are irrespective of industry and occupation) as required in the AHRI algorithm could be utilized directly, but data at the occupation and at the 3-digit and 4-digit SIC levels could not be used directly without introducing a great amount of uncertainty in the calculations. Since one objective in this model is to permit maximum algorithm input flexibility, it was decided that the same set of data files should be used in all of the algorithms that employ NOHS data. Mechanisms were considered, therefore, for the examination and comparison of worker groups within only the NOHS sample of <u>people seen</u> (actual observations), rather than within the NOHS projections to the national universe.

Computer processing of the NOHS data base is illustrated in Figure 6.

Searches of the NOHS files demonstrated that the total number of people surveyed in each worker group could be accurately determined from the NOHS raw data master file. However, precautions had to be taken to avoid multiple counting of individuals exposed to specific agents. This potential multiple counting of individuals is due to the following characteristics of the NOHS data:

a. Potential exposure of an individual to a specific identified hazard in up to eight forms - dust, liquid, gas, particles, fumes, mist, smoke, vapor.

b. Potential exposure of an individual to a specific chemical substance as a component of several trade name compounds present in his/her work environment.

c. Potential exposure of an individual to a specific substance, singly or multiply, in pure form (actual) or as a trade name component, determined by resolution of the components of trade name products.

---

* A worker group is defined as all workers observed in NOHS that have the same occupation/industry characteristics. Different worker groups are involved in each of the indexes. (See Table 4.)

FIGURE 6. NOHS Computer Processing Considerations

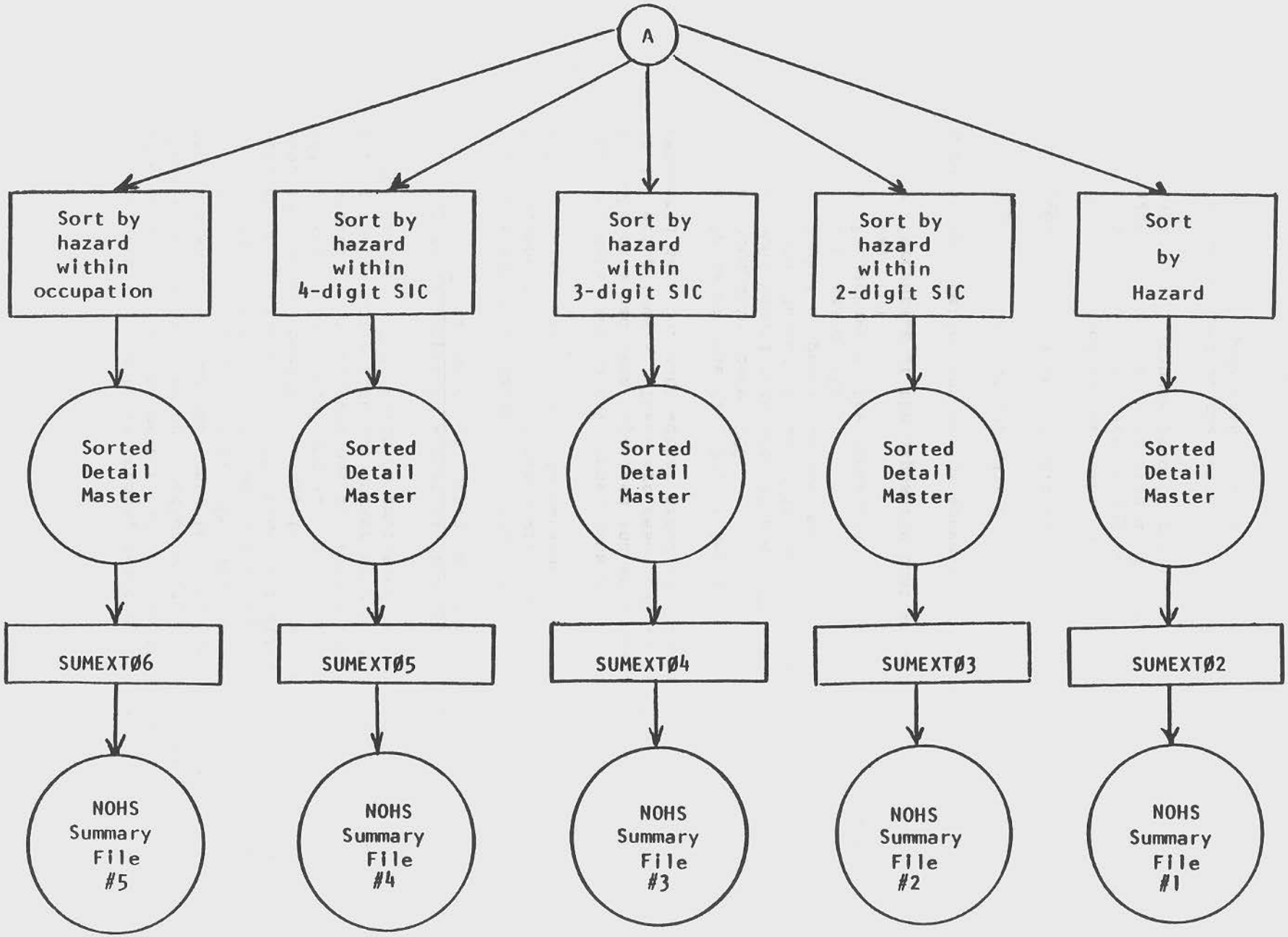


FIGURE 6. (Continued)

To eliminate such multiple counts, searches of the NOHS data base were made by NIOSH and "people exposed" counts were produced. These counts eliminated duplication within any "worker group" and reported an individual only once for each identified hazard in the relevant "worker group" cell. NOHS data tapes showing these data were prepared by NIOSH and used in the high risk model. Successful production of data for (1) the non-duplicative number of people exposed (hazard specific) at the five worker group levels (see below) used in this model and (2) the total number of people in each worker group, allowed use of "worker exposed ratios" in comparing the relative risk for worker groups at the defined levels of specificity. This ratio is expressed as:

$$\frac{\text{Number of people in worker group X exposed to hazard Y}}{\text{Total number of people in worker group X}}$$

With this ratio we compare, for example, the exposure of one out of forty plumbers (1/40) to benzene with the exposure of twelve out of ninety (12/90) electricians to benzene.

The NOHS data used in this model consists of five files in which the NOHS data had been organized and accumulated by worker groups at differing levels. These are described in Table 4. The files presented data for each worker group as follows:

- Industry code (2-, 3-, or 4-digit SIC).
- Occupation code (OCC).
- NOHS Hazard code and "linked" RTECS number.
- Total number of people in the worker group (PEN).
- Number of people in the worker group that were exposed to the hazard (PES).
- Percentage of the exposures that were controlled in some way (PC).
- Percentage of the exposures that were full-time (PFT).

A more exact definition of the above key factors is as follows:

SIC, see codes in Appendix C.

OCC, see codes in Appendix D.

PEN is defined as the number of people in a worker group noted as potentially exposed to any chemical, physical or biological agent in the NOHS data base as determined by direct observation or tradename product resolution.

PES is defined as the number of people in a worker group noted in the NOHS data base as potentially exposed to a specific

TABLE 4 - NOHS DATA FILES

File Number	Number of Records	Worker Group
1	2,092	Workers exposed to a linked hazard without regard to industry or occupation.
2	20,060	Workers exposed to a linked hazard within an industry at the 2-digit SIC level, without regard to occupation.
3	42,125	Workers exposed to a linked hazard within an industry at the 3-digit SIC level, without regard to occupation.
4	56,206	Workers exposed to a linked hazard within an industry at the 4-digit SIC level, without regard to occupation.
5	48,768	Workers exposed to a linked hazard within an occupation without regard to industry.

chemical hazard as determined by direct observation or trade-name product resolution.

PC is defined as the percentage of observed exposures to the given hazard where some valid type or types of exposure control mechanism was employed.

PFT is defined as the percentage of observed exposures to the given chemical hazard where the exposure normally occurred more than 4 hours each working day.

THE ADJUSTED HAZARD RISK INDEX

The Adjusted Hazard Risk Index (AHRI) represents accomplishment of the second major NIOSH goal in development of this model - to provide a mechanism for the assessment of the relative workforce health effect posed by specific chemical agents.

The AHRI algorithm provides a rank-ordering of the linked chemicals based on both RTECS toxicological data and NOHS incidence, duration and exposure control data.

An estimate of the relative health risk posed by any linked chemical to the working population is provided in numerical form by the AHRI algorithm. This number is used to rank-order all linked chemicals in descending order of relative workforce health effect. The resulting list provides the simultaneous evaluation of chemical toxicity and worker exposure data needed to establish priorities in the effort to control occupational hazards.

The AHRI Algorithm

The rationale for the Adjusted Hazard Risk Index algorithm is that the overall risk posed by a chemical hazard is dependent upon both the chemical's toxicity and the extent to which workers are exposed to the chemical. Accordingly, a highly toxic chemical to which a small number of persons are exposed is considered to pose less risk than a chemical of similar toxicity to which many persons are exposed, and a moderately toxic chemical to which many persons are exposed poses more risk than one that is highly toxic but to which only a few persons are exposed.

The AHRI is concerned only with the toxicity of each chemical and the extent of worker exposure to that chemical. Therefore, data from NOHS file number 1 (which provides exposure data on workers without regard to their industry or occupation) was used in the

AHRI calculations. The records in this file correspond to the 2,092 hazards (chemicals) that appear in both the RTECS and NOHS data files. However, as explained on page 11, only 1721 of these records were utilized in the model algorithms.

In examining the NOHS data, it was decided the extent of chemical-specific worker exposure could best be described for use in the AHRIN by utilizing data on: (1) the total number of workers seen potentially exposed to any NOHS hazard, (2) the number of people seen potentially exposed to a specific linked chemical, (3) the percent of the chemical-specific exposures observed which were controlled by some valid procedure, and (4) the percent of chemical-specific exposures observed which were full-time by NOHS criteria.

It was decided that the most logical approach in describing the inter-relationship between chemical-specific toxicity and the extent of worker exposure was to multiply the HRIN by those factors describing the extent of worker exposure. The algorithm for the Adjusted Hazard Risk Index Number (AHRIN) is therefore as follows:

$$AHRIN = (HRIN)(PES/PEN)(1.0 - 0.9\ PC)(0.5 + 0.5\ PFT)(K)$$

where:

- HRIN = Hazard Risk Index Number.
- PES = Number of people potentially exposed to the hazard.
- PEN = Number of people in the worker group (In the AHRIN, this is equal to the number of people potentially exposed to <u>any</u> NOHS hazard. Therefore, the PEN factor is a constant 545,569 in all AHRIN calculations.)
- PC = Percentage of controlled exposures.
- PFT = Percentage of full-time exposures, and
- K = A constant used to remove leading zeroes.

In this algorithm the hazard risk index numbers (HRIN) come directly from the Hazard Risk Index, the PES/PEN ratio indicates the percentage of all workers observed in the NOHS survey who were potentially exposed to the hazard, the (1.0 - 0.9 PC) factor reduces the significance of controlled exposures to ten percent*

---

* The ten percent factor for controlled exposures corresponds to the minimum acceptable effect produced by use of a respirator, and is considered to be indicative of the order of magnitude protection that can be expected from the use of exposure controls.

of that of uncontrolled exposures, and the (0.5 + 0.5 PFT) factor reduces the significance of part-time exposures to one-half of that of full-time exposures. The constant K is used to remove leading zeroes in the resulting index number. The algorithm produces an AHRIN that has a direct relationship to the potential risk posed by the hazard: the higher the AHRIN the higher the potential health risk to the workforce.

Computer programs to operate this algorithm and display the data in standard format (flow-charted in Figure 7) were developed and tested. A sample page from an Adjusted Hazard Risk Index is shown in Figure 8. Complete examples of the AHRI are provided in microfiche form (See page E-3).

As shown in Figure 8, the data display format for the AHRI is in several parts, as follows:

(1) The first line of the heading at the top of each page identifies the index as the HRIN trial and run* from which the HRIN input came, the date of the RTECS and NOHS file update versions used, the date of the AHRIN printout, and the page number within the specific AHRI printout.

(2) The second line of the heading at the top of each page repeats the multiplier values and "NEO OPTION" settings used in the source HRIN.

(3) The third line of the heading at the top of each page repeats the constant values and "CAR OPTION" settings used in the source HRIN.

(4) The entry for each linked chemical consists of two lines of data. The first line gives the sequence (rank-order) number for the chemical, its RTECS and NOHS identification codes (in RTECS/NOHS format), and the prime RTECS name for the chemical. The second line gives the sequence (rank-order) number for the chemical in the source HRIN, the source HRIN value used, the exposure extent values used (PES, PEN, PC, PFT), and the final AHRIN calculated.

For details on the computer programs which produce the AHRI, see Appendix A.

---

* The words "trial" and "run" and attached numbers related to the HRIN are internal tracking system references which further identify the specific source HRIN and the "dial settings" used to produce it. (See discussion in Appendix A for CIORICAL and CIORISUM programs.)

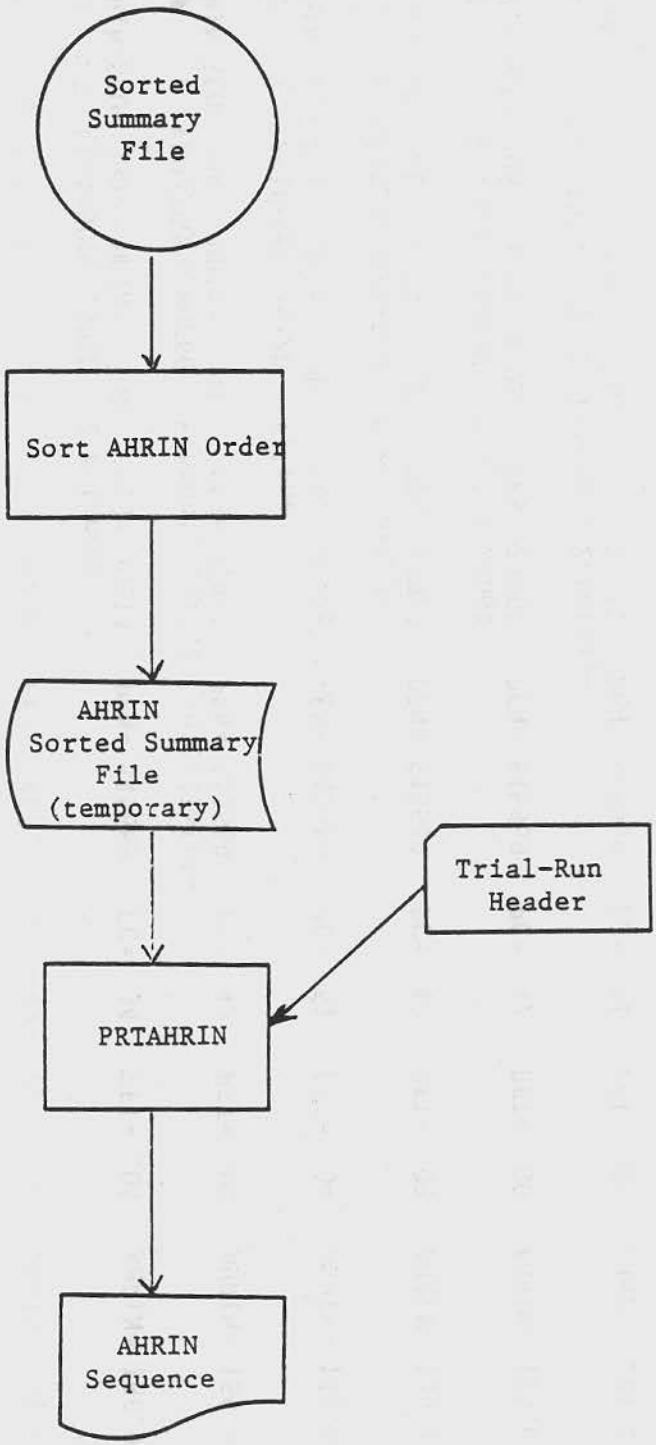


FIGURE 7. AHRI Algorithm Computer Programs Flow Chart

AHRIN calculation based on HRIN Trial 02 Run 01 RTECS Date 01/81 NOHS Date 07/80 Date: 08/31/81 page 1

Multipliers for AT=1 CAR=1 ETA=1 MUT=1 NEO=1 PI=1 TER=1 TFX=1 NEO OPTION= YES
Constants for AT=0 CAR=0 ETA=0 MUT=0 NEO=0 PI=0 TER=0 TFX=0 CAR OPTION= NO

SEQ# 1 KQ6300000/31500 Ethyl Alcohol
HRIN SEQ= 242 HRIN= .970 PES= 50539 PEN= 545569 PC= .27 PFT= .02 AHRIN= 347.241

SEQ# 2 NT8050000/40987 Isopropyl Alcohol
HRIN SEQ= 584 HRIN= .575 PES= 70218 PEN= 545569 PC= .26 PFT= .03 AHRIN= 292.226

SEQ# 3 KJ2975000/46970 Ethane, 1,1,1-trichloro-
HRIN SEQ= 394 HRIN= .761 PES= 42605 PEN= 545569 PC= .26 PFT= .01 AHRIN= 229.964

SEQ# 4 XR2275000/A1358 Titanium Oxide
HRIN SEQ= 399 HRIN= .755 PES= 34656 PEN= 545569 PC= .43 PFT= .30 AHRIN= 191.181

SEQ# 5 EL6475000/13980 2-butanone
HRIN SEQ= 380 HRIN= .782 PES= 30314 PEN= 545569 PC= .34 PFT= .04 AHRIN= 156.968

SEQ# 6 KL9275000/M0260 Ethanol, 2,2',2''-nitrilotri-
HRIN SEQ= 348 HRIN= .814 PES= 31868 PEN= 545569 PC= .42 PFT= .05 AHRIN= 155.402

SEQ# 7 ZE2100000/76720 Xylene
HRIN SEQ= 291 HRIN= .897 PES= 31029 PEN= 545569 PC= .51 PFT= .04 AHRIN= 143.634

SEQ# 8 LP8925000/33640 Formaldehyde
HRIN SEQ= 21 HRIN= 2.223 PES= 10907 PEN= 545569 PC= .48 PFT= .08 AHRIN= 136.337

SEQ# 9 E01400000/13850 Butyl Alcohol
HRIN SEQ= 206 HRIN= 1.030 PES= 23069 PEN= 545569 PC= .47 PFT= .00 AHRIN= 125.652

SEQ# 10 KJ8575000/29930 Ethanol, 2-butoxy-
HRIN SEQ= 360 HRIN= .801 PES= 25711 PEN= 545569 PC= .41 PFT= .04 AHRIN= 124.008

FIGURE 8. Example AHRI

OCCUPATIONAL GROUP RISK INDICES

The occupational group indices represent accomplishment of the final NIOSH goal in development of this model - to provide a mechanism for the assessment of the relative health risk borne by various occupational groups due to chemical exposure.

The occupational group risk algorithms provide a rank-ordering of the relative risk associated with specific occupational groups on the basis of the HRIN's of the chemicals to which each group is exposed, and the incidence, duration and control of exposure data specific to that group.

An estimate of the relative risk borne by an occupational group is provided in numerical form by the occupational group algorithms. This number is used to rank-order the occupational groups in descending order of relative health risk. The resulting list provides the assessment of occupation group aggregate risk necessary to establish priorities in the study and correction of health risks associated with occupational groups.

Occupational Group Risk Algorithms

Algorithm Development

The objective of the Occupational Group Risk Indices are to rank the occupational groups covered in the National Occupational Hazard Survey on the basis of the potential toxicological risk to workers. Since workers in a given group are exposed to a number of chemical hazards the risk associated with each occupational group can best be approximated by summing the risk associated with each of these chemicals. Since the risk posed by one chemical is described in the Adjusted Hazard Risk Index algorithm as:

$$AHRIN = (HRIN)(PES/PEN)(1.0 - 0.9\ PC)(0.5 + 0.5\ PFT)$$

the Occupational Risk Index algorithm should take the form:

$$IRIN \text{ or } ORIN = (HRIN)(PES/PEN)(1.0 - 0.9\ PC)(0.5 + 0.5\ PFT)(N)$$

where: IRIN = Industrial Risk Index Number (at the 2-, 3-, or 4-digit level).
ORIN = Occupational Risk Index Number.
N = Number of workers in the occupational group (from Census Bureau data).

and all of the other factors are as previously defined. The summation is developed for each occupational worker group across all of the matched chemicals to which workers in the group were observed to be exposed in the NOHS survey. It should be recognized that the increment is zero when no workers in a specific group were observed to be exposed to a chemical in the NOHS survey, i.e., when there is no data for a chemical in the NOHS data file for a specific group.

Since the NOHS data are not directly applicable to the worker population of the U.S. at other than the hazard specific or 2-digit SIC level (see discussion on page 29), the need for additional data became clear. Census Bureau data were located, converted to computer form, and used optionally in the algorithm calculations as the (N)* factor. It is interesting to note that while use of the census data in the algorithm results in a risk expression for the employee group as a whole, not using this data results in an expression of risk for an individual employed in that group.

A problem was encountered in coordination of the occupation codes used in the Census Bureau data with those used in the NOHS data. The NOHS data assigned separate codes to journeymen and apprentices in the same occupation while the Census Bureau did not differentiate between the two. Consequently, there are a number of NOHS occupation codes for which there are no corresponding Census Bureau data. This problem was resolved by combining some NOHS data categories to make them correspond to the Census Bureau codes and titles. Unusual (alphabetic) code numbers were assigned to each of the combined categories. The NOHS codes involved and the resultant codes and occupation titles are listed in Table 5.

As in the use of the Census Bureau occupation data, a problem was encountered in coordination of the Census Bureau industry population data with the NOHS data. In a number of cases no Census Bureau data were available at the 3- and 4-digit SIC level, even though NOHS data were presented at these levels. In these cases, the NOHS data were combined to the extent necessary to match the Census Bureau data. Codes ending in zero (a condition that does

---

* The N factor, number of workers in a specific occupation, was obtained from Census Bureau Publication CBP-73-1, U.S. Summary, County Business Patterns, 1973, Table 221. The N factor, number of workers in a specific industry, was obtained from Census Bureau Publication CBP-73-1, U.S. Summary, County Business Patterns, 1973, Table 1B. Data from the 1973 edition of this publication were used because they correspond in time with the NOHS survey.

TABLE 5 - NOHS OCCUPATION CODES
COMBINED IN PREPARATION OF THE
OCCUPATIONAL RISK INDEX

ORIGINAL NOHS CODES	NEW CODE	OCCUPATION TITLE
473, 474	00A	Automobile Mechanics
410, 411	00B	Bricklayers and Stonemasons
415, 416	00C	Carpenters
430, 431	00D	Electricians
561, 562	00E	Tool and Die Makers
522, 523	00F	Plumbers and Pipefitters
423, 530, 531	00G	Pressmen and Plate Printers
371, 372	00H	Secretaries, NEC
461, 462	00I	Machinists
491, 495, 571, 572	00J	Not Specified Mechanics and Repairmen
220, 245	00K	Managers and Administrators, N.E.C.
535, 536	00L	Sheet Metal Workers and Tinsmiths

TABLE 6 - NOHS SIC CODES/TITLES
COMBINED OR CHANGED IN PREPARATION
OF THE INDUSTRIAL RISK INDEX AT THE
3-DIGIT LEVEL

Combined/Original NOHS Codes	Produced Codes
082, 085	080 Forestry
091	090 Fisheries
192, 193, 194, 199	190 Ordnance and Accessories
451, 452	450 Transportation by Air
598	590 Fuel Oil Dealers

TABLE 7 - NOHS SIC CODES/TITLES
COMBINED OR CHANGED IN
PREPARATION OF THE INDUSTRIAL RISK
INDEX AT THE 4-DIGIT LEVEL

Combined/Original NOHS Code	Produced Code
0722, 0729	0720 Animal Husbandry Services
0822, 0851	0800 Forestry
0912, 0913	0900 Fisheries
1925, 1929, 1931, 1941 1951, 1999	1900 Ordnance and Accessories
4212, 4213	4210 Trucking Local and Long Distance
4454, 4459	4450 Local Water Transportation
4511, 4521	4500 Transportation by Air
4582, 4583	4580 Air Transportation Services
4612, 4613, 4619	4610 Pipeline Transportation, Except Natural Gas
4832, 4833	4830 Radio and Television Broadcasting
4922, 4923, 4924	4920 Gas Companies and Systems
5812, 5813	5810 Eating and Drinking Places
5983	5900 Fuel Oil Dealers
6023, 6023, 6024, 6025 6026	6020 Commercial and Stock Savings Banks
6122, 6123	6120 Savings and Loan Associations
6144, 6145, 6149	6140 Personal Credit Institutions
6312, 6313	6310 Life Insurance
6332, 6333, 6339	6330 Fire, Marine, and Casualty Insurance
6351	6350 Surety Insurance

(TABLE 7 Continued)

Combined/Original NOHS Code	Produced Code
6512, 6513, 6514, 6519	6510 Real Estate Operators and Lessors
6552, 6553	6550 Subdividers and Developers
6724	6720 Investment Companies

not exist in the SIC coding scheme), were assigned to the combined NOHS data and the associated Census Bureau data. The codes that were combined are listed in Tables 6 and 7.

Confidence Interval Calculations

In the occupational group risk index number calculations, the number of people in worker groups observed during the NOHS survey (PEN, see page 32) differs from occupation to occupation and from industry to industry. Review of the NOHS data indicated the magnitude of the PEN for occupational and industrial worker groups varies widely, and that there are a number of instances where the PEN was quite small (e.g., less than ten). It was also observed that when the PEN was small, the PES/PEN ratio was frequently quite large; examples of PES/PEN (see page 32) ratios of 1.0 were observed which were derived from calculations of 1/1, 2/2. etc. Such sample statistics are not characteristic of random samples, and would seem to be an artifact of a particular observation rather than probability sampling.

It was decided that NOHS worker group data should only be used when there is a reasonable probability that the observed proportion is within some selected range of the Gaussian approximation of the expected proportion. This decision was implemented by first defining the confidence interval to be used as:

$$P\left(\bar{x} - 2\sqrt{\frac{pq}{n}} < p < \bar{x} + 2\sqrt{\frac{pq}{n}}\right) = .95$$

where:

$\bar{x}$ = observed proportion of exposure
p = true proportion of exposure (unknown)
q = true proportion of non-exposure (unknown) = 1-p
n = number of observations

This equation is based on the Gaussian approximation to the binomial distribution with two standard deviations added and subtracted from x.

Since the true proportion, p, in the above equation is unknown, the worst case, (i.e., when pq/n is a maximum) should be used. The value of p which achieves this is 0.5. Substituting in the above equation, one has:

$$P\left(\bar{x} - 2\sqrt{\frac{0.25}{n}} < p < \bar{x} + 2\sqrt{\frac{0.25}{n}}\right) = .95$$

or

$$P\left(\bar{x} - \sqrt{\frac{1}{n}} < p < \bar{x} + \sqrt{\frac{1}{n}}\right) = .95$$

Using this equation one can calculate the 95 percent confidence interval for the exposure ratio and, since the ORIN is directly proportional to the exposure ratio, for the ORIN. In addition, one can select an accuracy range and calculate the minimum sample size that can be expected to yield an observed ratio within the range 95 percent of the time. At an accuracy of $\pm$ 0.10, the equation becomes:

$$P\left(\bar{x} - 0.10 < p < \bar{x} + 0.10\right) = .95$$

and $\sqrt{1/n}$ is equal to 0.10, which makes n equal to 100.

Based on these considerations, the algorithm computer programs were modified to omit worker groups with sample sizes (i.e., PEN) of less than 100. In addition, a routine was introduced into the programs to calculate the 95 percent confidence interval of the occupational group risk index numbers based on the PEN value.

The occupational group risk index algorithm computer programs check the PEN value for each worker group against the selected minimum value, calculate the incremental risk involved in potential exposure of workers in a group to each matched chemical, sum these incremental risks over all chemicals to which workers in a group are exposed to produce a risk index number for each occupational group, calculate the 95 percent confidence interval limits for each, sort the occupations into rank-order (descending), and print the Risk Index Number.

For details regarding the computer programs which permit input of Census data for occupations and 2-, 3-, or 4-digit SIC's as well as selecting worker groups with PEN values of 100 or more and calculate the confidence intervals, see Appendix A.

The occupational group indices are produced by employment within standard occupations and within 2-, 3-, or 4-digit Standard Industrial Classifications. A discussion of each follows:

THE INDUSTRY RISK INDEX

The objective of the Industry Risk Index (IRI) is to rank the industries covered in the National Occupational Hazard Survey on the basis of the potential risk to workers at the 2-, 3-, and 4-digit SIC levels, so that the IRI is produced in three parts corresponding to the three SIC levels.

The IRI algorithm sums the risk associated with each of the toxic chemicals to which workers in an industry are potentially exposed. The IRI algorithm used in production of the Industry Risk Index is:

$$IRIN = (HRIN)(PES/PEN)(1.0 - 0.9\ PC)(0.5 + 0.5\ PFT)(N)$$

where: IRIN = Industrial Risk Index Number,
N = Number of workers in the Industry (from Census Bureau data),

and all of the other factors are as previously defined. The summation is developed for each worker group across all of the matched chemicals, recognizing that the increment is zero when no workers in a specific SIC are observed to be exposed to a chemical in the NOHS survey, i.e., when there is no data for a chemical in the NOHS data file for a given SIC. In this algorithm a worker group is defined as all workers in the NOHS survey that were employed in the same industry. The NOHS industry codes reported in this model are listed in Appendix C.

As in the AHRIN algorithm, source HRIN's are obtained from the Hazard Risk Index calculations and all of the other factors except N are obtained from the NOHS data. NOHS file numbers 2, 3, and 4, as described in Table 4, supply exposure data on industrial worker groups at the 2-, 3-, and 4-digit SIC levels, respectively.

A sample page from each of the three Industrial Risk Indices are shown in Figures 9, 10, and 11. The description of format that follows applies equally to all three.

As seen in Figures 9, 10, and 11, the IRI display format is in several parts, as follows:

(1) The first line of the heading at the top of each page identifies the index (2-, 3-, or 4-digit SIC level is self-evident), the HRIN trial and run, the RTECS and NOHS file update versions used, the "CENSUS OPTION" ("YES" meaning that census totals are used in the algorithm), the date of the printout, and the sequential page number within the IRI.

(2) The second line of the heading at the top of each page identifies the settings of the multipliers and NEO OPTION in the source HRI.

(3) The third line of the heading identifies the settings for the constants and CAR OPTION in the source HRIN.

(4) The first line of the index entry for each SIC group consists of a sequence number, SIC numerical designation and title, and the calculated Industry Risk Index Number (IRIN). The second line of the entry for each SIC group

IRI Calculation based on HRIN Trial 02 Run 01 RTECS Date 01/81 NOHS Date 07/80 CENSUS OPTION=YES Date: 09/01/81 page 1

Multipliers for AT=1 CAR=1 ETA=1 MUT=1 NEO=1 PI=1 TER=1 TFX=1 NEO OPTION= YES
Constants for AT=0 CAR=0 ETA=0 MUT=0 NEO=0 PI=0 TER=0 TFX=0 CAR OPTION= NO

SEQ#	1	SIC 80	MEDICAL AND OTHER HEALTH SERVICES	IRIN =	716.138
			NUMBER OF CHEMICALS = 678	+/-	5.320
SEQ#	2	SIC 55	AUTOMOTIVE DEALERS & SERVICE STATIONS	IRIN =	308.163
			NUMBER OF CHEMICALS = 197	+/-	8.606
SEQ#	3	SIC 73	MISCELLANEOUS BUSINESS SERVICES	IRIN =	241.982
			NUMBER OF CHEMICALS = 325	+/-	5.490
SEQ#	4	SIC 50	WHOLESALE TRADE	IRIN =	224.829
			NUMBER OF CHEMICALS = 259	+/-	3.419
SEQ#	5	SIC 28	CHEMICALS AND ALLIED PRODUCTS	IRIN =	188.836
			NUMBER OF CHEMICALS = 1162	+/-	1.529
SEQ#	6	SIC 35	MACHINERY, EXCEPT ELECTRICAL	IRIN =	150.886
			NUMBER OF CHEMICALS = 538	+/-	.748
SEQ#	7	SIC 59	MISCELLANEOUS RETAIL STORES	IRIN =	149.967
			NUMBER OF CHEMICALS = 205	+/-	4.573
SEQ#	8	SIC 53	RETAIL GENERAL MERCHANDISE	IRIN =	143.952
			NUMBER OF CHEMICALS = 257	+/-	1.451
SEQ#	9	SIC 72	PERSONEL SERVICES	IRIN =	141.854
			NUMBER OF CHEMICALS = 188	+/-	5.376
SEQ#	10	SIC 58	EATING AND DRINKING PLACES	IRIN =	140.413
			NUMBER OF CHEMICALS = 95	+/-	2.603

FIGURE 9. Example 2-SIC IRI

IRI calculation based on HRIN Trial 02 Run 01 RTECS Date 01/81 NOHS Date 07/80 CENSUS OPTION=YES Date: 09/02/81 page 1

Multipliers for AT=1 CAR=1 ETA=1 MUT=1 NEO=1 PI=1 TER=1 TFX=1 NEO OPTION= YES
Constants for AT=0 CAR=0 ETA=0 MUT=0 NEO=0 PI=0 TER=0 TFX=0 CAR OPTION= NO

SEQ#	1	SIC 806	HOSPITALS	IRIN =	422.822
			NUMBER OF CHEMICALS = 658	+/-	3.378
SEQ#	2	SIC 581	EATING AND DRINKING PLACES	IRIN =	140.413
			NUMBER OF CHEMICALS = 95	+/-	2.603
SEQ#	3	SIC 551	NEW AND USED CAR DEALERS	IRIN =	137.032
			NUMBER OF CHEMICALS = 162	+/-	4.761
SEQ#	4	SIC 554	GASOLINE SERVICE STATIONS	IRIN =	120.240
			NUMBER OF CHEMICALS = 96	+/-	6.284
SEQ#	5	SIC 541	GROCERY STORES	IRIN =	101.718
			NUMBER OF CHEMICALS = 75	+/-	2.445
SEQ#	6	SIC 734	SERVICES TO BUILDINGS	IRIN =	97.429
			NUMBER OF CHEMICALS = 75	+/-	3.643
SEQ#	7	SIC 531	DEPARTMENT STORES	IRIN =	97.368
			NUMBER OF CHEMICALS = 238	+/-	1.103
SEQ#	8	SIC 809	HEALTH AND ALLIED SERVICES, NEC	IRIN =	91.642
			NUMBER OF CHEMICALS = 152	+/-	2.053
SEQ#	9	SIC 739	MISCELLANEOUS BUSINESS SERVICES	IRIN =	91.592
			NUMBER OF CHEMICALS = 282	+/-	2.971
SEQ#	10	SIC 508	MACHINERY, EQUIPMENT, AND SUPPLIES	IRIN =	86.639
			NUMBER OF CHEMICALS = 145	+/-	2.794

FIGURE 10. Example 3-SIC IRI

IRI calculation based on HRIN Trial 02 Run 01 RTECS Date 01/81 NOHS Date 07/80 CENSUS OPTION=YES Date: 09/02/81 page 1

Multipliers for		AT=1	CAR=1	ETA=1	MUT=1	NEO=1	PI=1	TER=1	TFX=1	NEO OPTION= YES
Constants for		AT=0	CAR=0	ETA=0	MUT=0	NEO=0	PI=0	TER=0	TFX=0	CAR OPTION= NO

SEQ#	1	SIC 8061	HOSPITALS	IRIN =	422.822
			NUMBER OF CHEMICALS = 658	+/-	3.378
SEQ#	2	SIC 5810	EATING AND DRINKING PLACES	IRIN =	140.413
			NUMBER OF CHEMICALS = 95	+/-	2.603
SEQ#	3	SIC 5511	NEW AND USED CAR DEALERS	IRIN =	137.032
			NUMBER OF CHEMICALS = 162	+/-	4.761
SEQ#	4	SIC 5541	GASOLINE SERVICE STATIONS	IRIN =	120.240
			NUMBER OF CHEMICALS = 96	+/-	6.284
SEQ#	5	SIC 5411	GROCERY STORES	IRIN =	101.718
			NUMBER OF CHEMICALS = 75	+/-	2.445
SEQ#	6	SIC 5311	DEPARTMENT STORES	IRIN =	97.368
			NUMBER OF CHEMICALS = 238	+/-	1.103
SEQ#	7	SIC 7349	MISCELLANEOUS SERVICES TO BUILDINGS	IRIN =	71.950
			NUMBER OF CHEMICALS = 43	+/-	2.898
SEQ#	8	SIC 2834	PHARMACEUTICAL PREPARATIONS	IRIN =	69.563
			NUMBER OF CHEMICALS = 360	+/-	2.741
SEQ#	9	SIC 6510	REAL ESTATE OPERATORS AND LESSORS	IRIN =	66.673
			NUMBER OF CHEMICALS = 114	+/-	2.547
SEQ#	10	SIC 8092	SANATORIA, CONVALESCENT & REST HOMES	IRIN =	65.624
			NUMBER OF CHEMICALS = 135	+/-	1.517

FIGURE 11. Example 4-SIC IRI

consists of the number of linked chemicals (out of 1721) to which workers in the industry group are exposed, and the 95 percent confidence limits of the IRIN. Printing of the second line is a program option.

For a listing of the subset of NOHS 2-, 3-, and 4-digit Standard Industrial Classifications covered by this model, see Appendix C - Standard Industrial Classifications Reported In A Model For the Identification of High Risk Occupational Groups Using RTECS and NOHS Data.

For details on the computer programs which produce the IRI, see Figure 12 -IRI Algorithm Computer Programs Flowchart, and the IRI material in Appendix A. Complete examples of IRI listings are provided in microfiche form (See pages E-3, E-4, and E-5).

THE OCCUPATIONAL RISK INDEX

The objective of the Occupational Risk Index (ORI) is to rank occupations on the basis of the potential risk to workers employed in these occupations due to chemical exposure.

The ORI algorithm sums the risk associates with each of the toxic chemicals to which workers in a specific occupation are potentially exposed. The ORI algorithm used in production of the Occupational Risk Index Number (ORIN) is:

$$ORIN = (HRIN)(PES/PEN)(1.0 - 0.9\ PC)(0.5 + 0.5\ PFT)(N)$$

where: ORIN = Occupational Risk Index Number,
N = Number of workers in the occupation (from Census Bureau data),

and all other factors are as previously defined. The summation is developed for each worker group across all the linked chemicals, recognizing that the increment is zero when no workers in a specific occupation are observed to be exposed to a chemical in the NOHS data file for a given occupation. In this algorithm, a worker group is defined as all workers employed in the same occupation. The occupation codes reported in this model are listed in Appendix D - Occupation Reported In A Model For the Identification of High Risk Occupational Groups Using RTECS and NOHS Data.

As in the AHRIN and IRIN, source HRIN's are obtained from the Hazard Risk Index calculations, and all other factors except N are obtained from the NOHS data. NOHS file number 5, as described in Table 4, supplies exposure data on worker groups at the occupation level.

FIGURE 12. IRI Algorithm Computer Programs Flow Chart

A sample page from the ORI is shown in Figure 13. The ORI display format is in several parts, as follows:

(1) The first line of the heading at the top of each page identifies the index, the HRIN trial and run, the RTECS and NOHS file update versions used, the "CENSUS OPTION" function (previously explained), the date of the print-out, and the sequential page number within the ORI.

(2) The second line of the heading at the top of each page identifies the settings of the multipliers and NEO OPTION in the source HRI.

(3) The third line of the heading identifies the settings for the constants and CAR OPTION in the source HRI.

(4) The first line of the index entry for each occupational group consists of a sequence number, occupation numerical designation and title, and the calculated Occupational Risk Index Number (ORIN). The second line of the entry for each occupation consists of the number of linked chemicals (out of 1721) to which workers in the occupational group are exposed and the 95 percent confidence limits of the ORIN. Printing of the second line is a program option.

For details on the computer programs which produce the ORI, see Figure 14, ORI Algorithm Computer Programs Flow Chart, and Appendix A. Complete examples of the ORI are provided in microfiche form (See pages E-5 and E-6).

ORI calculation based on HRIN Trial 02 Run 01 RTECS Date 01/81 NOHS Date 07/80 CENSUS OPTION=YES Date: 0-/03/81 page 1

Multipliers for	AT=1	CAR=1	ETA=1	MUT=1	NEO=1	PI=1	TER=1	TFX=1	NEO OPTION= YES
Constants for	AT=0	CAR=0	ETA=0	MUT=0	NEO=0	PI=0	TER=0	TFX=0	CAR OPTION= NO

SEQ#	1	OCC 944	HAIRDRESSERS AND COSMETOLOGISTS NUMBER OF CHEMICALS = 105	ORIN = 322.960 +/- 22.836
SEQ#	2	OCC 075	REGISTERED NURSES NUMBER OF CHEMICALS = 300	ORIN = 215.201 +/- 2.702
SEQ#	3	OCC 903	JANITORS AND SEXTONS NUMBER OF CHEMICALS = 627	ORIN = 165.088 +/- 1.530
SEQ#	4	OCC 280	SALESMEN AND SALES CLERKS, N.E.C. NUMBER OF CHEMICALS = 163	ORIN = 153.046 +/- 1.824
SEQ#	5	OCC 00A	AUTOMOBILE MECHANICS NUMBER OF CHEMICALS = 264	ORIN = 137.280 +/- 2.177
SEQ#	6	OCC 925	NURSING AIDES, ORDERLIES, AND ATTENDANTS NUMBER OF CHEMICALS = 153	ORIN = 120.208 +/- 2.175
SEQ#	7	OCC 510	PAINTERS, CONSTRUCTION AND MAINTENANCE NUMBER OF CHEMICALS = 227	ORIN = 100.437 +/- 2.548
SEQ#	8	OCC 00H	SECRETARIES, N.E.C. NUMBER OF CHEMICALS = 204	ORIN = 83.692 +/- .731
SEQ#	9	OCC 690	MACHINE OPERATIVES, MISCELLANEOUS SPECIFIED NUMBER OF CHEMICALS = 1086	ORIN = 77.529 +/- .352
SEQ#	10	OCC 441	FOREMEN, N.E.C. NUMBER OF CHEMICALS = 931	ORIN = 74.126 +/- .719

FIGURE 13. Example ORI

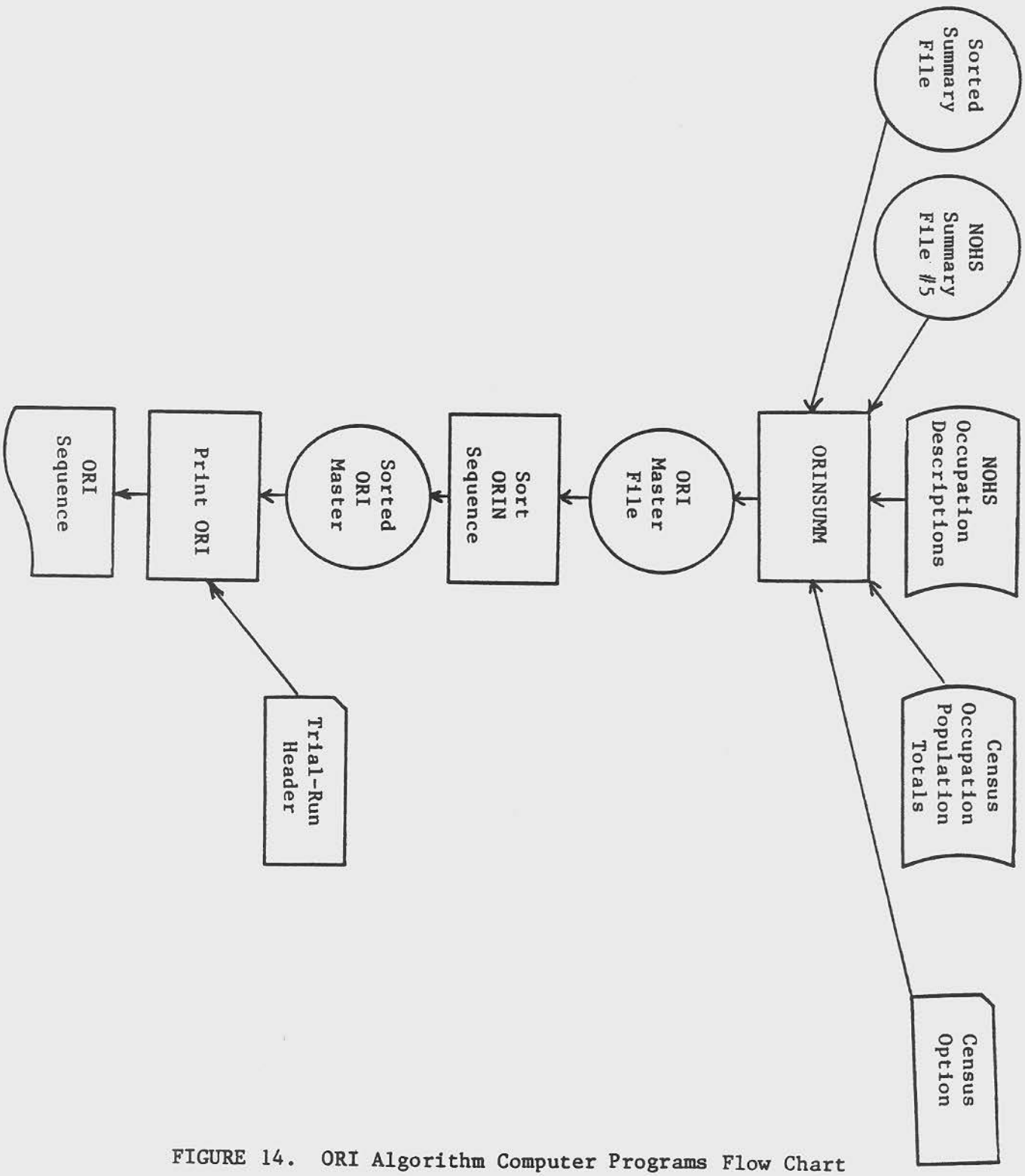


FIGURE 14. ORI Algorithm Computer Programs Flow Chart

APPENDIX A

NIOSH RISK IDENTIFICATION MODEL

COMPUTER PROGRAM CONSIDERATIONS

I. NOHS DATA PROCESSING

A. Extract NOHS Chemical Data for Chemicals Found in RTECS

Program: CNVT2E4Ø

The purposes of this program are to: (1) produce a master file of NOHS data to be used in the high risk identification model, (2) eliminate ambiguous hazards from model consideration, (3) identify and merge replicate chemical terms, (4) eliminate generically resolved data from model consideration, (5) merge SIC codes, and (6) merge occupation codes.

In order to produce NOHS data at the specific levels used for input to the several model algorithms, it was necessary to manipulate several of the data elements from the NOHS Data Base Master Load File and the NOHS Master Hazard Summary File.

Using Chemical Abstract System (CAS) numbers assigned to NOHS chemicals existing in the NOHS Master Hazard Summary File, a file of the chemicals common to RTECS and NOHS was established. Examination of this file indicated the presence of ambiguous and replicate hazards as well as generically resolved data.

Twenty-one ambiguous hazards (e.g. decomposition products of calcium hydroxide, decomposition products of ammonium chloride, and products of combustion - naphtha petroleum) were identified. A decision was made that such terms should be excluded from consideration in the model. Accordingly, they were eliminated from further consideration through use of a computer card deck program.

Seventy-two chemicals were identified as replicates. The term replicate as used here means that two or more of these chemicals were defined by CAS as synonymous. After examination of these chemicals it was decided to combine synonymous chemicals under one chemical name, and combine the NOHS data specific to each under one preferred term. An example of these combinations is: 2 - (2-methy - 4-chlorophenoxy) propionic acid and methyl chlorophenoxy propionic acid combined as methyl chlorophenoxy propionic acid. Combining the 72 replicates in this manner resulted in a final definition of 34 composite chemical-specific sets of data. This was accomplished through use of the card deck displayed at the top of Figure 6.

Additionally, chemicals were matched between RTECS and NOHS which were present in the NOHS data base due only or in part to the generic resolution of tradename products. It was decided that

generic resolution was imprecise, and should not be used in the various algorithms of the model. Therefore, any generic data was eliminated. This had the effect of deleting several chemicals from any model consideration, as well as discarding those portions of the NOHS data associated with other chemicals which were of generic origin.

As mentioned in the text on page 40, and illustrated in Tables 5, 6, and 7, it was necessary to combine 3- and 4-digit SIC codes and Standard Occupation Codes from the NOHS data in order to make it possible to use census population data specific to industry and occupation groups in the model algorithms.

B. Produce Summary Records at the Most Specific Possible Summary Level

Program: SUMEXT1Ø

The purpose of this program is to produce non-duplicative records of potential exposure to NOHS hazards, in order to avoid the multiple counting of potentially exposed individuals discussed in the text on pages 29 and 32.

NOHS Summary File #10 therefore contains non-duplicative records of workers exposed to a linked hazard seen in a specific occupation within each NOHS facility surveyed. This file can then be sorted at the level necessary for input to the various algorithms without multiple counting of individual potentially exposed workers.

C. Create Summary Files used as Input to the Model Algorithms

Programs: SUMEXTØ2, SUMEXTØ3, SUMEXTØ4, SUMEXTØ5

The purpose of these programs is to utilize the sorted data sets (e.g. hazard within occupation or hazard within 2-digit SIC) to produce the various summary files used as input to the model algorithms. The association of the various files and algorithms is displayed on the figures illustrating computer program flow for the HRI, AHRI, IRI and ORI programs. (See Figures 4, 7, 12, and 14)

Data included in these summary files includes number of workers exposed to specific hazards, and the control and duration of exposure observed during the NOHS survey expressed as percent exposure controlled and percent full-time (more than 4 hours a day) exposure. For each occupational group (see Table 4), these files also contain the total number of workers observed exposed to any NOHS hazard.

II. RTECS DATA PROCESSING

A. Extract RTECS Data Lines (Records)

Program: CIORIEXT

The purposes of this program are to: (1) Select only those RTECS records meeting established project data parameters, (2) avoid the necessity of scanning the entire RTECS base (over 600,000 records) in subsequent programs, thereby shortening total system execution time considerably.

Each RTECS number (chemical) may contain many separate data lines (designated as line types A through Z - each containing different data elements). For this model, line types A, H, R, S, and T are selected.

Model data requirements, specifications and program functions for each of these line types are as follows:

A-line (chemical name)

By model criteria, each RTECS number must have a name. If the name exceeds 94 characters, multiple A-lines will occur. However, CIORIEXT uses only the first line. In those cases where A-line data are missing, the program generates an A-line and inserts "*** no name given in RTECS ***" into the name field.

H-line (molecular weight)

By model criteria, each RTECS number must have a molecular weight to be used for calculations in subsequent programs. Molecular weight on the H-line is a seven-character field with a decimal in position 5 (i.e., 9999.99, blank 999.99, or blank-blank 99.99). Leading blank spaces are converted to a zero designation.

Data entry errors in the insertion of a two or three whole number molecular weight were occasionally noted (i.e. 999.99 or leading blank, 99.99 instead of the proper leading blank 999.99, or two leading blanks 99.99), which resulted in shifting the entire field one position to the left and displaying the decimal in position four rather than the formatted position 5.

After questioning RTECS editorial personnel, it was determined that the given values were correct.

Accordingly, the program shifts these erroneous fields one position to the right (shifting the decimal to position 5) and inserts a leading zero or zeroes. If the RTECS number lacks an H-line or the H-line contains a non-numeric entry (other than blanks), all data lines for that RTECS number are rejected.

R-line (mutagenic data)

R-line data are selected in conformance to model criteria. Accordingly, the program selects in-vivo and in-vitro records which are project-restricted to "in-vivo studies on mammalian species, or in-vitro studies on mammalian cells".

Acceptable in-vivo tests must:

1. Be performed on mammalian species CAT, CTL, CHD, DOG, DOM, GRB, GBG, HAM, HMN, INF, MAM, MAN, MKY, MUS, PIG, RBT, RAT, SQL, WMN. (See Appendix B for definitions.)

2. Be performed utilizing any of the seventeen tests listed on page 6, Appendix B.

3. Be performed utilizing any route specified in RTECS, except MUL, REC, and UNK.

Acceptable in-vitro tests must:

1. Be performed on specified cells originating from the mammalian species specified for in-vivo studies.

2. Be performed utilizing cell types BMR, EMB, FBR, HLA, LEU, LVR, LNG, LYM, MMR, OVR. (See Appendix B for definitions.)

3. Be performed utilizing any of the test types specified for in-vivo studies.

R-line data not matching these criteria are rejected.

S-line (irritation data)

S-line data is selected in conformance to project criteria. Therefore the program selects only those records where:

1. The route of administration is "EYE" or "SKN" (See Appendix B)

2. The test species is "RBT".

T-line (toxicity data)

T-line data is also selected according to model criteria.

Any route of administration (except "UNK") is accepted. In addition, the program converts routes of administration "IDR" and "IMS" to "SCU".

Any species (except "UNK") is accepted. Species "INF", "CHD", "MAN", and "WMN" are converted to "HMN". In addition, species, "BDW", "CKN", "DCK", "PGN", "QAL", and "TRK" are converted to "BRD".

Additional notes:

1. It is possible, using the screening processes defined above, that the only records selected for a given chemical would be A & H line data. These chemicals are eliminated in the CIORISTD program, which uses the output from the CIORIEXT program.

2. This program converts all lower case characters to upper case.

B. Standardize RTECS Data

Program: CIORISTD

The purpose of this program is to provide a standardized format file from a file with many variable formats. This program performs many functions against the output file of program CIORIEXT. It serves to:

1. Identify RTECS data entry errors.

2. Identify variable fields and convert to a fixed position.

3. Identify various dose measurement units and convert to either:

   a. Parts per million (ppm), or

   b. Millimole (MM) notation.

4. Assure uniformity of the dose units within test classes (either ppm or millimole).

5. Eliminate unusable records (in accordance with model specifications).

6. Calculate the natural log of the dose and assure positive value by adding 30.00 to the calculated log.

7. Generate minimum and maximum natural logs (+30.00) of dose values for each test class.

8. Exercise the option to generate neoplasm data lines from carcinogen data (see NEO OPTION).

9. Identify and link RTECS chemicals occurring in the NOHS data base. (See NOHS Summary File #1 generation discussion and Figure 6.)

NOTE: In addition to other specific conversion routines mentioned in this text, dose unit uniformity is achieved through use of the first and second dose conversion routines. They are:

First Conversion Routine:

The first routine converts everything that is not PPM, MG/KG, or MG/M3, to these notations using the following equations:

pph to ppm = pph x 10,000
ppb to ppm = ppb x .001
ppt to ppm = ppt x .000001

UG/M3 to MG/M3 = UG/M3 x .001
NG/M3 to MG/M3 = NG/M3 x .000001
GM/M3 to MG/M3 = GM/M3 x 1,000

UG/KG to MG/KG = UG/KG x .001
NG/KG to MG/KG = NG/KG x .000001
GM/KG to MG/KG = GM/KG x 1,000
KG/KG to MG/KG = KG/KG x 1,000,000
PG/KG to MG/KG = PG/KG x .000000001

Second Conversion Routine:

This routine converts MG/KG to millimoles/KG (expressed as mm) using: MG/KG divided by molecular weight, and; MG/M3 to ppm using: (24.45 divided by molecular weight) x MG/M3.

The field resulting from these conversions is an 18-digit field defined as 9(9)V9(9). (i.e. 9 digits, decimal, 9 digits.)

R-line (mutagenic data)

RTECS record definitions are:

1. Position 17 equals a dash (-). It is the separator between test and species.

2. Position 21 equals a colon (:) for in-vitro data, and a dash (-) for in-vivo data. They are separators between species and route or cell type.

3. Position 25 is a blank. It is the separator between route or cell and dose amount.

If these conditions are not met, the record is rejected.

In-vitro dose amount

Dose amount starts in position 26 and continues for a variable number of positions (see "dose amount" for T-line data).

In-vitro dose types

The dose type is separated from dose amount by one blank.

Dose amount types accepted:

GM/L, MG/L, UG/L, NG/L, MOL/L, MMOL/L, UMOL/L, NMOL/L, PMOL/L, PPH, PPM, PPB.

Types rejected:

Per kilogram (/KG), per plate (/plate), per well (/well), per disc (/disc), and doses expressed as NG, MG, UG, PG, GM.

In-vitro dose conversions (See first and second conversion steps). Conversion of volumetric measurements to millimole notation is possible because of assumptions for a constant volume of 1.0 liters and a specific gravity of 1.0 permitting conversion to equivalent MG/L notation. Conversions are made in the following order:

1. MG/L is given an MG/KG designation.

2. GM/L, UG/L, and NG/L are changed to MG/L equivalence via the first conversion step, and is given an MG/KG designation.

3. PPH and PPB are changed to PPM via the first conversion step.

4. PPM (original or converted) are given an MG/KG designation.

5. MG/KG (converted) is changed to millimole (MM) designation via the second conversion step.

6. The following are conversions of various per liter (/L) measurements to millimole equivalence designated as (MM).

   a. MMOL/L to MM = no conversion.

   b. MOL/L to MM = MOL/L x 1,000.

   c. UMOL/L to MM = UMOL/L x .001.

   d. NMOL/L to MM = NMOL/L x .000001.

   e. PMOL/L to MM = PMOL/L x .000000001.

In-vivo dose amount

Dose amount starts in position 26 and continues for a variable number of positions.

In-vivo dose types

The dose type is separated from dose amount by one blank.

Dose amount types accepted:

All per kilogram (/KG) measurements, including: MG/KG, UG/KG, GM/KG, NG/KG, NMOL/KG, MMOL/KG, UMOL/KG.

Types rejected:

All types that cannot be converted to equivalent millimole format. Note that use of the constant volume assumption is not possible for in-vivo data. Rejected types include: MMOL/L, UMOL/L, UG/L, G/L, PPT, PPM, PPB, MG/M3, UG/M3.

In-vivo dose conversions (See first and second conversion steps). Conversions are made in the following order:

1. UG/KG, GM/KG, and NG/KG to MG/KG via the first conversion step.

2. MG/KG (original or converted) to millimole (MM) equivalence via the second conversion step.

3. The following are conversions of various mole per kilogram

measurements to millimole equivalence (designated as MM).

a. MMOL/KG to MM = no conversion.

b. NMOL/KG to MM = NMOL/KG x .000001.

c. UMOL/KG to MM = UMOL/KG x .001.

S-line (irritation data)

RTECS record definitions are:

1. Position 17 should always equal a dash (-). It is the separator between route and species.

2. Position 21 should always equal a blank. It is the separator between species and dose amount.

Screening Process

RTECS S-line data is obtained from many sources. Model criteria specifies use of only standard Draize Test procedure data. Therefore, the following screening process was developed to eliminate non-Draize data.

Delete data lines where:

1. Dose type is expressed as per kilogram (/KG).

2. The chemical was applied intermittently (denoted as "-I" following the test duration).

3. Test duration is other than:

   a. 1 day (1D)

   b. 3 days (3D)

   c. 24 hours (24H)

   d. 72 hours (72H)

   Note: If a duration is not specified, it is assumed to be an acceptable duration in accordance with RTECS statements.

   Durations eliminated were:

   a. seconds

b. weeks

c. months

d. days other than 1 or 3

e. hours other than 24 or 72

4. Citations "NSE" or "RNS"

An "NSE" citation indicates a non-standard exposure, usually resulting from such things as accidental spills. Model criteria defines this as an imprecise dose that cannot be compared to laboratory testing.

An "RNS" citation means that the eyes were washed after dose instillation. By model criteria, an irritant dose that was washed immediately after instillation cannot be directly compared to a continuous exposure.

Irritation Dose Amount

Dose amount starts in Position 22 and continues for a variable number of positions.

Doses found to be acceptable were those:

1. Expressed as a whole number percentage, with or without decimal numbers (i.e. 10.5% or 10%).

2. Expressed as a whole number, with or without decimal numbers, in various gram notation (i.e. 10 MG or 10.5 MG).

NOTE: The program accepts only the first decimal digit.

Dose Types

This field is separated from dose amount by a blank.

Types accepted:

%, GM, GM/M3, MG, MG/M3, NG, NG/M3, UG, UG/M3, PPH, PPM, PPB, PPT

Types rejected:

All per kilogram types (/KG).

Severity Rating

This field, if present, follows the dose type and duration, if present, in no set position.

Acceptable values are mild (MLD), moderate (MOD), severe (SEV). Records that do not contain a severity rating are arbitrarily given a rating of moderate (MOD).

Dose Conversions (see first and second conversion steps)
Conversions are performed in the following order:

1. Percent records where route of administration is "SKN" are multiplied by 5.

2. Percent records (expressed as a whole number) are converted to milligrams on the basis of two assumptions.

   a. Doses reported as percent are liquids.

   b. The specific gravity is equal to 1.0.

Draize test states that the amount of solution is .5 ML for skin studies, and .1 ML for eye studies; therefore the following conversion steps are performed:

For skin studies using, for example, a 50% solution:

1. The dose volume is .5 ML, so a 50% solution = .25 ML of a 100% solution.

2. Assume specific gravity of 1.0, therefore .25 ML = .25 grams = 250 milligrams.

For eye studies using, for example, a 50% solution:

1. The dose is .1 ML, so a 50% solution = .05 ML of a 100% solution.

2. Assume specific gravity of 1.0, therefore .05 ML = .05 grams = 50 milligrams.

These records are assigned an MG/KG designation, and the record is converted to millimoles via the second conversion step.

3. Doses reported as UG, NG, GM, etc. are converted to MG via the first conversion step and given an MG/KG designation.

4. Volumetric doses (UG/M3, NG/M3, etc.) are converted to MG/M3 via the first conversion step.

5. Doses reported as PPH, PPB, PPT are converted to PPM via the first conversion step.

6. Doses reported (original or converted) as MG/M3 are converted to PPM via the second conversion step.

7. PPM doses (original or converted) are converted to MG via the following equation:

   $$\frac{\text{PPM}}{10000} \times (.5 \text{ for skin route}) \text{ or } (.1 \text{ for eye route}) \times 1000$$

   which reduces to:

   PPM x .0005 or .0001 (depending on route) = MG

   The resulting milligram dose is converted to millimoles via the second conversion step.

8. Adjustment of moderate and severe dose amounts are performed to permit direct comparison of doses by standardizing the outcome, as follows:

   a. Records with a "MLD" rating are held constant.

   b. Records with a "MOD" rating are multiplied by .50.

   c. Records with a "SEV" rating are multiplied by .25.

   d. Records with no rating are assumed to be moderate.

T-line (toxicity data)

RTECS record definitions are:

1. Position 27 should always equal a dash (-), (separator for route and species).

2. Position 31 should always equal a blank (separator for species and test end point).

3. Position 36 should always equal a colon (:), (separator for test end point and dose amount).

4. Position 37 should always be numeric (first position of dose amount).

Toxicity data dose amount:

Dose amount starts in position 37 and continues until a space is found. The maximum accepted by the program is 9 whole number digits. The maximum found in RTECS data was 5 whole number digits. Some dose amounts have decimal parts (i.e. 10.5). The program accepts only the first decimal digit.

Dose amount types:

This field is separated from dose amount by a blank.

Dose amount types accepted:

PPH, PPM, PPB, PPT, PG/KG, MG/KG, MG/M3, UG/KG, UG/M3, NG/KG, NG/M3, G/KG, G/M3, GM/KG, GM/M3, KG/KG.

Types rejected:

MG(CA)KG, MG(LA)KG, MG(AS)KG, MG(SB)KG, MG(SE)KG, MG(MN)KG, MG(MO)KG, IU/KG, PARTICLES/CC, MPPCF.

TFX Notation:

Following the dose type (no standard position), there may or may not be a TFX value (expressed as TFX:). These values identify the outcome of the test. If a TFX: is not present on a record, it is assumed to be an acute effect.

Acceptable TFX notations: (model defined)

ALR, BCM, BLD, BPR, CAR, CNS, COR, CVS, ETA, GIT, GLN, IRR, MMI, NSK, NEO, PNS, PSY, PUL, RBC, SYS, TER, WBC.

Unacceptable notations:

CUM, DDP, EYE, MLD, MOD, MUT, SEV, SKN, UNS.

Dose conversions: (See first and second conversion routines)

After the dose has been converted, the dose type (either ppm or mm) is compared against the route of administration to assure that volumetric measurements (ppm) appear only in inhalation studies and per kilogram measurements (mm) appear only in routes of administration other than inhalation. If this check is not performed, subsequent comparisons of data within test classes would be comparing PPM dose values with millimole dose values. Records that do not conform to this criteria are rejected.

After these assurances are made, the dose amount is passed to a FORTRAN module called "ALOGX". This module calls the FORTRAN subroutine "ALOG" to obtain the natural log of the dose. A constant of 30 is added to the calculated log to assure that all log values are positive. The calculated value is then returned to the CIORISTD program.

Note:

Dose conversion assumptions:

1. A grams per kilogram (G/KG or Gm/KG) or grams per meter cubed (G/m3 or Gm/M3) dose will be less than seven whole number digits.

2. A part per hundred (PPH) dose will be less than six whole number digits.

3. A kilograms per kilogram (KG/KG) dose will be less than four whole number digits.

4. A parts per million (PPM) or milligram per kilogram (MG/KG) dose will be less than ten whole number digits.

Should these maximums be exceeded, the resulting high order (whole number) digits would be truncated.

These conversion routines could possibly result in a zero value, i.e. (400 PG/KG x .000000001) divided by molecular-weight (500). The converted dose value is checked before the log value is calculated. If a dose value is zero, the minimum value (.000000001) is inserted and the record in question is displayed. The displayed records are manually reviewed for accuracy.

NEO option:

By RTECS definitions (page xxvii, 1979 RTECS), the difference between a neoplasm and a carcinoma consists of cell cytology and metastasizing of tumors. Carcinogens may therefore be viewed as a subset of neoplastigens since both involve tumor formation. Noting that the data lines within certain chemicals contained a test class specific CAR citation, but no corresponding NEO citation, it was decided that creation of a NEO citation based on CAR data (specific to test class within chemical) was appropriate in such cases.

C. Calculate values for HRIN computation

Program: CIORICAL

The purposes of the program are to: (1) eliminate duplicate chemical-specific test class citations, (2) create minimum and maximum natural log of dose value files (ranges) for each test class, (3) exercise option to perform d_n calculation on all RTECS or RTECS/NOHS linked chemicals only, (4) calculate d_n values for each test class within chemical, (5) calculate sub-HRI's, (6) exercise CAR OPTION.

Due to project-directed combination of species, routes, test and toxic effects in the establishment of test classes, duplicate test class citations within chemical were created. CIORICAL, in accordance with RTECS policy, eliminates all but the most toxic test class-specific citation within each chemical.

Based on the natural log values calculated in CIORISTD, CIORICAL establishes range values for each test class by determining the minimum and maximum natural log (+30.00) values for each test class across all RTECS chemicals. As displayed in the text, these tabulations also include the RTECS number citations for the minimum and maximum log values, and the number of chemicals contained in each test class citation.

Since all indices except the HRI depend on NOHS data input, CIORICAL was designed to calculate d_n and sub-HRI values for linked chemicals as a primary option. Sub-HRIN values are calculated by averaging the d_n numbers within each of the sub-HRIN categories (i.e. CAR, MUT, TER). At user discretion, these values can be calculated for all RTECS chemicals, and an HRI produced for all RTECS chemical listings containing toxicity data defined within the 98 test classes.

At user discretion CIORICAL will utilize calculated NEO sub-HRIN's as an estimator of the CAR sub-HRIN where no CAR data exists (CAR sub-HRIN = 0.000) for the same chemical. This is accomplished by moving the NEO sub-HRIN value into the CAR sub-HRIN field after all d_n and sub-HRIN values have been calculated.

At this point in the programming of the high risk model, only two options (NEO and CAR) have been potentially exercised which affect the outcome of the various risk indices. Therefore, it is necessary to run the CIORICAL program only four times to cover all possibilities. Each of these possibilities has a "TRIAL" designation, which is repeated in the header data on the AHRI, IRI and ORI, and mentioned in the main text as an "internal tracking system". The Trial numbers and associated CAR and NEO option settings are:

TRIAL 1 - CAR OPTION = NO, NEO OPTION = NO
TRIAL 2 - CAR OPTION = NO, NEO OPTION = YES

TRIAL 3 - CAR OPTION = YES, NEO OPTION = NO
TRIAL 4 - CAR OPTION = YES, NEO OPTION = YES

Because the NEO OPTION is exercised in the CIORISTD program, production of the four trials requires two CIORISTD runs from the extract file (NEO OPTION = YES, and NEO OPTION = NO). The NEO OPTION = NO run is used in creating TRIALS 1 and 3, and the NEO OPTION = YES run is used to create TRIALS 2 and 4.

D. Calculate HRIN values

Program: CIORISUM

The purposes of this program are to: (1) calculate HRIN values based on user selection of NEO and CAR OPTIONS and user settings for the multiplier and constant variables introduced in the HRI algorithm format, (2) exercise the user option for "long" or "short" print options, (3) create the sorted summary file (source HRI) used to create the AHRI, IRI and ORI indices, (4) calculate AHRIN values resulting from modifying source HRIN values with hazard-specific NOHS exposure data.

As explained in the main text, calculation of the final HRIN value is a simple summing of the eight sub-HRI values.

Following the algorithm format, CIORISUM modifies the calculated sub-HRIN values derived by the CIORICAL program in accordance with user settings of the multiplier and constant values. The original sub-HRIN is either multiplied by the multiplier term or (if non-zero) added to the constant value set. This modified number (where applicable) is then substituted for the original sub-HRIN value, and the sum of all sub-HRIN's computed. Note: the program will accept only single-digit (0 - 9) whole number terms as input for the constant and/or multiplier terms. However, the user may simultaneously enter positive values in as many of the multiplier or constant modifiers as is desired, and must specify some value for each lower case a - p term in the algorithm.

User exercise of the "long" print option as illustrated on Microfiche Card Nos. 1 and 2, allows examination of the data input to the HRIN at the test class level, including specific test classes and chemical specific d_n values within test class.

NOHS Summary file #1 data (hazard-specific) is used to modify source HRIN values in accordance with the AHRI algorithm explained in the text to create a specific summary file based on user exercise of the options to this point.

Note: Subsets of the four TRIALS are created through user choice of the options discussed previously. Any change in user option selection creates a new summary file or "run", as referred to in the internal tracking system. Additionally, all user option selections are displayed in the header information at the top of each risk index page.

E. Create Adjusted Hazard Risk Printouts

Program: PRTAHRIN

The purpose of this program is to produce a listing of the linked chemicals in AHRIN order.

The setting of the algorithm variables and calculation of the AHRIN values is accomplished by the CIORISUM program. Since the sorted summary file used as input to the AHRIN is maintained in RTECS # sequence, an intermediate step orders the file in AHRIN sequence.

Use of a control card in this program provides the "Trial-run" input data for the printout header needed for the internal tracking system.

F. Create Industrial Risk Index (2-, 3-, or 4-digit SIC)

Program: CIORIIRI

The purposes of this program are to: (1) calculate IRI values by modifying source HRIN's produced by the CIORISUM program with exposure data specific to NOHS Summary Files 2, 3, or 4 (2-digit, 3-digit, or 4-digit SIC), (2) input SIC descriptions from the NOHS Standard Industrial Classification Descriptions File, (3) permit optional input of census data for SIC-specific populations as an algorithm factor, and (4) calculate a confidence interval for the calculated IRIN.

As explained in the text on page 47, source HRIN values for every linked chemical observed for the SIC are used. Each of these is modified by the proportion of workers in the SIC (see PES/PEN, page 32) observed to be exposed to it, as well as factors for control and duration of that exposure. The modified HRIN values are then summed across all observed chemical exposures specific to an industrial group.

The resulting sum is optionally modified by the (N) or census population factor for the SIC group.

Calculation of the confidence interval (see text page numbers 45 and 46) is accomplished by machine processing of the equation $\sqrt{1/n}$ (IRIN) which is expressed as $\sqrt{1/PEN}$ ** (0.5)(IRIN). This calculates a confidence interval for the IRIN based on the size of the PEN or total number of workers observed in the SIC group exposed to any NOHS hazard. (See text, page 51.)

G. Create Industrial Risk Index Printouts

Program: PRINTIRI

The purpose of this program is to produce a listing of 2-, 3-, or 4-digit SIC's in IRIN order.

The setting of the algorithm variables for source HRIN data is accomplished in the CIORISUM program, and the calculation of the IRIN's is accomplished in the CIORIIRI program.

Since the output from CIORIIRI is in SIC-code sequence, an intermediate step orders the SIC-listings in IRIN order.

Use of a control card in this program provides the "Trial-run" input for the printout header exactly as in the PRTAHRIN program.

H. Create Occupational Risk Index

Program: CIORIORI

The purposes of this program are to: (1) calculate ORI values by modifying source HRIN's produced by the CIORISUM program with exposure data specific to NOHS Summary File 5 (Standard Occupations), (2) input occupation titles from the NOHS Occupation Descriptions File, (3) permit optional use of the occupation-specific census population total as an algorithm factor, and (4) calculate a confidence interval for the calculated ORIN.

As illustrated in the main text on page 51, source HRIN values for every linked chemical observed in the occupation are used. Each of these is modified by the proportion of workers in the occupation (see PES/PEN, page 32) observed to be exposed to it, as well as factors for control and duration of that exposure. The modified HRIN values are then summed across all chemical exposures specific to the occupation, and the resulting sum optionally modified by the (N) or census population for the occupation.

Calculation of the confidence interval is performed in exactly the same manner discussed in the CIORIIRI program.

I. Create Occupational Risk Index Printouts

Program: PRINTORI

The purpose of this program is to produce a listing of NOHS occupations in ORIN order.

The setting of the algorithm variables for source HRIN data is accomplished in the CIORISUM program, and the calculation of the ORIN's is performed by the CIORIORI program.

Since the output from the CIORIORI program is in occupation-code sequence, an intermediate step orders the occupation listings in ORIN order.

Use of a control card in this program provides the "Trial run" input for the printout header as in the PRTAHRIN program.

Note:

All software for this model will be on file with the Department of Commerce, National Technical Information Service (NTIS), Federal Software Exchange. Alternatively, questions relating to this model may be addressed to the authors at NIOSH.

APPENDIX B

RTECS ABBREVIATIONS

ALR	allergenic effects
AQTX	aquatic toxicity
BCM	blood clotting mechanism effects
bdw	wild bird species
BLD	blood effects
bmr	bone marrow
BPR	blood pressure effects
brd	bird (domestic or lab)
C	continuous
CAR	carcinogenic effects
cat	cat
cc	cubic centimeter
chd	child
ckn	chicken
CL	ceiling concentration
CNS	central nervous system effects
COR	corrosive effects
ctl	cattle
CRIT DOC	criteria document
CUM	cumulative effects
CVS	cardiovascular effects
D	day
dck	duck
DDP	drug dependence effects
DEF	definition

dog	dog
dom	domestic
DOT	Department of Transportation
emb	embryo
EPA	Environmental Protection Agency
EYE	eye effects
fbr	fibroblast
frg	frog
GIT	gastrointestinal tract effects
GLN	glandular effects
gm	gram
gpg	guinea
grb	gerbil
H	hour
ham	hamster
hla	HeLa cell
hmn	human
I	intermittent
IARC	International Agency for Research on Cancer
iat	intraarterial
ial	intraaural
ice	intracerebral
icv	intracervical
idr	intradermal
idu	intraduodenal

ihl	inhalation
imp	implant
ims	intramuscular
inf	infant
ipc	intraplacental
ipl	intrapleural
ipr	intraperitoneal
irn	intrarenal
IRR	irritant effects
isp	intraspinal
itr	intratracheal
ivg	intravaginal
ivn	intravenous
kg	kilogram (one thousand grams)
LC50	lethal concentration 50 percent kill
LCLo	lowest published lethal concentration
LD50	lethal dose 50 percent kill
LDLo	lowest published lethal dose
leu	leucocyte
lng	lung
lvr	liver
lym	lymphocyte
M	minute
M^3	cubic meter
mam	mammal (species unspecified)

man	man
mg	milligram (one thousandth of a gram: 10^{-3} gm)
mky	monkey
ml	milliliter
MMI	mucous membrane effects
mmr	mammary gland
mppcf	million particles per cubic foot
MSK	musculo-skeletal effects
MTH	mouth effects
mul	multiple routes
mus	mouse
MUT	mutagenic effects
NEO	neoplastic effects
ng	nanogram (one billionth of a gram: 10^{-9} grams)
ocu	ocular
ovr	ovary
orl	oral
ORM	Other Regulated Materials (DOT)
OSHA	Occupational Safety and Health Administration
par	parenteral
pg	picogram (one trillionth of a gram: 10^{-12} gm)
pgn	pigeon
pig	pig
Pk	peak concentration
PNS	peripheral nervous system effects

ppb	parts per billion (v/v)
pph	parts per hundred (v/v) (percent)
ppm	parts per million (v/v)
ppt	parts per trillion (v/v)
preg	pregnancy
PSY	psychotropic effects
PUL	pulmonary system effects
qal	quail
rat	rat
RBC	red blood cell effects
rbt	rabbit
rec	rectal
SCP	Standards Completion Program
scu	subcutaneous
SKN	skin effects
sql	squirrel
SSSS	skin/eye sensitivity (not RTECS, model definition)
sup	superscript
SYS	systemic effects
TCLo	lowest published toxic concentration
TDLo	lowest published toxic dose
TER	teratogenic effects
TFX	toxic effects
TLV	threshold limit value
TOX REV	toxicology review

trk	turkey
TWA	time weighted average
TXDS	qualifying toxic dose
ug	microgram (One millionth of a gram: 10^{-6} gram)
unk	unreported
UNS	toxic effects unspecified in source
W	week
WBC	white blood cell effects
wmn	woman
Y	year

RTECS Mutation Test Systems

1.	mmo	mutation in microorganisms
2.	mma	microsomal mutagenicity assay
3.	mnt	micronucleus test
4.	slt	specific locus test
5.	dnd	DNA damage
6.	dnr	DNA repair
7.	dns	unscheduled DNA synthesis
8.	mrc	gene conversion and mitotic recombination
9.	cyt	cytogenic analysis
10.	sce	sister chromatid exchange
11.	sln	sex chromosome loss and nondisdinction
12.	dlt	dominant lethal test
13.	msc	mutation in mammalian somatic cells
14.	hma	host-mediated assay
15.	spm	sperm morphology
16.	trn	heritable translocation test
17.	otr	oncogenic transformation

APPENDIX C

STANDARD INDUSTRIAL CLASSIFICATIONS REPORTED IN A MODEL FOR THE IDENTIFICATION OF HIGH RISK OCCUPATIONAL GROUPS USING RTECS AND NOHS DATA

NUMBER	STANDARD INDUSTRIAL CLASSIFICATIONS
072	ANIMAL HUSBANDRY SERVICES
0720	ANIMAL HUSBANDRY SERVICES
073	HORTICULTURAL SERVICES
0731	HORTICULTURAL SERVICES
08	FORESTRY
080	FORESTRY
0800	FORESTRY
09	FISHERIES
090	FISHERIES
0900	FISHERIES
13	OIL AND GAS EXTRACTION
131	CRUDE PETROLEUM AND NATURAL GAS
1311	CRUDE PETROLEUM AND NATURAL GAS
138	OIL AND GAS FIELD SERVICES
1381	DRILLING OIL AND GAS WELLS
1382	OIL AND GAS EXPLORATION SERVICES
1389	OIL AND GAS FIELD SERVICES, NEC
15	GENERAL BUILDING CONTRACTORS
151	GENERAL BUILDING CONTRACTORS
1511	GENERAL BUILDING CONTRACTORS
16	HEAVY CONSTRUCTION CONTRACTORS
161	HIGHWAY AND STREET CONSTRUCTION
1611	HIGHWAY AND STREET CONSTRUCTION

162	HEAVY CONSTRUCTION, NEC
1621	HEAVY CONSTRUCTION, NEC
17	SPECIAL TRADE CONTRACTORS
171	PLUMBING, HEATING, AIR CONDITIONING
1711	PLUMBING, HEATING, AIR CONDITIONING
172	PAINTING, PAPER HANGING, DECORATING
1721	PAINTING, PAPER HANGING, DECORATING
173	ELECTRICAL WORK
1731	ELECTRICAL WORK
174	MASONRY, STONEWORK, AND PLASTERING
1741	MASONRY AND OTHER STONEWORK
1742	PLASTERING AND LATHING
1743	TERRAZZO, TILE, MARBLE, MOSAIC WORK
175	CARPENTERING AND FLOORING
1751	CARPENTERING
1752	FLOOR LAYING AND FLOOR WORK, NEC
176	ROOFING AND SHEET METAL WORK
1761	ROOFING AND SHEET METAL WORK
179	MISC. SPECIAL TRADE CONTRACTORS
1791	STRUCTURAL STEEL ERECTION
1794	EXCAVATING AND FOUNDATION WORK
1799	SPECIAL TRADE CONTRACTORS, NEC
19	ORDNANCE AND ACCESSORIES
190	ORDNANCE AND ACCESSORIES

1900	ORDNANCE AND ACCESSORIES
20	FOOD AND KINDRED PRODUCTS
201	MEAT PRODUCTS
2011	MEAT PACKING PLANTS
2013	SAUSAGES AND OTHER PREPARED MEATS
2015	POULTRY DRESSING PLANTS
202	DAIRY PRODUCTS
2022	CHEESE, NATURAL AND PROCESSED
2026	FLUID MILK
203	CANNED, CURED, AND FROZEN FOODS
2033	CANNED FRUITS AND VEGETABLES
2035	PICKLES, SAUCES, AND SALAD DRESSINGS
2036	FRESH OR FROZEN PACKAGED FISH
2037	FROZEN FRUITS AND VEGETABLES
204	GRAIN MILL PRODUCTS
2042	PREPARED FEEDS FOR ANIMALS AND FOWLS
2044	RICE MILLING
2045	BLENDED AND PREPARED FLOUR
205	BAKERY PRODUCTS
2051	BREAD, CAKE, AND RELATED PRODUCTS
2052	COOKIES AND CRACKERS
207	CONFECTIONERY AND RELATED PRODUCTS
2071	CONFECTIONERY PRODUCTS
208	BEVERAGES

2082	MALT LIQUORS
2085	DISTILLED LIQUOR, EXCEPT BRANDY
2086	BOTTLED AND CANNED SOFT DRINKS
209	MISC. FOODS AND KINDRED PRODUCTS
2095	ROASTED COFFEE
2099	FOOD PREPARATION, NEC
21	TOBACCO MANUFACTURES
211	CIGARETTES
2111	CIGARETTES
212	CIGARS
2121	CIGARS
213	CHEWING AND SMOKING TOBACCO
2131	CHEWING AND SMOKING TOBACCO
214	TOBACCO STEMMING AND REDRYING
2141	TOBACCO STEMMING AND REDRYING
22	TEXTILE MILL PRODUCTS
221	WEAVING MILLS, COTTON
2211	WEAVING MILLS, COTTON
222	WEAVING MILLS, SYNTHETICS
2221	WEAVING MILLS, SYNTHETICS
224	NARROW FABRIC MILLS
2241	NARROW FABRIC MILLS
225	KNITTING MILLS

2253	KNIT OUTERWEAR MILLS
2256	KNIT FABRIC MILLS
2259	KNITTING MILLS, NEC
226	TEXTILE FINISHING, EXCEPT WOOL
2262	FINISHING PLANTS, SYNTHETICS
2269	FINISHING PLANTS, NEC
228	YARN AND THREAD MILLS
2281	YARN MILLS, EXCEPT WOOL
2283	WOOL YARN MILLS
2284	THREAD MILLS
229	MISCELLANEOUS TEXTILE GOODS
2293	PADDINGS AND UPHOLSTERY FILLING
2294	PROCESSED TEXTILE WASTE
2295	COATED FABRICS, NOT RUBBERIZED
23	APPAREL AND OTHER TEXTILE PRODUCTS
231	MEN'S AND BOYS' SUITS AND COATS
2311	MEN'S AND BOYS' SUITS AND COATS
232	MEN'S AND BOYS' FURNISHINGS
2321	MEN'S AND BOYS' SHIRTS AND NIGHTWEAR
2323	MEN'S AND BOYS' NECKWEAR
2329	MEN'S AND BOYS' CLOTHING, NEC
233	WOMEN'S AND MISSES' OUTERWEAR
2331	WOMEN'S AND MISSES' BLOUSES AND WAISTS
2335	WOMEN'S AND MISSES' DRESSES

2337	WOMEN'S AND MISSES' SUITS AND COATS
2339	WOMEN'S AND MISSES' OUTERWEAR, NEC
234	WOMEN'S AND CHILDREN'S UNDERGARMENTS
2341	WOMEN'S AND CHILDREN'S UNDERWEAR
2342	CORSETS AND ALLIED GARMENTS
235	HATS, CAPS, AND MILLINERY
2352	HATS AND CPAS, EXCEPT MILLINERY
236	CHILDREN'S OUTERWEAR
2369	CHILDREN'S OUTERWEAR, NEC
238	MISCELLANEOUS APPAREL AND ACCESSORIES
2381	FABRIC DRESS AND WORK GLOVES
239	MISC. FABRICATED TEXTILE PRODUCTS
2391	CURTAINS AND DRAPERIES
2392	HOUSEFURNISHING, NEC
2395	PLEATING AND STITCHING
2399	FABRICATED TEXTILE PRODUCTS, NEC
24	LUMBER AND WOOD PRODUCTS
242	SAWMILLS AND PLANING MILLS
2421	SAWMILLS AND PLANING MILLS, GENERAL
2429	SPECIAL PRODUCT SAWMILLS, NEC
243	MILLWORK, PLYWOOD & RELATED PRODUCTS
2431	MILLWORK
2432	VENEER AND PLYWOOD
2433	PREFABRICATED WOOD STRUCTURES

244	WOODEN CONTAINERS
2445	COOPERAGE
249	MISCELLANEOUS WOOD PRODUCTS
2499	WOOD PRODUCTS, NEC
25	FURNITURE AND FIXTURES
251	HOUSEHOLD FURNITURE
2511	WOOD HOUSEHOLD FURNITURE
2512	UPHOLSTERED HOUSEHOLD FURNITURE
2514	METAL HOUSEHOLD FURNITURE
2515	MATTRESSES AND BEDSPRINGS
252	OFFICE FURNITURE
2522	METAL OFFICE FURNITURE
253	PUBLIC BUILDING FURNITURE
2531	PUBLIC BUILDING FURNITURE
254	PARTITIONS AND FIXTURES
2541	WOOD PARTITIONS AND FIXTURES
2542	METAL PARTITIONS AND FIXTURES
259	MISCELLANEOUS FURNITURE AND FIXTURES
2591	VENETIAN BLINDS AND SHADES
2599	FURNITURE AND FIXTURES, NEC
26	PAPER AND ALLIED PRODUCTS
262	PAPER MILLS, EXCEPT BUILDING PAPER
2621	PAPER MILLS, EXCEPT BUILDING PAPER
263	PAPERBOARD MILLS

2631	PAPERBOARD MILLS
264	MISC. CONVERTED PAPER PRODUCTS
2641	PAPER COATING AND GLAZING
2642	ENVELOPES
2643	BAGS, EXCEPT TEXTILE BAGS
2645	DIE CUT PAPER AND BOARD
2647	SANITARY PAPER PRODUCTS
2649	CONVERTED PAPER PRODUCTS, NEC
265	PAPERBOARD CONTAINERS AND BOXES
2651	FOLDING PAPERBOARD BOXES
2652	SET-UP PAPERBOARD BOXES
2653	CORRUGATED AND SOLID FIBER BOXES
2654	SANITARY FOOD CONTAINERS
2655	FIBER CANS, DRUMS, & RELATED MATERIAL
266	BUILDING PAPER AND BOARD MILLS
2661	BUILDING PAPER AND BOARD MILLS
27	PRINTING AND PUBLISHING
271	NEWSPAPERS
2711	NEWSPAPERS
272	PERIODICALS
2721	PERIODICALS
273	BOOKS
2731	BOOK PUBLISHING
2732	BOOK PRINTING

274	MISCELLANEOUS PUBLISHING
2741	MISCELLANEOUS PUBLISHING
275	COMMERCIAL PRINTING
2751	COMMERCIAL PRINTING, EXCEPT LITHOGRAPHIC
2752	COMMERCIAL PRINTING, LITHOGRAPHIC
276	MANIFOLD BUSINESS FORMS
2761	MANIFOLD BUSINESS FORMS
277	GREETING CARD PUBLISHING
2771	GREETING CARD PUBLISHING
278	BLANKBOOKS AND BOOKBINDING
2789	BOOKBINDING AND RELATED WORK
279	PRINTING TRADE SERVICES
2791	TYPESETTING
28	CHEMICALS AND ALLIED PRODUCTS
281	INDUSTRIAL CHEMICALS
2815	CYCLIC INTERMEDIATES AND CRUDES
2816	INORGANIC PIGMENTS
2818	INDUSTRIAL ORGANIC CHEMICALS, NEC
2819	INDUSTRIAL INORGANIC CHEMICALS, NEC
282	PLASTICS MATERIALS AND SYNTHETICS
2821	PLASTICS MATERIALS AND RESINS
2822	SYNTHETIC RUBBER
2823	CELLULOSIC MAN-MADE FIBERS
283	DRUGS

2831	BIOLOGICAL PRODUCTS
2833	MEDICINALS AND BOTANICALS
2834	PHARMACEUTICAL PREPARATIONS
284	SOAP, CLEANERS, AND TOILET GOODS
2841	SOAP AND OTHER DETERGENTS
2842	POLISHES AND SANITATION GOODS
2843	SURFACE ACTIVE AGENTS
2844	TOILET PREPARATIONS
285	PAINTS AND ALLIED PRODUCTS
2851	PAINTS AND ALLIED PRODUCTS
287	AGRICULTURAL CHEMICALS
2871	FERTILIZERS
289	MISCELLANEOUS CHEMICAL PRODUCTS
2893	PRINTING INK
2899	CHEMICAL PREPARATIONS, NEC
29	PETROLEUM AND COAL PRODUCTS
291	PETROLEUM REFINING
2911	PETROLEUM REFINING
295	PAVING AND ROOFING MATERIALS
2951	PAVING MIXTURES AND BLOCKS
2952	ASPHALT FELTS AND COATINGS
299	MISC. PETROLEUM AND COAL PRODUCTS
2992	LUBRICATING OILS AND GREASES
30	RUBBER AND PLASTICS PRODUCTS, NEC
301	TIRES AND INNER TUBES

3011	TIRES AND INNER TUBES
302	RUBBER FOOTWEAR
3021	RUBBER FOOTWEAR
306	FABRICATED RUBBER PRODUCTS, NEC
3069	FABRICATED RUBBER PRODUCTS, NEC
307	MISCELLANEOUS PLASTICS PRODUCTS
3079	MISCELLANEOUS PLASTICS PRODUCTS
31	LEATHER AND LEATHER PRODUCTS
311	LEATHER TANNING AND FINISHING
3111	LEATHER TANNING AND FINISHING
313	FOOTWEAR CUT STOCK
3131	FOOTWEAR CUT STOCK
314	FOOTWEAR, EXCEPT RUBBER
3141	SHOES, EXCEPT RUBBER
3142	HOUSE SLIPPERS
316	LUGGAGE
3161	LUGGAGE
317	HANDBAGS AND PERSONAL LEATHER GOODS
3171	WOMEN'S HANDBAGS AND PURSES
3172	PERSONAL LEATHER GOODS
32	STONE, CLAY, AND GLASS PRODUCTS
321	FLAT GLASS
3211	FLAT GLASS
322	GLASS AND GLASSWARE, PRESSED OR BLOWN
3221	GLASS CONTAINERS

323	PRODUCTS OF PURCHASED GLASS
3231	PRODUCTS OF PURCHASED GLASS
324	CEMENT, HYDRAULIC
3241	CEMENT, HYDRAULIC
325	STRUCTURAL CLAY PRODUCTS
3251	BRICK AND STRUCTURAL CLAY TILE
326	POTTERY AND RELATED PRODUCTS
3269	POTTERY PRODUCTS, NEC
327	CONCRETE, GYPSUM, AND PLASTER PRODUCTS
3271	CONCRETE, BLOCK AND BRICK
3272	CONCRETE PRODUCTS, NEC
3273	READY-MIXED CONCRETE
3274	LIME
328	CUT STONE AND STONE PRODUCTS
3281	CUT STONE AND STONE PRODUCTS
329	MISC. NONMETALLIC MINERAL PRODUCTS
3291	ABRASIVE PRODUCTS
3292	ASBESTOS PRODUCTS
3295	MINERALS, GROUND OR TREATED
3299	NONMETALLIC MINERAL PRODUCTS, NEC
33	PRIMARY METAL INDUSTRIES
331	BLAST FURNACE AND BASIC STEEL PRODUCTS
3312	BLAST FURNACES AND STEEL MILLS
3313	ELECTROMETALLURGICAL PRODUCTS
3315	STEEL WIRE AND RELATED PRODUCTS

3316	COLD FINISHING OF STEEL SHAPES
3317	STEEL PIPE AND TUBES
332	IRON AND STEEL FOUNDRIES
3321	GRAY IRON FOUNDRIES
3322	MALLEABLE IRON FOUNDRIES
3323	STEEL FOUNDRIES
333	PRIMARY NONFERROUS METALS
3334	PRIMARY ALUMINUM
3339	PRIMARY NONFERROUS METALS, NEC
335	NONFERROUS ROLLING AND DRAWING
3351	COPPER ROLLING AND DRAWING
3352	ALUMINUM ROLLING AND DRAWING
3356	NONFERROUS ROLLING AND DRAWING, NEC
3357	NONFERROUS WIRE DRAWING AND INSULATING
336	NONFERROUS FOUNDRIES
3361	ALUMINUM CASTINGS
3362	BRASS, BRONZE, AND COPPER CASTINGS
3369	NONFERROUS CASTINGS, NEC
339	MISCELLANEOUS PRIMARY METAL PRODUCTS
3391	IRON AND STEEL FORGINGS
3399	PRIMARY METAL PRODUCTS, NEC
34	FABRICATED METAL PRODUCTS
341	METAL CANS
3411	METAL CANS
342	CUTLERY, HAND TOOLS, AND HARDWARE

3421	CUTLERY
3423	HAND AND EDGE TOOLS, NEC
3429	HARDWARE, NEC
343	PLUMBING AND HEATING, EXCEPT ELECTRIC
3432	PLUMBING FITTINGS AND BRASS GOODS
3433	HEATING EQUIPMENT, EXCEPT ELECTRIC
344	FABRICATED STRUCTURAL METAL PRODUCTS
3441	FABRICATED STRUCTURAL STEEL
3442	METAL DOORS, SASH, AND TRIM
3443	FABRICATED PLATE WORK (BOILER SHOPS)
3444	SHEET METAL WORK
3446	ARCHITECTURAL METAL WORK
3449	MISCELLANEOUS METAL WORK
345	SCREW MACHINE PRODUCTS, BOLTS, ETC.
3451	SCREW MACHINE PRODUCTS
3452	BOLTS, NUTS, RIVETS, AND WASHERS
346	METAL STAMPINGS
3461	METAL STAMPINGS
347	METAL SERVICES, NEC
3471	PLATING AND POLISHING
3479	METAL COATING AND ALLIED SERVICES
348	MISC. FABRICATED WIRE PRODUCTS
3481	MISC. FABRICATED WIRE PRODUCTS
349	MISC. FABRICATED METAL PRODUCTS
3491	METAL BARRELS, DRUMS, AND PAILS

3493	STEEL SPRINGS
3494	VALVES AND PIPE FITTINGS
3496	COLLAPSIBLE TUBES
3498	FABRICATED PIPE AND FITTINGS
3499	FABRICATED METAL PRODUCTS, NEC
35	MACHINERY, EXCEPT ELECTRICAL
351	ENGINES AND TURBINES
3511	STEAM ENGINES AND TURBINES
3519	INTERNAL COMBUSTION ENGINES, NEC
352	FARM MACHINERY
3522	FARM MACHINERY
353	CONSTRUCTION AND RELATED MACHINERY
3531	CONSTRUCTION MACHINERY
3532	MINING MACHINERY
3533	OIL FIELD MACHINERY
3534	ELEVATORS AND MOVING STAIRWAYS
3535	CONVEYORS AND CONVEYING EQUIPMENT
3537	INDUSTRIAL TRUCKS AND TRACTORS
354	METAL WORKING MACHINERY
3541	MACHINE TOOLS, METAL CUTTING TYPES
3542	MACHINE TOOLS, METAL FORMING TYPES
3544	SPECIAL DIES, TOOLS, JIGS & FIXTURES
3545	MACHINE TOOL ACCESSORIES
3548	METALWORKING MACHINERY, NEC
355	SPECIAL INDUSTRY MACHINERY

3551	FOOD PRODUCTS MACHINERY
3552	TEXTILE MACHINERY
3553	WOODWORKING MACHINERY
3554	PAPER INDUSTRIES MACHINERY
3559	SPECIAL INDUSTRY MACHINE, NEC
356	GENERAL INDUSTRIAL MACHINERY
3561	PUMPS AND COMPRESSORS
3562	BALL AND ROLLER BEARINGS
3564	BLOWERS AND FANS
3565	INDUSTRIAL PATTERNS
3566	POWER TRANSMISSION EQUIPMENT
3567	INDUSTRIAL FURNACES AND OVENS
3569	GENERAL INDUSTRIAL MACHINERY, NEC
357	OFFICE AND COMPUTING MACHINES
3573	ELECTRONIC COMPUTING EQUIPMENT
3579	OFFICE MACHINES, NEC
358	SERVICE INDUSTRY MACHINES
3581	AUTOMATIC MERCHANDISING MACHINES
3582	COMMERCIAL LAUNDRY EQUIPMENT
3585	REFRIGERATION MACHINERY
3589	SERVICE INDUSTRY MACHINES, NEC
359	MISC. MACHINERY, EXCEPT ELECTRICAL
3599	MISC. MACHINERY, ESCEPT ELECTRICAL
36	ELECTRICAL EQUIPMENT AND SUPPLIES
361	ELECTRIC TEST & DISTRIBUTING EQUIPMENT

3611	ELECTRIC MEASURING INSTRUMENTS
3612	TRANSFORMERS
3613	SWITCHGEAR AND SWITCHBOARD APPARATUS
362	ELECTRICAL INDUSTRIAL APPARATUS
3621	MOTORS AND GENERATORS
3622	INDUSTRIAL CONTROLS
3623	WELDING APPARATUS
363	HOUSEHOLD APPLIANCES
3632	HOUSEHOLD REFRIGERATORS AND FREEZERS
3634	ELECTRIC HOUSEWARES AND FANS
364	ELECTRIC LIGHTING AND WIRING EQUIPMENT
3641	ELECTRIC LAMPS
3642	LIGHTING FIXTURES
3643	CURRENT-CARRYING WIRING DEVICES
3644	NON CURRENT-CARRYING WIRING DEVICES
365	RADIO AND TV RECEIVING EQUIPMENT
3651	RADIO AND TV RECEIVING SETS
3652	PHONOGRAPH RECORDS
366	COMMUNICATION EQUIPMENT
3661	TELEPHONE AND TELEGRAPH APPARATUS
3662	RADIO AND TV COMMUNICATION EQUIPMENT
367	ELECTRONIC COMPONENTS AND ACCESSORIES
3673	ELECTRON TUBES, TRANSMITTING
3679	ELECTRONIC COMPONENTS, NEC
369	MISC. ELECTRICAL EQUIPMENT & SUPPLIES

3691	STORAGE BATTERIES
3694	ENGINE ELECTRICAL EQUIPMENT
3699	ELECTRICAL EQUIPMENT, NEC
37	TRANSPORTATION EQUIPMENT
371	MOTOR VEHICLES AND EQUIPMENT
3711	MOTOR VEHICLES
3713	TRUCK AND BUS BODIES
3714	MOTOR VEHICLE PARTS AND ACCESSORIES
3715	TRUCK TRAILERS
372	AIRCRAFT AND PARTS
3721	AIRCRAFT
3722	AIRCRAFT ENGINES AND ENGINE PARTS
3729	AIRCRAFT EQUIPMENT, NEC
373	SHIP AND BOAT BUILDING AND REPAIRING
3731	SHIP BUILDING AND REPAIRING
3732	BOAT BUILDING AND REPAIRING
374	RAILROAD EQUIPMENT
3742	RAILROAD AND STREET CARS
379	MISCELLANEOUS TRANSPORTATION EQUIPMENT
3791	TRAILER COACHES
3799	TRANSPORTATION EQUIPMENT, NEC
38	INSTRUMENTS AND RELATED PRODUCTS
381	ENGINEERING & SCIENTIFIC INSTRUMENTS
3811	ENGINEERING & SCIENTIFIC INSTRUMENTS
382	MECHANICAL MEASURING & CONTROL DEVICES

3821	MECHANICAL MEASURING DEVICES
3822	AUTOMATIC TEMPERATURE CONTROLS
383	OPTICAL INSTRUMENTS AND LENSES
3831	OPTICAL INSTRUMENTS AND LENSES
384	MEDICAL INSTRUMENTS AND SUPPLIES
3841	SURGICAL AND MEDICAL INSTRUMENTS
3842	SURGICAL APPLICANCES AND SUPPLIES
3843	DENTAL EQUIPMENT AND SUPPLIES
385	OPHTHALMIC GOODS
3851	OPHTHALMIC GOODS
386	PHOTOGRAPHIC EQUIPMENT AND SUPPLIES
3861	PHOTOGRAPHIC EQUIPMENT AND SUPPLIES
387	WATCHES, CLOCKS, AND WATCHCASES
3871	WATCHES AND CLOCKS
39	MISCELLANEOUS MANUFACTURING INDUSTRIES
391	JEWELRY, SILVERWARE, AND PLATED WARE
3911	JEWELRY, PRECIOUS METAL
3912	JEWELERS' FINDINGS AND MATERIALS
393	MUSICAL INSTRUMENTS AND PARTS
3931	MUSICAL INSTRUMENTS AND PARTS
394	TOYS AND SPORTING GOODS
3941	GAMES AND TOYS
3942	DOLLS
3949	SPORTING AND ATHLETIC GOODS, NEC
395	PENS, PENCILS, OFFICE AND ART SUPPLIES

3951	PENS AND MECHNICAL PENCILS
3952	LEAD PENCILS AND ART GOODS
3953	MARKING DEVICES
3955	CARBON PAPER AND INKED RIBBONS
396	COSTUME JEWELRY AND NOTIONS
3961	COSTUME JEWELRY
3964	NEEDLES, PINS, AND FASTENERS
399	MISCELLANEOUS MANUFACTURES
3991	BROOMS AND BRUSHES
3993	SIGNS AND ADVERTISING DISPLAYS
3994	MORTICIANS' GOODS
3996	HARD SURFACE FLOOR COVERINGS
3999	MANUFACTURES, NEC
41	LOCAL AND INTERURBAN PASSENGER TRANSIT
411	LOCAL AND SUBURBAN TRANSPORTATION
4111	LOCAL AND SUBURBAN TRANSIT
4119	LOCAL PASSENGER TRANSPORTATION, NEC
412	TAXICABS
4121	TAXICABS
413	INTERCITY HIGHWAY TRANSPORTATION
4131	INTERCITY BUS LINES
415	SCHOOL BUSSES
4151	SCHOOL BUSSES

42	TRUCKING AND WAREHOUSING
421	TRUCKING, LOCAL AND LONG DISTANCE
4210	TRUCKING, LOCAL AND LONG DISTANCE
4214	LOCAL TRUCKING AND STORAGE
422	PUBLIC WAREHOUSING
4222	REFRIGERATED WAREHOUSING, NEC
4225	GENERAL WAREHOUSING AND STORAGE
4226	SPECIAL WAREHOUSING AND STORAGE, NEC
44	WATER TRANSPORTATION
441	DEEP SEA FOREIGN TRANSPORTATION
4411	DEEP SEA FOREIGN TRANSPORTATION
442	DEEP SEA DOMESTIC TRANSPORTATION
4422	COASTWISE TRANSPORTATION
444	TRANSPORTATION ON RIVERS AND CANALS
4441	TRANSPORTATION ON RIVERS AND CANALS
445	LOCAL WATER TRANSPORTATION
4450	LOCAL WATER TRANSPORTATION
446	WATER TRANSPORTATION SERVICES
4463	MARINE CARGO HANDLING
45	TRANSPORTATION BY AIR
450	TRANSPORTATION BY AIR
4500	TRANSPORTATION BY AIR
452	NONCERTIFICATED AIR TRANSPORTATION
458	AIR TRANSPORTATION SERVICES

4580	AIR TRANSPORTATION SERVICES
46	PIPE LINE TRANSPORTATION
461	PIPE LINES, EXCEPT NATURAL GAS
4610	PIPELINE TRANSPORTATION, EXCEPT NATURAL GAS
47	TRANSPORTATION SERVICES
471	FREIGHT FORWARDING
4712	FREIGHT FORWARDING
472	ARRANGEMENT OF TRANSPORTATION
4721	ARRANGEMENT OF TRANSPORTATION
48	COMMUNICATION
481	TELEPHONE COMMUNICATION
4811	TELEPHONE COMMUNICATION
483	RADIO AND TELEVISION BROADCASTING
4830	RADIO AND TELEVISION BROADCASTING
489	COMMUNICATION SERVICES, NEC
4899	COMMUNICATION SERVICES, NEC
49	ELECTRIC, GAS, AND SANITARY SERVICES
491	ELECTRIC COMPANIES AND SYSTEMS
4911	ELECTRIC COMPANIES AND SYSTEMS
492	GAS COMPANIES AND SYSTEMS
4920	GAS COMPANIES AND SYSTEMS
493	COMBINATION COMPANIES AND SYSTEMS
4931	ELECTRIC AND OTHER SERVICES COMBINED
4932	GAS AND OTHER SERVICES COMBINED
50	WHOLESALE TRADE

501	MOTOR VEHICLES & AUTOMOTIVE EQUIPMENT
5013	AUTOMOTIVE EQUIPMENT
502	DRUGS, CHEMICALS, AND ALLIED PRODUCTS
504	GROCERIES AND RELATED PRODUCTS
5041	GROCERIES, GENERAL LINE
5047	MEATS AND MEAT PRODUCTS
5048	FRESH FRUITS AND VEGETABLES
505	FARM PRODUCT RAW MATERIALS
5053	GRAIN
506	ELECTRICAL GOODS
5063	ELECTRICAL APPARATUS AND EQUIPMENT
5065	ELECTRONIC PARTS AND EQUIPMENT
507	HARDWARE, PLUMBING & HEATING EQUIPMENT
5077	AIR CONDITIONING AND REFRIGERATION
508	MACHINERY, EQUIPMENT, AND SUPPLIES
5081	COMMERCIAL MACHINES AND EQUIPMENT
5084	INDUSTRIAL MACHINERY AND EQUIPMENT
509	MISCELLANEOUS WHOLESALERS
5091	METALS & MINERALS, EXCEPT PETROLEUM
5092	PETORLEUM AND PETROLEUM PRODUCTS
5099	WHOLESALERS, NEC
52	BUILDING MATERIALS AND FARM EQUIPMENT
521	LUMBER AND OTHER BUILDING MATERIALS

5211	LUMBER AND OTHER BUILDING MATERIALS
525	HARDWARE AND FARM EQUIPMENT
53	RETAIL GENERAL MERCHANDISE
531	DEPARTMENT STORES
5311	DEPARTMENT STORES
532	MAIL ORDER HOUSES
5321	MAIL ORDER HOUSES
533	VARIETY STORES
5331	VARIETY STORES
534	MERCHANDISING MACHINE OPERATORS
5341	MERCHANDISING MACHINE OPERATORS
539	MISC. GENERAL MERCHANDISE STORES
54	FOOD STORES
541	GROCERY STORES
5411	GROCERY STORES
55	AUTOMOTIVE DEALERS & SERVICE STATIONS
551	NEW AND USED CAR DEALERS
5511	NEW AND USED CAR DEALERS
553	TIRE, BATTERY, AND ACCESSORY DEALERS
554	GASOLINE SERVICE STATIONS
5541	GASOLINE SERVICE STATIONS
56	APPAREL AND ACCESSORY STORES
562	WOMEN'S READY-TO-WEAR STORES
5621	WOMEN'S READY-TO-WEAR STORES
565	FAMILY CLOTHING STORES

5651	FAMILY CLOTHING STORES
566	SHOE STORES
57	FURNITURE AND HOME FURNISHING STORES
571	FURNITURE AND HOME FURNISHINGS
58	EATING AND DRINKING PLACES
581	EATING AND DRINKING PLACES
5810	EATING AND DRINKING PLACES
59	MISCELLANEOUS RETAIL STORES
591	DRUG STORES AND PROPRIETARY STORES
5912	DRUG STORES AND PROPRIETARY STORES
592	LIQUOR STORES
5921	LIQUOR STORES
590	FUEL OIL DEALERS
5900	FUEL OIL DEALERS
599	RETAIL STORES, NEC
5999	MISCELLANEOUS RETAIL STORES, NEC
60	BANKING
602	COMMERCIAL AND STOCK SAVINGS BANKS
6020	COMMERCIAL AND STOCK SAVINGS BANKS
61	CREDIT AGENCIES OTHER THAN BANKS
62	SECURITY, COMMODITY BROKERS & SERVICES
621	SECURITY BROKERS AND DEALERS
6211	SECURITY BROKERS AND DEALERS
63	INSURANCE CARRIERS

631	LIFE INSURANCE
6310	LIFE INSURANCE
633	FIRE, MARINE, AND CASUALTY INSURANCE
6330	FIRE, MARINE, AND CASUALTY INSURANCE
64	INSURANCE AGENTS, BROKERS & SERVICE
641	INSURANCE AGENTS, BROKERS & SERVICE
6411	INSURANCE AGENTS, BROKERS & SERVICE
65	REAL ESTATE
651	REAL ESTATE OPERATORS AND LESSORS
6510	REAL ESTATE OPERATORS AND LESSORS
653	AGENTS, BROKERS, AND MANAGERS
6531	AGENTS, BROKERS, AND MANAGERS
66	COMBINED REAL ESTATE, INSURANCE, ETC.
67	HOLDING AND OTHER INVESTMENT COMPANIES
70	HOTELS AND OTHER LODGING PLACES
701	HOTELS, TOURIST COURTS, AND MOTELS
7011	HOTELS, TOURIST COURTS, AND MOTELS
72	PERSONAL SERVICES
721	LAUNDRIES AND DRY CLEANING PLANTS
7211	POWER LAUNDRIES, FAMILY & COMMERCIAL
7213	LINEN SUPPLY
7216	DRY CLEANING PLANTS, EXCEPT RUG
73	MISCELLANEOUS BUSINESS SERVICES
731	ADVERTISING
7311	ADVERTISING AGENCIES

734	SERVICES TO BUILDINGS
7349	MISCELLANEOUS SERVICES TO BUILDINGS
739	MISCELLANEOUS BUSINESS SERVICES
7391	RESEARCH & DEVELOPMENT LABORATORIES
7399	BUSINESS SERVICES, NEC
75	AUTO REPAIR, SERVICES, AND GARAGES
76	MISCELLANEOUS REPAIR SERVICES
762	ELECTRICAL REPAIR SHOPS
769	MISCELLANEOUS REPAIR SHOPS
7699	REPAIR SERVICES, NEC
78	MOTION PICTURES
79	AMUSEMENT & RECREATION SERVICES, NEC
792	PRODUCERS, ORCHESTRAS, ENTERTAINERS
7929	ENTERTAINERS' & ENTERTAINMENT GROUPS
793	BOWLING AND BILLIARD ESTABLISHMENTS
7933	BOWLING ALLEYS
794	MISC. AMUSEMENT, RECREATION SERVICES
7946	AMUSEMENT PARKS
7947	GOLF CLUBS AND COUNTRY CLUBS
7949	AMUSEMENT AND RECREATION, NEC
80	MEDICAL AND OTHER HEALTH SERVICES
801	OFFICES OF PHYSICIANS AND SURGEONS
8011	OFFICES OF PHYSICIANS AND SURGEONS
806	HOSPITALS
8061	HOSPITALS

809	HEALTH AND ALLIED SERVICES, NEC
8092	SANITORIES, CONVALESCENT & REST HOMES
8099	HEALTH AND ALLIED SERVICES, NEC
81	LEGAL SERVICES
811	LEGAL SERVICES
8111	LEGAL SERVICES
82	EDUCATIONAL SERVICES
86	NONPROFIT MEMBERSHIP ORGANIZATION
89	MISCELLANEOUS SERVICES
891	ENGINEERING & ARCHITECTURAL SERVICES
8911	ENGINEERING & ARCHITECTURAL SERVICES
893	ACCOUNTING, AUDITING & BOOKKEEPING
8931	ACCOUNTING, AUDITING & BOOKKEEPING

APPENDIX D

OCCUPATION CODES REPORTED IN A MODEL FOR THE IDENTIFICATION OF HIGH RISK OCCUPATIONAL GROUPS USING RTECS AND NOHS DATA

NUMBER	OCCUPATION
001	ACCOUNTANTS
006	AERONAUTICAL AND ASTRONAUTICAL ENGINEERS
010	CHEMICAL ENGINEERS
011	CIVIL ENGINEERS
012	ELECTRICAL AND ELECTRONIC ENGINEERS
013	INDUSTRIAL ENGINEERS
014	MECHANICAL ENGINEERS
015	METALLUGICAL AND MATERIALS ENGINEERS
023	ENGINEERS, NEC
044	BIOLOGICAL SCIENTISTS
045	CHEMISTS
055	OPERATIONS AND SYSTEMS RESEARCHERS AND ANALYSTS
056	PERSONNEL AND LABOR RELATIONS WORKERS
064	PHARMACISTS
065	PHYSICIANS, MEDICAL AND OSTEOPATHIC
075	REGISTERED NURSES
076	THERAPISTS
080	CLINICAL LABORATORY TECHNOLOGISTS AND TECHNICIANS
083	RADIOLOGIC TECHNOLOGISTS AND TECHNICIANS
085	HEALTH TECHNOLOGISTS AND TECHNICIANS, NEC
150	AGRICULTURE AND BIOLOGICAL TECHNICIANS, EXCEPT HEALTH
151	CHEMICAL TECHNICIANS

152	DRAFTSMEN
153	ELECTRICIAL AND ELECTRONIC ENGINEERING TECHNICIANS
154	INDUSTRIAL ENGINEERING TECHNICIANS
155	MECHANICAL ENGINEERING TECHNICIANS
162	ENGINEERING AND SCIENCE TECHNICIANS, NEC
163	AIRPLANE PILOTS
170	FLIGHT ENGINEERS
171	RADIO OPERATORS
183	DESIGNERS
184	EDITORS AND REPORTERS
190	PAINTERS AND SCULPTORS
191	PHOTOGRAPHERS
195	RESEARCH WORKERS, NOT SPECIFIED
221	OFFICERS, PILOTS, AND PURSERS: SHIP
225	PURCHASING AGENTS AND BUYERS, NEC
230	RESTAURANT, CAFETERIA, AND BAR MANAGERS
233	SALES MANAGERS, EXCEPT RETAIL TRADE
00K	MANAGERS AND ADMINISTRATORS, NEC
260	ADVERTISING AGENTS AND SALESMEN
280	SALESMEN AND SALES CLERKS, NEC
301	BANK TELLERS
303	BILLING CLERKS
305	BOOKKEEPERS
310	CASHIERS

312	CLERICAL SUPERVISORS, NEC
314	COUNTER CLERKS, EXCEPT FOOD
315	DISPATCHERS AND STARTERS, VEHICLE
321	ESTIMATORS AND INVESTIGATORS, NEC
323	EXPEDITERS AND PRODUCTION CONTROLLERS
325	FILE CLERKS
332	MAIL HANDLERS, EXCEPT POST OFFICE
343	COMPUTER AND PERIPHERAL EQUIPMENT OPERATORS
344	DUPLICATING MACHINE OPERATORS
345	KEY PUNCH OPERATORS
355	OFFICE MACHINE OPERATORS, NEC
360	PAYROLL AND TIMEKEEPING CLERKS
362	PROOFREADERS
364	RECEPTIONISTS
00H	SECRETARIES, NEC
374	SHIPPING AND RECEIVING CLERKS
375	STATISTICAL CLERKS
376	STENOGRAPHERS
381	STOCK CLERKS AND STOREKEEPERS
385	TELEPHONE OPERATORS
390	TICKET, STATION, AND EXPRESS AGENTS
391	TYPISTS
392	WEIGHERS
394	MISCELLANEOUS CLERICAL WORKERS

395	NOT SPECIFIED CLERICAL WORKERS
402	BAKERS
403	BLACKSMITHS
404	BOILERMAKERS
405	BOOKBINDERS
00B	BRICKLAYERS AND STONEMASONS
412	BULLDOZER OPERATORS
413	CABINETMAKERS
00C	CARPENTERS
421	CEMENT AND CONCRETE FINISHERS
422	COMPOSITORS AND TYPESETTERS
424	CRANEMEN, DERRICKMEN, AND HOISTMEN
00D	ELECTRICIANS
433	ELECTRIC POWER LINEMEN AND CABLEMEN
435	ENGRAVERS, EXC. PHOTOENGRAVERS
436	EXCAVATING, GRADING, AND ROAD MACHINE OPERATORS: EXC. BULLDOZER
441	FOREMEN, NEC
442	FORGEMEN AND HAMMERMEN
443	FURNITURE AND WOOD FINISHERS
446	HEAT TREATERS, ANNEALERS, AND TEMPERERS
452	INSPECTORS, NEC
453	JEWELERS AND WATCHMAKERS
454	JOB AND DIE SETTERS, METAL
455	LOCOMOTIVE ENGINEERS

001	MACHINISTS
470	AIR CONDITIONING, HEATING, AND REFRIGERATION
471	AIRCRAFT
472	AUTOMOBILE BODY REPAIRMEN
00A	AUTOMOBILE MECHANICS
481	HEAVY EQUIPMENT MECHANICS, INC. DIESEL
482	HOUSEHOLD APPLIANCE AND ACCESSORY INSTALLERS AND MECHANICS
484	OFFICE MACHINE
485	RADIO AND TELEVISION
492	MISCELLANEOUS MECHANICS AND REPAIRMEN
00J	NOT SPECIFIED MECHANICS AND REPAIRMEN
502	MILLWRIGHTS
503	MOLDERS, METAL
506	OPTICIANS, AND LENS GRINDERS AND POLISHERS
510	PAINTERS, CONSTRUCTION AND MAINTENANCE
514	PATTERN AND MODEL MAKERS, EXC. PAPER
515	PHOTOENGRAVERS AND LITHOGRAPHERS
520	PLASTERERS
00F	PLUMBERS AND PIPEFITTERS
525	POWER STATION OPERATORS
00G	PRESSMEN AND PLATE PRINTERS
533	ROLLERS AND FINISHERS, METAL
534	ROOFERS AND SLATERS
00L	SHEETMETAL WORKERS AND TINSMITHS

540	SHIPFITTERS
545	STATIONARY ENGINEERS
550	STRUCTURAL METAL CRAFTSMEN
551	TAILORS
552	TELEPHONE INSTALLERS AND REPAIRMEN
554	TELEPHONE LINEMEN AND SPLICERS
560	TILE SETTERS
00E	TOOL AND DIE MAKERS
563	UPHOLSTERERS
575	CRAFTSMEN AND KINDRED WORKERS, NEC
601	ASBESTOS AND INSULATION WORKERS
602	ASSEMBLERS
604	BOTTLING AND CANNING OPERATIVES
610	CHECKERS, EXAMINERS, AND INSPECTORS: MANUFACTURING
611	CLOTHING IRONERS AND PRESSERS
612	CUTTING OPERATIVES, NEC
613	DRESSMAKERS AND SEAMSTRESSES, EXCEPT FACTORY
614	DRILLERS, EARTH
615	DRY WALL INSTALLERS AND LATHERS
620	DYERS
621	FILERS, POLISHERS, SANDERS, AND BUFFERS
622	FURNACEMEN, SMELTERMEN, AND POURERS
623	GARAGE WORKERS AND GAS STATION ATTENDANTS
624	GRADERS AND SORTERS, MANUFACTURING

626	HEATERS, METAL
630	LAUNDRY AND DRY CLEANING OPERATIVES, NEC
631	MEAT CUTTERS AND BUTCHERS, EXC. MANUFACTURING
633	MEAT CUTTERS AND BUTCHERS, MANUFACTURING
634	MEAT WRAPPERS, RETAIL TRADE
635	METAL PLATERS
640	MINE OPERATIVES, NEC
641	MIXING OPERATIVES
642	OILERS AND GREASERS, EXC. AUTO
643	PACKERS AND WRAPPERS, EXCEPT MEAT AND PRODUCE
644	PAINTERS, MANUFACTURED ARTICLES
645	PHOTOGRAPHIC PROCESS WORKERS
650	DRILL PRESS OPERATIVES
651	GRINDING MACHINE OPERATIVES
652	LATHE AND MILLING MACHINE OPERATIVES
653	PRECISION MACHINE OPERATIVES, NEC
656	PUNCH AND STAMPING PRESS OPERATIVES
660	RIVETERS AND FASTENERS
661	SAILORS AND DECKHANDS
662	SAWYERS
663	SEWERS AND STITCHERS
664	SHOEMAKING MACHINE OPERATIVES
665	SOLDERS
666	STATIONARY FIREMEN

670	CARDING, LAPPING, AND COMBING OPERATIVES
671	KNITTERS, LOOPERS, AND TOPPERS
672	SPINNERS, TWISTERS, AND WINDERS
673	WEAVERS
674	TEXTILE OPERATIVES, NEC
680	WELDERS AND FLAME-CUTTERS
681	WINDING OPERATIVES, NEC
690	MACHINE OPERATIVES, MISCELLANEOUS SPECIFIED
692	MACHINE OPERATIVES, NOT SPECIFIED
694	MISCELLANEOUS OPERATIVES
695	NOT SPECIFIED OPERATIVES
703	BUS DRIVERS
705	DELIVERYMEN AND ROUTEMEN
706	FORK LIFT AND TOW MOTOR OPERATIVES
710	MOTORMEN: MINE, FACTORY, LOGGING CAMP, ETC.
713	RAILROAD SWITCHMEN
714	TAXICAB DRIVERS AND CHAUFFEURS
715	TRUCK DRIVERS
740	ANIMAL CARETAKERS, EXC. FARM
750	CARPENTERS' HELPERS
751	CONSTRUCTION LABORERS, EXC. CARPENTER HELPERS
753	FREIGHT AND MATERIAL HANDLERS
755	GARDENERS AND GROUNDSKEEPERS, EXC. FARM
760	LONGSHOREMEN AND STEVEDORES

762	STOCK HANDLERS
764	VEHICLE WASHERS AND EQUIPMENT CLEANERS
770	WAREHOUSEMEN, NEC
780	MISCELLANEOUS LABORERS
785	NOT SPECIFIED LABORERS
901	CHAMBERMAIDS AND MAIDS, EXC. PRIVATE HOUSEHOLD
902	CLEANERS AND CHARWOMEN
903	JANITORS AND SEXTONS
910	BARTENDERS
911	BUSBOYS
912	COOKS, EXCEPT PRIVATE HOUSEHOLDS
913	DISHWASHERS
914	FOOD COUNTER AND FOUNTAIN WORKERS
915	WAITERS
916	FOOD SERVICE WORKERS, NEC, EXCEPT PRIVATE HOUSEHOLD
922	HEALTH AIDES, EXC. NURSING
925	NURSING AIDES, ORDERLIES, AND ATTENDANTS
926	PRACTICAL NURSES
931	AIRLINE STEWARDESSES
932	ATTENDANTS, RECREATION AND AMUSEMENT
933	ATTENDANTS, PERSONAL SERVICE, NEC
934	BAGGAGE PORTERS AND BELLHOPS
944	HAIRDRESSERS AND COSMETOLOGISTS
950	HOUSEKEEPERS, EXC. PRIVATE HOUSEHOLD

961	FIREMEN, FIRE PROTECTION
962	GUARDS AND WATCHMEN

APPENDIX E

NIOSH RISK IDENTIFICATION MODEL OUTPUT

APPENDIX E -

Selected Output On Microfiche

As an aid to potential users of this model, and as a demonstration of the flexibility of the model, a sample of selected output has been made a part of this report. Twenty-eight different types of illustrative output listings were selected to serve as examples and are presented in microfiche form.

Each microfiche contained in the pocket on the inside back cover of this report has a two-line title. The first line reads "NIOSH RISK IDENTIFICATION MODEL" and is printed on each microfiche as the overall title. The second title is specific to the data on the microfiche, and corresponds to the listing and explanations that follow.

Microfiche Nos. 1 and 2 - LINKED CHEMICAL LIST IN RTECS ORDER

These microfiche display the 1721 chemicals common to both RTECS and NOHS which were utilized in this model. The data for each chemical is displayed in the "long" format discussed on page 28 of the text. The chemicals are displayed in RTECS order for ease of reference.

Microfiche No. 3 - HAZARD RISK INDEX - TRIAL 1

This microfiche displays the linked chemicals in descending HRIN-order, with the CAR and NEO OPTIONS both set at "NO", all multipliers set at 1, and constants set at 0. This is an "all toxic effects considered equal" model. The Trial 1 identification is referred to in the text on page 36.

Microfiche No. 4 - HAZARD RISK INDEX - TRIAL 2

This microfiche displays the linked chemicals in descending HRIN-order with the NEO OPTION set at "YES". All other settings are identical to those displayed on microfiche number 3. This display exhibits the effect of utilizing CAR data as a surrogate for NEO data, as discussed in the text on page 15.

Microfiche No. 5 - HAZARD RISK INDEX - TRIAL 3

This microfiche displays the linked chemicals in descending HRIN-order with the CAR OPTION set at "YES". All other settings are identical to those displayed on microfiche

number 3. This display exhibits the effect of utilizing chemical-specific NEO sub-HRIN's as an estimator of carcinogenic effect, as discussed in the text on page 15.

Microfiche No. 6 - HAZARD RISK INDEX - TRIAL 4

This microfiche displays the linked chemicals in descending HRIN-order with both the CAR and NEO OPTIONS set at "YES". All other settings are identical to those displayed on microfiche number 3. This display exhibits the effects of simultaneously utilizing both options, thereby increasing the amount of RTECS data available to the model's algorithms.

Microfiche No. 7 - HAZARD RISK INDEX - CARCINOGEN SELECTOR

This microfiche displays the capability of the model to rank chemicals on the basis of carcinogenic potential only. Note that the CAR OPTION was set at "NO".

Microfiche No. 8 - HAZARD RISK INDEX - MUTAGEN SELECTOR

This microfiche further displays the capability of the model to select only certain effects. In this example, chemicals are ranked only on the basis of mutagenic activity.

Microfiche No. 9 - HAZARD RISK INDEX - NEOPLASTIC SELECTOR

This microfiche displays the capability of the model to rank-order the linked chemicals on the basis of reported and calculated neoplastic effect only. Note that, in this example, the NEO OPTION is set at "YES", utilizing the model's ability to generate surrogate neoplastic data on the basis of carcinogen citations.

Microfiche No. 10 - HAZARD RISK INDEX - TERATOGEN SELECTOR

This microfiche displays the linked chemicals rank-ordered on the basis of teratogenic potential only.

Microfiche No. 11 - HAZARD RISK INDEX - CARCINOGEN EMPHASIS

This microfiche shows the effect of the use of the "constant" factors in the HRIN algorithm. This results is an HRIN listing that considers all the selected data from RTECS, but emphasizes carcinogenic potential instead of selecting only a single effect as displayed on microfiche 7, 8, and 9.

Microfiche No. 12 - HAZARD RISK INDEX - MUTAGEN EMPHASIS

This microfiche displays use of the "constant" factor in the HRIN algorithm. The list shown here rank-orders the linked chemicals by descending HRIN. In this case the HRIN results from considering all RTECS cited toxic effects with an emphasis on mutagenesis.

Microfiche No. 13 - HAZARD RISK INDEX - TERATOGEN EMPHASIS

The list displayed on this microfiche is the final demonstration of the use of the "constant" factor in this series. This HRIN emphasizes teratogenic effects.

Microfiche No. 14 - HAZARD RISK INDEX - CARCINOGENIC EFFECT WEIGHTING

The list displayed on this microfiche is an example of the multiplier factor as a toxic effect weighting device. Note that while all data is considered in calculating the HRIN, the CAR data is given a weight of 5.

Microfiche No. 15 - ADJUSTED HAZARD RISK INDEX - ALL EFFECTS EQUAL

The AHRI displayed on this microfiche results from considering all effects equal in weight (i.e., setting all multipliers at 1, and all constants at 0) and modifying the resulting HRIN's by NOHS exposure data as detailed in the text on page 35. Note that the NEO OPTION is set at "YES".

Microfiche No. 16 - ADJUSTED HAZARD RISK INDEX - ACUTE TOXICITY SELECTOR

The AHRI on this microfiche is the result of considering only the acute toxicity data cited in RTECS for the linked chemicals to derive source HRIN's which are then modified by NOHS exposure data as previously explained.

Microfiche No. 17 - ADJUSTED HAZARD RISK INDEX - CARCINOGEN EMPHASIS

The AHRI displayed on this microfiche is a result of emphasizing carcinogenic effect, and then modifying the HRIN values with NOHS exposure data.

Microfiche No. 18 - 2-SIC INDUSTRIAL RISK INDEX - ALL EFFECTS EQUAL

This microfiche displays Standard Industrial Classifications at the 2-digit level, rank-ordered by descending potential health risk due to potential chemical exposure. The Industrial Risk Index displayed on this microfiche results from considering all toxic effects equal in the source HRIN with the NEO OPTION set at "YES". (See the explanations for microfiche 3 and 4.) Note that the CENSUS OPTION is also set at "YES" indicating use of census population data as a modifier in the algorithm, as discussed in this report on page 40.

Microfiche No. 19 - 2-SIC INDUSTRIAL RISK INDEX - CARCINOGEN SELECTOR

This microfiche displays Standard Industrial Classifications at the 2-digit level, rank-ordered by calculated potential health risk due to potential exposure to carcinogens only. The source HRIN for this IRI is displayed on microfiche No. 7, and results from considering only carcinogenic data. Note that the option to utilize census data in the IRI algorithm has been exercised.

Microfiche No. 20 - 2-SIC INDUSTRIAL RISK INDEX - TERATOGEN SELECTOR

This microfiche displays Standard Industrial Classifications at the 2-digit level, rank-ordered by calculated health risk due to potential exposure to teratogens only. The source HRIN for this IRI is displayed on microfiche No. 10, and results from considering only teratogenic data. Note that the CENSUS OPTION is set at "YES", indicating use of census data in the IRI algorithm.

Microfiche No. 21 - 3-SIC INDUSTRIAL RISK INDEX - ALL EFFECTS EQUAL

This microfiche displays Standard Industrial Classifications at the 3-digit level, rank-ordered by health risk due to all potential chemical exposures. The explanations for data input are the same as for microfiche No. 3.

Microfiche No. 22 - 3-SIC INDUSTRIAL RISK INDEX - CARCINOGEN SELECTOR

This microfiche displays Standard Industrial Classifications at the 3-digit level, rank-ordered by health risk due to potential exposure to carcinogens only. The explanation for data input are the same as for microfiche No. 7.

Microfiche No. 23 - 3-SIC INDUSTRIAL RISK INDEX - TERATOGEN SELECTOR

This microfiche displays Standard Industrial Classifications at the 3-digit level, rank-ordered by health risk due to potential exposure to teratogens only. The explanations for data input are the same as for microfiche No. 10.

Microfiche No. 24 - 4-SIC INDUSTRIAL RISK INDEX - ALL EFFECTS EQUAL

This microfiche displays Standard Industrial Classifications at the 4-digit level, rank-ordered by health risk due to all potential chemical exposures. The explanations for data input are the same as for microfiche No. 3.

Microfiche No. 25 - 4-SIC INDUSTRIAL RISK INDEX - CARCINOGEN SELECTOR

This microfiche displays Standard Industrial Classifications at the 4-digit level, rank-ordered by health risk due to potential exposure to carcinogens only. The explanations for data input are the same as for microfiche No. 7.

Microfiche No. 26 - 4-SIC INDUSTRIAL RISK INDEX - TERATOGEN SELECTOR

This microfiche displays Standard Industrial Classifications at the 4-digit level, rank-ordered by health risk due to potential exposure to teratogens only. The explanations for data input are the same as for microfiche No. 10.

Microfiche No. 27 - OCCUPATIONAL RISK INDEX - ALL EFFECTS EQUAL

This microfiche displays Bureau of the Census Standard Occupational Classifications rank-ordered by health risk due to all potential chemical exposures. The explanations for data input to the ORI algorithm (see page 39 in the text) are the same as for microfiche No. 3.

Microfiche No. 28 - OCCUPATIONAL RISK INDEX - CARCINOGEN SELECTOR

This microfiche displays Bureau of the Census Standard Occupational Classifications rank-ordered by health risk due to potential exposure to carcinogens only. The explanations for data input to the ORI algorithm are the same as for microfiche No. 7.

Microfiche No. 29 - OCCUPATIONAL RISK INDEX - TERATOGEN SELECTOR

This microfiche displays Bureau of the Census Standard Occupational Classifications rank-ordered by health risk due to potential exposure to teratogens only. The explanations for data input to the ORI algorithm are the same as for microfiche No. 10.

* U.S. GOVERNMENT PRINTING OFFICE: 1983 - 661-899