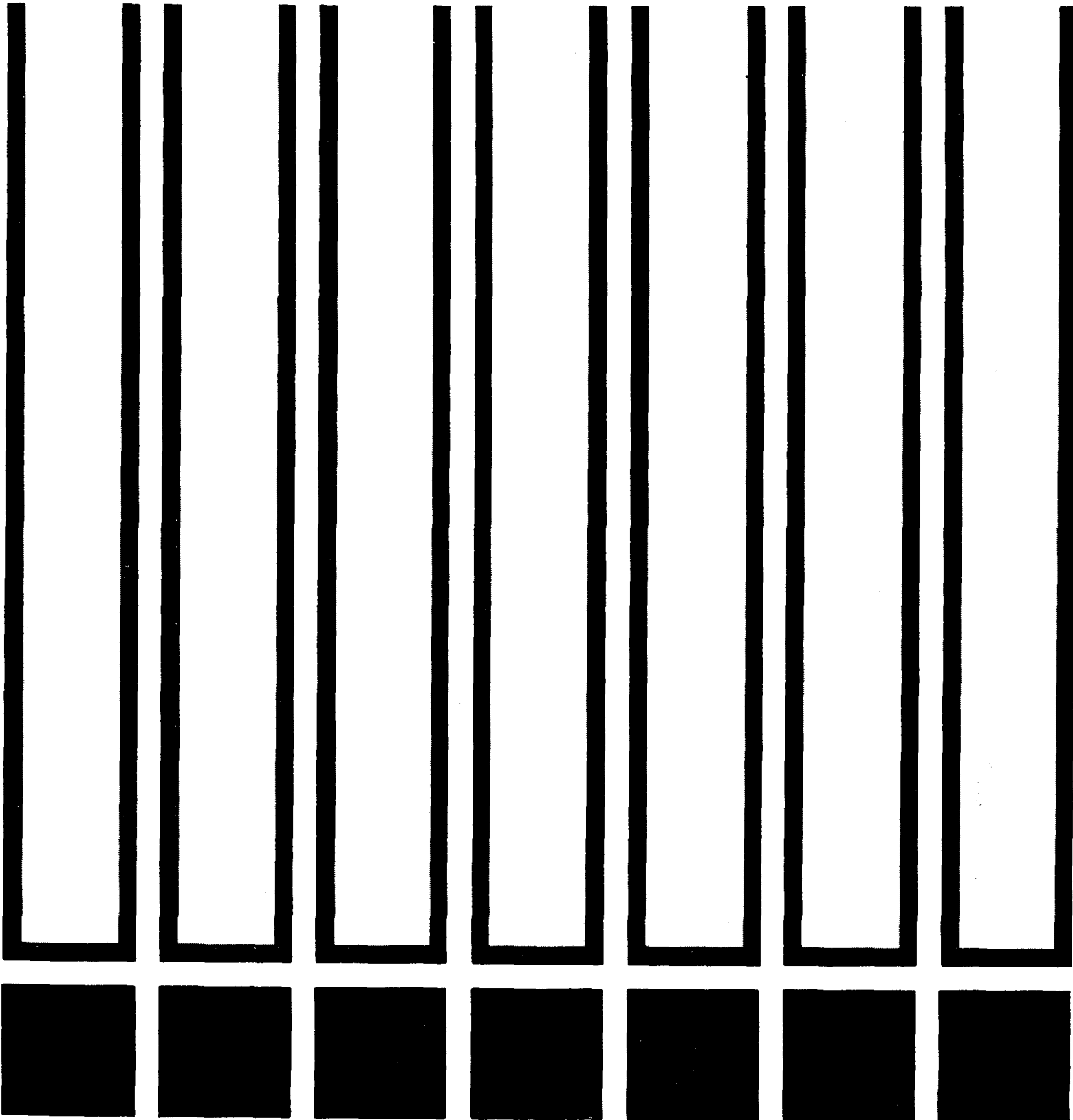


criteria for a recommended standard
occupational exposure to

inorganic fluorides



criteria for a recommended standard

**OCCUPATIONAL EXPOSURE
TO
INORGANIC FLUORIDES**



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

Center for Disease Control

National Institute for Occupational Safety and Health

1975

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PREFACE

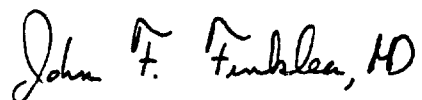
The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace.

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 deleterious 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 fluoride by members of my staff and the valuable constructive comments by the Review Consultants on Fluorides, by the ad hoc committees of the American Industrial Hygiene Association and the American Medical Association, by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, and by Bruce J. Held on respiratory protection. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and professional societies that reviewed this criteria document

on fluorides. Lists of the NIOSH Review Committee members and of the Review Consultants appear on the following pages.

A handwritten signature in black ink that reads "John F. Finklea, MD". The signature is written in a cursive style with a large initial 'J' and 'F'.

John F. Finklea, M.D.
Director, National Institute for
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The Office of Research and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for development of the criteria and recommended standard for fluoride. University of Washington, School of Public Health and Community Medicine developed the basic information for consideration by NIOSH staff and consultants under contract No HSM-99-73-36. Bryan D. Hardin had NIOSH program responsibility. Patricia G. Heitman served as criteria manager.

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CRITERIA DOCUMENT: RECOMMENDATIONS FOR AN
OCCUPATIONAL EXPOSURE STANDARD FOR INORGANIC FLUORIDES

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I. RECOMMENDATIONS FOR AN INORGANIC FLUORIDE STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to inorganic fluorides be controlled by requiring compliance with the following sections. The standard is designed to protect the health and safety of workers for up to a 10-hour workday, 40-hour workweek over a working lifetime. Compliance with all sections of the standard should prevent adverse effects of exposure to fluorides in the workplace air. Fluoride is measurable by techniques that are valid, reproducible, and available. Sufficient technology exists to permit compliance with the recommended standard. The standard will be subject to review and revision as necessary.

Fluorides (abbreviated as "F" throughout this document) are defined as:

Those compounds of fluoride which are inorganic solids at normal workroom temperatures (20 C), and are compounds without radioactive elements, and are compounds having components which do not have exposure limits more restrictive than that proposed here for fluoride. In addition this definition includes any gaseous fluorides which are emitted simultaneously with particulate fluorides as defined above.

"Occupational exposure to fluorides" is defined as exposure above one-half the recommended workroom environmental limit.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Occupational exposure shall be controlled so that no worker is exposed to a concentration of fluorides greater than 2.5 mg of F (combined ionic fluoride, atomic weight 19) per cubic meter of air determined as a time-weighted average (TWA) exposure for up to a 10-hour workday, 40-hour workweek.

(b) Sampling and analysis

Procedures for sampling, calibration of equipment, and analysis of fluoride samples shall be as provided in Appendices I and II, or by any method shown to be equivalent in precision, accuracy, and sensitivity to the methods specified.

Section 2 - Medical

(a) Medical Examinations

Comprehensive medical examinations including complete urinalysis shall be made available to all workers subject to exposure to fluorides prior to placement and biannually thereafter. These examinations should place emphasis on musculoskeletal, pulmonary, and gastrointestinal symptoms, and kidney dysfunction. Evidence of kidney dysfunction or moderate to severe osteosclerosis should be evaluated by a physician for consideration of disqualification for placement in fluoride exposure. Employees who experience breathing difficulty while using respirators shall be evaluated by a physician to determine the ability of the worker to wear respirators. In addition, a radiological examination of the male pelvis with proper gonadal shielding should be considered when preplacement

examinations are conducted and every 6 years when the average of preshift urinary fluoride concentrations for the preceding 6 years exceeds 4.0 mg/liter. The physician evaluating the X-rays shall have knowledge of the radiological signs of fluorosis, and shall be made aware of the fluoride exposure of the worker.

(b) Biologic Monitoring

Urinary postshift F analysis shall be made available at an interval not exceeding every 3 months to at least one-fourth of all workers subject to occupational exposure to inorganic fluorides. Participating workers shall be rotated to provide all exposed workers the opportunity for urinalysis every year. Spot urine samples shall be collected at the conclusion of the workshift after 4 or more consecutive days of exposure. Urinary preshift F analysis shall be made available to all exposed workers at least annually. Preshift spot samples shall be collected at the start of the workshift at least 48 hours after a previous occupational exposure. Results shall be corrected for a specific gravity of 1.024. Procedures for sampling and analysis shall be as described in Appendix II.

If an individual's postshift urinary F level exceeds 7.0 mg/liter, preshift spot urine samples shall be collected within 2 weeks at the start of a workshift at least 48 hours after a previous occupational exposure and a repeat postshift spot sample shall be collected at the conclusion of the workshift. This shall be done at the end of the workweek in which the preshift sample is collected. If the F level of the second sample is above either the preshift limit of 4.0 mg/liter or the postshift limit of 7.0 mg/liter, steps shall be taken to evaluate dietary sources, personal hygiene, basic work practices, and environmental controls.

In case the group (job classification) median postshift urinary F levels exceed 7.0 mg/liter, the working environment shall be evaluated through an industrial hygiene survey and steps shall be taken to ensure compliance with the environmental limit. Urinary F analyses shall be performed monthly until the cause of elevated urinary F has been corrected as demonstrated by a return of the group median to a value not exceeding 7.0 mg/liter. The primary method of control will be engineering and work practices. Use of administrative controls for the individual or group can also be considered.

(c) Medical Records

Medical records including information on all biologic determinations shall be available to the medical representatives of the employer, of the Secretary of Labor, of the Secretary of Health, Education and Welfare, and of the employee at his request. These records shall be kept for the duration of employment plus 20 years.

Section 3 - Labeling (Posting)

(a) Containers of materials composed of fluoride in quantities comprising 5% or more of the total content shall bear the following label in addition to or in combination with labels required by other statutes, regulations, or ordinances:

WARNING
CONTAINS FLUORIDES
MAY BE FATAL IF SWALLOWED

Avoid breathing dusts, fumes, or mists of solutions.
Use with adequate ventilation.
Wash thoroughly after handling.
For skin or eye contact, flush with plenty of water.
If swallowed, get medical attention immediately.
Store away from acids.

(b) Fluxes containing fluorides shall bear the following label in addition to or in combination with labels required by other statutes, regulations or ordinances:

CAUTION
CONTAINS FLUORIDES
FUMES HARMFUL IF INHALED

Use with adequate ventilation.
Do not get on skin or in eyes.
Wash thoroughly after handling.

(c) Containers of welding rods with coatings comprised of fluorides shall bear the following label in addition to or in combination with labels required by other statutes, regulations, or ordinances:

CAUTION
COATING CONTAINS FLUORIDES
FUMES HARMFUL IF INHALED

Use with adequate ventilation.

(d) The following warning sign shall be affixed in a readily visible location at or near entrances to areas in which respirators are required for protection against occupational exposure to fluorides. The sign shall be printed both in English and in the predominant language of non-English-speaking workers, if any, unless they are otherwise trained and

informed of the hazardous areas. All illiterate workers shall receive such training.

CAUTION
FLUORIDE EXPOSURE AREA
RESPIRATORY PROTECTION REQUIRED

Section 4 - Personal Protective Equipment and Work Clothing

(a) Protective clothing

(1) The type of protective clothing required will be dictated by the chemical nature and the physical form of the fluorides present and the duration and magnitude of worker exposure. The primary purpose of protective clothing is twofold: the worker must be protected from the effects of eye or skin contamination; and fluoride-contaminated clothing must not be allowed to present an exposure hazard to persons outside the workplace, eg, in the worker's home. Typical items of protective clothing include coveralls, shoe covers, caps, gloves, and goggles. Control practices may include provision of lockers for separation of protective clothing and street clothing, frequent changing of protective clothing, or provision of a vacuum or other mechanical means of removing gross contamination without producing significant airborne concentrations of fluorides. The type and manner of use of protective clothing shall be determined by professional occupational health personnel.

(2) Personnel working with acidic solutions of fluorides shall wear impervious gloves, shoe covers or boots, and aprons. Unless eye and face protection is afforded by a respirator hood or facepiece, chemical goggles and face shields shall be worn. Before removing protective

clothing, the worker shall rinse off fluoride solutions with clean water.

(3) All required eye protection shall conform to 29 CFR 1910.133.

(4) All protective clothing and equipment shall be maintained in a clean, sanitary, and workable condition.

(b) Respiratory Protection

(1) Engineering controls shall be used wherever feasible to maintain fluoride concentrations below the prescribed limit. Compliance with the permissible exposure limit may not be achieved by the use of respirators except:

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

(B) For nonroutine operations such as a brief exposure to concentrations in excess of the permissible exposure limit as a result of maintenance or repair activities.

(C) During emergencies when air concentrations of fluoride may exceed the permissible limit.

(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) For the purpose of determining the type of respirator to be used, the employer shall measure the atmospheric concentration of fluoride in the workplace initially and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the fluoride concentrations; this requirement shall not apply when only atmosphere-supplying positive pressure respirators will be

used. Odors, irritation, or other symptoms of exposure do not provide adequate warning of exposure to concentrations of fluorides above the recommended limit. The employer shall ensure that no worker is being exposed to fluoride in excess of the environmental limit because of improper respirator selection, fit, use, or maintenance.

TABLE I-1

RESPIRATOR SELECTION GUIDE

<u>Maximum Use Concentration (Multiples of TWA Limit)</u>	<u>Respirator Type</u>
Less than or equal to 5x (no acid gases present)	Single use, dust respirator.
Less than or equal to 10 x (no acid gases present)	Half-mask respirator with replaceable dust filter, or supplied-air, demand type respirator with half mask facepiece.
Less than or equal to 10x (acid gases present with particulates)	Half-mask respirator with replaceable combination acid gas/dust filter* cart- ridge or supplied-air demand type respirator with half-mask facepiece.
Less than or equal to 50x (no acid gases present)	Full facepiece with replaceable high efficiency filter or supplied-air demand type respirator with full facepiece.
Less than or equal to 50x (acid gases present with particulates)	Full facepiece with replaceable com- bination acid gas/high efficiency filter* or supplied-air demand type respirator with full facepiece.
Less than or equal to 100x (no acid gases present)	Powered air purifying respirator with replaceable high efficiency filter* and a full facepiece, hood, or helmet, or supplied-air pressure-demand or continuous flow type with full facepiece, hood or helmet.

TABLE I-1 (continued)

RESPIRATOR SELECTION GUIDE

<u>Maximum Use Concentration (Multiples of TWA Limit)</u>	<u>Respirator Type</u>
Greater than 100x (with or without acid gases present)	Self-contained breathing apparatus, pressure-demand mode with full face- piece or combination supplied-air pressure-demand type, full facepiece, with auxiliary self-contained air supply.
Evacuation or escape from known or unknown concentrations if acid gases present.***	Gas mask or mouthpiece respirator with acid gas canister.**

* Since some filter elements, because of materials of construction, are not suitable for exposure to hydrogen fluoride, manufacturer's recommendations should be followed.

** Above 50 mg/cu m of HF, severe eye irritation can occur, necessitating the use of eye protection for escape (eg full facepiece or chemical goggles).

***Any dust respirator can be used for escape from known or unknown concentrations of fluorides in particulate form only.

(B) A respiratory protection program meeting the requirements of 29 CFR 1910.134 as amended shall be established and enforced by the employer.

(C) The employer shall provide respirators in accordance with Table I-1 above and shall ensure that the employee uses the respirator provided.

(D) Respiratory protective devices described in Table I-1 shall be those approved under the provisions of 30 CFR 11, or approved under a Bureau of Mines schedule if the approval is recognized as being valid by the appropriate government agency or agencies.

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

Section 5 - Informing Employees of Hazards from Fluorides

At the beginning of employment in an area in which there exists occupational exposure to fluorides, employees shall be informed of the hazards, relevant symptoms of acute overexposure, chronic fluorosis, appropriate emergency procedures when applicable, and proper conditions and precautions for safe use or exposure. Instruction shall include, as a minimum, applicable information in Appendix III. The information shall be posted in the work area and maintained on file, and be readily accessible to the worker at all places of employment where fluorides are involved in unit processes and operations.

A continuing educational program shall be instituted to ensure that all workers have current knowledge of job hazards, proper maintenance procedures, and clean-up methods, and that they know how to use respiratory equipment and protective clothing.

Information as required shall be recorded on the "Material Safety Data Sheet" shown in Appendix III or on a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices

(a) Control of Airborne Fluorides

Fluorides shall be controlled at sources of dispersion by means of effective and properly maintained local exhaust ventilation or by fully enclosed process operations. Other methods may be used if they are shown to effectively control atmospheric levels of fluorides below the recommended environmental limit. Ventilation systems shall be subjected to regular preventive maintenance and cleaning to ensure maximum effectiveness, which shall be verified by periodic airflow measurements. An adequate source of make-up air shall be provided. Ventilation system discharges should be provided with air cleaners as required to meet ambient air quality standards.

(1) Ventilation for electroplating or other open surface tanks containing solutions of fluorides shall conform to the requirements of 29 CFR 1910.94.

(2) Ventilation for welding with electrodes having coatings containing fluorides shall conform to the requirements of 29 CFR 1910.252.

(b) Housekeeping

Workrooms, including remote points of accumulation, shall be kept clean and free of fluoride residues by any method which avoids redispersion in the workroom atmosphere in concentrations exceeding the environmental limit.

(c) Waste Disposal

Disposal of fluorides and discharges of fluorides into the environment should conform to all applicable local, state, and federal regulations.

(d) Storage

Fluorides should be stored in dry, well-ventilated areas, and should be protected from contact with acids.

(e) Handling

Fluorides shall be handled so as to minimize dispersion in the workroom atmosphere and into the community air. Skin contact shall be minimized.

(f) Unauthorized Entry

In areas where there is occupational exposure to fluorides a policy defining unauthorized entry shall be established. Considerations shall include the chemical and physical nature of the fluoride present, fluctuations in the airborne concentration, the duration of exposure, and any need for medical clearance.

Section 7 - Sanitation Practices

(a) Plant sanitation shall meet the requirements of 29 CFR 1910.141.

(b) Good personal hygiene shall be enforced. Hands, arms, and face shall be thoroughly washed prior to eating and at the end of the shift. Facilities shall be provided for this purpose in conformance with 29 CFR 1910.141(d).

(c) Emergency eye-wash fountains shall be conveniently placed in work areas where solutions of fluorides or acidic fluorides are handled or used.

(d) Food shall not be stored, prepared, dispensed (including vending machines), or eaten in areas where occupational exposure to

fluorides may occur. Drinking (except from authorized fountains), smoking, and chewing (eg, tobacco or gum) shall be prohibited in fluoride exposure areas. The employer shall furnish an uncontaminated area for these purposes in conformance with 29 CFR 1910.141(g). Tobacco or foodstuffs should not be carried in fluoride-contaminated clothing.

(e) Protective clothing shall be changed at least weekly. Appropriate locker rooms shall be available for changing into required protective clothing in conformance with 29 CFR 1910.141(e). Where necessary, storage facilities sufficient to prevent gross contamination of street clothing shall be provided where bulk fluorides are handled under dusty conditions.

Section 8 - Monitoring and Recordkeeping Requirements

Work areas shall not be considered to have fluoride exposure if work area air levels, as determined on the basis of an industrial hygiene survey or by the judgment of a compliance officer, do not exceed half of the environmental limit. Records of these surveys, including the basis for concluding that air levels are below half the limit, shall be maintained until a new survey is conducted. Surveys shall be repeated when any process change indicates a need for reevaluation or when in the judgment of the compliance officer it is deemed necessary. Requirements set forth below apply to areas in which there is fluoride exposure.

Employers shall maintain records of work area exposures to fluorides based upon the following sampling and recording schedules:

(a) In all monitoring, samples representative of the exposure in the breathing zone of employees shall be collected. An adequate number of

samples shall be collected to characterize every operation or process. The minimum number of representative workshift TWA determinations for an operation or process shall be based on the number of workers exposed as provided in Table I-2.

(b) The first sampling of the work environment shall be completed within 6 months of the promulgation of a standard incorporating these recommendations.

(c) Samples of the work environment shall be taken within 30 days after first operation of a new process or process changes.

(d) Samples shall be collected at least semiannually in accordance with Appendix I for the evaluation of the work environment with respect to the recommended environmental limit.

(e) Monitoring of an operation or process shall be repeated within one month when the fluoride concentration has been found to exceed the recommended environmental limit. When the results of the repeat survey

TABLE I-2

SAMPLING SCHEDULE

Number of Employees Exposed	Minimum Number of Employees Whose Individual Exposures Shall Be Determined
1-20	50% of the number of workers
21-100	10 plus 25% of the excess over 20 workers
over 100	30 plus 5% of the excess over 100 workers

reveal a concentration in excess of the limit, suitable controls shall be initiated and monitoring shall continue at monthly intervals until the adequacy of these controls has been demonstrated.

(f) Monitoring of an operation or process shall also be repeated when group median biological monitoring reveals urinary fluoride excretion above the postshift level of 7.0 mg/liter, adjusted to a specific gravity of 1.024. Monitoring of the work environment in response to high postshift urinalyses should be conducted on the same day as the repeat postshift urinalysis required by section 2.

(g) Records of all sampling, medical examinations, and biological monitoring shall be maintained for the duration of employment plus 20 years. Records shall be maintained so that exposure information is available for individual employees and shall indicate the type of personal protective devices, if any, in use at the time of sampling.

II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing occupational diseases arising from exposure to inorganic fluorides. 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 of workers from exposure to hazardous chemical and physical agents. It should be pointed out that criteria for a recommended standard should enable management and labor to develop better engineering controls resulting in more healthful work environments and mere compliance with the recommended standard should not be used as a final goal.

These criteria for a standard for fluorides are part of a continuing series of criteria developed by NIOSH. The proposed standard applies only to the processing, manufacture, and use of fluorides as applicable under the Occupational Safety and Health Act of 1970. The standard was not designed for the population-at-large, and any extrapolation beyond occupational exposures is not warranted. It is intended to (1) protect against injury from fluorides, (2) be measurable by techniques that are

valid, reproducible, and available to industry and official agencies, and (3) be attainable with existing technology.

The extensive industrial use of and exposure to fluorides, the concern over adverse effects of fluorides on plants and farm animals, and perhaps most importantly, the interest in adding fluoride to the water supply to reduce dental caries have stimulated a great amount of scientific controversy as well as scientific study. It is not feasible for any review of fluorides and their effects on health to discuss all the available evidence. This criteria document has attempted to review critically that evidence bearing on a recommended occupational health standard for inorganic fluorides. For additional information on the effects of fluorides on health, other scientific references are available and recommended. Among these are the National Academy of Sciences-National Research Council review Fluorides, [1] the World Health Organization monograph Fluorides and Human Health, [2] the chapter by Hodge and Smith "Fluorides and Man" [3] found in the 1968 issue of the Annual Review of Pharmacology, the chapter by Hodge and Smith "Biological Properties of Inorganic Fluorides," found in the series Fluorine Chemistry, [4] and "Pharmacology of Fluorides" found in the 1966 and 1970 issues of the Handbook of Experimental Pharmacology. [5]

The criteria and recommended standard contained herein is intended to apply to occupational exposure to inorganic fluorides whose primary effect at low exposure levels is bone deposition. Bone deposition in excess of minimal change may in certain circumstances prove to be detrimental to human health. Other risks of fluoride exposure, such as those posed by strong oxidizing substances (eg, elemental fluorine) and gaseous fluorides

alone (eg, hydrogen fluoride) will be the subject of additional or different recommendations in later criteria documents.