THE DOW CHEMICAL COMPANY

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July 15, 1987

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EMERGENCY RESPONSE PLANNING GUIDELINES

As a follow up of our cab conversation, on July 10, please find the attached information about Emergency Response Planning Guidelines (ERPGs).

- Protocol for Developing ERPGs
  (Background Information, Philosophy, and Definitions)
- Procedures and Format for ERPG Documents
- Example of an ERPG Document : HF
- Some Visual Aids from our ERPG Awareness Package

Since the ORC-AIHA process is step up and functioning, our collective efforts are now focused on approving as many scientifically dependable ERPGs as we can as fast as we can. That is why it was pleasing to hear of your possible interest in ERPGs for methyl acrylate, vinyl chloride, and benzene. If you really are able to generate an inhouse commitment to prepare a draft document, please call Becky Daiss at ORC (202-737-6330) with a target date.

If you have any questions, please do not hesitate to call.

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rlm

attachments

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I. Introduction

The tragic incident in Bhopal, India heightened concern about potential adverse health effects which might result from an accidental chemical release to a neighboring community and the r sulting short-term, or acute exposures. This concern has led many companies to re-evaluate possible "worst case" situations which might occur as a result of process or human failures. To fully evaluate the potential for release, and to do proper planning, there is a need for certain emergency response planning guidelines for these acute incidents. These guidelines are for use as a planning tool for evaluating the adequacy of precautions and containment measures at chemical manufacturing or using facilities or for transportation purposes. When an actual emergency occurs there is usually not time to measure airborne concentrations and then take action. Emergency Response Planning Guidelines (ERPGs) can be used as one piece of data together with information such as volatility, storage volumes, etc., in a computer for predicting the extent of actions necessary in case of a release. The actions may vary depending on such things as population density, type of population (e.g. schools), terrain, the nature of the release etc. The numbers may also be useful in evaluating whether engin ring controls are necessary to diminish or eliminate the potential for release.

II. ORC's Role

It was recognized that an ORC Task Force could serve as the vehicle to develop an industry-wide protocol and documentation format for development of emergency exposure guidance levels. This group could serve best in developing a protocol, not as a "number consensus" group. It could serve as a the vehicle to help spread the task of preparation over a number of companies if the preparation were all done according to an agreed upon protocol. The Task Force could also serve as the vehicle to exchange levels and their documentation with specific company identifiers removed.

The participants in the Task Force agreed to develop their emergency response planning guidelines according to the protocol developed by the group, and then exchange those numbers and their documentation. The group also agreed to collectively develop a list of materials needing emergency response planning guidelines, and distribute them among the companies developing those guidelines.

III. Long Term Goal

Participation in the ERPG effort is voluntary, and participants are in no way obligated to adhere to the numbers produced via the ERPG protocol. If, after several companies have compiled data

P nnsylvania D partment of Health. Guidelines from these organizations are either very limited in scope, directed only to occupational exposure, and/or no longer being generated. Others, such as the World Bank and the European Community (EEC) provide guidance in terms of acutely hazardous quantities which are based on LC50 values. These are inappropriate since lethality is the only h alth effect considered. Human experience data, escape-impairing ffects, and serious nonlethal effects, such as lung or liver injury, are not considered. The National Fire Protection Association (NFPA) has developed a list of acute health hazard ratings on a one to four scale for use as an indicator to emergency service personnel and relative rankings, and do not meet the needs for airborne concentrations to be used in planning for emergency situations.

Although "emergency numbers" have been put together by several organizations as indicated above, none of them have been specifically developed for use by industry for potential emergency releases. Because of the various short- comings in their development, only the NRC EEGLs appear to be of some value for present purposes.

V. Background

None of those values cited above, with the exception of some of the NRC EEGLs, are applicable in whole or in part for present purposes. For this reason, several companies, responding to internal needs, undertook development of these emergency planning numbers themselves. Each had separately agreed on several principals:

1. The numbers are useful primarily for emergency planning and response.

2. The numbers are suitable for protection from acute effects due to short term exposures. They are not suitable for effects due to repeated exposures, nor as ambient air quality guidelines.

3. The numbers are guidelines. They are not absolute levels demarcating safe from hazardous conditions.

4. The numbers do not necessarily indicate levels at which certain actions must be taken.

5. The numbers are only one element of the planning activities which must be done to develop a program to protect and involve the neighboring community.

In discussions among personnel in companies carrying out these guideline development efforts, it became evident that there was a definite need for consistency through a uniform procedure. Consistent procedures would allow for exchange of information among companies with a resulting utility to all participants.

In developing the ERPG rationale, it is important to primarily use acute or short-term exposure data. When evaluating the adverse health effects, both immediate and delayed health effects should be considered.

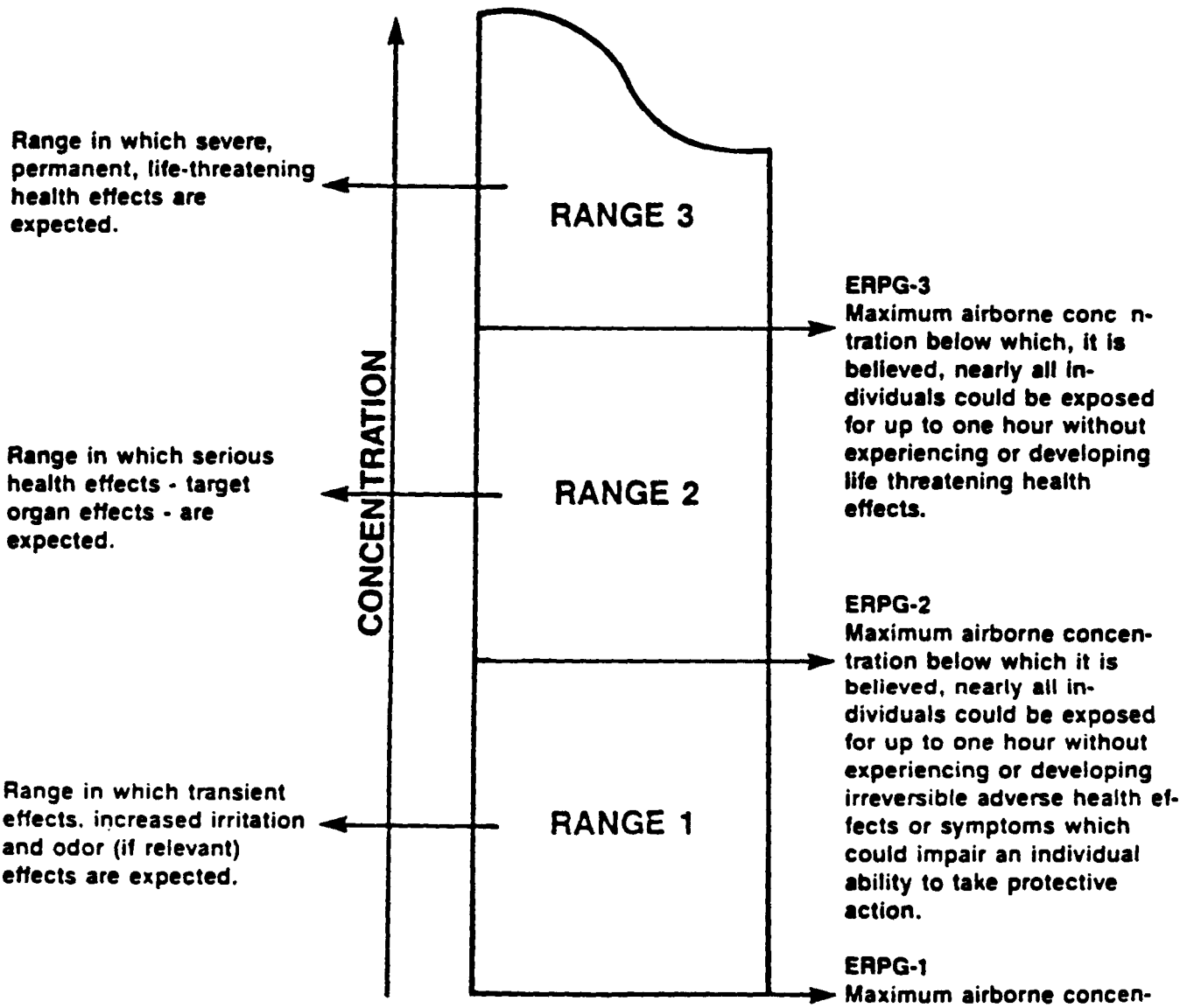
When it is believed that adverse reproductive, developmental, and/or carcinogenic effects might be caused by an acute exposure, and therefore are relevant, the data should be included in the derivation of the ERPG's. If it is desired that carcinogenicity data be used, the National Research Council has developed mathematical approaches which may be useful for the desired purpose.

Selection of ERPG values may include use of judgemental factors based on uncertainties about the data or its extrapolation.

VII Limitations

ERPGs are general reference levels that are intended to be used as part of an overall emergency planning program. The application and use of ERPG values requires a careful evaluation of a number of factors for any given situation. These may include how the on hour ERPG values might relate to exposures of several minutes or several hours, whether potential adverse effects on special risk groups, including the elderly, the young, and those individuals with underlying medical illnesses need further consideration, as w ll as other factors such as volatilities, storage quantities, w ather conditions, etc. Assessment of these factors is needed to determine what actions should be taken in planning for and responding to a given emergency. The levels are not to be used as safe limits for routine operations. The ERPGs are general reference levels, the best judgement of specialists using the best available data; they are not to be taken as definitive delineators between safe and unsafe exposure conditions.

EMERGENCY RESPONSE PLANNING GUIDELINES



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INSTRUCTIONS FOR PREPARING

EMERGENCY RESPONSE PLANNING GUIDELINE (ERPG)

1. ERPG Procedure
2. ERPG Format

The following procedure and format are quite close to the WEEL procedure and format developed by the AIHA Workplace Environmental Exposure Level (WEEL) committee. In addition, the following is consistent with that used by Dow, NAS, and other organizations developing workplace or environmental guidelines.

RECOMMENDED ERPG PROCEDURE

1. Establish, if appropriate, a committee composed of toxicology, medicine, industrial hygiene, and other health professionals to gather, review and draft ERPG.

2. Identify producers and users of the material and associations if appropriate and request information on unpublished toxicology, medical, industrial hygiene, and epidemiologic information.

3. Conduct a literature search including the appropriate on-line databases. (For example: MEDLINE, TOXLINE, CHEMLINE, etc.)

4. Prepare a draft ERPG document using the attached format while following these additional guidelines:

   (a). Give physical properties at 760 mmHg and 20-25 ° C centigrade whenever possible.

   (b). Use consistent units. Use mg/kg for LD50's and use ppm and mg/m^3 for LC50's.

   (c). When no information is available, retain the heading and state no data available.

   (d). Include negative findings as well as positive.

   (e). Always identify the meaning of any abbreviations the first time they appear.

   e.g. MCA (monochloroacetic acid) is....
   SC (subcutaneous) dose...

5. Send copies of the draft through the appropriate review channels within your company in order to obtain approval for release.

6. Once your company has approved the ERPGs, the document nd copies of all supporting references, including translations, should be appended <u>if possible</u> so that a complete package could be made available for review. If the references are too numerous and can not be reproduced then effort should be given to attaching only those references which provide the most support for the ERPGs.

7. If your company prefers to remain anonymous, you may do so by specifying this intention at the outset.

III. Toxicity Data

A. Acute Toxicity
(1-5 days)

1. Oral
(ex. LD50, rats: 100 mg/kg)

2. Eye

3. Skin

a) Irritation

b) Absorption

4. Inhalation
(State exposure duration if giving LC50. e.g. 4-hr. LC50, rats: 325 ppm)

5. Other
(Include subcutaneous, intraperitoneal, intravenous etc.)

B.* Mutagenicity (specify tests relevant to ERPG only)

C.* Reproductive/Developmental Toxicity
(Include teratology and reproduction studies)

D.* Metabolism and Pharmacokinetics

E.* Subacute
(5-14 days)

F.* Subchronic Toxicity
(15 days to 6 months)

(List each study separately in order of duration rather than route. Give duration, route, species, all doses tested and the effects observed at each dose.)

G.* Chronic Toxicity and Carcinogenicity
(>6 month)

(Present in same manner as subchronic studies.)

*Only if data are useful in establishing an ERPG.

IV. Human Experience (Summarize data if appropriate)

A. Acute (1-5 days)

B. Subacute (5-14 days)

C. Emergency Response Planning Guid line-1
(Valu , unite, time, and definition of ERPG-1)
Rationale (Summarize the data which most appropriately supports the value and the effects which are to be avoided.)

VII. Summary Tables/Plots

A. Table Concentration/Effect

(Develop a table of concentrations in descending order vs. effects in animals and humans. For example:

Concentration	Species	Route/ Duration	Effect	Comments/Reference
400 ppm	rat	inhal/ 6 hours	Death	
50 ppm	man	inhal/ 4 hours	Irritation to URS...	Author
25 ppm	man	inhal/ 4 hours	None observed	

B. Summary Plot (Optional)

VIII. References

Cite references following the procedure and format found in the AIHA's "Guidelines for Authors" (see attached copy).

Identify which on-line databases were searched at the beginning of the references - "Literature searches performed". Include the date the literature search was performed.

Always cite primary references where possible. e.g., Cite primary references not NIOSH RTECS.

"Company name, unpublished data, date..." referenced if hard copy is obtained.

AIHA Ref rence Procedure and Format*

Reference Designations in Text

References are to be cited in text using superscript **Arabic** numericals, **numbered sequentially** in order of citation. Reference superscript numerals **must** appear **outside** punctuation to the **right** of any punctuation marks. **Enclose all single groups of references in parentheses.** If references "1,2,3,4,5,8,9 & 10" are cited at one point use "(1-3,5,8-10)". **Do not include any author's names, publication titles, or dates in body of text.** Refer only by superscript number to listing at end of article.

Reference Listing Following Text

References **must be** numbered and listed in the same order they are cited in text. Type **(double spaced)** on separate pages. Follow arrangement, order, capitalization and punctuation shown in examples exactly. Manuscripts not adhering to instructions regarding reference listing **will be returned** for correction.

In the listing, **references** to journals or sources **should show:** author(s) name(s) **typed** in **initial capitals**, with first author's name presented with **last name** then **first name** or initials; other authors, name(s). **Next** title of article (with **initial capitals** on major words **only** and **no quotation marks**) followed by a period. Finally, name of publication (abbreviate journal names according to Bibliographic Guide for Editors & Authors. American Chemical Society (1974) plus volume no., colon(:) **first and last** pages, plus year (in parenthese) and final period. **Review example** b fore preparing reference listing.

Correct Reference Format...
(capitalization, punctuation, spacing)

1. **Fulwiler, R.D., J.C. Abbott and F.J. Darcy:** The Evaluation of Detergent Enzymes in Air. Am. Ind Hyg. Assoc. J. 33:231-236 (1972.

2. **Drinker, P. and T. Hatch:** Industrial Dust. 2nd Ed. pp. 40-43. McGraw-Hill, New York (1964).

Reproduced from "Guidelines for Authors," periodically published in the American Industrial Hygiene Association Journal.

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EMERGENCY RESPONSE PLANNING GUIDELINES (ERPGs):

RECOMMENDED PROCEDURES AND DOCUMENTATION FORMAT

JUNE 15, 1987

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION

ERPG COMMITTEE

RECOMMENDED ERPG PROCEDURE

1. The authoring company should use a multi-disciplinary team (including toxicology, medical, industrial hygiene and other health professionals) to collect and review data and to develop draft ERPG documentations.

2. The author should identify producers, major users and industry associations having a significant interest in the chemical and should request information from them (especially unpublished data giving observed effects in humans or animals at known airborne concentrations).

3. A literature search should be conducted and should include appropriate on-line databases such as MEDLINE and TOXLINE.

4. The draft ERPG documentation should follow the attached format and these additional guidelines:

   a. Give physical properties at 760 mm Hg and 20-25°C whenever possible.

   b. Use consistent units.

      ex. Use mg/kg for all LD50's; ppm and/or mg/m^3 for all LC50's. Convert mg/m^3 to ppm for all vapors.

   c. When no information is available, retain the subject heading and state "No data available". Several headings may be combined for this purpose.

   d. Include negative findings as well as positive.

   e. Identify the meaning of abbreviations the first time they appear in the document. Abbreviations used for the chemical name should be included in the synonyms.

   f. Whenever possible, obtain the original reference for all data as there are frequently errors or significant omissions in secondary references.

5. The authoring company should submit the draft ERPG document, marked "ORC Preliminary Draft" to the Organization Resources Councellors (ORC) ERPG Task Force.

6. When the preliminary draft is ready for review by the AIHA ERPG Committee, it should be marked "Final ORC Draft".

7. The author's final draft should be sent to the Chairman of the AIHA ERPG Committee along with copies of the reference documents.

   a. For very lengthy reports, such as NTP chronic studies, the full report is not needed.

b. For company reports which are considered confidential, an abstract which gives some details of methods, results and conclusions of the study should be provided.

c. For lengthy review articles covering many chemicals, some irrelevant pages may be omitted from the copy.

8. If the authoring company does not wish to be identified on the document, they may omit that information.

9. The AIHA Committee will assign a primary and secondary reviewer for each ERPG submitted to them.

10. The primary reviewer will work directly with the author when addressing any questions or modifications regarding the draft document.

11. Only after this preliminary review and possible revision, should the document be presented to the full AIHA ERPG Committee for discussion. The author will be invited to attend the meeting.

12. A majority vote of members in attendance is needed before sending the draft to all members for ballot. (If all members are present, balloting may be done verbally at the meeting.) Members may vote "yes", "no" or "abstain". "No" votes must be accompanied by a specific explanation. Two-thirds of the non-abstaining votes received are needed for final approval of the ERPG.

13. Following approval, the documentation will be sent to the AIHA Akron office for publication.

14. Following publication, the documentation will be filed at Akron along with any references which would be difficult to replace.

Author (optional) _____
Draft Number _____
Date _____

EMERGENCY RESPONSE PLANNING GUIDELINE (ERPG)

CHEMICAL NAME

ERPG-1: _____

ERPG-2: _____

ERPG-3: _____

I. Identification

Chemical Name:

Synonyms: (separate by semi-colon)

CAS Number:

Molecular Formula:

Structural Formula:

II. Chemical and Physical Properties

Physical State and Appearance: (at ambient conditions)

Odor Description: (not thresholds, etc.)

Molecular Weight:

Conversion Factors: 1 mg/m^3 = _____ppm v/v

1 ppm v/v = _____mg/m^3

Boiling Point: _____°C (_____°F) at _____mm Hg

Vapor Pressure: _____mm Hg at _____°C (_____°F)
(May include for several temperatures, if available, but especially for ambient conditions.)

Saturated Vapor Concentration: _____ppm at _____°C (_____°F)

Vapor Density:

Flash Point (closed cup): _____°C (_____°F)

Flammability Limits: LEL _____ UEL _____

Autoignition Temperature: _____°C (_____°F)

Stability and Reactivity:

Solubility in Water:

III. Animal Toxicology Data

(NOTE: Summarize each study separately. Give duration, route, species, and the effects at each dose, not just the no-effect level. Lengthy detail is unnecessary for some studies judged to be of minimal relevance for establishing an ERPG.)

A. Acute Toxicity
(include studies of <5 days exposure)

1. Oral
(ex: LD50, rats: 100 mg/kg/day)

2. Eye

3. Skin Irritation

4. Skin Absorption

5. Inhalation
(NOTE: State exposure duration for all LC50s; state whether nominal or actual concentration; include pathology if available; give mortalities at individual doses, not just the LC50, if available; give lowest lethal concentrations and highest non-lethal concentrations when available)

B. Subacute Toxicity
(5 to 14-day studies)

C. Subchronic Toxicity
(15-day to 6-months studies)

D. Chronic Toxicity and Carcinogenicity
(>6-months studies)

E. Reproductive and Developmental Toxicity
(include teratology and reproduction studies)

F. Genotoxicity/Mutagenicity

G. Other

IV. Human Experience

A. Toxicity and Odor Test Data
(NOTE: Include only actual test data; that is, where humans were exposed to controlled concentrations. Do not include accidental exposures or estimates of human effects based only on animal data.)

B. Workplace Experience
(NOTE: Include subjective response information, such as vapor concentrations which caused eye or respiratory discomfort or produced objectionable odors.)

C. Epidemiology
(NOTE: A brief summary is sufficient.)

D. Other
(NOTE: May include opinions or estimates of human effects which are based only on animal data.)

V. Current Occupational and Emergency Exposure Guidelines

(Give the source or organization, the guideline number, and a brief statement about the rationale used. Rationales for STELs or other short-term guidelines are of particular interest.)

A. ACGIH TLV® or AIHA WEEL®

B. OSHA PEL

C. NRC EEGL

D. Others

VI. Recommended ERPGs and Rationales

(Although three ERPG levels are preferred for each chemical, occasionally only one or two ERPG levels will be judged appropriate. For instance, if the odor and irritancy concentrations are higher than the ERPG-2 level, an ERPG-1 value is inappropriate. This section should include an explanation for any ERPG level omitted.)

A. ERPG-3: _____ppm (_____mg/mα)

It is believed that nearly all individuals could be exposed to _____ppm for up to one hour without experiencing or developing life-threatening health effects. (Add basis for number selected -- ex. most important studies/data, expected effects.)

B. ERPG-2: _____ppm (_____mg/mα)

It is believed that _____ppm is the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious adverse health effects or symptoms which could impair an individual's ability to take protective action. (Add basis for number selected.)

C. ERPG-1: _____ppm (_____mg/mα)

It is believed that _____ppm is the maximum airborne concentration below which nearly all individuals could be exposed for up to an hour without experiencing or developing effects more serious than mild irritation, other mild transient health effects or perception of a clearly objectionable odor. (Add basis for number selected.)

VII. References

- Use the format shown in the attached "AIHA Reference Procedure and Format".

- Always review and cite primary references whenever possible.

- When secondary references must be used, state as follows: "(primary reference), as cited in (secondary reference)."

- If a company submitting unpublished data gives permission to identify them, cite as follows: "(Company name), unpublished data, (date).

- If a company does not want to be identified, cite as follows:

  "Confidential unpublished data, (date)."

VIII. Summary Tables or Plots (optional)

(Summary tables giving species, concentration, duration, effects and references may be included. Tables are generally most useful when there is a lot of acute data. Plots may be useful for "visualizing" the more important data. These tables and/or plots may be helpful during the ERPG development and review stages.)

AIHA Reference Procedure and Format*

Reference Designations in Text

References are to be cited in text using superscript Arabic numericals, numbered sequentially in order of citation. Reference superscript numerals must appear outside punctuation to the right of any punctuation marks. Enclose all single groups of references in parentheses. If references "1,2,3,4,5,8,9 & 10" are cited at one point use "(1-3,5,8-10)". Do not include any author's names, publication titles, or dates in body of text. Refer only by superscript number to listing at end of article.

Reference Listing Following Text

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In the listing, references to journals or sources should show: author(s) name(s) typed in initial capitals, with first author's name presented with last name then first name or initials; other authors, name(s). Next, title of article (with initial capitals on major words only and no quotation marks) followed by a period. Finally, name of publication (abbreviate journal names according to Bibliographic Guide for Editors & Authors, American Chemical Society (1974), plus volume no., colon(:) first and last pages, plus year (in parentheses) and final period. Review examples before preparing reference listing.

Correct Reference Format...
(capitalization, punctuation, spacing)

1. Fulwiler, R.D., J.C. Abbott and F.J. Darcy: The Evaluation of Detergent Enzymes in Air. Am. Ind Hyg. Assoc. J. 33:231-236 (1972).

2. Drinker, P. and T. Hatch: Industrial Dust. 2nd Ed. pp. 40-43. McGraw-Hill, New York (1964).

* Reproduced from "Guidelines for Authors," periodically published in the American Industrial Hygiene Association Journal.

DEFINITIONS FOR EMERGENCY RESPONSE PLANNING GUIDELINES (ERPGs)

ERPG-3

Maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

ERPG-2

Maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious adverse health effects, or symptoms which could impair an individual's ability to take protective action.

ERPG-1

Maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour without experiencing or developing effects more serious than mild irritation, other mild transient health effects, or perception of a clearly objectionable odor.

EMERGENCY RESPONSE PLANNING GUIDELINE
HYDROGEN FLUORIDE

ERPG 3 = 20 ppm
*ERPG 2 = 8 ppm
ERPG 1 = 2 ppm

I. Identification

Chemical Name: Hydrogen Fluoride

Synonyms: Hydrogen Fluoride anhydrous. HF. Hydrofluoric Acid. Hydrofluoric Acid, anhydrous. Hydroflouride. UN1052. Antisol 2B.

CAS Number: 7664-39-3

Structure: HF

II. Chemical and Physical Properties

Physical State: HF is a colorless, fuming, mobile liquid or gas with strong irritating vapors.

Molecular Weight: 20.01

Conversion: 1 ppm = 0.82 mg/m^3, 1 mg/m^3 = 1.22 ppm

Boiling Point: 67^oF, 19.4^oC

Solubility: miscible in water

Flammability: not combustible

Vapor Pressure: 60 mm Hg at 20^oC

Specific Gravity: 0.991 at 67^oF

Vapor Density: 0.7

Odor Threshold: 0.04 - 0.13 ppm

Incompatibilities: Metals, concrete, glass and ceramics

Reactivity: HF's corrosive action on metals can result in formation of hydrogen in containers and piping to create an explosion hazard. Will react with water or steam to produce toxic and corrosive fumes. Violent reactions occur with As_2O_3, P_2O_5, acetic anhydride, 2-aminoethanol,

BGC:aeb-r/0287-84
3/11/87

NH_4OH, $HBiO_3$, CaO, chlorosulfonic acid, ethylene diamine, ethylene imine, F_2, (HNO_3 + lactic acid), oleum, beta propiolactone, propylene oxide, Na, NaOH, H_2SO_4, and vinyl acetate.

III. Animal Toxicity Data

A. Acute Inhalation Toxicity

1. Inhalation

a. Species: guinea pigs and rabbits

Reference: Machle, et al. (1)

30 ppm	41 hour	no deaths, subsequent weight loss.
122 ppm	5 hour	no deaths
610 ppm	15 min.	weakness and ill health
1220 ppm	30 min.	no deaths, damage to tissues
1830 ppm	5 min.	death 100%

b. Species: guinea pigs and rabbits

Reference: Ronzani (2)

600 ppm	0.5 -1.1 h	all animals, death between 0.5 -1.5 h.
250 ppm	1 - 3 h	all animals, death between 1- 3 h
50 ppm	0 - 2 h	all guinea pigs died. Rabbits shoved severe distress
30 ppm	1 - 3 day	guinea pigs died. Rabbits in poor condition
10 ppm	0 - 5 day	no deaths

At 250 and 600 ppm, all animals shoved severe signs of irritation with labored breathing, ulcerations of upper respiratory tract and eye corneas and pulmonary edema.

c. Species: rats

Reference: Higgins, et al. (3)

LC_{100}:	25,690 ppm	5 min.
LC_{80}:	18,580 ppm	5 min.
LC_{50}:	18,200 ppm (calculated)	5 min.
LC_{30}:	17,615 ppm	5 min.
LC_{10}:	12,440 ppm	5 min.
LC_{0}:	11,550 ppm + 25% CO	5 min.

d. Species: mice

Reference: Higgins, et al. (3)

LC_{100}:	11,010 ppm	5 min.
LC_{67}:	7,615 ppm	5 min.
LC_{53}:	8,140 ppm	5 min.
LC_{50}:	6,247 ppm (calculated)	
LC_{33}:	4,500 ppm	5 min.
LC_{0}:	2,430 ppm	5 min.

2. Dermal

Species: rabbits

Reference: Derelanko et al. (4)

2% HF solution	1 hour	Necrotic lesions of ear
2% HF solution	4 hours	Increased number of lesions over 1 hour exposure, transient total serum fluoride increase, (dose dependent) reduction in testicular weight.

2% HF solution	>15 min.	Produced greater number of lesions at increased size over 2% HF for 5 min. or 0.5% at any exposure period. Neutralized solution (2%) HF produced no visible lesions after 1 hour.

B. Subchronic Toxicity

Guinea pigs, rabbits and monkeys were exposed to 18.5 ppm HF for 2 months (5). Two of three guinea pigs died, one with pulmonary hemorrhage, the other with a low grade inflammatory reaction in the alveolar walls. Focal necroses with fatty changes in livers and necroses in the renal cortex were also observed. Both animals lost considerable weight. In rabbits leukocytic infiltration of the alveolar wall with and without edema was found although the sacrifice occurred 7-8 months after exposure. Two rabbits of the five had lobular pneumonia and kidney damage was observed in all rabbits. Monkeys showed kidney damage only.

Dogs were subjected to 8.5 ppm HF for 6 hours a day, 6 days a week for 5 weeks(6). Minor pulmonary changes were noted.

Existing Exposure Guidelines

A. ACGIH TLV: 3 ppm ceiling

B. OSHA PEL: 3 ppm

C. NIOSH/OSHA IDLH: 20 ppm

D. NIOSH RECOMMENDED TWA: 2.5 mg/m^3, 3.0 ppm

NIOSH RECOMMENDED CEILING (15 min): 5.0 mg/m^3, 6.1 ppm

E. NAS - Atmospheric Limits in Submarines (1 hour): 10 ppm

Human Toxicity Data

A. Inhalation

1. Braun, et al.(7) revealed the case histories of four workers exposed to a mixture of sulfuric and hydrofluoric acid, liquid and fumes. One worker was hit by a few drops and was treated only for minor acid burns. The second died unexpectedly a few hours after the accident. No autopsy was done. The third and fourth victims were treated in the hospital showing signs and symptoms of liver and kidney damage. Victim #3 died after four weeks from respiratory insufficiency. The fourth worker recovered, yet still complains of coughing and hoarseness one year after the accident. Hydrofluoric acid was reported to be the main toxic agent.

2. Mayer & Gruelich (8) reported two deaths from pulmonary edema after an exposure of only minutes to greater than 10,000 ppm HF (calculated).

3. Largent (9) reported no noticeable effects observed after exposure to average concentrations of 1.42 - 4.74 ppm for 6 hours a day, 5 days a week and continuing from 10 to 50 days. At ranges up to 8.1 ppm, slight eye and face irritation and cutaneous erythema were found. Redness of the skin was noted at 3.39 ppm which also resulted in some flaking of the skin after 11 days of exposure. Five subjects were studied.

4. Machle, et al. (1) found irritation of the larger airways at 30.5 ppm but no coughing or sneezing. Exposure was for several minutes. At 61 ppm for 1 minute they noted discomfort of the large air passages but no skin irritation, 122 ppm was the highest tolerable concentration for 1 minute and smarting of the skin was experienced along with conjunctival and respiratory irritation.

5. Kleinfield (10) related a fatal case of exposure resulting in severe tracheobronchitis with hemorrhagic pulmonary edema after a chemist was splashed with hydrofluoric acid from a broken vat. The workman died 10 hours later.

6. The American Petroleum Institute (11) reports that 50 ppm HF, for 30-60 minutes, may be fatal.

B. Dermal

1. A splashing incident was reported with 60% solution of HF leading to mild erythema and some tissue destruction. Healing was complete in 2-6 weeks. (12)

2. A fatality was reported from cardiac arrythemia. The victim suffered a third degree facial burn from anhydrous HF on the skin less than 10

minutes after the incident. Profound hypocalcemia was noted. Exposure was attributed to skin absorption. (13)

Epidemiology

Machle & Evans (14) reported on workmen exposed to levels of HF for nine years. Although initial exposure may have been "high", improved ventilation reduced the concentration after one year. Average concentrations during later years were measured in the range of 13-26 ppm. No skeletal fluorosis was found after prolonged exposure at these levels. Others have reported osteroesclerosis after chronic worker exposure at unreported levels. (15)

Hodge & Smith (16) describe the effects of long term worker inhalation as chronic irritation and congestion of the nose, throat, and bronchi. This does not seem, however, to cause lung alterations since in a study of 74 men exposed to HF for an average of 2.7 years, Evans (17) reported cases of upper respiratory tract infection but no evidence of lung change or increased death from pulmonary infection. The concentrations were, at times, severe enough to etch glass.

Summary

Exposure to hydrogen fluoride has proved fatal to humans in documented cases from both dermal and inhalation routes. The intensely painful skin burns have been treated effectively with injections or topical use of calcium gluconate. Dermal exposure has also resulted in lung pathology although some inhalation cannot be excluded from the case histories. Pulmonary edema may be delayed for hours or days after the initial exposure. Hypocalcemia has been a finding in patients who died of cardiac arrythmias.

Recommended ERPGs and Rationale

A. ERPG-3: 20 ppm for one hour

ERPG-3 is the maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour without experiencing or developing life threatening health effects. The value was based on both the animal and human studies by Machle et al., (1) who observed mild eye and nose irritation in humans exposed to 32 ppm HF for several minutes and worker exposure in the range of 13-26 ppm withstood for 9 years (17). This guideline also corresponds to the IDLH value for occupational exposure (NIOSH/OSHA).

B. ERPG-2: 8 ppm for one hour

ERPG-2 is the maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible adverse health effects or symptoms which could impair an individual's ability to take protective action. The value is based on human data from Largent (9) where approximately 4 ppm for 10

days yielded minor irritation. This ERPG is also consistent with the NAS limit of 10 ppm (1 hour) for atmospheric limits in submarines which is applicable to (healthy worker) crew performance in emergencies and the avoidance of permanent injury.

C. ERPG-1: 2 ppm for one hour

ERPG-1 is the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing health effects more severe than mild odor perception or irritation, if relevant. The value is based on human data from Largent (9) who observed no noticeable effects after exposure of healthy volunteers to average concentrations of 1.4 - 4.7 ppm for 6 hours a day, 5 days a week for 10 to 50 days.

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Concentration ppm	Duration	Species	Comments	Reference
>10,000	Minutes	Man	Death from pulmonary edema, 2 hours after exposure	Mayer & Geulich,(8)
4953	5 Min.	Rat	LC_{50}	Rosenholtz, et al.(18)
4319	15 Min.	Guinea Pig	LC_{50}	Rosenholtz, et al.(18)
2684	15 Min.	Rat	LC_{50}	Rosenholtz, et al.(18)
2037	30 Min.	Rat	LC_{50}	Rosenholtz, et al.(18)
1830	5 Min.	Guinea Pigs, Rabbits	LC_{100}	Machle, et al.(1)
1342	1 Hour	Rat	LC_{50}	Morris & Smith(20)
1305	1 Hour	Rat	LC_{50}	Rosenholtz, et al.(18)
1220	30 Min.	Guinea Pigs, Rabbits	No deaths	Machle, et al.(1)
660	0.5-1.5 Hours	Guinea Pigs, Rabbits	Death between 0.5 - 1.5 Hours	Ronzani(2)
610	15 Min.	Guinea Pigs, Rabbits	Weakness and ill health	Machle, et al.(1)
250	1-3 Hours	Guinea Pigs, Rabbits	Death in 1-3 Hours	Ronzani(2)
180	6 Hours	Rat	100% lethality, no sign of pulmonary damage or cyanosis prior to death	Morris & Smith(20)

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Concentration ppm	Duration	Species	Comments	Reference
122	5 Hours	Guinea Pigs, Rabbits	No deaths	Machle, et al.(1)
122	1 Min.	Man	Highest tolerable concentration. Smarting of exposed skin, conjunctival and respiratory irritation	Machle, et al.(1)
61	1 Min.	Man	Conjunctival and respiratory irritation, discomfort of large air passages, no skin irritation	Machle, et al.(1)
50	1 Day	Rats	Poor condition	Ronzani(2)
50	1 Day	Guinea Pigs	Death	Ronzani(2)
50	30-60 Min.	Man	May be fatal	API(11)
36-214	6 Hours	Rat	Virtually all inhaled HF deposited in upper respiratory tract	Morris & Smith(20)
31.7	Several Min.	Man	Mild eye and nose irritation, no cough or sneezing	Machle(1)
29.3	41 Hours	Guinea Pigs, Rabbits	No deaths, but a subsequent weight loss	Machle(1)
20	30 Min.	Man	Immediately dangeous to life & health	OSHA
18.5	6 Hours/Day 50 Days	Guinea Pigs, Rabbits, Monkey	Two guinea pigs died, one rabbit became pregnant and gave birth to 3 normal offspring. Necropsy revealed damage to lung, liver and kidney in all animals except in the one exposed monkey who had kidney damage only.	Machle and Kitzmiller(5)

Concentration ppm	Duration	Species	Comments	Reference
12.2	84 Hours	Guinea Pigs	Altered lipid metabolism in liver and plasma.	Dousset, et al.(19)
10	5 Days	Guinea Pigs, Rats	Not fatal, guinea pigs showed labored breathing and eye irritation.	Ronzani(2)
8.5	6 Hours/Day, 6 Days/Week 5 Weeks	Dogs	Minor pulmonary changes	Stokinger(6)
3.39 Aver.	10 Days	1 Man	Flaking of epithlium resembling mild sunburn	Largent(9)
3	30 Days	Rabbits, Guinea Pigs, Pigeons	No effect level	Ronzani(2)
3	8 Hours/Day	Man	ACGIH - TLV-TWA	ACGIH(21)
3	8 Hours/Day	Man	PEL	NIOSH(22)
2.59-4.74	6 Hours/Day, 5 Days/Week 50 Days	Man	Slight irritation of face and eyes, cutaneous erythema.	Largent(9)
1.42-4.74	6 Hours/Day, 5 Days/Week 50 Days	Man	No noticeable effect.	Largent(9)
0.04-0.13		Man	Odor Thresholds (detection & recognition)	

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