

United States
Environmental Protection
Agency

Office of Research and
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Washington, DC 20460

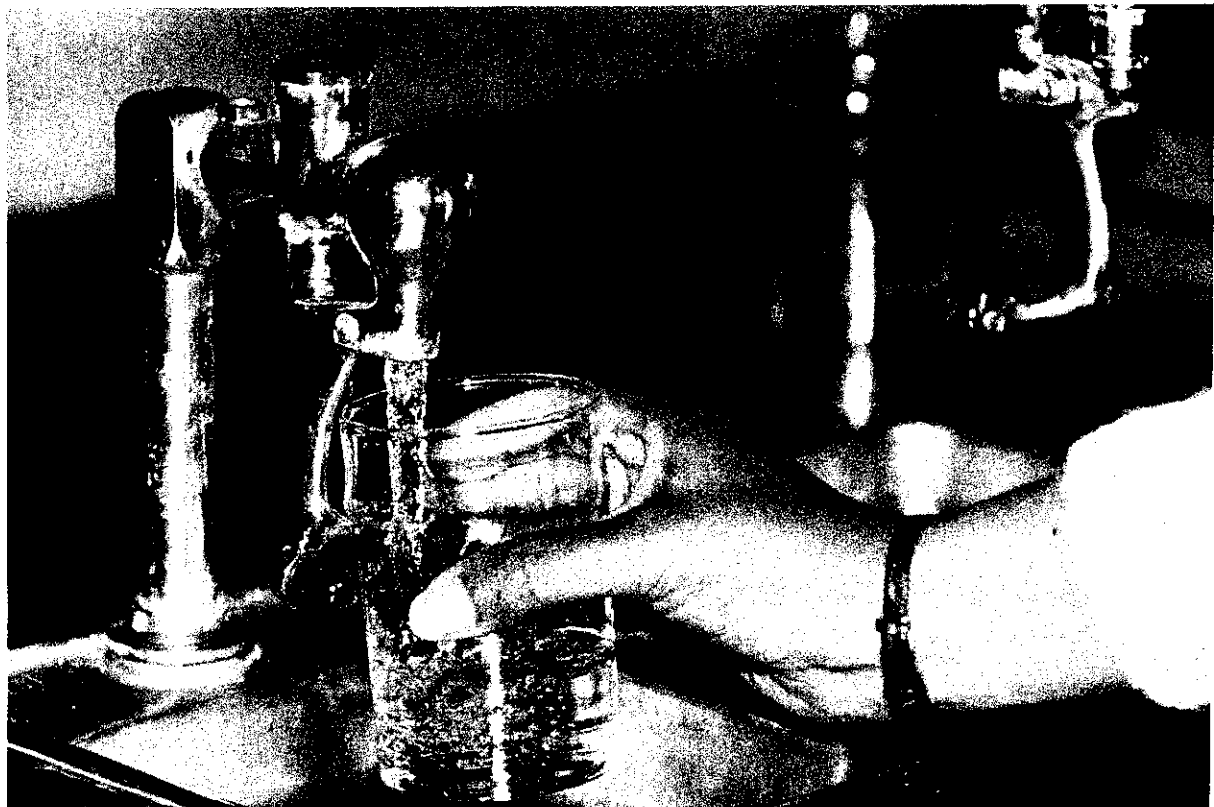
Office of International
Activities
Washington, DC 20460

Office of Water
Washington, DC 20460

EPA/600/M-91/012
August 1991



Ensuring Safe Drinking Water



EPA Technical Information Packages

This brochure is part of a series of information packages prepared by the United States Environmental Protection Agency (EPA). Aimed at the international community, the packages focus on key environmental and public health issues being investigated by EPA. The products highlighted within these packages provide a sound technical basis for decisions regarding the development of environmental policy, abatement activities, and pollution prevention. By pooling expertise in the areas of environmental science and technology, significant progress can be anticipated to ensure a habitable environment for all nations.

"Ensuring Safe Drinking Water" describes drinking water contaminants, the steps taken to determine maximum allowable contaminant levels, sampling and analysis methods, and current treatment technologies. Brochures and associated support material are available on the following topics:

- **Ensuring Safe Drinking Water**EPA/600/M-91/012
- **Mining Waste Management**EPA/600/M-91/027
- **Pesticide Waste Disposal**EPA/600/M-91/028
- **Air Quality Management**EPA/600/M-91/029
- **Solid Waste Disposal**EPA/600/M-91/030
- **Hazardous Waste Management** ..EPA/600/M-91/031
- **Small Community Wastewater Systems**EPA/600/M-91/032
- **Water Quality**EPA/600/M-91/033
- **Risk Assessment**EPA/600/M-91/034
- **Pesticide Usage Guidelines**EPA/600/M-91/035
- **Pollution Prevention**EPA/600/M-91/036
- **Environmental Impact Assessments**EPA/600/M-91/037
- **EPA Information Sources**EPA/600/M-91/038
- **Environmental Management** ...EPA/600/M-91/039

Each complete Technical Information Package (TIP) consists of a cover brochure as well as all of the documents highlighted within the body of the brochure. Generally, the cover brochures contain a section discussing the environmental issue, associated health and environmental effects, guidelines, sampling and analytical methods, as well as treatment and disposal technologies. Following this section, a bibliography is provided to identify other important sources and documents in the field. An attempt has been made to provide references that are readily available in technical libraries. Finally, a number of Office of Research and Development (ORD) technical experts followed by some additional EPA resources are listed to facilitate consultation and technical assistance. Document ordering information is provided on page 9.

Drinking Water Contamination

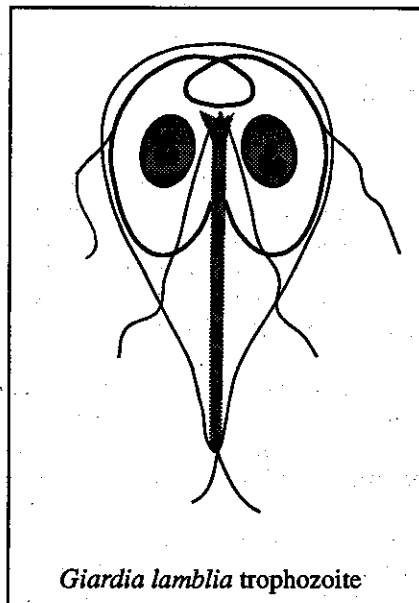
Surface and groundwater supplies often require treatment to remove particles of solid matter, reduce health risks, and improve aesthetic qualities such as appearance, odor, color and taste. The introduction of the disinfection and/or sand filtration processes into water treatment at many utilities has dramatically reduced the incidence of waterborne diseases such as typhoid, cholera and hepatitis. However, more than 89,000 cases each year of waterborne disease caused by microorganisms still occur in the United States.

Chemical contaminants, both natural and synthetic, might also be present in water supplies. Contamination problems in ground water are frequently chemical in nature and can include pesticides and nitrates from agricultural lands, metals and organic chemicals from leaking underground storage tanks and landfills, and microbial contaminants from septic tanks.

More recently, concern has increased about contaminants that are introduced by the water treatment process and distribution system, such as lead, copper, coliforms from biofilm growths on the inside of piping, and disinfection by-products.

The following is the product of a compendium of scientists and engineers meeting to discuss outbreaks of waterborne disease, methods of public notification, and the investigation and resolution of the incidents:

- EPA 600/1-90/005a "Methods for the Investigation and Prevention of Waterborne Disease Outbreaks" - The emphasis of this document is on the prevention of infectious waterborne diseases and the improvement of surveillance, reporting, epidemiologic investigations, and laboratory analyses. The need for multiple barriers to infection is stressed. In addition to a high quality supply, proper disinfection and perhaps filtration, including any required pretreatment, may be required in all but exceptional situations to insure the removal and inactivation of waterborne pathogens.



What Level of Contamination is Acceptable?

The document, "Guidelines for Drinking Water Quality," has been developed by the World Health Organization (WHO) for use by countries as a basis for the development of standards to ensure the safety of drinking water supplies. Recommended values are given for the levels of fecal coliforms and total coliforms; 17 inorganic constituents of health significance including cadmium, chromium, cyanide and lead; 22 organic constituents of health significance including trihalomethanes, hexachlorobenzene, DDT and aldrin; and gross alpha and beta activity. The USEPA was instrumental in the production of the WHO guidelines and continues to develop and compile health effects information for use in assessing the risks from various contaminants in drinking water. This information is then used to provide advice on safe levels for the contaminants in drinking water (Health Advisories) and in the development, as needed, of updated Federal and State drinking water regulations. Several compendiums exist of current U.S. health assessments and standards. The following documents address acceptable levels of contaminants and some associated health effects:

- EPA 625/4-89/024 "Risk Assessment and Management of Drinking Water Contamination" - Principal topics include

information on health effects of contaminants, an approach to risk assessment, risk communication, corrosion control, and abatement of lead, biological contaminants, particulates, organics, and radon. A case study is included to illustrate the elements of risk assessment, communication, and management.

- **"IRIS Database"** - Integrated Risk Information System (IRIS) contains summaries of health risk and regulatory information and authoritative consensus opinions on a range of chemicals and other agents. The database is updated quarterly and is very useful in deciding when water treatment is necessary. The IRIS software and introductory material is included in the Technical Information Package.



Sampling and Analysis

Proper sampling and analysis of drinking water supplies and treated waters are essential to ensure that current standards and guidelines are met. Giving credibility to a contaminant concentration that was determined in a poor sampling and analysis program could lead to serious health concerns for the consumers. Methods manuals are available that present approved sampling and analysis methods, requirements for laboratory certification, and appropriate quality assurance programs. For regulators and decision makers, it must be recognized that the standard for a specific contaminant must not be set below the detection limit of the available analytical techniques. The following documents deal with sampling and analysis techniques:

- EPA 600/4-85/076 *"Test Methods for Escherichia coli and Enterococci in Water by the Membrane Filter Procedure"* - A report on methods used to measure the bacteriological quality of recreational, shellfish growing, ambient, and potable waters.

- EPA 600/8-78/017 *"Microbiological Methods for Monitoring the Environment: Water and Wastes"* - A manual containing methods selected by consensus of EPA senior microbiologists for important parameters. National agencies, states, municipalities, universities, private laboratories, and industry should find this manual of assistance in moni-

toring and controlling microbiological pollution in the environment.

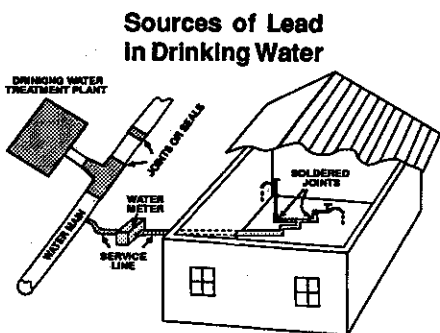


- EPA 600/4-79/017 *"Methods for Chemical Analysis of Water and Wastes"* - The manual contains the chemical analytical procedures used in USEPA laboratories for the examination of ground and surface waters, domestic and industrial waste effluents, and treatment process samples. It provides test procedures for the measurement of physical, inorganic, and selected organic constituents and parameters.

- EPA 600/4-88/039 *"Methods for the Determination of Organic Compounds in Drinking Water"* - The manual provides thirteen analytical methods for the identification and measurement of organic compounds in drinking water. Six of the methods are for volatile organic compounds (VOCs) and certain disinfection by-products. The other seven

methods are designed for the determination of a variety of synthetic organic compounds and pesticides.

- EPA 600/4-84/013 "USEPA Manual of Methods for Virology" - The manual presents a standardized, step-by-step procedure for recovering viruses from most environmental samples other than air.



Water Treatment Processes

Major water treatment processes include filtration, disinfection, treatment of organic and inorganic contaminants. Often ahead of filtration are several processes to clean up the water by removing solids and turbidity. These may include chemical addition, rapid mixing,

coagulation and flocculation, and sedimentation. Filtration to remove the remaining solids as well as microorganisms like *Giardia* and *Cryptosporidium* can be accomplished by conventional filtration systems (rapid sand, direct, slow sand, diatomaceous earth, membrane) or cartridge filtration systems.

The three most commonly used disinfection technologies are chlorine, ozone, and chloramines. When choosing the most appropriate disinfection technology for a given water system, the specific requirements for residual disinfectant levels in the distribution system must be considered along with the health risks associated with the by-products of the chosen disinfection technology.

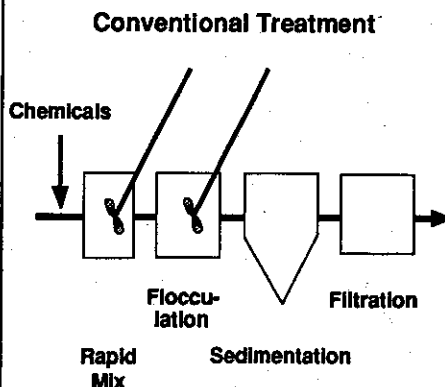
Treatment technologies for organics removal include granular activated carbon,

packed column aeration, powdered activated carbon, diffused aeration, multiple tray aeration, oxidation, and membrane filtration. Treatment technologies for inorganics removal include corrosion control, reverse osmosis, ion exchange, and aeration.

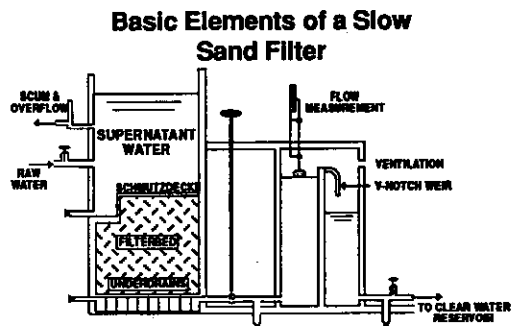
The following documents describe many of the concerns inherent to the treatment of drinking water:

- EPA 625/4-89/023 "Technologies for Upgrading Existing or Designing New Drinking Water Treatment Facilities" - Topics covered in detail are filtration, disinfection, organic contaminant removal and current and emerging research. Case histories are provided for improving existing systems and the use of emerging technologies.

- EPA 625/5-90/025 "Drinking Water Treatment for Small Communities" - This report provides information for small system owners, operators, managers, and local decision makers regarding drinking water treatment requirements and the treatment technologies suitable for small systems. Major sections discuss in detail the topics of: selection of drinking water treatment technologies, filtration, disinfection, organic and inorganic contaminant removal, sources of assistance, collection of bacteriologic samples, a checklist on factors affecting water treatment system performance, selecting a consultant, chlorine residual monitoring, and contact time values and their calculation.



• EPA 600/2-81/156 "Treatment Techniques for Controlling Trihalomethanes in Drinking Water" - This report provides a state-of-the-art review of treatment techniques for trihalomethane control, of control measures on the bacteriologic quality of the treated water, and economic impact of their application.



Additional References

What Level of Contamination is Acceptable?

DeRosa, Christopher T. Project Summary: Health Effects Assessment Documents. ECAO/USEPA, Cincinnati, OH, EPA/540/S1-86/059. (1986).

Health and Environmental Effects Profiles: Fiscal Year 1984. ECAO/USEPA. EPA-600/S8-88/072.

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Ho, James Shou-Yien. 1989. A Sequential Analysis for Volatile Organics in Water by Purge-and-trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series. *Journal of Chromatographic Science*. 27:91-98.

Hurst, C. J., W. H. Benton and R.E. Stetler. 1989. Isolation of Enterovirus and Reovirus from Sewage and Treated Effluents in Selected Puerto Rican Communities. *Journal of American Water Works Association*. 81:71-80.

McDaniels, A.E., R.H. Bordner, P.S. Gartside, J.R. Haines, K.P. Brenner and C.C. Rankin. 1985. Holding Effects on Coliform Enumeration in Drinking Water Samples. *Applied and Environmental Microbiology*. 50:755-762.

Sauch, Judith F. 1985. Use of Immunofluorescence and Phase-contrast Microscopy for Detection and Identification of *Giardia* Cysts in Water Samples. *Applied and Environmental Microbiology*. 50:1434-1438.

Water Treatment Processes

Costs

Gumerman, Robert C., Russell L. Culp, and Sigurd P. Hansen. 1979. Estimating Water Treatment Costs. Volume 1. Summary. MERL/USEPA, Cincinnati, OH, EPA-600/2-79-162a.

Gumerman, Robert C., Russell L. Culp, and Sigurd P. Hansen. 1979. Estimating Water Treatment Costs. Volume 2. Cost Curves Applicable to 1 to 200 mgd Treatment Plants. MERL/USEPA, Cincinnati, OH, EPA-600/2-79-162b.

Gumerman, Robert C., Russell L. Culp, and Sigurd P. Hansen. 1979. Estimating Water Treatment Costs. Volume 3. Cost Curves Applicable to 2,500 gpd to 1 mgd Treatment Plants. MERL/USEPA, Cincinnati, OH, EPA-600/2-79-162c.

Gumerman, Robert C., Bruce E. Burris, and Sigurd P. Hansen. 1985. Estimation of Small System Water Treatment Costs. MERL/USEPA, Cincinnati, OH, EPA-600/S2-84-184. PB 85-161644.

Letterman, Raymond D. and Thomas R. Cullen, Jr. 1985. Slow Sand Filter Maintenance: Costs and Effects on Water Quality. WERL/USEPA, Cincinnati, OH, EPA-600/S2-85/056. PB 85-199669/AS.

Lineck, Thomas S., Robert C. Gumerman, and Russell L. Culp. 1979. Estimating Water Treatment Costs. Volume 4. Computer User's Manual for Retrieving and Updating Costs Data. MERL/USEPA, Cincinnati, OH, EPA-600/2-79-162d.

Pyper, Gordon R. 1985. Slow Sand Filter and Package Treatment Plant Evaluation: Operating Costs and Removal of Bacteria, *Giardia*, and Trihalomethanes. WERL/USEPA, Cincinnati, OH, EPA-600/S2-85/052. PB 85-197051/AS.

Treatment

Adams, Jeffrey Q., Robert M. Clark, and Richard J. Miltner. 1989. Controlling Organics with GAC: A Cost and Performance Analysis. Journal of American Water Works Association. 81(4):132-140.

Baier, Joseph H., Benjamin W. Lykins, Jr., Carol A. Fronk, and Steven J. Kramer. 1988. Using Reverse Osmosis to Remove Agricultural Chemicals from Groundwater. Journal of American Water Works Association. 79(8):55-60.

Geldreich, Edwin E. 1989. Drinking Water Microbiology—New Directions Toward Water Quality Enhancement. International Journal of Food Microbiology. 9:295-312.

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- Logsdon, Gary S., Thomas Sorg, and Robert M. Clark. 1990. Capability and Cost of Treatment Technologies for Small Systems. *Journal of American Water Works Association*. 82(6):60-66.
- Love, O. Thomas, Jr. and Richard G. Eilers. 1982. Treatment of Drinking Water Containing Trichloroethylene and Related Industrial Solvents. *Journal of American Water Works Association*. 74:413-425.
- Miltner, Richard J., David B. Baker, Thomas F. Speth, and Carol A. Fronk. 1989. Treatment of Seasonal Pesticides in Surface Waters. *Journal of American Water Works Association*. 81(1):43-52.
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- Reasoner, Donald J. 1988. Drinking Water Microbiology Research in the United States: An Overview of the Past decade. *Water Science Technology*. 20 (11/12): 101-107.
- Schock, Michael. 1989. Understanding Corrosion Control Strategies for Lead. *Journal of American Water Works Association*. 81(7):88-100.
- Sorg, Thomas J. 1978. Treatment Technology to Meet the Interim Primary Drinking Water Regulations for Inorganics, Part I: Nitrite and Fluoride. *Journal of American Water Works Association*. 70(2):105-112.
- Sorg, Thomas J. and G. Logsdon. July 1978. Treatment Technology to Meet the Interim Primary Drinking Water Regulations for Inorganics, Part II: Arsenic and Selenium. *Journal of American Water Works Association*. 70(7):379-393.
- Sorg, Thomas J., M. Csanady, and G. Logsdon. December 1978. Treatment Technology to Meet the Interim Primary Drinking Water Regulations for Inorganics, Part III: Cadmium, Lead, and Silver. *Journal of American Water Works Association*. 70(12):680-691.
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- Sorg, Thomas J. and G. Logsdon. July 1980. Treatment Technology to Meet the Interim Primary Drinking Water Regulations for Inorganics, Part V: Barium and Radionuclides. *Journal of American Water Works Association*. 72(7):411-422.

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Drinking Water Expertise List

<u>Project Area</u>	<u>Contact</u>	<u>FAX</u>
Drinking Water Treatment		
Inorganics Control Technology	Thomas Sorg	513-569-7609
Corrosion	Mike Schock	513-569-7609
Microbiology Treatment	Donald Reasoner	513-569-7609
Organics Control Technology	Ron Dressman	513-569-7609
Gran. Act. Carbon Adsorption	Richard Miltner	513-569-7609
Ground Water		
Contaminant Transport	Carl Enfield	405-332-2256
Hydrogeology	Joseph D'Lugosz	702-798-2692
Monitoring	Richard Scalf	405-332-2256
Health & Environmental Effects	Cynthia Sonich-Mullin	513-569-7475
Sampling and Analysis		
Bacteriology	Robert Bordner	513-569-7276
Inorganic Chemistry	Larry Lobring	513-569-7276
Organic Chemistry	James Eichelberger	513-569-7276
Parasitology and Immunology	Walter Jakubowski	513-569-7276
Radiochemistry	Terence Grady	702-798-2233
Virology	Robert S. Safferman	513-569-7276
Waterborne Outbreaks	Gunther Craun	513-569-7609

Note: Telex number to contact most of the above scientists and engineers is 989-296-(US EPA UD).

Additional Opportunities for Obtaining Technical Information

EPA WORKSHOP: Emerging Technologies for Upgrading Existing or Designing New Drinking Water Treatment Facilities

A presentation of technical information on proven technologies to encourage their use in either planning process modification or new construction. Removal processes for lead, radon, volatile organics, synthetic organics and disinfection by-products are discussed along with filtration, disinfection and corrosion control technologies.

Sessions are primarily intended for drinking water regulatory personnel who approve plans for upgrading existing drinking water facilities or the construction of new ones. Consultants and drinking water treatment equipment manufacturers will also find these workshops helpful. For EPA workshop information, contact: J. E. Smith, USEPA, CERL, G-75, Cincinnati, OH 45268. FAX: 513-569-7566.

EPA WORKSHOP: Risk Assessment, Management and Communication of Drinking Water Contamination

Workshop designed to provide uniform and consistent approaches and processes nationwide for those officials involved in investigating, communicating about, and managing drinking water contamination incidents. Lecture topics include corrosion control, information on health effects of contaminants, an approach to risk assessment, risk communication, and abatement of lead, biological contaminations, particulates, organics, and radon. Current regulatory initiatives and an update of the Office of Water's Health Advisory Program are discussed. Each workshop attendee participates in a hands-on case study designed to illustrate the elements of risk assessment, communication and management.

Participants who can benefit from attending this program include drinking water regulatory personnel working in the health and technology areas related to the development of new or upgraded drinking water treatment facilities as well as those who must respond to contamination incidents. The program should also be of interest to consultants and drinking water utility staff actively engaged in the design, operation and/or upgrading of their treatment systems.

ORD TECHNOLOGY TRANSFER NEWSLETTER

An ORD newsletter that provides a current listing of scheduled workshops, conferences, and seminars. It also announces the availability of new publications, reports, databases, and expert systems. A publication order sheet is included. To be added to the Technology Transfer Newsletter mailing list, write to: CERL, Technology Transfer, U.S. Environmental Protection Agency, P.O. Box 19963, Cincinnati, OH 45219-0963.

DATABASES

ATTIC - The Alternative Treatment Technology Information Center database is an information retrieval network that provides up-to-date technical information on innovative treatment methods for hazardous wastes. It facilitates access to innovative technology demonstration studies, remediation ideas and experiences, vendor identification, and expert assistance. This on-line system contains literature search databases, treatability databases, a message center, a calendar of events, and a publication listing. Call 301-816-9153 for information or assistance.

Additional Opportunities for Obtaining Technical Information

ORD-BBS - The ORD Electronic Bulletin Board System, in addition to fostering communication among officials, researchers and the private sector, facilitates the exchange of technical information and ORD products in the form of electronic messages, brief bulletins about ORD products and activities, files for downloading, participation in conferences, and on-line databases for identifying ORD publications. For additional information and assistance in using the BBS, call 513-569-7272 or write to: CERI, U.S. Environmental Protection Agency, ORD-BBS, G-76, Cincinnati, OH 45268.

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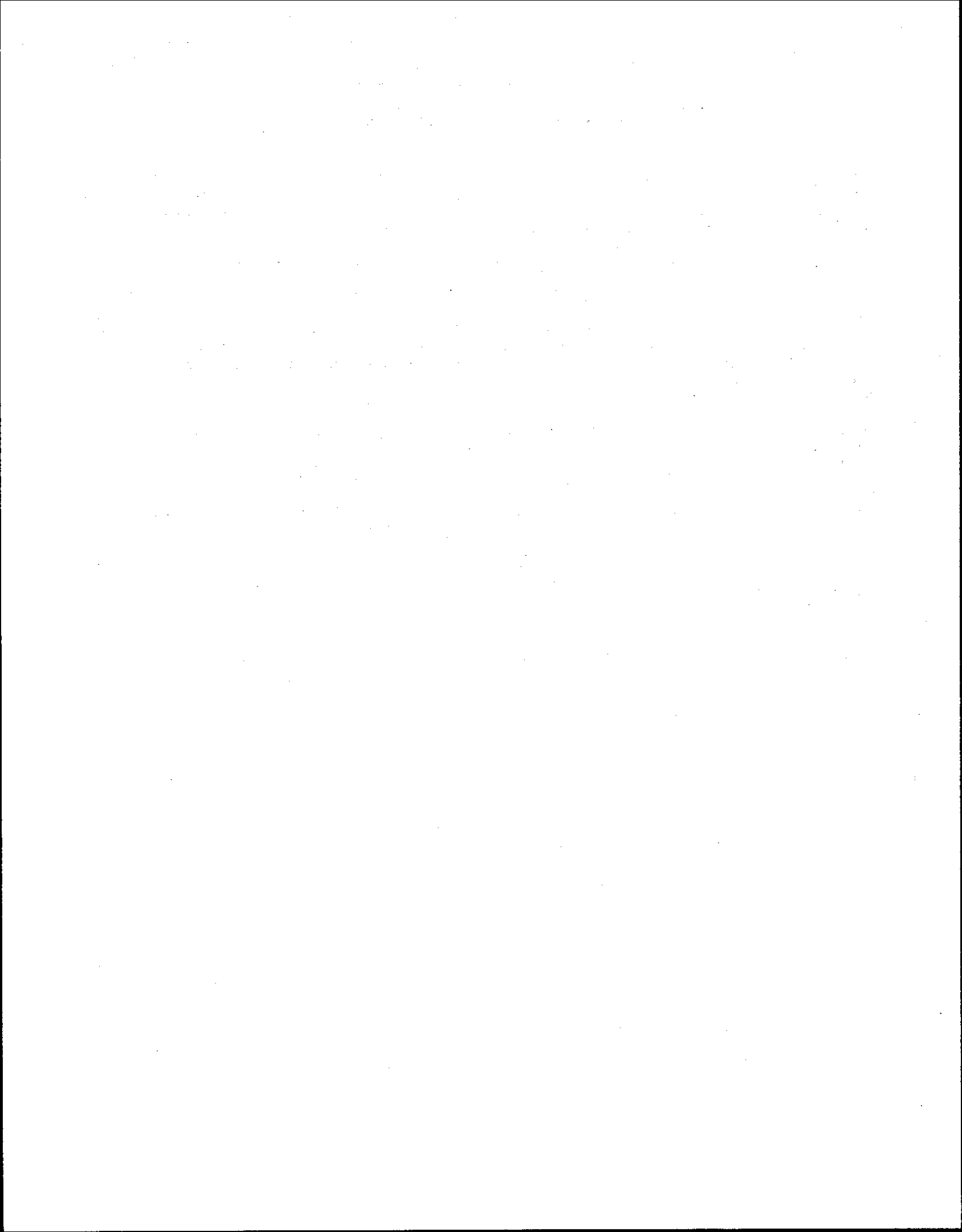
Ordering Technical Documents

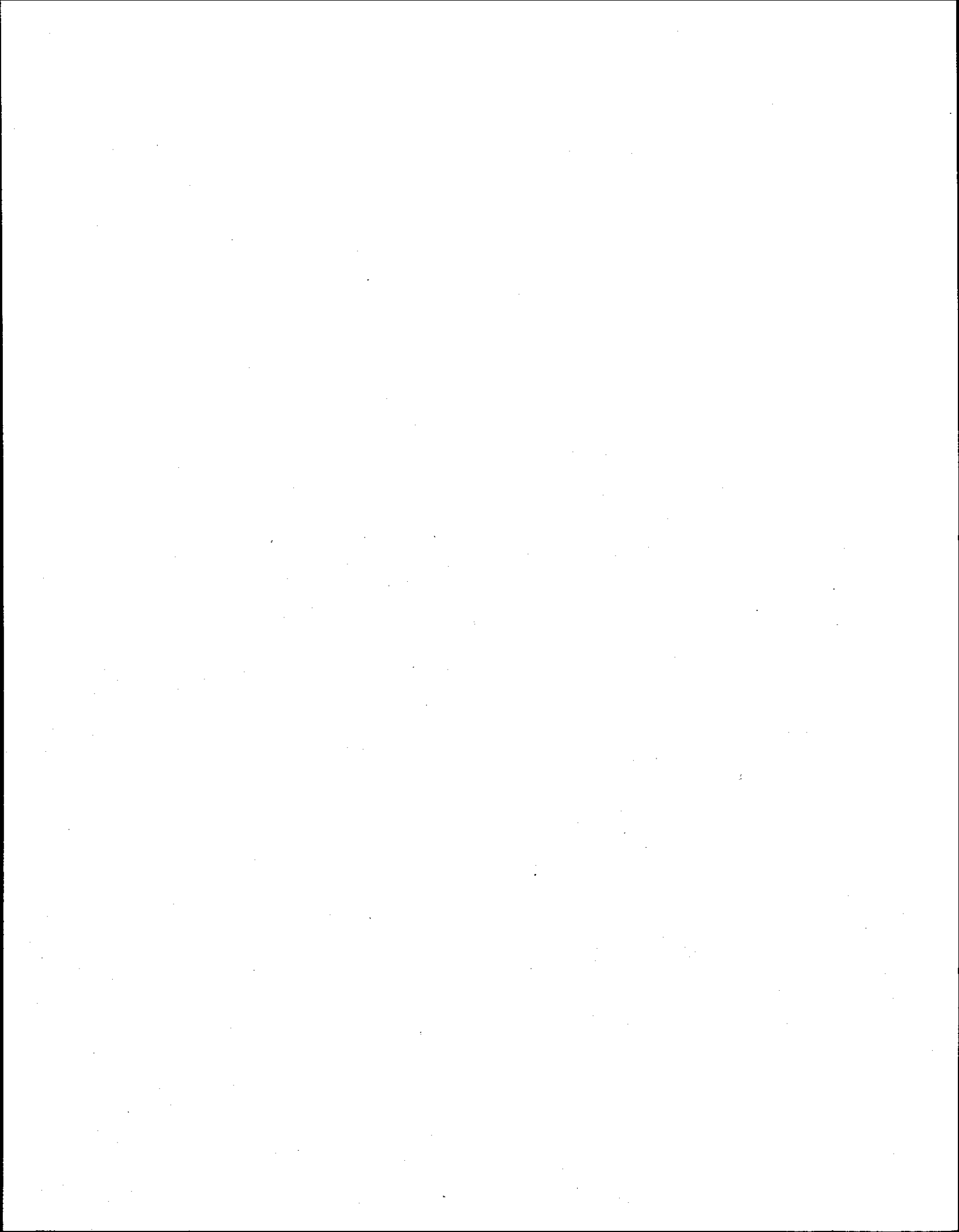
The EPA documents mentioned in the Technical Information Package brochures can be ordered at no charge (while supplies are available) from the Center for Environmental Research Information (CERI). Once the CERI inventory is exhausted, clients will be directed to the National Technical Information Service (NTIS) where documents may be purchased. Orders can be placed by mail, phone, or FAX. To order documents, have the document number or the EXACT title ready. The journal articles listed in the *Additional References* section may be ordered from the U.S. National Focal Point of INFOTERRA.

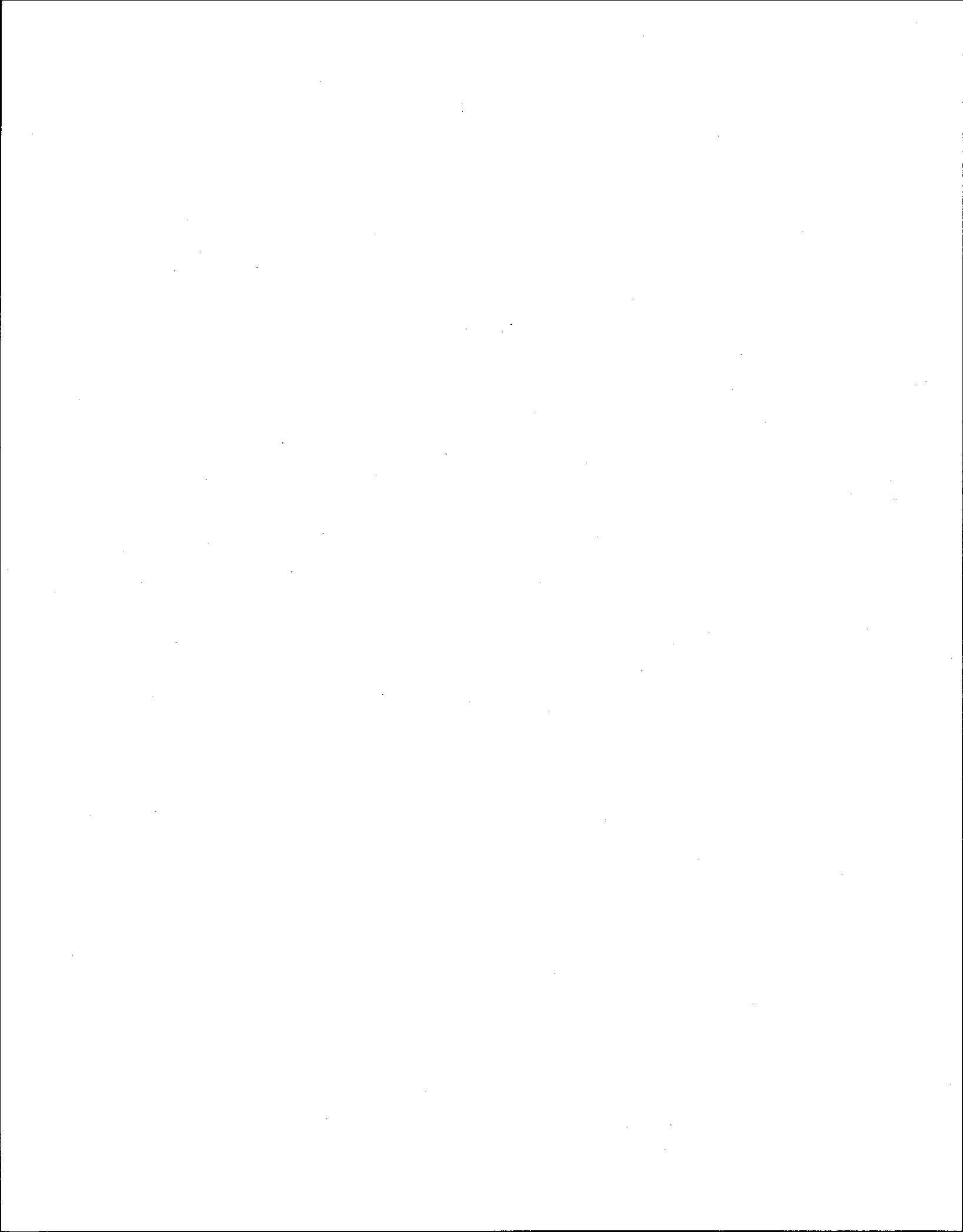
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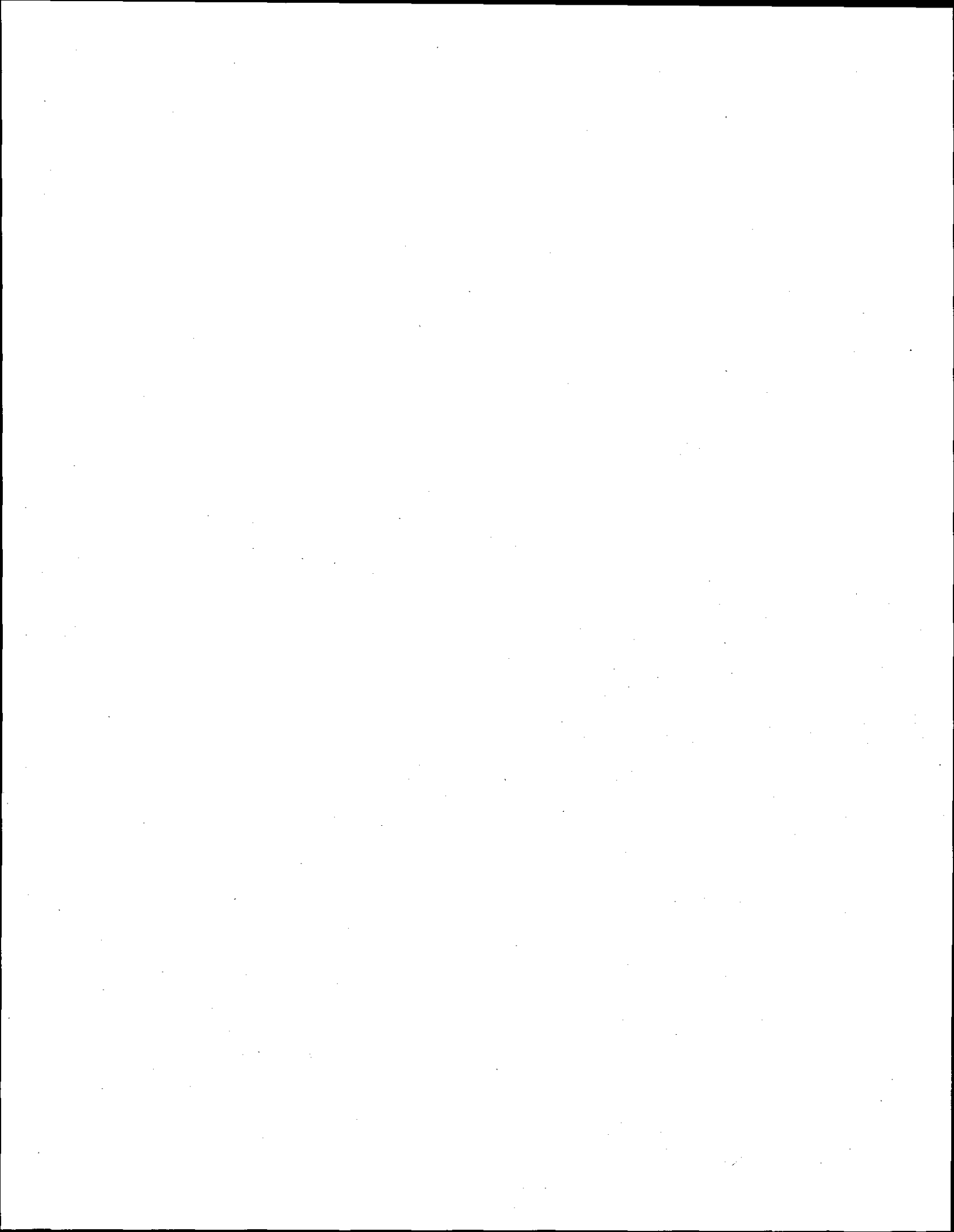
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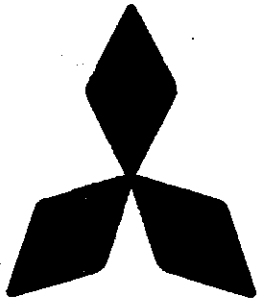
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