

NIOSH

CRITERIA FOR A RECOMMENDED STANDARD....
OCCUPATIONAL EXPOSURE TO

HYDROQUINONE



U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

criteria for a recommended standard....

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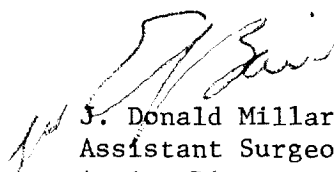
PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace. The National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices, to provide relevant data from which valid criteria for effective standards can be derived. Recommended standards for occupational exposure, which are the result of this work, are based on the health effects of exposure. The Secretary of Labor will weigh these recommendations along with other considerations such as feasibility and means of implementation in developing regulatory standards.

It is intended to present successive reports as research and epidemiologic studies are completed and as sampling and analytical methods are developed. Criteria and standards will be reviewed periodically to ensure continuing protection of the worker.

I am pleased to acknowledge the contributions to this report on hydroquinone by members of the NIOSH staff and the valuable constructive comments by the Review Consultants on Hydroquinone, by the reviewers selected by the American Conference of Governmental Industrial Hygienists

and American Occupational Medical Association, and by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and professional societies that reviewed this criteria document on hydroquinone. A list of review consultants and a list of the Federal agencies to which the document was submitted are given on pages vi and vii.



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The Division of Criteria Documentation and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for the development of the criteria and recommended standard for hydroquinone. Alfred N. Milbert, Ph.D., and Herbert L. Venable of this Division served as criteria managers. SRI International developed the basic information for consideration by NIOSH staff and consultants under contract No. CDC-99-74-31.

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The views expressed and conclusions reached in this document, together with the recommendations for a standard, are those of NIOSH. These views and conclusions are not necessarily those of the consultants, other federal agencies or professional societies that reviewed the document, or of the contractor.

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Bureau of Medicine and Surgery
Navy Environmental Health Center

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Consumer Product Safety Commission
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Energy Research and Development Administration
Division of Safety Standards and Compliance

Environmental Protection Agency
Health Effects Research Laboratory
Office of Research and Development

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I. RECOMMENDATIONS FOR A HYDROQUINONE STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that employee exposure to hydroquinone in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and provide for the safety of employees for up to a 10-hour workshift, 40-hour workweek, over a working lifetime. Compliance with all sections of the standard should prevent adverse effects of hydroquinone on the health and safety of employees. Techniques recommended in the standard are valid, reproducible, and available to industry and government agencies. Sufficient technology exists to permit compliance with the recommended standard. Although the workplace environmental limit is considered to be a safe level based on current information, it should be regarded as the upper boundary of exposure, and every effort should be made to maintain personnel exposures at levels as low as is technically feasible. The criteria and standard will be subject to review and revision as necessary.

The recommended standard is not intended to interfere with commercial or private photographic development; it is designed to protect workers' health under more hazardous conditions. Operators of darkrooms will not be required to collect and analyze air samples, provide respiratory protective equipment, supply the special labels and posters specified, and maintain the required records. They nevertheless should recognize, and ensure that all employees recognize, the possible dangers inherent in prolonged exposure to hydroquinone and follow the work practices and sanitary

procedures recommended in the proposed standard. Darkrooms to be occupied for prolonged periods of time should be ventilated sufficiently to provide at least four changes of air/hour.

Synonyms for hydroquinone include hydroquinol, para-hydroquinone, dihydroxybenzene, para-dihydroxybenzene, 1,4-dihydroxybenzene, para-dioxybenzene, para-benzenediol, 1,4-benzenediol, benzoquinol, benzoquinone, para-diphenol, and para-hydroxyphenol. Table XI-1 contains a list of synonyms and trade names for hydroquinone.

"Occupational exposure to hydroquinone," because of eye injuries, systemic effects, and dermal irritation produced by contact of hydroquinone with the eyes and skin, is defined as work in an area where hydroquinone is stored, produced, processed, or otherwise used, except as a component of other materials at a concentration of 5% or less by weight. This exception is made so that the recommended standard will not interfere with those work situations in which hydroquinone occurs as a component of other materials at a concentration of 5% or less by weight, e.g., as in most private or commercial photographic developing facilities. In these work situations, the employer will not be required to collect and analyze air samples, provide respiratory protective equipment and protective clothing, supply the special labels and posters specified, and maintain the required records. However, both the employer and the employee must recognize the potential for development of adverse effects inherent in prolonged exposure to hydroquinone. Therefore, sufficient protection of the workers' health should be insured by avoiding excessive contact of the chemical with the skin, eyes, and respiratory and gastrointestinal systems and by following effective procedures for maintaining cleanliness. If an employee is

exposed to concentrations of airborne hydroquinone in the workplace at more than the recommended ceiling value, all sections of the recommended standard shall be complied with; if the employee is exposed at or below the recommended ceiling value, all of the sections of the recommended standard shall be complied with except 4(b), 8(a)(5), and 8(b). Again, every effort should be made to maintain personal exposures at levels as low as is technically feasible. If "exposure" to other chemicals also occurs, for example to a combination of hydroquinone and sodium hydroxide, provisions of any applicable standards for such other chemicals shall be followed also.

Hydroquinone is extensively used as a photographic developer, an antioxidant, and a stabilizing agent for readily oxidizable polymers. It is also used to prepare 2% bleaching creams and certain intermediates for the synthesis of dyes, and it has some activity as an antitumor agent.

Airborne hydroquinone may be oxidized to quinone at ordinary room temperatures in the presence of moisture. Since neither the rate of oxidation nor the equilibrium concentrations at room temperatures are known, methods need to be developed to determine the oxidizing rate of hydroquinone to quinone and to distinguish between these two substances.

No studies have been found that document serious eye injuries caused by exposure to airborne hydroquinone in the absence of quinone vapor. There are no available studies of morbidity and mortality among persons who work with hydroquinone, of the effects of exposure to hydroquinone by inhalation, or of teratogenic actions caused by exposure of pregnant animals or women to hydroquinone. Although hydroquinone seems definitely to have effects on the mitotic process in unicellular organisms and to

decrease reproductive success in mammals, no evidence of mutagenicity in organisms other than bacteria and yeasts has been presented to date, and further study of the ability of hydroquinone to induce this type of toxic response is needed.

The recommended standard is based on presently available data, which indicate that hydroquinone dust or quinone vapor has produced eye injuries and that higher concentrations of hydroquinone have also caused dermatitis and damage to the central nervous system (CNS).

Section 1 - Environmental (Workplace Air)

(a) Concentration

The employer shall control workplace concentrations of hydroquinone so that no employee is exposed at a concentration greater than 2.0 milligrams per cubic meter (mg/cu m) (about 0.44 ppm) of air determined as a ceiling concentration during a 15-minute collection period.

(b) Sampling and Analysis

Environmental samples shall be collected and analyzed as described in Appendix I or by any method shown to be at least equivalent in accuracy, precision, and sensitivity to the methods specified.

Section 2 - Medical

Medical surveillance shall be made available to all employees subject to occupational exposure to hydroquinone as described below.

(a) Replacement medical examinations shall include:

(1) Comprehensive work and medical histories with special emphasis on eye injuries, dermatitis, and gastrointestinal disturbances.

(2) Physical examination giving particular attention to the eyes and skin.

(3) A slit lamp examination of the eyes.

(4) Judgment of the worker's ability to use positive pressure respirators.

(b) Periodic examinations shall be made available at least annually or as otherwise determined by the responsible physician. These examinations shall include at least:

(1) Interim work and medical histories.

(2) Annual ophthalmic examinations by a trained individual with a slit lamp (biomicroscope) or any better technique. If evidence of damage to the cornea has been found, workers' eyes shall be examined by an ophthalmologist. The use of fluorescein or other disclosing preparations is recommended as an aid in the detection of incipient corneal ulcers.

(3) Physical examination as outlined in (a)(2) above.

(c) During examinations, applicants or employees having medical conditions regarding the skin or eyes which would be directly or indirectly aggravated by exposure to hydroquinone shall be counseled on the increased risk of impairment of their health from working with this material and on the value of periodic examinations. The responsible physician should also counsel employees on the importance of not rubbing smarting or itching eyelids with unwashed fingers.

(d) In an emergency involving exposure to hydroquinone, all affected personnel shall be provided immediate first-aid assistance and

prompt medical attention, especially with respect to the eyes and skin. Medical attendants shall be informed of the possibility of delayed eye effects and of the need for observation and followup when these injuries occur. In the case of eye contact with hydroquinone, eyes shall be flushed with copious amounts of water and a physician shall be consulted promptly.

(e) All contaminated shoes, clothing, or other body coverings shall be removed. Any contaminated body area shall be immediately and thoroughly washed with soap and water.

(f) Initial medical examinations shall be made available to all employees as soon as practicable after the promulgation of a standard based on these recommendations.

(g) Pertinent medical records shall be maintained by the employer for all employees occupationally exposed to hydroquinone. Such records shall be retained for at least 30 years after termination of employment. These records shall be made available to the designated medical representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.

Section 3 - Labeling and Posting

All labels and warning signs shall be printed both in English and in the predominant language of non-English-reading workers. Illiterate workers and workers reading languages other than those used on labels and posted signs shall receive information regarding hazardous areas and shall be informed of the instructions printed on labels and signs.

(a) Labeling

Containers of hydroquinone shall carry in a readily visible location a label stating:

HYDROQUINONE

MAY BE HARMFUL TO EYES

DO NOT INHALE OR SWALLOW.

Wear eye protection.
Avoid contact with eyes, skin, and clothing.
Avoid prolonged or repeated breathing of dust or vapor.
Do not take into your mouth.
Use only with adequate ventilation.
Wash thoroughly after handling.

First Aid: In case of eye or skin contact, flush affected areas thoroughly with water for at least 15 minutes; call a physician. If this substance is swallowed, induce vomiting.

(b) Posting

Areas where hydroquinone is present shall be posted with a sign reading:

HYDROQUINONE

EYE PROTECTION REQUIRED

HARMFUL IF INHALED OR SWALLOWED

Avoid contact with eyes, skin, and clothing.
Avoid prolonged or repeated breathing of dust or vapor.
Do not enter areas where used unless they are adequately ventilated.

Section 4 - Personal Protective Clothing and Equipment

(a) Protective Clothing

(1) Appropriate protective clothing, including gloves, long-sleeved coveralls, rubber footwear, face shields (8-inch minimum), and goggles, shall be worn where needed to limit eye and skin contact with hydroquinone. Water resistant clothing is advisable in operations involving solutions of hydroquinone. Appropriate eye protection (face shields with or without safety goggles) shall be worn in any operation in which hydroquinone (solid, liquid, or spray) may contact the eyes. Where aerosolization of concentrated solutions of hydroquinone is likely, face shields should be supplemented with safety goggles.

(2) The employer shall provide the employee with the appropriate equipment specified in paragraph (a)(1) of this section.

(b) Respiratory Protection

(1) Engineering controls shall be used when needed to keep concentrations of the airborne hydroquinone at or below the environmental limit. Respiratory protective equipment may be used when the concentration of hydroquinone in the workplace exceeds the occupational exposure limit, such as:

(A) During the time necessary to install or test required engineering controls.

(B) During emergencies or during the performance of nonroutine maintenance or repair activities that may cause exposures to concentrations in excess of the environmental concentration stated in Section 1 above.

(2) When a respirator is permitted by paragraph (b)(1) of this section, it shall be selected and used pursuant to the following requirements:

(A) The employer shall establish and enforce a respiratory protective program meeting the requirements of 29 CFR 1910.134.

(B) The employer shall provide respirators in accordance with Table I-1 and shall ensure that the employee uses the respirator provided when necessary. The respiratory protective devices provided in conformance with Table I-1 shall comply with the standards jointly approved by NIOSH and the Mining Enforcement and Safety Administration (formerly by the Bureau of Mines) as specified under the provisions of 30 CFR 11.

(C) Respirators specified for use in higher concentrations of hydroquinone may be used in atmospheres of lower concentrations.

(D) The employer shall ensure that respirators are adequately cleaned and maintained and that employees are instructed in the proper use and testing for leakage of respirators assigned to them.

(E) Respirators shall be easily accessible, and employees shall be informed of their location.

Section 5 - Informing Employees of Hazards from Hydroquinone

(a) The employer shall ensure that each employee who may be occupationally exposed to hydroquinone is informed verbally at the beginning of employment or assignment to a hydroquinone area of the

TABLE I-1

RESPIRATOR SELECTION GUIDE

Concentration (mg/cu m)		Respirator Type Approved under Provisions of 30 CFR 11
Hydroquinone*	Quinone	
Less than or equal to 100	20	(1) Air-purifying full facepiece respirator equipped with combination high-efficiency filter** and organic vapor cartridge or canister (2) Type C supplied-air respirator, demand (negative pressure) mode, with full facepiece (3) Self-contained breathing apparatus, demand (negative pressure) mode, with full facepiece
Greater than 100	20	(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand mode, with auxiliary self-contained air supply
Emergency entry (into an area of unknown concentration)		(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand mode, with auxiliary self-contained air supply

*Since workers are potentially exposed to both hydroquinone dust and quinone vapor, the concentration limits of both are listed.

**The high-efficiency filter has a penetration of less than 0.03% when tested against 0.3- μ m dioctyl phthalate (DOP) aerosol.

hazards, relevant symptoms (such as dermatitis, eye irritation, discoloration of conjunctiva, staining and opacity of the cornea, and a general loss of pigment), appropriate emergency procedures, personal hygiene and good housekeeping programs used, and proper conditions and precautions for the safe use of hydroquinone. People engaged in maintenance and repair operations or activities shall be included in these training programs.

(b) Employers shall review the hazards of hydroquinone with each employee at least annually. They shall advise each employee that relevant information, including the "Material Safety Data Sheet," is on file and available on the hazards of hydroquinone and the symptoms and signs of adverse effects caused by hydroquinone.

(c) Required information shall be recorded on the "Material Safety Data Sheet" shown in Appendix II, or on a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices

(a) Engineering Controls

(1) Ventilation systems shall be used when needed and shall be designed to prevent the accumulation or recirculation of hydroquinone in the workplace, to maintain hydroquinone exposures at or below the recommended environmental limit, and to remove hydroquinone effectively from the breathing zones of employees. Ventilation systems shall be subject to regular preventive maintenance and cleaning to ensure effectiveness, which shall be verified by periodic performance

measurements.

(2) Use of an enclosed, ventilated, and automated system is recommended in place of local exhaust ventilation to empty and transfer drums and bags of solid hydroquinone into a bin or hopper or to put newly produced hydroquinone into bags or drums for shipment. Bags should be opened automatically and any dust removed by local exhaust ventilation.

(b) Storage, Handling, and General Work Practices

(1) Containers of hydroquinone shall be kept tightly closed when not in use. Only properly informed, trained, and equipped personnel shall be involved in storage, loading and unloading, or process activities involving hydroquinone.

(2) Contact of hydroquinone with eyes and skin of workers shall be prevented if possible. Equipment, walls, and floors shall be kept clean to limit employees' exposure.

(3) Before maintenance work begins, sources of hydroquinone dust and its vapor or the vapor of quinone shall be eliminated to the extent feasible. If concentrations at or below the recommended workplace environmental limit cannot be assured, respiratory protective equipment as specified in Table I-1 shall be used during maintenance work.

(4) Employees whose skin becomes contaminated with hydroquinone shall immediately wash or shower to remove all traces of hydroquinone from the skin. Clothing contaminated with hydroquinone shall be disposed of or cleaned before reuse.

(5) Work clothing and street clothing shall be exchanged at the beginning and at the end of each workday, so that work clothing will not be worn outside the workplace.

(6) The employer shall provide for proper laundry of clothing and shall instruct launderers on procedures to be taken to avoid contamination with hydroquinone.

(7) Any spills shall be removed immediately by either vacuuming, mopping, or aspirating into a vacuum receiver and either decontaminated by washing or stored appropriately in covered drums labeled as contaminated waste.

(c) Waste Disposal

Solid hydroquinone waste shall be disposed of either by burial in an environmentally acceptable manner or by burning in an approved manner. Liquid hydroquinone waste shall be drained into a closed holding tank for subsequent treatment before discharge into an open lagoon or sewer.

(d) Confined Spaces

Confined spaces that previously contained hydroquinone shall be thoroughly aerated as well as inspected and tested for oxygen deficiency, hydroquinone, and other known contaminant exposure concentrations before entry. This should also apply to confined spaces which still contain hydroquinone. If the concentration of hydroquinone is above the workplace environmental limit, the confined spaces should be ventilated while work is in progress to keep the concentration of hydroquinone at or below the workplace environmental limit. The following requirements shall be followed if the concentration of hydroquinone cannot be controlled at levels below the environmental limit:

(1) Individuals entering these confined spaces shall wear respirators as outlined in Section 4.

(2) Use of safety harness and life line is recommended for all confined space entries.

(3) When a person enters a confined space, another properly protected worker shall be on standby outside.

(4) Effective communication shall be maintained between the involved persons.

(e) Emergency Procedures

For all work areas where there is a reasonable potential for accidents involving hydroquinone, the employer shall take necessary steps to ensure that employees are instructed in and follow the procedures specified below and any others appropriate for safeguarding employees at a specific operation or process.

(1) Procedures shall include prearranged plans for obtaining emergency medical care and for the necessary transportation of injured workers. Employees shall also be trained in administering immediate first aid and shall be prepared to render such assistance when necessary.

(2) Approved eye, skin, and respiratory protection, as specified in Section 4, shall be used by persons involved in cleaning the accident site.

(3) All persons who may be required to shut off sources of hydroquinone, clean up spills, and repair leaks shall be properly trained in emergency procedures and shall be adequately protected against attendant hazards from exposure to hydroquinone.

(4) Employees not essential to cleanup operations shall be evacuated from exposure areas during emergencies. Perimeters of hazardous exposure areas shall be delineated, posted, and secured.

(5) Eyewash fountains and showers shall be provided in accordance with 29 CFR 1910.151.

Section 7 - Sanitation

(a) Food or beverage preparation and dispensing (including vending machines), drinking, eating, and smoking shall be prohibited in work areas where hydroquinone is present.

(b) Employees who handle any form of hydroquinone shall be instructed to wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

(c) All contaminated gloves shall be washed before removal.

(d) Disposable gloves should be discarded after contamination with hydroquinone.

Section 8 - Monitoring and Recordkeeping Requirements

As soon as practicable after the promulgation of a standard based on these recommendations, each employer with a place of employment in which hydroquinone is present shall determine by an industrial hygiene survey whether occupational exposure to airborne hydroquinone is occurring at concentrations above the ceiling value. Records of these surveys, including the basis for concluding that air levels are at or below the ceiling value, shall be maintained. Surveys shall be repeated annually and quarterly, where necessary, and not more than 10 days after any process change likely to increase airborne hydroquinone concentrations. If the hydroquinone environmental concentrations exceed or seem likely to exceed the ceiling value, then the following requirements apply:

(a) Personal Monitoring

(1) A program of personal monitoring shall be instituted to identify and measure, or permit calculation of, the exposure of all employees occupationally exposed to airborne hydroquinone.

(2) In all personal monitoring, samples representative of the exposure to airborne hydroquinone in the breathing zone of the employee shall be collected.

(3) For each determination, a sufficient number of samples shall be taken to characterize employee exposures during each workshift. Variations in work and production schedules as well as employee locations and job functions shall be considered in deciding sampling times, locations, and frequencies.

(4) Each work area shall be sampled quarterly or as indicated by a professional industrial hygienist.

(5) If an employee is found to be exposed to a concentration of hydroquinone above the recommended ceiling value, the exposure of that employee shall be measured at least once a week, control measures shall be initiated, and the employee shall be notified of the exposure and of the control measures being implemented. Weekly monitoring shall continue until two consecutive determinations, at least 1 week apart, indicate that the employee's exposure no longer exceeds the recommended environmental limit; routine monitoring may then be resumed.

(b) Recordkeeping

Records of environmental monitoring shall be maintained for at least 30 years after termination of employment. These records shall include the dates of measurements, job function and location of the employees at the

worksite, sampling and analytical methods used, number, duration, and results of the samples taken, concentrations estimated from these samples, type of personal protective equipment used, and exposed employees' names. Each employee shall have access to information on his or her environmental exposures. Environmental records shall be made available to designated medical representatives of the Secretary of Labor and of the Secretary of Health, Education, and Welfare. Records of environmental exposures applicable to an employee shall be included in that employee's medical records.

II. INTRODUCTION

This report presents the criteria and the recommended standard that were prepared to meet the need for preventing disease or injury arising from occupational exposure to hydroquinone. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to "...develop criteria dealing with toxic materials and harmful physical agents and substances which will describe...exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health (NIOSH), after a review of data and consultation with others, formalized a system for the development of criteria upon which standards can be established to protect the health and to provide for the safety of employees exposed to hazardous chemical and physical agents. Criteria for this recommended standard should enable management and labor to develop better engineering controls and more healthful work practices. Simple compliance with the provisions of the recommended standard should not be regarded as a final goal.

These criteria for a recommended standard for hydroquinone are part of a continuing series of documents published by NIOSH. The recommended standard applies to processing, manufacture, or use of hydroquinone or to other occupational exposure to hydroquinone as applicable under the Occupational Safety and Health Act of 1970. The standard was not designed

for the population-at-large, and any application outside occupational environments is not warranted. It is intended to (1) protect against development of eye injuries, systemic toxic effects, and local effects on the skin, (2) be measurable by techniques that are valid, reproducible, and available to industry and government agencies, and (3) be attainable with existing technology.

The major concern in occupational exposure to hydroquinone is the potential for causing eye injuries. In addition, hydroquinone can cause depigmentation of skin, dermatitis, and CNS damage in humans and animals.

There are a number of areas that need further research with respect to hydroquinone. Epidemiologic studies of occupationally exposed people, experimental inhalation exposures, and assessment of the teratogenic potential of hydroquinone are needed. Extensive studies of the possible carcinogenic, mutagenic, and reproductive effects of hydroquinone are also needed. Furthermore, present toxicologic information on hydroquinone is deficient for all physiologic systems other than the gastrointestinal system. Animal toxicity experiments with hydroquinone on several organ systems, such as the cardiovascular and pulmonary systems, have not been reported. Pharmacokinetic (absorption, distribution, metabolism, and excretion) studies are also needed to understand the mechanism of action of hydroquinone. There is also a need to develop a sensitive, practical, and economical method for determining the rate of oxidation of hydroquinone to quinone. This information will indicate the concentration of hydroquinone that is permissible at a workplace before toxic concentrations of quinone become present.

Adherence to all provisions of the recommended standard is required in work areas where the recommended ceiling for hydroquinone is likely to be reached or exceeded. The available evidence indicates that the greatest hazard to employees exposed to hydroquinone is from eye contact; however, hazards from skin contact, inhalation, and ingestion cannot be neglected.