PNAAN 728
ISN 31975

# Pollution Control at the Chlorine-Caustic Plant of the Kasserine Paper Mill, Tunisia

by L. W. Patterson
(Tenneco Inc., Houston, Texas)

WORLD ENVIRONMENT CENTER

605 THIRD AVENUE - 17th FLOOR, NEW YORK, NY 10158, (212)986-7200. CABLE ADDRESS. ENVIROCENT NEWYORK

# PREFACE

This report -- prepared by Tenneco Inc. of Houston, U.S.A. -- is transmitted by the World Environment Center to the Government of Tunisia.

It is the result of a detailed survey of the factory of the Societe Nationale Tunisienne De Cellulose, Kasserine, by L. W. Patterson, a professional engineer made available by Tenneco for this project. The Center wishes to express its appreciation to Tenneco for offering Mr. Patterson's services.

Mr. Patterson's trip to Tunisia is the first under a new program inaugurated by the Center together with the U.S. Agency for International Development and U.S. industry. It provides technical assistance to deal with problems of pollution in developing countries. The U.S. companies provide the services free of charge to eligible countries requesting them as a contribution to the quality of life in those countries. It is expected that the program will expand over the course of the next few years.

The World Environment Center is a not-for-profit information and education service on international environmental issues. It was established in 1974 with funding from the United Nations Environment Program (UNEP). The center has overall planning and administrative responsibility for the technical assistance program.

## Information on the Report Author

Leland W. Patterson is a chemical engineer with 30 years of industrial experience. He is presently Manager of Environmental Affairs, Engineering for Tenneco Inc. He holds a Bachelors Degree in chemical engineering from Ohio State University, and is a licensed Professional Engineer in the states of Ohio and Texas. His experience includes a wide variety of engineering jobs in the oil refining and petrochemical industries with Shell Oil, Gulf Oil, Commonwealth Oil Refining, and Tenneco Oil. His experience also includes a number of years of technical work in environmental affairs concerning the many types of industries of Tenneco Inc., including many types of pollution control technologies.

In relation to this report, Mr. Patterson has experience in chlorine-caustic plant operations from employment by PPG Industries, and has experience in planning of chlorine-caustic plants for several petrochemical projects.

**Tenneco Inc**

1100 Milam Building
P. O. Box 2511
Houston, Texas 77001
(713) 757-3140

**L. W. Patterson**
Manager Environmental Affairs - Engineering

June 24, 1982

Dr. Ali Ben Gaied
Director
Office of Environment Standards
and Quality Control
Ministry of National Economy
Government of Tunisia
Tunis, Tunisia

Dear Dr. Ben Gaied:

In reference to my visit to Tunisia in May 1982, attached is my report on pollution control at the chlorine-caustic plant of the Kasserine paper mill. It was a pleasure to work with you and your staff during this visit.

This chlorine-caustic plant has large losses of mercury from the process area which causes direct exposure of workers to toxic elemental mercury, and public exposure to toxic mercury and mercury compounds contained in waste waters that flow to lands outside of the plant area.

A three phase mercury control program has been recommended. This consists of improved equipment maintenance, an improved mercury spill cleanup program, and a chemical treating system to remove mercury from waste water.

Leakage of toxic chlorine gas at the electrolysis plant cell room presents a safety hazard to workers in the cell room and other nearby areas. A program for improved worker safety to minimize exposure to chlorine gas has been recommended. This consists of improved equipment maintenance, improved availability of emergency breathing equipment, and improved ventilation in the electrolysis cell room.

It should be noted that improved equipment maintenance is an important point for the control of both mercury and chlorine leaks.

It is also recommended that any new chlorine-caustic plants that may be built in Tunisia should use the membrane cell process. This process eliminates the use of toxic mercury, and is a less costly process.

**Tenneco Inc**

Dr. Ali Ben Gaied

June 24, 1982

During my visit to this plant, it was agreed that a detailed study of waste water disposal from the main paper mill operations should not be done until after a current study is completed to gather basic data on plant waste waters.

I hope that my recommendations will be of help in the control of toxic materials at this plant.

Sincerely yours,

L. W. Patterson

L. W. Patterson

LWP/mj
Attachment

# Pollution Control at the Chlorine-Caustic Plant of the Kasserine Paper Mill, Tunisia

by L. W. Patterson
(Tenneco Inc., Houston, Texas))

## Introduction

A visit was made to the Kasserine paper mill on May 19, 1982, to examine environmental problems at the associated chlorine-caustic plant. The author of this report was accompanied by members of the technical staff of the Tunisian Office of Environment Standards and Quality Control, by Saadi Zoulton (AID staff), and by I. E. Wallen (AID consultant). Discussions and a plant tour were conducted by the Assistant Plant Manager, Md. Besbes, and by the Electrolysis Plant Manager, Mr. Zoglami.

The paper mill at Kasserine manufactures pulp stock and finished paper from locally grown alpha-grass. A sodium carbonate system is used for pulp digestion. This chemical system is made alkaline by the addition of both lime (calcium oxide) and caustic soda (sodium hydrioxide). A chlorine-caustic plant is associated with this paper mill, to supply caustic soda for pulp digestion, and to supply chlorine for pulp bleaching. There are also outside sales of caustic and chlorine to other industrial plants in Tunisia.

This plant visit was for the purpose of study of environmental and health and safety problems associated with the chlorine-caustic plant. Environmental problems of the paper mill operations were not discussed in detail.

## Electrolysis Plant Operations

Chlorine and caustic soda are produced at this plant by the electrolysis of a sodium chloride solution, using an Italian mercury cell process. Solid salt is dissolved in water, and calcium and magnesium impurities are then

removed by chemical precipitation. The purified salt solution is then sent to the mercury cell process for production of chlorine and caustic soda (sodium hydroxide).

In the mercury cell process, elemental mercury is used as one of the electrodes. In this electrolysis process, chlorine is produced as a gaseous product, and a sodium-mercury amalgam is formed at the mercury electrode. This amalgam is then decomposed to form caustic soda product, and elemental mercury for recycle in the process. Chlorine product is dried with a conventional sulfuric acid contact system.

Plant operations suffer from an unreliable outside electrical power supply, which may contribute to mercury losses. This plant is now operating with 10 electrolysis cells. In the past, all cells were connected together, so that a complete shutdown of all cells was required when maintenance was done on one cell. A manifold system is now being installed which allows a single cell to be shutdown without affecting the operation of the other cells. This should result in improved maintenance, which will reduce mercury losses.

Production of this plant is currently 14 metric tons per day of caustic soda, and 12 metric tons per day of chlorine.

Mercury Pollution

In 1981, mercury losses were 4,700 kilograms per year at this plant. High mercury losses are expensive to operations, and result in pollution problems. Mercury and mercury compounds are very toxic. Human exposure to mercury can result in severe health problems. Some data on the toxic properties of mercury and mercury compounds are attached.

Some of the mercury losses are caused by mechanical leakage from equipment. This results in exposure to workers, and in water pollution when mercury goes into floor drains. During this visit, it was observed that the



1

floor of the mercury recovery room, below the cell room, was covered with elemental mercury. This gives direct exposure to workers and causes water pollution through the floor drains.

Another source of water pollution by mercury is from cleanout of electrolysis cells during maintenance.

Worker exposure to mercury can come from direct contact and from breathing of aubient air that contains mercury. If mercury is spilled, some of it will volatize into the ambient air. Tests should be made at this plant to determine the concentration of mercury in the ambient air of the cell room and the mercury recovery room. The United States federal standard for the maximum concentration of mercury in air is 1 milligram mercury per 10 cubic meters of air.

It is recommended that the following things be done to control mercury pollution problems at this plant:

1. An improved maintenance program to prevent mercury leaks from plant equipment.
2. Immediate cleanup of all spilled mercury.
3. Separate and treat all waste water streams that contain mercury.

Only waste water streams from the electrolysis plant that potentially contain mercury will require treatment. For example, there is no mercury in the waste water from brine treatment to remove calcium and magnesium. Waste water from all floor drains and other waste water sources in the cell room and mercury recovery room should be treated.

Waste water containing mercury can be treated with sodium sulfide. A pH of 4 to 6 must be maintained for this chemical reaction. During treatment, mercury compounds will precipitate as a mercury sulfide sludge. Any unreacted elemental mercury will also be contained in this sludge. The



8

treated water is then filtered to remove the mercury sludge. Many types of filters can be used. Tenneco Chemicals has successfully used both plate-and-frame and pressure type filters for this operation. Diatomaceous earth is used as a filter precoat. It is recommended that the produced sludge be mixed with building cement to form a permanent solid material for final disposal at a hazardous waste disposal site. A flow diagram of this waste water mercury treatment system is shown in Figure 1. The final treated water should be tested before it is sent to the main plant sewer system, to make sure that all mercury has been removed.

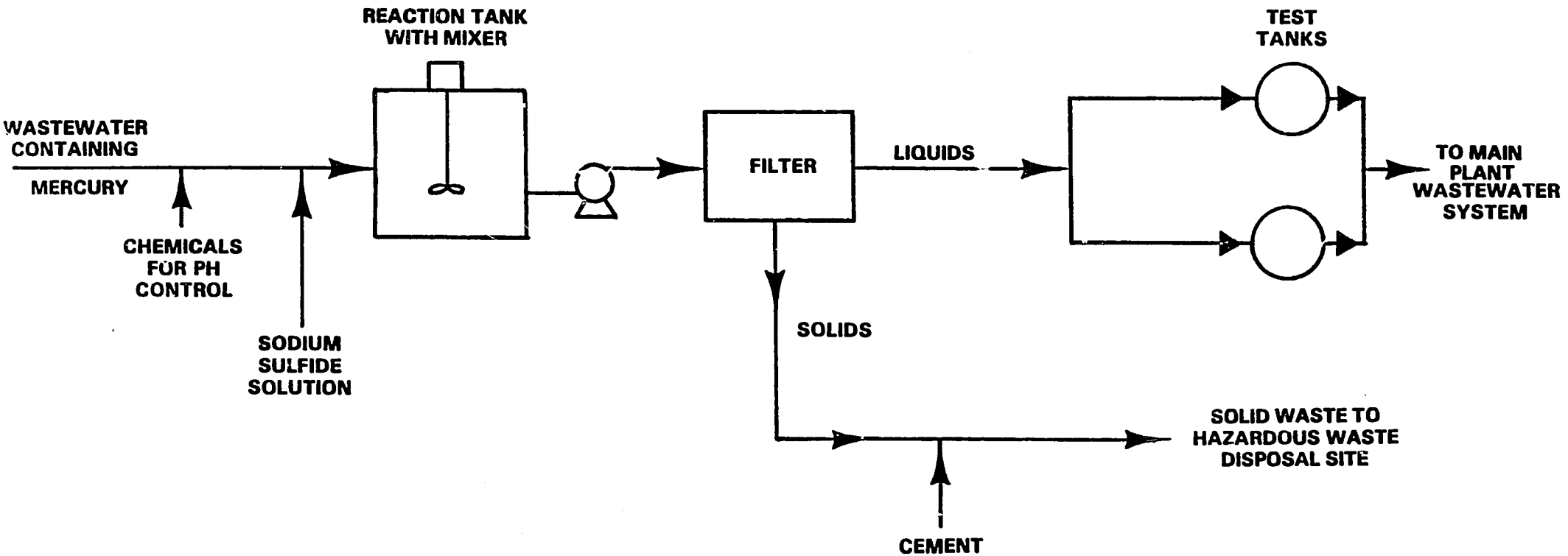
It appears that elemental mercury has been going into the main paper mill sewer system for some time. There could be a significant quantity of mercury in the waste water sewer system from the location of the caustic-chlorine plant to the location of the open sewer outfall at the edge of the plant property. A new mercury treatment system installed near the caustic-chlorine plant would not remove this accumulated mercury from the main plant sewer system. After installation of a mercury treatment system, the main sewer outfall line should be separately checked for accumulated mercury. This check can be made by testing for mercury in waste water at the main sewer outfall location.

A treating system to remove mercury from waste water can probably be installed at a cost of less than 100,000 Dinars (185,000 U.S. dollars). It should be noted, however, that there would be additional costs to install a system to collect all waste water streams that potentially contain mercury.

Waste water from this plant flows into a dry stream bed outside. There is a potential for exposure of both people and animals to mercury at the location of this stream bed. If mercury contamination of the surrounding soil is found to be severe, it is recommended that this soil be sprayed with

## FIGURE I

### Wastewater Mercury Treatment System



a sodium sulfide solution. This will fix the mercury as a water insoluble compound that is not so easily absorbed by people and animals, and which will not be further spread by water. This is not a permanent solution to mercury contamination of soil, but it does prevent the rapid release and spread of highly toxic, water soluble mercury compounds.

The Chlorine Institute has informed me that mercury losses from well-run chlorine-caustic plants would be approximately 0.1 kilograms per metric ton of chlorine produced. The Kasserine electrolysis plant mercury loss is approximately 1.0 kilograms per metric ton of chlorine. This is approximately ten times normal expected losses as compared to general industry data. At the current price of mercury, there is a potential cost savings of approximately 5 Dinars per ton of chlorine produced, if mercury losses at the Kasserine plant could be reduced to that of other well-run plants.

Chlorine Safety

Chlorine is a poisonous gas that presents a continuing danger to workers in chlorine plants. During this visit to the Kasserine plant, the electrolysis cell room could not be entered by visitors, as the room was filled with chlorine gas. There was no apparent availability of gas masks, and visitors and workers in adjacent areas did not have any emergency breathing equipment. Appropriate gas masks should be available to all people who are potentially exposed to chlorine gas.

Several types of breathing equipment should be available in chlorine plants for use when high concentrations of chlorine are present in ambient air. A maximum of 3 milligrams per cubic meter in ambient air is used in the United States as a maximum level of chlorine exposure to workers. The types of emergency breathing equipment that should be available are as follows:



11

1. Self-contained air breathing apparatus: This is used where very high concentrations (above 2%) of chlorine are present, or when long work periods are required.
2. Canister-type gas masks: This is used where moderate concentrations of chlorine are present (under 2%), and only short work periods are involved.
3. Emergency escape device: This is a small, highly portable device that can be carried by visitors and workers in areas located close to chlorine operations. This device allows people to escape from an area contaminated with chlorine gas, without being overcome by the poisonous gas. It is not intended to replace other types of breathing apparatus used by workers in areas contaminated with chlorine.
4. Pullmotor devices for medical aid: Chlorine is a heavy gas which is difficult to expell from human lungs. When a person has breathed a high concentration of chlorine, it may be necessary to provide mechanical assistance to remove chlorine from the lungs. Every chlorine plant should have a vacuum type breathing apparatus (pullmotor) available to provide this type of medical assistance. Literature on various types of emergency breathing apparatus is attached to this report.

Good ventilation is necessary for chlorine plant cell rooms. The Kasserine plant electrolysis cell room is in a rather enclosed building. It is recommended that wall sections in the cell room building be removed to obtain improved ventilation for better dispersion of chlorine gas leaks.

Improved maintenance should also be considered for electrolysis equipment to reduce the frequency of chlorine leaks.



12

## Comments on Paper Mill Waste Water

No detailed tour of the paper mill was made during this visit, but some general comments can be made observations and discussions that occurred during this visit. There is no treatment system being used for waste water from the paper mill at the present time. A study is now being made to collect data on waste water streams at this plant. It was agreed that consultants should not visit the paper mill to study waste water disposal problems until these new data are available.

The following are potential advantages for use of a waste water treatment system in this paper mill:

1. Reuse of waste water for agriculture
2. Recycle of water in plant to reduce fresh water makeup requirements.
3. Recovery of fibers from waste water to reduce production costs and increase paper and pulp production.
4. Reduction of waste water pollution

During this visit, it was noticed that some chemical storage tanks in the paper mill were either leaking or overflowing into the sewer system. Elimination of this situation would decrease pollutants in the waste water and would reduce costs resulting from chemical losses.

The chlorine-caustic plant is closely integrated with the paper mill. When caustic soda production decreases, the paper mill operations are rapidly affected. The effects on the paper mill of short term fluctuations in caustic soda production could be minimized by installation of more caustic soda storage tank capacity. Smoother paper mill operations from a steady supply of caustic soda could make control of water pollution easier.

## Alternate Chlorine Plant Technologies

Because of mercury pollution problems, fewer new caustic-chlorine plants are being built that use the mercury cell process. Alternate technologies



13

are available using membrane and diaphragm type electrolysis cells, where no mercury is used. Current process designs allow these alternate technologies to be economically competitive with the mercury cell process. A description of various types of chlorine-caustic processes is attached. If a new chlorine-caustic plant is built in Tunisia, processes that do not use mercury should be considered.

A recent study by Fluor Engineers and Constructors, Inc. shows that capital costs would be approximately 50% lower and operating costs approximately 20% lower for small chlorine-caustic plants using the membrane cell process, compared to more expensive diaphragm cell and mercury cell processes. The membrane cell process can now be licensed from companies such as Asahi, Diamond-Shamrock, and ICI.

Summary

Comments have been made here on mercury pollution control at the Kasserine chlorine-caustic plant. Worker exposure to mercury could be greatly reduced by improved equipment maintenance and by improved mercury spill cleanup practices. Mercury in waste water could be controlled by use of a sodium sulfide process for mercury removal.

It has been recommended here that a more adequate supply of emergency breathing equipment be obtained for protection from chlorine gas of electrolysis cell room workers and workers in nearby areas. Ventilation in the cell room should also be improved.

# Dangerous Properties of Industrial Materials

Fifth Edition

N. IRVING SAX

Assisted by:

Marilyn C. Bracken/Robert D. Bruce/William F. Durham/Benjamin Feiner/
Edward G. Fitzgerald/Joseph J. Fitzgerald/Barbara J. Goldsmith/John H. Harley/
Robert Herrick/Richard J. Lewis/James R. Mahoney/John F. Schmutz/
E. Juna Thompson/Elizabeth K. Weisburger/David Gordon Wilson

VNR VAN NOSTRAND REINHOLD COMPANY
NEW YORK CINCINNATI ATLANTA DALLAS SAN FRANCISCO
LONDON TORONTO MELBOURNE

15

**2-MERCAPTOETHANOIC ACID.**
See thioglycolic acid.

**2-MERCAPTOETHANOL.** Syn: *2-hydroxyethylmercaptan*. Water white, mobile liquid. $HSCH_2CH_2OH$, mw: 78.13, bp: 157.1°, flash p: 165°F (COC), d: 1.1168 @ 20°/20°, vap. press: 1.0 mm @ 20°, vap. d: 2.69.
Acute tox data: Oral $LD_{50}$ (rat) = 300 mg/kg; dermal $LD_{50}$ (rabbit) = 150 mg/kg; dermal $LD_{50}$ (guinea pig) = 300 mg/kg; iv $LD_{50}$ (mouse) = 480 mg/kg. [*3*]
THR = HIGH via oral, dermal and iv routes.
Fire Hazard: Mod, when exposed to heat, flame or oxidizers.
Disaster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of oxides of sulfur; can react with oxidizing materials.
To Fight Fire: Alcohol foam, $CO_2$, dry chemical.

**2-MERCAPTOETHYLAMINE HYDROCHLORIDE.**
White, slightly hygroscopic crystals. $HSCH_2CH_2NH_2 \cdot HCl$, mw: 113.6, mp: 70.2°–70.7°.
Acute tox data: ip $LD_{LO}$ (mouse) = 425 mg/kg. [*3*]
THR = HIGH via ip and probably oral routes.
Disaster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of $SO_x$; will react with water or steam to produce toxic fumes.

**2-MERCAPTO-4-HYDROXYPYRAMIDINE.**
See thiouracil.

**MERCAPTOPURINE-3-N-OXIDE.** $C_6H_3ON_4$, mw: 179.2.
THR = An exper teratogen. [*3*]

**MERCAPTOPURINE RIBONUCLEOSIDE.**
$C_{10}H_{12}O_4N_4S$, mw: 284.3.
THR = An exper teratogen. [*3*]

**MERCURIC ACETATE.** White crystalline powder. $Hg(C_2H_3O_2)_2$, mw: 318.70, mp: decomp, d: 3.270.
Acute tox data: Oral $LD_{50}$ (rat) = 76 mg/kg; oral $LD_{50}$ (mouse) = 62 mg/kg; iv $LD_{50}$ (mouse) = 4.4 mg/kg. [*3*]
THR = HIGH via oral and iv routes. See also mercury compounds, organic.

**MERCURIC ACETYLIDE.** White powder. $3HgC_2 \cdot H_2O$, mw: 691.85, mp: explodes, d: 5.3.
THR = HIGH. See mercury compounds, organic.
Fire Hazard: Details U. See also acetylides.
Explosion Hazard: Severe, when shocked or exposed to heat.
Disaster Hazard: Dangerous! Heat or shock will cause detonation; when heated, emits highly toxic fumes of mercury.

**MERCURIC AMINOACETATE.** Syn: *mercuric glycocollate*. Crystals, sol in water. $Hg[CH_2(NH_2)COO]_2$, mw: 348.7.
THR = HIGH. See mercury compounds, organic.

**MERCURIC AMINOPROPIONATE.** Syn: *mercu alanine*. $Hg[CH_3CH(NH_2)COO]_2$, mw: 374.77.
THR = HIGH. See mercury compounds, organic.

**MERCURIC AMMONIUM CHLORIDE.** White, pu verulent lumps or powder. $HgNH_2Cl$, mw: 252.1.
THR = HIGH. See mercury compounds, inorganic

**MERCURIC ARSENATE.** Yellow powder. HgHAsO mw: 340.5, mp: decomp.
THR = HIGH. See mercury compounds, inorganic and arsenic compounds.
Disaster Hazard: Dangerous; when heated to decomp or on contact with acid or acid fumes, emits highl toxic fumes of mercury and arsenic.

**MERCURIC AZIDE.** $Hg(N_3)_2$, mw: 284.6.
THR = HIGH. See mercury compounds and azides. is explosively unstable. Also, decomp violently @ 190°. [*19*]

**MERCURIC BARIUM BROMIDE.** Syn: *barium mercury bromide*. Colorless, very hygroscopic crystals $HgBr_2 \cdot BaBr_2$, mw: 657.6.
THR = HIGH. See mercury compounds, inorganic barium compounds and bromides.

**MERCURIC BARIUM IODIDE.** Reddish or yellow unstable, deliquescent, crystalline mass.
$HgI_2 \cdot BaI_2 \cdot 5H_2O$, mw: 935.73.
THR = HIGH. See mercury compounds, inorganic iodides and barium compounds.

**MERCURIC BENZOATE.** White crystalline powder $Hg(C_7H_5O_2)_2$, mw: 442.83, mp: 165°.
THR = HIGH. See mercury compounds, organic.

**MERCURIC BROMATE.** Crystals. $Hg(BrO_3)_2 \cdot 2H_2O$ mw: 492.47, mp: decomp @ 130°–140°.
THR = HIGH. See mercury compounds, inorganic and bromates.

**MERCURIC BROMIDE.** Rhombic, colorless crystals. $HgBr_2$, mw: 360.44, mp: 237°, bp: 322° (sublimes), d: 6.109 @ 25°, vap. press: 1 mm @ 136.5°.
THR = HIGH. See mercury compounds, inorganic, and bromides. Reacts violently with Na, K. [*19*]

**MERCURIC BROMIDE, AMMONOBASIC.** White powder. $Hg(NH_2)Br$, mw: 296.55, mp: decomp.
THR = HIGH. See mercury compounds, inorganic, and bromides.

**MERCURIC BROMIDE DIAMMINE.** White powder. $Hg(NH_3)_2Br_2$, mw: 394.51, mp: 180°.
THR = HIGH. See mercury compounds, inorganic, and bromides.

**MERCURIC BROMIDE IODIDE.** Rhombic yellow crystals. HgBrI, mw: 407.45, mp: 229°, bp: 360°.
THR = HIGH. See mercury compounds, inorganic, and bromides.



16

RCURIC CACODYLATE. Hygroscopic, somewhat nstable crystalline powder, sol in water and alcohol, sol in ether. $Hg[(CH_3)_2AsO_2]_2$, mw: 474.52.
HR = HIGH. A recognized carc. [*14*] See mercury compounds, organic and arsenic compounds.

RCURIC CHLORATE. Colorless, needle-like crysls. $Hg(ClO_2)_2$, mw: 367.52, mp: decomp, d: 4.998.
HR = HIGH. See mercury compounds, inorganic and chlorates.

RCURIC CHLORIDE. Syn: *corrosive sublimate.* hite crystals or powder. $HgCl_2$, mw: 271.52, mp: 6°, bp: 302°, d: 5.440 @ 25°, vap. press: 1 mm @ 6.2°.
cute tox data: Oral $LD_{50}$ (rat) = 37 mg/kg; $scLD_{50}$ (rat) = 14 mg/kg; $ipLD_{50}$ (mouse) = 5 mg/kg; dermal $LD_{LO}$ (guinea pig) = 345 mg/kg; oral $LD_{LO}$ (human) = 29 mg/kg. [*3*]
HR = HIGH via all routes. A deadly poison. See mercury compounds, inorganic, and chlorides. Reacts violently with K, Na. [*19*]

RCURIC CHLORIDE DIAMMINE. Fusible white ecipitate. $Hg(NH_3)_2Cl_2$, mw: 305.59, mp: 300°.
HR = HIGH. See mercury compounds, inorganic, and chlorides.

RCURIC CHLORIDE IODIDE. Rhombic red ystals. HgClI, mw: 362.99, mp: 153°, bp: 315°.
HR = HIGH. See mercury compounds, inorganic, chlorides and iodides.

RCURIC CHLORITE. $Hg(ClO_2)_2$, mw: 335.5.
HR = HIGH. See mercury compounds, inorganic. This salt is explosive. [*19*]

RCURIC CHLOROIODIDE. White crystals. $HgCl_2 \cdot HgI_2$, mw: 997.48.
HR = HIGH. See mercury compounds, inorganic.

RCURIC CHROMATE. Rhombic red crystals. $HgCrO_4$, mw: 316.62, mp: decomp.
HR = HIGH. See mercury compounds, inorganic, and chromates.
re Hazard: Mod, by chemical reaction; an oxidizer.
saster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of mercury; can react with reducing materials.

RCURIC CUPROUS IODIDE. Syn: *copper-rcury iodide.* Dark red, crystalline powder. $HgI_2 \cdot 2CuI$, mw: 835.42.
HR = See mercury compounds, inorganic.

RCURIC CYANIDE. Colorless, transparent prisms, rkened by light. $Hg(CN)_2$, mw: 252.65, mp: decomp, 3.996.
ute tox data: Oral $LD_{50}$ (rat) = 25 mg/kg; $ipLD_{LO}$ (rat) = 7.5 mg/kg; $ivLD_{LO}$ (rabbit) = 2 mg/kg; $TD_{LO}$ = 10 mg/kg (human) → GI symptoms. [*3*]
THR = HIGH via oral, ip and iv routes. See cyanides and mercury compounds, organic.
Fire Hazard: See cyanides.
Explosion Hazard: See cyanides. Reacts violently with Mg, $F_2$. [*19*]
Disaster Hazard: Dangerous; when heated to decomp, or on contact with acid or acid fumes, emits highly toxic fumes of cyanides and mercury; will react with water or steam to produce toxic fumes.

MERCURIC CYANIDE OXIDE. $Hg_2(CN)_2O$, mw: 469.2.
Acute tox data: $ivLD_{LO}$ (rabbit) = 2.5 mg/kg. [*3*]
THR = HIGH via iv route. See mercury compounds and cyanides. Often explodes, possibly if rubbed. [*19*]

MERCURIC DINAPHTHYLAMINE DISULFONATE. $C_{21}H_{14}O_6S_2 \cdot (Hg)_x$.
Acute tox data: Oral $LD_{50}$ (mouse) = 30 mg/kg. [*3*]
THR = HIGH via oral route. See also mercury compounds, organic.

MERCURIC ETHYL MERCAPTIDE. Crystals, insol in water. $(SC_2H_5)_2Hg$, mw: 322.9, mp: 77°.
THR = HIGH. See mercury compounds, organic, and sulfides.

MERCURIC FLUORIDE. Transparent crystals. $HgF_2$, mw: 238.61, mp: 645°, bp: >650°, d: 8.95 @ 15°.
THR = HIGH. See fluorides and mercury compounds, inorganic. Reacts violently with K, Na. [*19*]

MERCURIC FLUOSILICATE. Colorless, deliquescent crystals. $HgSiF_6 \cdot 6H_2O$, mw: 450.77.
THR = HIGH. See mercury compounds, inorganic, and fluosilicates.

MERCURIC FORMAMIDE. A mixture of mercuric oxide + formamide.
THR = HIGH. See mercury compounds, organic.

MERCURIC GALLATE. Gray-green powder, insol in water. $Hg[C_6H_2(OH)_3COO]_2$, mw: 538.8.
THR = HIGH. See mercury compounds, organic.

MERCURIC GLYCOCOLLATE. See mercuric aminoacetate.

MERCURIC GUAIACOLSULFONATE. Brown crystals, sol in water. $Hg[C_6H_3(OH)(OCH_3)SO_3]_2$, mw: 606.99.
THR = HIGH. See mercury compounds, organic, and sulfonates.

MERCURIC IODATE. White crystals, slightly water-sol. $Hg(IO_3)_2$, mw: 550.45.
THR = HIGH. See mercury compounds, inorganic, and iodates.

**MERCURIC IODIDE.** (1) Rhombic yellow crystals; (2) tetragonal red crystals or powder. $HgI_2$, mw: 454.9, d: (1) 6.271, (2) 6.283; mp: (1) 259°, (2) 126°–127°; bp: 354° (sublimes), vap. press: (1) 1 mm @ 157.5°.
Acute tox data: Oral $LD_{LO}$ (human) = 357 mg/kg; oral $LD_{50}$ (rat) = 40 mg/kg; ip$LD_{50}$ (mouse) = 60 mg/kg. [*3*]
THR = HIGH via oral and ip routes. See mercury compounds, inorganic, and iodides. Violent reaction with $ClF_3$, K, Na. [*19*]

**MERCURIC IODIDE AMMONOBASIC.** Dirty white crystals. $Hg(NH_2)I$, mw: 343.55.
THR = HIGH. See mercury compounds, inorganic, and iodides.

**MERCURIC IODIDE, AQUOBASIC-AMMONOBASIC.** Yellow to brown crystals. $OHg_2NH_2I$, mw: 560.16, mp: >128°, bp: explodes.
THR = HIGH. See mercury compounds, inorganic, and iodides.

**MERCURIC IODIDE DIAMMINE.** Colorless or pale yellow powder or needles. $Hg(NH_3)_2I_2$, mw: 488.51.
THR = HIGH. See mercury compounds, inorganic, and iodides.

**MERCURIC IODIDE SOLUTION.** See mercuric iodide.

**MERCURIC LACTATE.** White crystalline powder. $Hg(C_3H_5O_3)_2$, mw: 378.71.
Acute tox data: Oral $LD_{50}$ (rat) = 200 mg/kg. [*3*]
THR = HIGH via oral route. See mercury compounds, organic.

**MERCURIC NAPHTHOLATE.** Syn: *mercury-β-naphthol.* Brown powder, insol in water. $Hg(C_{10}H_7O)_2$, mw: 486.9.
THR = HIGH. See mercury compounds, organic and β-naphthol.

**MERCURIC NITRATE.** White-yellowish, deliquescent powder. $Hg(NO_3)_2$, mw: 324.6, mp: 79°, bp: decomp, d: 4.39.
Acute tox data: ip$LD_{50}$ (mouse) = 8 mg/kg. [*3*]
THR = HIGH via ip route. See mercury compounds, inorganic, and nitrates. Forms a sensitive explosive product with acetylene, ethanol, $PH_3$, S; reacts violently with hypophosphoric acid, unsaturates, aromatics. [*19*]

**MERCURIC NITRIDE.** $Hg_3N_2$, mw: 629.8.
THR = HIGH. See mercury compounds. Very explosive. Explodes on contact with $H_2SO_4$. [*19*]

**MERCURIC OLEATE.** Syn: *mercury oleate.* Yellowish to red liquid, semisolid or solid mass. $(C_{17}H_{33}CO_2)_2Hg$, mw: 763.6.
THR = HIGH. See mercury compounds, organic.

**MERCURIC OXALATE.** White powder. $HgC_2O_4$, mw: 288.63, mp: decomp.
THR = HIGH. See mercury compounds, organic and oxalates.

**MERCURIC OXIDE.** Heavy, bright orange-red powder or orange-yellow powder. HgO, mw: 216.61, mp: decomp @ 500°, d: 11.14.
Acute tox data: Oral $LD_{50}$ (rat) = 18 mg/kg; im$LD_{50}$ (rat) = 2.5 mg/kg. [*3*]
THR = HIGH via oral and im routes. See mercury compounds, inorganic.
Fire Hazard: By chemical reactions; an oxidizer. Reacts violently with $Cl_2$, hydrazine hydrate, $H_2O$, hypophosphorus acid, (I + $CH_3OH$ + $C_2H_5OH$), Mg, P, phosphan, NaK, S. [*19*]
Disaster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of mercury; can react with reducing materials.

**MERCURIC OXYBROMIDE.** Yellow crystals. $HgBr_2 \cdot 3HgO$, mw: 1010.27.
THR = HIGH. See mercury compounds, inorganic and bromides.

**MERCURIC OXYCHLORIDE.** Hexagonal yellow crystals. $HgCl_2 \cdot 3HgO$, mw: 921.35, mp: decomp @ 260°, d: 7.93.
THR = HIGH. See mercury compounds, inorganic and chlorides.

**MERCURIC OXYCYANIDE.** See mercuric cyanide oxide.

**MERCURIC OXYFLUORIDE.** Yellow crystals. $HgF_2 \cdot HgO \cdot H_2O$, mw: 473.24, mp: decomp @ 100°.
THR = HIGH. See fluorides and mercury compounds, inorganic.

**MERCURIC OXYIODIDE.** Yellow-brown crystals. $HgI_2 \cdot 3HgO$, mw: 1104.28.
THR = HIGH. See mercury compounds, inorganic, and iodides.

**MERCURIC PERCHLORATE.** Colorless deliquescent crystals. $Hg(ClO_4)_2 \cdot 6H_2O$, mw: 507.62.
THR = HIGH. See mercury compounds, inorganic, and perchlorates.

**MERCURIC PHENATE.** Syn: *mercury carbolate.* Gray or reddish-gray powder, nearly insol in water. $Hg(C_6H_5O)_2$, mw: 386.8.
THR = HIGH. See mercury compounds, organic.

**MERCURIC PHENYL CYANAMIDE.** Powder. $C_6H_5HgNCNH$, mw: 318.8.
THR = HIGH. See mercury compounds, organic, and cyanides.



18

**MERCURIC PHENYL MERCAPTIDE.** Light yellow crystals, insol in water. $(C_6H_5S)_2Hg$, mw: 418.9, mp: 153° (decomp).
THR = HIGH. See mercury compounds, organic.

**MERCURIC PHOSPHATE.** Syn: *mercuri-o-phosphate.* Heavy white or yellowish powder. $Hg_3(PO_4)_2$, mw: 791.87.
THR = HIGH. See mercury compounds, inorganic.

**MERCURIC-o-PHOSPHATE.** See mercuric phosphate.

**MERCURIC POTASSIUM CYANIDE.** Colorless crystals. $Hg(CN)_2 \cdot 2KCN$, mw: 382.85.
THR = HIGH. See cyanides and mercury compounds, organic.
Fire Hazard: See cyanides.
Disaster Hazard: Dangerous; when heated to decomp, or on contact with acid or acid fumes, emits highly toxic fumes of cyanides and mercury; will react with water or steam to produce toxic and flam vapors.
Explosion Hazard: See cyanides.

**MERCURIC POTASSIUM IODIDE.** Heavy, bright orange-red to yellow powder. $HgI_2 \cdot 2KI$, mw: 786.4.
Acute tox data: Dermal $LD_{LO}$ (guinea pig) = 1000 mg/kg; ip$LD_{LO}$ (guinea pig) = 1000 mg/kg. [*3*]
THR = MOD via ip and dermal routes. See mercury compounds, inorganic, and iodides. A poison.

**MERCURIC POTASSIUM THIOSULFATE.** White powder. $HgS_2O_3K_2S_2O_3$, mw: 503.1.
THR = HIGH. See mercury compounds, inorganic, and sulfates.

**MERCURIC RESORCINOL ACETATE.** Syn: *resorcinol mercury acetate.* Contains approx 69% mercury, yellow crystalline powder, insol in water, sol in hot glacial acetic acid and solutions of fixed alkali hydroxides.
THR = HIGH. See mercury compounds, organic.

**MERCURIC SALICYLATE.** Syn: *mercury subsalicylate.* White to yellowish powder. $C_7H_4O_3Hg$, mw: 336.7.
THR = HIGH. See mercury compounds, organic.

**MERCURIC SELENIDE.** Syn: *tiemannite.* Gray plates. HgSe, mw: 279.57, mp: sublimes, d: 8.21.
THR = HIGH toxicity. See mercury compounds, inorganic. See also selenium.
Fire Hazard: This material readily liberates hydrogen selenide upon contact with acids or moisture.
Disaster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of mercury and selenium; will react with water, steam or acid to produce toxic fumes; can react with oxidizing materials.

**MERCURIC SESQUIIODIDE.** See mercury compounds, inorganic, and iodides.

**MERCURIC SILVER IODIDE.** Deep yellow powder. $HgI_2 \cdot 2AgI$, mw: 924.1.
THR = HIGH. See mercury compounds, inorganic, silver and iodides.

**MERCURIC STEARATE.** Yellowish granular powder. $(C_{18}H_{35}O_2)_2Hg$, mw: 767.5.
THR = HIGH toxicity. See mercury compounds, organic.

**MERCURIC SUBSULFATE.** Lemon yellow powder. $HgSO_4 \cdot 2HgO$, mw: 729.90, bp: volatilizes, d: 6.44, vap. d: 25.2.
THR = HIGH. See mercury compounds, inorganic, and sulfates.

**MERCURIC SUCCINATE.** White to yellowish crystalline powder, slightly sol in water, sol in aqueous sodium chloride. $Hg(CH_2COO)_2$, mw: 316.68.
THR = HIGH. See mercury compounds, organic.

**MERCURIC SULFATE.** White crystalline powder. $HgSO_4$, mw: 296.67, mp: decomp, d: 6.47.
Acute tox data: Oral $LD_{50}$ (rat) = 57 mg/kg; oral $LD_{50}$ (mouse) = 40 mg/kg. [*3*]
THR = HIGH via oral route. See mercury compounds, inorganic, and sulfates. Absorption of HCl can become violent @ 125°. [*19*]

**MERCURIC SULFIDE, BLACK.** Syn: *metacinnabarite.* Black powder. HgS, mw: 232.67, mp: 583.5°, d: 7.73.
THR = HIGH. See mercury compounds, inorganic, and sulfides. Can react violently with $Cl_2$, ClO, $Ag_2O$. [*19*]

**MERCURIC SULFIDE, RED.** Syns: *cinnabar, vermillion.* Hexagonal red crystals or powder. HgS, mw: 232.68, vap. d: 8.0, mp: sublimes @ 583.5°, d: 8.10.
THR = HIGH. See mercury compounds, inorganic, and sulfides. See also mercuric sulfide, black.

**MERCURIC SULFOCYANATE.** Syns: *mercury rhodanide, mercuric thiocyanate.* White powder. $Hg(SCN)_2$, mw: 316.77, mp: decomp.
THR = HIGH. See mercury compounds, organic and cyanates.

**MERCURIC TELLURATE.** Amber cubic crystals. $Hg_3TeO_6$, mw: 825.44.
THR = HIGH. See mercury compounds, inorganic and tellurium.

**MERCURIC THALLIUM IODIDE.** Red crystalline lumps. $HgI_2 \cdot TlI$, mw: 708.9.
THR = HIGH. See mercury compounds, inorganic, and thallium.

**MERCURIC THIOCYANATE.** See mercuric sulfocyanate.



19

**MERCURIC THYMOLATE.** Yellowish gray powder, variable composition.
THR = HIGH. See mercury compounds, organic.

**MERCURIC THYMOL NITRATE.** Amorphous, white to reddish-white powder.
THR = HIGH. See mercury compounds, organic and nitrates.

**MERCURIC THYMOLSALICYLATE.** White to reddish powder.
THR = HIGH. See mercury compounds, organic.

**MERCURIC THYMOLSULFATE.** White to reddish-white powder.
THR = HIGH. See mercury compounds, organic.

**MERCURIC TUNGSTATE.** Yellow crystals. $HgWO_4$, mw: 448.53, mp: decomp.
THR = HIGH. See mercury compounds, inorganic.

**MERCURIC ZINC ACETATE.** White crystals. $Hg(C_2H_3O_2)_2 + Zn(C_2H_3O_2)_2$.
THR = HIGH. See mercury compounds, organic.

**MERCURIC ZINC CYANIDE.** White powder, a mixture of zinc cyanide with varying quantities of mercuric cyanide. Water dissolves the mercuric cyanide.
THR = HIGH. See mercury compounds and cyanides.

**MERCURIC PHENYL ACETATE.** See phenyl mercuric acetate.

**"MERCUROCHROME."** Syn: *merbromin.*
$C_{20}H_8Br_2HgNa_2O_6 \cdot 3H_2O$, mw: 804.4.
Acute tox data: ivLD$_{50}$ (rabbit) = 15 mg/kg. [*3*]
THR = HIGH via iv and oral routes. Relatively nonirr and nontoxic to damaged skin or tissue. An antiseptic. See mercury compounds, organic.

**MERCUROL, SOLID.** Colorless to brownish powder. Contains 20% mercury.
THR = HIGH. See mercury compounds, organic.

**"MERCUROSAL."** Syn: *disodium hydroxymercury salicyloxyacetate.* White amorphous powder. $(HOHg)NaOOCC_6H_3OCH_2COONa$, mw: 456.69.
THR = HIGH. See mercury compounds, organic.

**MERCUROUS ACETATE.** Colorless scales or plates. $Hg(C_2H_3O_2)$, mw: 259.7, mp: decomp.
THR = See mercury compounds, organic.

**MERCUROUS ARSENITE.** Unstable brown powder.
THR = HIGH. See mercury compounds, inorganic, and arsenic.

**MERCUROUS AZIDE.** White crystals. $HgN_3$, 242.6, mp: explodes @ 210°.
THR = HIGH. See mercury compounds, inorganic, and azides. A sensitive explosive.

**MERCUROUS BROMATE.** Crystals. $Hg_2(BrO_3)_2$, mw 657.06, mp: decomp.
THR = See mercury compounds, inorganic, and bromates.

**MERCUROUS BROMIDE.** Tetragonal, white-yellow crystals. $Hg_2Br_2$, mw: 561.07, mp: sublimes @ 345°, d 7.307, vap. d: 19.3.
THR = See mercury compounds, inorganic, and bromides.

**MERCUROUS CARBONATE.** Yellow-brown crystals $Hg_2CO_3$, mw: 461.23, mp: decomp @ 130°, d: 5.07 @ 218°.
THR = See mercury compounds, inorganic.

**MERCUROUS CHLORATE.** White crystals. $HgClO_3$ mw: 284.1, mp: decomp @ 250°, d: 6.409.
THR = See mercury compounds, inorganic, and chlorates.

**MERCUROUS CHLORIDE.** Syn: *calomel.* White rhombic crystals or crystalline powder. $Hg_2Cl_2$, mw: 472.14, mp: sublimes @ 400°, d: 7.150.
Acute tox data: Oral LD$_{50}$ (rat) = 210 mg/kg. [*3*]
THR = HIGH via oral route. See mercury compounds, inorganic, and chlorides. Violent reaction with K, Na. [*19*]

**MERCUROUS CHROMATE.** Red needles or powder. $Hg_2CrO_4$, mw: 517.23, mp: decomp.
THR = HIGH. See mercury compounds, inorganic, and chromates.
Fire Hazard: Mod, by chemical reaction; an oxidizer.
Disaster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of mercury; can react with reducing materials.

**MERCUROUS FLUORACETYLIDE.** FCCHg, mw: 243.6.
THR = HIGH. See mercury compounds and fluorides. It is unstable and may explode.

**MERCUROUS FLUORIDE.** Cubic yellow crystals. $Hg_2F_2$, mw: 439.22, mp: 570°, d: 8.73.
THR = See fluorides and mercury compounds, inorganic.

**MERCUROUS FLUOSILICATE.** Colorless prisms. $Hg_2SiF_6 \cdot 2H_2O$, mw: 579.31.
THR = See mercury compounds, inorganic, and fluosilicates.

**MERCUROUS FORMATE.** Glistening scales. $Hg_2(CHO_2)_2$, mw: 491.26, mp: decomp.
THR = See mercury compounds, organic.

**MERCUROUS GLUCONATE.** White solid. $HgCO_2C_5H_6(OH)_5$, mw: 395.8.
THR = See mercury compounds, organic.



20

**MERCUROUS HYPOPHOSPHATE.** $Hg_4P_2O_6$, mw: 960.3.
THR = HIGH. See mercury compounds. Unstable. Decomp explosively. [*19*]

**MERCUROUS IODATE.** Yellowish crystals. $Hg_2(IO_3)_2$, mw: 751.06, mp: decomp.
THR = See mercury compounds, inorganic, and iodates.

**MERCUROUS IODIDE.** Yellow tetragonal crystals or amorphous powder. HgI, mw: 327.50, mp: sublimes @ 140°, bp: decomp @ 290°, d: 7.70.
Acute tox data: Oral $LD_{50}$ (mouse) = 110 mg/kg; ip$LD_{50}$ (mouse) = 50 mg/kg. [*3*]
THR = HIGH via oral and ip routes. See mercury compounds, inorganic, and iodides.

**MERCUROUS MONOHYDROGEN-*o*-ARSENATE.** Yellow-red crystals. $Hg_2HAsO_4$, mw: 541.14.
THR = HIGH. See arsenic compounds and mercury compounds, inorganic.

**MERCUROUS NITRATE.** Short, colorless, efflorescent crystals. $Hg_2(NO_3)_2 \cdot 2H_2O$, mw: 561.26, mp: 70°, d: 4.79 @ 4°.
Acute tox data: Oral $LD_{50}$ (rat) = 297 mg/kg; oral $LD_{50}$ (mouse) = 388 mg/kg; ip$LD_{50}$ (mouse) = 5 mg/kg. [*3*]
THR = HIGH via oral and ip routes. See mercury compounds, inorganic, and nitrates. Violent reaction with C, P. [*19*]

**MERCUROUS NITRATE, AMMONIATED.** Syn: *black precipitate*. Black powder, $Hg_2ONH_2 \cdot Hg_2(NO_3)_2$, mw: 958.4.
THR = See mercury compounds, inorganic, and nitrates.

**MERCUROUS NITRITE.** Yellow crystals. $Hg_2(NO_2)_2$, mw: 493.24, mp: decomp @ 100°, d: 7.33.
THR = HIGH. See mercury compounds, inorganic, and nitrites.

**MERCUROUS OXALATE.** White crystals. $Hg_2C_2O_4$, mw: 489.24.
THR = See oxalates and mercury compounds, organic.

**MERCUROUS OXIDE, BLACK.** Black to grayish-black powder. $Hg_2O$, mw: 417.22, mp: decomp @ 100°, d: 9.8.
THR = HIGH. See mercury compounds, inorganic.
Fire Hazard: Mod, by chemical reaction; an oxidizer. Reacts violently with $H_2O_2$, K, Na, S, ($H_2S$ + BaO + air). [*19*]
Disaster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of mercury; can react with reducing materials.

**MERCUROUS PHOSPHATE.** Heavy white powder. $Hg_3PO_4$, mw: 696.85.
THR = See mercury compounds, inorganic.

**MERCUROUS SULFATE.** White crystalline powder. $Hg_2SO_4$, mw: 497.28, mp: decomp, d: 7.56.
THR = See mercury compounds, inorganic, and sulfates.

**MERCUROUS SULFIDE.** Black crystals. $Hg_2S$, mw: 433.24, mp: decomp.
THR = See mercury compounds, inorganic, and sulfides.

**MERCUROUS TARTRATE.** Yellowish-white crystalline powder. $Hg_2C_4H_4O_6$, mw: 549.29.
THR = See mercury compounds, organic.

**MERCURY.** Silvery liquid, metallic element. Hg, atwt: 200.7, mp: −38.89°, bp: 356.9°, d: 13.546, vap. press: 1 mm @ 126.2°.
Acute tox data: Oral $LD_{LO}$ (human) = 1429 mg/kg; inhal $TC_{LO}$ (human) = 0.17 mg/m$^3$ for 40 yrs ⟶ CNS problems; ivT$D_{LO}$ (human) = 29 mg/kg; ⟶ GI symptoms. [*3*]
THR = HIGH to CNS, GI tract. See mercury compounds. An exper neo. [*3*] Reacts violently with acetylene, $NH_3$, $BPI_2$, $Cl_2$, $ClO_2$, $CH_3N_3$, $Na_2C_2$, nitromethane (butyne diol + acid). [*19*]
Radiation Hazard: For permissible levels, see Section 5, Table 5A.5. Artificial isotope $^{203}$Hg, $T_{\frac{1}{2}}$ = 47d. Decays to stable $^{203}$Tl by emitting $\beta$'s of 0.21 MeV. Emits $\gamma$'s of 0.28 MeV.
Disaster Hazard: Dangerous; when heated emits highly toxic fumes.

**MERCURY ACETAMIDE.** White powder. $CH_3CONHg$, mw: 257.7.
THR = HIGH. See mercury compounds, organic.

**MERCURY ACETATE.** See mercurous acetate or mercuric acetate.

**MERCURY ALANINE.** See mercury-$\alpha$-aminopropionate.

**MERCURY-*p*-AMINOPHENOL ARSENATE.** See mercury atoxylate.

**MERCURY-$\alpha$-AMINOPROPIONATE.** Syn: *mercury alanine*. White crystals, water-sol. $Hg[CH_3CH(NH_2)COO]_2$, mw: 374.8.
THR = HIGH. See mercury compounds, organic.

**MERCURY, AMMONIATED.** See mercuric ammonium chloride.

**MERCURY ANTIMONY SULFIDE.** Gray-black powder. Mixture of equal parts of black mercury sulfide and gray antimony sulfide.
THR = See mercury compounds, antimony and sulfides.

**MERCURY ARC RADIATION.** A recog carc. [*14*] See radiation, ultra-violet.

**MERCURY ATOXYLATE.** Syn: *mercury-p-aminophenol arsenate.* White powder. $C_{12}H_{14}O_4N_2As_2Hg$, mw: 632.71.

THR = HIGH. See arsenic compounds and mercury compounds, organic.

**MERCURY BENZAMIDE.** White powder. $C_6H_5CONHg$, mw: 319.7.

THR = HIGH. See mercury compounds, organic.

**MERCURY BISULFATE.** See mercuric sulfate.

**MERCURY CARBOLATE.** See mercuric phenate.

**MERCURY COLLOIDAL.** See mercury.

**MERCURY COMPOUNDS, INORGANIC.**

THR = Mercury is a general protoplasmic poison; after absorption it circulates in the blood and is stored in the liver, kidneys, spleen and bone. It is eliminated in the urine, feces, sweat, saliva and milk. In industrial poisoning, the chief effect is upon the CNS and upon the mouth and gums. Colitis has been reported frequently; a nephritis or nephrosis is rarely reported. Fulminate of mercury rarely produces symptoms of systemic poisoning, but frequently causes a dermatitis. The cardinal symptoms of industrial mercury poisoning are stomatitis, tremors, and psychic disturbances. Usually the first complaints are of excessive salivation and pain on chewing; in severe cases there may be gingivitis, with loosening of the teeth, and a dark line on the gum margins, resembling the "lead line." In slow poisoning the salivation may be absent, and the only complaint dryness of the throat and mouth. Tremor and psychic disturbances are commonly seen in the slow chronic form of the poisoning; the tremor is of the intention type, and may be seen when the patient spreads the outstretched fingers or protrudes the tongue, or attempts to perform specified movements. Muscles of the face, hands and arms are chiefly affected. In more severe cases there may also be convulsive or shaking movements; writing is frequently illegible. Hyperactive kneejerks and scanning speech may be present in advanced cases. The psychic disturbance (so called "erethism") includes such changes as loss of memory, insomnia, lack of confidence, irritability, vague fears and depression.

The dermatitis produced by fulminate of mercury takes the form of small, discrete ulcers on the exposed parts, and is usually accompanied by conjunctivitis and inflammation of the mu mem of the nose and throat.

Elemental mercury is probably not absorbed through the gastrointestinal tract, but many mercury compounds are. A number of mercury compounds, in addition to the fulminate, can cause skin irr and can be absorbed through the skin; they are strong allergens (Section 9).

These are common air contaminants.

Disaster Hazard: Dangerous; when heated to decomp they emit highly toxic fumes of mercury.

**MERCURY COMPOUNDS, N.O.S. LIQUID.** See mercury compounds, inorganic and organic.

**MERCURY COMPOUNDS, N.O.S. SOLID.** See mercury compounds, inorganic and organic.

**MERCURY COMPOUNDS, ORGANIC.**

THR = The customary grouping of all organic mercurials in a single category is not fully justified by the toxicity of the compounds. Alkyl mercurials have very high toxicity, aryl compounds, particularly the phenyls, are much less toxic, and the organomercurials used in therapeutics are less toxic. The alkyls and aryls commonly cause skin burns and other forms of irr, and both can be absorbed through the skin. Fatal poisoning has occurred due to exposure to alkyl mercurials and permanent damage to the brain has been reported. Extensive human observation on exposure to the phenyl mercurials have shown no greater toxicity than is caused by metallic mercury. In fact, up to the present time there has not been an authenticated case of occupational poisoning due to the phenyl mercurials reported in the literature. Organic mercury compounds, like organic lead compounds, seem to have an affinity for lipoid-containing organs, resulting in CNS disturbances such as from tetraethyl lead. These are common air contaminants.

Disaster Hazard: Dangerous; when heated to decomp, they emit highly toxic fumes of mercury.

**MERCURY CYANIDE.** See mercuric cyanide.

**MERCURY ETHYLENE DIAMINE SULFATE.** See sublamin.

**MERCURY FULMINATE, MERCURIC FULMINATE.** See fulminate of mercury, dry.

**MERCURY MORPHINE OLEATE.** An oleaginous mass.

THR = See mercury compounds, organic, and morphine.

**MERCURY NAPHTHENATE.** White crystals; syn: *dinaphthyl mercury*, mw: 454.9, d: 1.929, bp: 249°, mp: 188°.

THR = See mercury compounds, organic.

**MERCURY-β-NAPHTHOL.** See mercuric naphtholate.

**MERCURY NITRIDE.** Brown powder. $Hg_3N_2$, mw: 629.85, mp: explodes.
THR = HIGH. See mercury compounds, inorganic.
Explosion Hazard: Severe, when exposed to heat.
Disaster Hazard: Dangerous; when heated to decomp, emits highly toxic fumes of mercury and may explode.

**MERCURY NUCLEATE.** See mercurol, solid.

**MERCURY OLEATE.** See mercuric oleate.

**MERCURY RHODANIDE.** See mercuric sulfocyanate.

**MERCURY SUBSALICYLATE.** See mercuric salicylate.

**MERCURY TETRAPHOSPHIDE.** $Hg_3P_4$, mw: 725.8.
THR = HIGH toxicity, See mercury compounds and phosphides. Ignites if warmed in air. Burns in $Cl_2$. With $KClO_3$ it explodes by percussion. [*19*]

**MERCURY SUBSALICYLATE.** See mercuric salicylate.

**MESCALINE.** $C_{11}H_{17}O_3N$, mw: 211.3.
Acute tox data: Oral $TD_{LO}$ (human) = 5 mg/kg ⟶ CNS effects; iv$TD_{LO}$ (human) = 7 mg/kg ⟶ CNS effects; im$TD_{LO}$ (human) = 214 mg/kg ⟶ CNS effects; oral $LD_{50}$ (mouse) = 880 mg/kg. [*3*]
THR = HIGH via oral, iv, im routes. An exper teratogen. [*3*]

**MESIDINE.** Syn: *2,4,6-trimethyl aniline, mesityl amine.* $C_9H_{13}N$, mw: 135.2.
Acute tox data: oral $LD_{50}$ (rat) = 743 mg/kg; $LD_{50}$ (mouse) = 372 mg/kg; $LD_{50}$ (rabbit) = 338 mg/kg; $LD_{50}$ (guinea pig) = 338 mg/kg. [*3*]
THR = HIGH to most species. An exper neo to rats via oral route. [*103*]

**MESITYLENE.** Syn: *1,3,5-trimethylbenzene.* Liquid, peculiar odor, insol in water, sol in alcohol and benzene. $C_9H_{12}$, mw: 120.2, mp: −44.8°, d: 0.8637 @ 20°/4°, bp: 164.7°, autoign. temp.: 1022°F.
Acute tox data: Inhal $LC_{LO}$ (rat) = 2400 ppm for 24 hrs; ip$LD_{LO}$ (rat) = 1500 mg/kg; inhal $TC_{LO}$ (human) = 10 ppm ⟶ CNS effects. [*3*]
THR = MOD via ip and inhal routes. Causes CNS disturbances. Data based on animal exper show narcotic effects and some disturbances of blood. Leucopenia and thrombocytopenia have been reported in exper animals. Reacts violently with $NHO_3$. [*19*]
Fire Hazard: Mod, via heat, flames, oxidizers.
To Fight Fire: Water spray, fog, foam, $CO_2$.

**MESITYL OXIDE.** Syn: *4-methyl-3-penten-2-one.* Oily colorless liquid, strong odor. $(CH_3)_2CCHCOCH_3$, mw: 98.14, mp: −59°, bp: 130.0°, flash p: 87°F (CC), d: 0.8539 @ 20°/4°, autoign. temp.: 652°F, vap. press: 10 mm @ 26.0°, vap. d: 3.38.
Acute tox data: Oral $LD_{50}$ (rat) = 1120 mg/kg; inhal $LC_{LO}$ (rat) = 1000 ppm for 4 hrs; ip$LD_{50}$ (mouse) = 354 mg/kg; dermal $LD_{50}$ (rabbit) = 5990 mg/kg. [*3*]
THR = MOD via oral, inhal and dermal routes; HIGH via ip route. It can cause opaque cornea, keratoconus, and extensive necrosis of cornea. Guinea pigs and rats were subject to repeated inhal of the vapors of this material. No effect upon them was found after the conc had been reduced to 50 ppm even with 30 8-hr exposures. Single exposures tend to indicate that this ketone has greater acute and narcotic action than isophorone. It can have harmful effects upon the kidneys and liver, and may damage the eyes and lungs to a serious degree. Animals exposed to 100 ppm for 30 8-hr exposures showed internal damage as noted above. Exposure to 500 ppm caused their death. This compound is high irr to all tissues on contact and its vapors also are irr. High conc are narcotic. Prolonged exposure can injure liver, kidneys and lungs. It is readily absorbed through intact skin.
Fire Hazard: Dangerous, when exposed to heat or flame; can react with oxidizing materials. Reacts violently with 2-amino ethanol, chlorosulfonic acid, ethylene diamine, $HNO_3$, oleum, $H_2SO_4$. [*19*]
To Fight Fire: Alcohol foam, $CO_2$, dry chemical.

**MESTRANOL + ETHYNODIOL DIACETATE.**
THR = An exper neo to women via oral route. [*103*]

**METABOLISM OF TOXIC MATERIALS.** See Section 9.

**METABORATE PEROXYHYDRATE.** See sodium perborate.

**METACETONE.** See diethyl ketone.

**METACIDE.** See parathion.

**METACINNABARITE.** See mercuric sulfide, black.

**METALDEHYDE.** Syns: *m-acetaldehyde, polymerized acetaldehyde.* Colorless crystals. $(C_2H_4O)_4$, mw: 176.21, mp: 246° sealed in glass, sublimes @ 122°, flash p: 97°F (CC), vap. d: 6.06.
Acute tox data: Oral $LD_{50}$ (rat) = 630 mg/kg; oral $LD_{50}$ (dog) = 600 mg/kg; oral $LD_{LO}$ (human) = 60 mg/kg. [*2, 3*]
THR = HIGH via oral to humans; MOD via oral to test animals. An irr to skin, eyes and mu mem. Can cause kidney and liver damage. See also acetaldehyde. Used as a food additive permitted in food for human consumption. [*109*]
Fire Hazard: Dangerous, when exposed to heat or flame; can react with oxidizing materials.



23

# HAZARDOUS AND TOXIC EFFECTS OF INDUSTRIAL CHEMICALS

Marshall Sittig

NOYES DATA CORPORATION
Park Ridge, New Jersey, U.S.A.
1979

and kidney functions. Blood studies may be helpful in following acute intoxication from methyl mercaptan.

**Special Tests:** None commonly used.

**Personal Protective Methods:** In areas where liquid mercaptan is likely to be spilled or splashed on the skin, impervious clothing, gloves, gauntlets, aprons, and boots should be supplied. Otherwise protective methods are as for sulfur dioxide. (See Sulfur Dioxide.)

### Bibliography

Blinova, E.A. 1965. O normirovanii konstentratsii veshchestvs s sil'nym zapakhom v vozdukhe proizvodstvennykh pom eshchenit. *Gig. Sanit.* 30:18.

Fairchild, E.J., Stokinger, H.E. 1958. Toxicologic studies on organic sulfur compounds. 1. Acute toxicity of some aliphatic and aromatic thiols (mercaptans). *Am. Ind. Hyg. Assoc. J.* 19:171.

Gobbato, F., and Terribile, P.M. 1968. Toxicologic properties of mercaptans. *Folia Medica (Napoli)* 51:329.

Schults, W.T., Fountain, E.N., and Lynch, E.C. 1970. Methanethiol poisoning. *J. Am. Med. Assoc.* 211:2153.

## MERCURY—ALKYL

**Description:** Methyl mercury compounds: methyl mercury dicyandiamide—$CH_3HgNHC(NH)NHCN$. Soluble in water.

Ethyl mercury compounds: ethylmercuric chloride: $C_2H_5HgCl$. Insoluble in water. Ethylmercuric phosphate: $(C_2H_5HgO)_3PO$. Soluble in water. N-(Ethylmercuric)-p-toluenesulfonanilide: $C_6H_5N(HgC_2H_5)SO_2C_6H_4CH_3$. Practically insoluble in water.

### Synonyms

Methyl mercury compounds

Methyl mercury dicyandiamide: cyano (methyl mercury) guanidine, Panogen.

Ethyl Mercury compounds

Ethylmercuric chloride: Ceresan.
Ethylmercuric phosphate: New Ceresan.
N-(Ethylmercuric)-p-toluenesulfonanilide: Ceresan M.

**Potential Occupational Exposures:** These compounds are used in treating seeds for fungi and seedborne diseases, as timber preservatives, and disinfectants.

25

A partial list of occupations in which exposure may occur includes:

| | |
|---|---|
| Disinfectant makers | Seed handlers |
| Fungicide makers | Wood preservers |

**Permissible Exposure Limits:** The Federal standard is 0.01 mg/m$^3$ as an 8-hour TWA with an acceptable ceiling of 0.04 mg/m$^3$.

**Routes of Entry:** Inhalation of dust, percutaneous absorption.

**Harmful Effects**

*Local*—Alkyl mercury compounds are primary skin irritants and may cause dermatitis. When deposited on the skin, they give no warning, and if contact is maintained, can cause second-degree burns. Sensitization may occur.

*Systemic*—The central nervous system, including the brain, is the principal target tissue for this group of toxic compounds. Severe poisoning may produce irreversible brain damage resulting in loss of higher functions.

The effects of chronic poisoning with alkyl mercury compounds are progressive. In the early stages, there are fine tremors of the hands, and in some cases, of the face and arms. With continued exposure, tremors may become coarse and convulsive; scanning speech with moderate slurring and difficulty in pronunciation may also occur. The worker may then develop an unsteady gait of a spastic nature which can progress to severe ataxia of the arms and legs. Sensory disturbances including tunnel vision, blindness, and deafness are also common.

A later symptom, constriction of the visual fields, is rarely reversible and may be associated with loss of understanding and reason which makes the victim completely out of touch with his environment. Severe cerebral effects have been seen in infants born to mothers who had eaten large amounts of methyl mercury contamined fish.

**Medical Surveillance:** Preplacement and periodic physical examinations should be concerned particularly with the skin, vision, central nervous system, and kidneys. Consideration should be given to the possible effects on the fetus of alkyl mercury exposure in the mother. Constriction of visual fields may be a useful diagnostic sign. (See Mercury—Inorganic.)

**Special Tests:** Blood and urine levels of mercury have been studied, especially in the case of methyl mercury. A precise correlation has not been found between exposure levels and concentrations. They may be of some value in indicating that exposure has occurred, however.

**Personal Protective Methods:** (See Mercury—Inorganic.)

## Bibliography

Ahlmark, A. 1948. Poisoning by methyl mercury compounds. *Br. J. Ind. Med.* 5:119.
Kark, R.A.P., Poskanzer, D.C., Bullock, J.D., and Boylan, G. 1971. Mercury poisoning and its treatment with N-acetyl-d,1-penicillamine. *N. Engl. J. Med.* 285:10.
Lundgren, K.D., and Swensson, A. 1949. Occupational poisoning by alkyl mercury compounds. *J. Ind. Hyg. Toxicol.* 31:190.
Report of an International Committee. 1969. Maximum allowable concentrations of mercury compounds. *Arch. Environ. Health* 19:891.

## MERCURY—INORGANIC

**Description:** Hg, inorganic mercury, is here taken to include elemental mercury, inorganic mercury compounds, and organic mercury compounds, excluding alkyl mercury compounds. Metallic mercury is a silver-white liquid at room temperature. It occurs as the free metal or as cinnabar (HgS). Mercury is produced from the ore by roasting or reduction.

**Synonyms:** Quicksilver, hydrargyrum.

**Potential Occupational Exposures:** Elemental and inorganic mercury compounds are used in the manufacture of scientific instruments (barometers, thermometers, etc.), electric equipment (meters, switches, batteries, rectifiers, etc.), mercury vapor lamps, incandescent electric lamps, x-ray tubes, artificial silk, radio valves, amalgams with copper, tin, silver, or gold, and solders with lead and tin. In the chemical industry, it is used as a fluid cathode for the electrolytic production of caustic soda (sodium hydroxide), chlorine, and acetic acid. It is utilized in gold, silver, bronze, and tin plating, tanning and dyeing, feltmaking, taxidermy, textile manufacture, photography and photoengraving, in extracting gold and silver from ores, in paints and pigments, in the preparation of drugs and disinfectants in the pharmaceutical industry, and as a chemical reagent.

The aryl mercury compounds such as phenylmercury are primarily used as disinfectants, fungicides for treating seeds, antiseptics, herbicides, preservatives, mildew-proofing agents, denaturants for ethyl alcohol, germicides, and bactericides.

Hazardous exposure may occur during mining and extraction of mercury and in the use of mercury and its compounds. Elemental mercury readily volatilizes at room temperature.

A partial list of occupations in which exposure may occur includes:

| | |
|---|---|
| Amalgam makers | Caustic soda makers |
| Bactericide makers | Dental amalgam makers |
| Battery makers | Fungicide makers |

Gold extractors
Jewelers
Paper makers
Photographers
Taxidermists

It is estimated that approximately 150,000 workers are exposed to mercury.

**Permissible Exposure Limits:** The Federal standard for mercury is 0.1 mg/m$^3$ as a ceiling value. The NIOSH recommended standard is 0.05 mg Hg/m$^3$ as a TWA. ACGIH (1978) concurs in this value.

**Routes of Entry:** Inhalation of dust or vapor; percutaneous absorption of elemental mercury.

**Harmful Effects**

*Local*—Mercury is a primary irritant of skin and mucous membranes. It may occasionally be a skin sensitizer.

*Systemic*— Acute poisoning due to mercury vapors affects the lungs primarily, in the form of acute interstitial pneumonitis, bronchitis, and bronchiolitis.

Exposure to lower levels over prolonged periods produces symptom complexes that can vary widely from individual to individual. These may include weakness, fatigability, loss of appetite, loss of weight, insomnia, indigestion, diarrhea, metallic taste in the mouth, increased salivation, soreness of mouth or throat, inflammation of gums, black line on the gums, loosening of teeth, irritability, loss of memory, and tremors of fingers, eyelids, lips, or tongue. More extensive exposures, either by daily exposures or one-time, can produce extreme irritability, excitability, anxiety, delirium with hallucinations, melancholia, or manic depressive psychosis. In general, chronic exposure produces four classical signs: gingivitis, sialorrhea, increased irritability, and muscular tremors. Rarely are all four seen together in an individual case.

Either acute or chronic exposure may produce permanent changes to affected organs and organ systems.

**Medical Surveillance:** Preemployment and periodic examinations should be concerned especially with the skin, respiratory tract, central nervous system, and kidneys. The urine should be examined and urinary mercury levels determined periodically. Signs of weight loss, gingivitis, tremors, personality changes, and insomnia would be suggestions of possible mercury intoxication.

**Special Tests:** Urine mercury determination may be helpful as an index of amount of absorption. Opinions vary as to the significance of a given level. Generally, 0.1 to 0.5 mg Hg/l of urine is considered significant.

**Personal Protective Methods:** In areas where the exposures are excessive, respiratory protection shall be provided either by full face canister type mask

or supplied air respirator, depending on the concentration of mercury fumes. Above 50 mg Hg/m$^3$ requires supplied air positive pressure full face respirators. Full body work clothes including shoes or shoe covers and hats should be supplied, and clean work clothes should be supplied daily. Showers should be available and all employees encouraged to shower prior to change to street clothes. Work clothes should not be stored with street clothes in the same locker. Food should not be eaten in the work area.

**Bibliography**

National Institute for Occupational Safety and Health. *Criteria for a Recommended Standard: Occupational Exposure to Inorganic Mercury.* NIOSH Doc. No. 73-11024 (1973).

## MESITYL OXIDE (See "Ketones")

## METHYL ALCOHOL

**Description:** $CH_3OH$, methyl alcohol, is a colorless, volatile liquid with a mild odor.

**Synonyms:** Methanol, carbinol, wood alcohol, wood spirit.

**Potential Occupational Exposures:** Methyl alcohol is used as a starting material in organic synthesis of chemicals such as formaldehyde, methacrylates, methyl amines, methyl halides, and ethylene glycol, and as an industrial solvent for inks, resins, adhesives, and dyes for straw hats. It is an ingredient in paint and varnish removers, cleaning and dewaxing preparations, spirit duplicating fluids, embalming fluids, antifreeze mixtures, and enamels and is used in the manufacture of photographic film, plastics, celluloid, textile soaps, wood stains, coated fabrics, shatterproof glass, paper coating, waterproofing formulations, artificial leather, and synthetic indigo and other dyes. It has also found use as an extractant in many processes, an antidetonant fuel-injection fluid for aircraft, a rubber accelerator, and a denaturant for ethyl alcohol.

A partial list of occupations in which exposures may occur includes:

| | |
|---|---|
| Acetic acid makers | Ester makers |
| Art glass workers | Feather workers |
| Bookbinders | Felt hat makers |
| Bronzers | Foundry workers |
| Dyers | Gilders |
| Enamel makers | Ink makers |

29

~~3. Recommendations~~

~~60. It is recommended that:~~

~~(a) The primary source of lead pollution is the combustion of alkyllead fuel additives in motor vehicles. Because of the adverse effects of lead on the mental health of urban children, it is urgently recommended that alkyllead fuel additives are progressively phased out;~~

~~(b) Acceptable alternatives to the use of alkyllead fuel additives should be developed;~~

~~(c) There is a need for greater control of emissions and occupational exposure during secondary lead recovery operations.~~

## E. MERCURY

### 1. Global impact

61. Mercury is a trace metal which is found naturally throughout the environment. The volatility of mercury has made estimations of its natural biogeochemical cycle difficult to model, and estimates of the proportion of man-made mercury in the mercury content of the atmosphere range from 10 to 80 per cent. Current estimates of the natural and man-made flux of mercury throughout the environment should therefore be regarded as tentative. Man-made emissions, estimated by the United States National Academy of Sciences to be about 10,000 t $y^{-1}$, compared with a natural flux estimate of about 27,000 t y, are mainly from fossil fuel combustion, chloralkali works and metal smelting. The world production of mercury metal reached a peak of 10,577 t in 1971, and had fallen to 6,622 t in 1980. Mercury is used mainly as an electrode in chlorine gas manufacture; other uses include electrical equipment, pigments, agrochemicals, catalysts and pulp/paper making. However, its main input to the general environment will increasingly be due to fossil fuel consumption.

### 2. Threat to man and environment

62. The discharge of mercury in liquid effluents is of particular concern, in freshwater and marine sediments inorganic mercury compounds can be methylated by bacteria to produce methylmercury, which can bioaccumulate to a considerable extent in fish and so result in dietary exposure for man. Fish consumption is the primary source of dietary mercury in the general population, whose range of daily intake of mercury is from 1 - 20 µg. The provisional tolerable weekly intake of total mercury is 300 µg, of which no more than 200 µg should be methylmercury.

63. Historically, the problem of mercury poisoning has been associated either with consumption of treated seed grain or with consumption of fish from a locally highly polluted environment. The latter pollution has typically arisen from pulp and paper mills, where organomercurials have been used as slimicides, or in chloralkali plants, where mercury metal is used as an electrode. In some countries legislation has resulted in the cessation of these inputs. However, such applications still exist in many countries, and the problems could recur at any time.

64. Significant differences are observed in the metabolism of mercury depending on its chemical form. Inorganic and elemental mercury accumulate mainly in the kidneys, and to a lesser extent in the brain. Methylmercury can penetrate the blood-brain barrier, and both man and other primates concentrate methylmercury in the brain with exceptional efficiency. Elemental and organic mercury easily cross the placental barrier, and also enter maternal milk, contributing to the exposure of breast-fed infants. Ultimately, central nervous system dysfunction results, although the actual biochemical mechanisms of toxicity is uncertain. The damage persists even after exposure ceases, and no curative treatment is known.

65. There are two main populations of concern regarding mercury: workers who are occupationally exposed to mercury metal and vapour, and communities where fish represents a major food source. Available data on industrial exposure to mercury vapour indicate concentrations in the range of 10 - 100 $\mu g\ m^{-3}$. Much higher concentrations seem to be rare, at least in the larger industrial enterprises.

66. Intoxications caused by alkylmercury compounds have taken place in the general population on several occasions. These epidemics are of two main types; the first is characterized by the Iraqi outbreak (1971 - 1972), where the exposure was by consumption of bread prepared from seed grain dressed with methylor ethylmercury fungicides. Similar outbreaks are known to have occurred earlier in Iraq, Pakistan, Guatemala and Ghana. The other type of intoxication is that characterized by Minamata disease (first outbreak in 1953), caused by long-term consumption of fish highly contaminated with methylmercury. There is considerable discrepancy in the number of poisonings ascribed to Minamata disease at Minamata and Niigata, ranging from <200 to >1,600 cases. Other small human populations (several hundred people) in methylmercury-contaminated areas of Sweden, Peru, American Samoa, France, Canada and the Mediterranean, have been investigated, but evidence of methylmercury intoxication is not clear. Most fish species in the areas of concern have mercury concentrations in excess of 0.5 $\mu g\ g^{-1}$ wet weight. Blood mercury concentrations in some people were frequently close to the threshold concentrations of 20 - 50 $\mu g\ dl^{-1}$, and occasionally higher.

67. It is possible that environmental mercury poisoning will re-emerge as a problem in the near future, for quite a different reason. Three different phenomena could interact. First, concentrations of mercury found in certain apparently unpolluted environments may cause long-lived fish to bioaccumulate methylmercury to an extent where they may be only marginally safe for human consumption. Secondly, mercury is a significant contaminant of fossil fuels, the average concentration in coal being about 0.3 - 0.4 $\mu g\ g^{-1}$, and the mercury vapour resulting from combustion is difficult to remove from the flue gases. If fossil fuel consumption increases as rapidly as is predicted over the next decade or two, several thousands of tons of additional mercury will enter the atmosphere annually, increasing concentrations found everywhere. Thirdly, it is known that at higher acidity in aquatic systems (e.g., as caused by acid rain - see sect. G below, sulphur dioxide and derivatives), mercury is mobilized and becomes available for uptake by fish. Taken together,

these considerations suggest that, in some populations consuming large quantities of fish, methylmercury intoxication may emerge as a problem in the future.

68. Recognition of the health hazards of mercury in the environment has resulted in considerable improvements in occupational, ambient and emission standards for mercury. Environmental and food monitoring are in operation in many countries and at an international level. Excessive methylmercury exposure of certain groups in the general population has led to several thousand cases of poisoning, as a result either of accidental consumption of grain dressed with alkylmercury fungicides or of long-term consumption of highly contaminated fish. The extent and nature of the former is not global. The latter threat to human health may be of more concern in terms of dietary methylmercury exposure of the general population. It is possible that mercury poisoning may re-emerge as an environmental problem in the future as a result of fossil fuel combustion.

3. Recommendations

69. It is recommended that:

(a) Human populations that consume significant quantities of fish from mercury-contaminated waters should be monitored to provide early warning and make possible avoidance of further mercury poisoning incidents;

(b) Monitoring efforts should take into account the fact that mercury concentrations will be found to be elevated in environments with low pH;

(c) Mercury use in chloralkali plants and the pulp and paper industries should be progressively phased out where possible;

(d) Fossil fuels, notably coal, should be chosen wherever possible to have low concentrations of contaminants, particularly mercury.

## F. NITROGEN OXIDES AND PHOTOCHEMICAL OXIDANTS

1. Global impact

70. The estimated natural production of nitrogen oxides (NO and $N_2O$) is $990 \times 10^6$ t $y^{-1}$, mainly from volcanic emissions and bacterial activity. Man-made emissions of nitrogen oxides arise principally from the combustion of fossil fuels, producing an estimated $48 \times 10^6$ t $y^{-1}$. Man-made emissions of nitrogen dioxide and nitric oxide are generally referred to as $NO_x$. These are emitted by two main types of source - stationary sources such as power stations, industrial combustion, petroleum and metal refining, and mobile sources such as motor vehicles and aircraft. $NO_x$ can undergo various reactions in the atmosphere to form aerosols of nitric and nitrous acids, and nitrate and nitrite salts. Under certain conditions

United Nations Environment Programme

Distr.
GENERAL

UNEP/GC.10/5/Add.3
23 March 1982

ORIGINAL: ENGLISH

GOVERNING COUNCIL
Tenth session
Nairobi, 20 May - 2 June 1982
Item 6 of the provisional agenda

# PROGRAMME PERFORMANCE REPORT

## Addendum

## LIST OF DANGEROUS CHEMICAL SUBSTANCES AND PROCESSES

## Report of the Executive Director

### INTRODUCTION

1. At the eighth session of the Governing Council, it was suggested 1/ that the Executive Director submit to the Governing Council at its tenth session a provisional list of 10 to 20 of the most dangerous substances, groups of substances or processes to which Governments should pay special attention in their environmental policies. A provisional list could be submitted to the Council at its ninth session, which could determine the procedures for its adoption at the tenth session. It was subsequently clarified that the list should be restricted to dangerous chemical substances harmful at the global level.

2. A preliminary report on listing of dangerous chemical substances (UNEP/GC.9/2/Add.6), submitted to the Council at its ninth session, analysed the problems encountered in preparing such a list, attempted to state objectives and definitions, and outlined the difficulties in selecting the substances, the possible solutions to the problem, and a practical approach to the preparation of the list. Following discussion of the report, the Governing Council adopted decision 9/6, whereby it requested the Executive Director to continue his work on the preparation of a short list of environmentally dangerous chemical substances, harmful at the global level, to which environmental policies should pay special attention.

3. Following the ninth session of the Council, the secretariat held discussions with and obtained information from some national institutions and international organizations with relevant experience. Senior consultants advised on the format of the list and on chemicals to be proposed

1/ Report of the Governing Council on the work of its eighth session, Official Records of the General Assembly, Thirty-fifth Session, Supplement No.25 (A/35/25), para. 101.

*fourth edition*

# CHEMICAL PROCESS INDUSTRIES

**R. NORRIS SHREVE**

*Late Professor Emeritus of Chemical Engineering*
*Purdue University*

**JOSEPH A. BRINK, JR.**

*Consulting Chemical Engineer*
*Professor and Chairman of Chemical Engineering*
*Washington State University*

**McGRAW-HILL BOOK COMPANY**

*New York St. Louis San Francisco Auckland Bogotá*
*Düsseldorf Johannesburg London Madrid Mexico*
*Montreal New Delhi Panama Paris São Paulo*
*Singapore Sydney Tokyo Toronto*

(soda ash with 25 to 75% $NaHCO_3$) for mild-alkali demands, as in the tanning industry. *Sodium sesquicarbonate*, or the natural mineral trona, has the composition $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$ and is very stable. It finds use in wool scouring and in laundering. *Sal soda* ($Na_2CO_3 \cdot 10H_2O$) is also known as *washing soda* or *soda crystals*.

## MANUFACTURE OF CHLORINE AND CAUSTIC SODA

Chlorine and caustic soda are produced almost entirely by electrolytic methods from fused chlorides or aqueous solutions of alkali metal chlorides. In the electrolysis of brines, chlorine is produced at the anode, and hydrogen, together with sodium or potassium hydroxide, at the cathode. Since the anode and cathode products must be kept separate, many ingenious cell designs have been invented and commercialized. However, all these designs have been either variations on a type of diaphragm or on a mercury intermediate electrode.

**DIAPHRAGM CELLS**[3] Diaphragm cells produced approximately three-fourths of U.S. caustic. In the operation of a typical diaphragm cell, sodium or potassium chloride, nearly saturated and at approximately 60 to 70°C, is fed into the anolyte, which flows through the diaphragm into the catholyte, where caustic is formed. Flow is continuous through the diaphragm to the catholyte caused by a differential head.

**REACTIONS AND ENERGY CHANGES** *Decomposition voltage and voltage efficiency.* The energy consumed in the electrolysis of the brine is the product of the current flowing and the potential of the cell. The *theoretical*, or minimum, *voltage* required for the process may be derived from the Gibbs-Helmholtz equation, which expresses the relation between the electric energy and the heat of reaction of a system.[4]

$$E = \frac{-J\,\Delta H}{nF} + \frac{T\,dE}{dT}$$

where $E$ = theoretical decomposition voltage
$\Delta H$ = enthalpy change of reaction, cal
$J$ = electrical equivalent of heat, or J/cal (4.182)
$T$ = absolute temperature
$F$ = Faraday constant, coulombs/g-equiv (96,500)
$n$ = number of equivalents involved

The heat of reaction for the electrolysis of salt may be found from the heats of formation of the components of the overall reaction or from the negative of these values, the change in the heat contents of the system. The overall reaction is

$$NaCl(aq) + H_2O(l) \longrightarrow NaOH(aq) + \tfrac{1}{2}H_2(g) + \tfrac{1}{2}Cl_2(g)$$

This may be broken down to the following reactions for formation:

$$Na(s) + \tfrac{1}{2}Cl_2(g) \longrightarrow NaCl(aq) \qquad \Delta H = -97.1 \text{ kcal}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow H_2O(l) \qquad \Delta H = -68.4 \text{ kcal}$$

$$Na(s) + \tfrac{1}{2}O_2(g) + \tfrac{1}{2}H_2(g) \longrightarrow NaOH(aq) \qquad \Delta H = -112.1 \text{ kcal}$$

The net $\Delta H$ for the overall reaction results from

$$+97.1 + 68.4 - 112.1 = +53.4 \text{ kcal}$$

[3]Sconce (ed.), Chlorine, chap. 5, ACS Monograph 154, 1962; Sommers, The Chlor-Alkali Industry, *Chem. Eng. Prog.* 61(3), 94 (1965); Outlook for Chlorine-Caustic Production, *Chem. Eng. Prog.*, 70(3), 59 (1974).
[4]Perry, 5th ed., p. 4–70.

35

Then this value of $\Delta H$ is substituted in the Gibbs-Helmholtz equation and the change in voltage with emperature is neglected, the value of $E$ is found to be 2.31 V. The omission of $T\,dE/dT$ involves an rror of less than 10% for most cells.

The ratio of this theoretical voltage to that actually used is the *voltage efficiency* of the cell. oltage efficiencies range from 60 to 75%. According to Faraday's law, 96,500 C of electricity assing through a cell produce 1 g-equiv of chemical reaction at each electrode. Because of unvoidable side reactions, cells usually require more than this amount. The ratio of the theoretical to he actual current consumed is defined as the *current efficiency*. Current efficiencies run 95 to 97% nd, unless otherwise specified, are understood to be *cathode* current efficiencies. The current ivided by the area in square inches upon which the current in amperes acts is known as the *current ensity*. A high value is desirable in cases where the pr uct formed is subject to decomposition. he product of voltage efficiency and current efficiency is the *energy efficiency* of the cell. Another onsideration is the *decomposition efficiency*, which is the ratio of equivalents produced in the cell to quivalents charged. In the usual commercial cell this decomposition efficiency is about 60 to 65%. Then the cell is operated to attain a higher decomposition efficiency, the natural flow of brine through he cell decreases with the migration of $OH^-$ ions back to anode and formation of hypochlorite, which eans loss of caustic and chlorine. Also, when $OH^-$ ions reach the anode, the following reaction ccurs:

$$2OH^- \longrightarrow H_2O + \tfrac{1}{2}O_2 + 2e$$

he oxygen formed reacts with the graphite of the anodes, causing decreased anode life. In cells ith metal anodes, the oxygen does not react.

**TYPES OF CELLS** Diaphragm cells contain a diaphragm to separate the anode from the athode. This allows ions to pass through by electrical migration but reduces the diffusion of products. iaphragms permit the construction of compact cells of lowered resistance, because the electrodes an be placed close together. The diaphragms become clogged with use, as indicated by higher oltage and higher hydrostatic pressure on the brine feed. They must be replaced regularly. The iaphragm permits a *flow of brine* from anode to cathode and thus greatly lessens or prevents side actions (e.g., sodium hypochlorite formation). Cells with metal cathodes (titanium coated with re earth oxides, platinum or noble metals, or oxides) rarely develop clogged diaphragms and operate r 12 to 24 months without requiring diaphragm replacement. It is expected that Du Pont's Nafion perfluorosulfonic acid polymer), and similar materials used as membranes to replace asbestos, will crease service life. Permionic membranes passing NaOH while retaining NaCl presently increase e purity of diaphragm cell caustic, eliminating a purification step to remove chlorine.[5]

Mercury cells produce purer NaOH, but a small loss of mercury to the environment presents reme problems. Originally it was believed that this loss was unimportant, but marine life conntrates the mercury biologically, resulting in fish containing lethal amounts of methyl mercury. gestion of contaminated fish led to development of the so-called Minimata disease, resulting in aths and affliction. Japan outlawed mercury cell use after 1975, and the construction of mercury lls in the United States came to an abrupt halt. Careful process control,[6] combined with treatment water and air effluent may make it possible for mercury cell plants to meet environmental standards d survive, but most companies are hesitant to erect new units. Greatly improved diaphragm cell hnology, particularly the replacement of graphite anodes with dimensionally stable titanium anodes ted with a catalytic coating, has swung interest to large (200 kA) diaphragm cells. The use of stic has simplified cell construction, minimized and simplified maintenance, and allowed outdoor rooms in some cases, thus reducing costs.

[5]Dahl, Chlor-Alkali Cell Features New Ion-Exchange Membrane, *Chem. Eng. (N.Y.)*, 84(17), 60 (1975).
[6]Cell Systems Keep Mercury from Atmosphere, *Chem. Eng. News*, Feb. 14, 1972, p. 14.

36

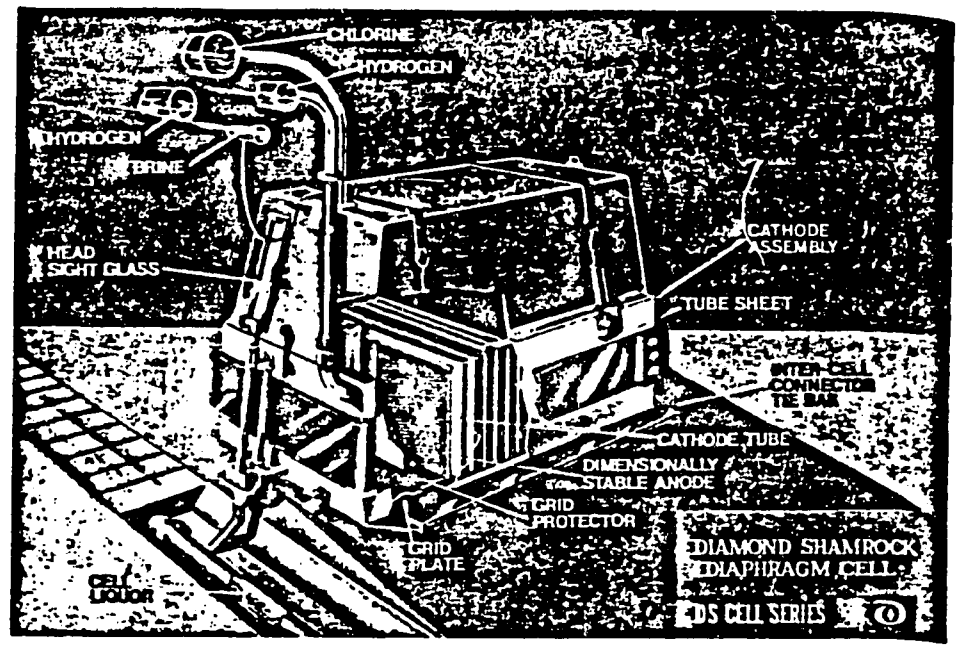



*Fig. 13.3* Diamond Shamrock diaphragm cell. The DS cell series is made in three sizes. The largest is the DS-85 which handles a current up to 150 kA and produces 5.05 short tons of chlorine per day. This cell is 112 in. long, 60 in. wide, and 81 in. high. It has dimensionally stable anodes. (*Diamond Shamrock Corp.*)

Diaphragm cell liquor requires concentration (from about 12% NaOH containing 16% NaCl) and chloride removal. Increasing fuel costs have made quadruple-effect evaporators economically desirable,[7] and ammonia extraction can reduce the NaCl level to 200 to 300 ppm—rayon-grade specifications. Cells enjoying particular favor at this time include those produced by Diamond-Shamrock, PPG-DeNora, Hooker, Dow, Olin, Solvay, Hoechst-Uhde, Kureha, and Toyo Soda. The differences in total production cost among the several proprietary cells, monopolar and bipolar systems, and mercury and diaphragm cells are small. Large diaphragm cells seem to be the current trend.

The *Dow cell* (Dow Chemical Co.) has a bipolar design which usually results in the erection of blocks of 50 cells, where the butting frames are pressed together to form a tight block operating as a single unit. Each such unit is connected electrically to the next cell unit within the frames constituting the block. Chlorine and hydrogen gases are each collected in inverted troughs (concrete headers on top of the cells) and caustic at the side through a trap.

**UNIT OPERATIONS AND CHEMICAL CONVERSIONS** The main steps in a typical diaphragm-cell flowchart, as depicted in Fig. 13.5 may be represented by the following *unit operations* and *chemical* conversions:

*Brine purification.* To make a purer caustic soda and to lessen clogging of the cell diaphragm with a consequent voltage increase, purification of the NaCl solution of calcium, iron, and magnesium compounds is practiced, using soda ash with some caustic soda. Sometimes sulfates are removed with $BaCl_2$ or the hot brine is treated with hydroxyl and carbonate ions.[8] The clear brine is neutral-

[7]New Chlorine Plants Watch Their Watts, *Chem. Week*, Nov. 27, 1974, p. 45.

[8]Shearon *et al.*, Modern Production of Chlorine and Caustic Soda, *Ind. Eng. Chem.*, **40**, 2002 (1948); Hightower, Chlorine-caustic Soda, *Chem. Eng.*, 55(12), 112 (1948) (pictured flowchart); Integrated Alkali Industry, *Chem. Eng.* (N.Y.), 53(2), 172 (1946) (pictured flowchart).

37

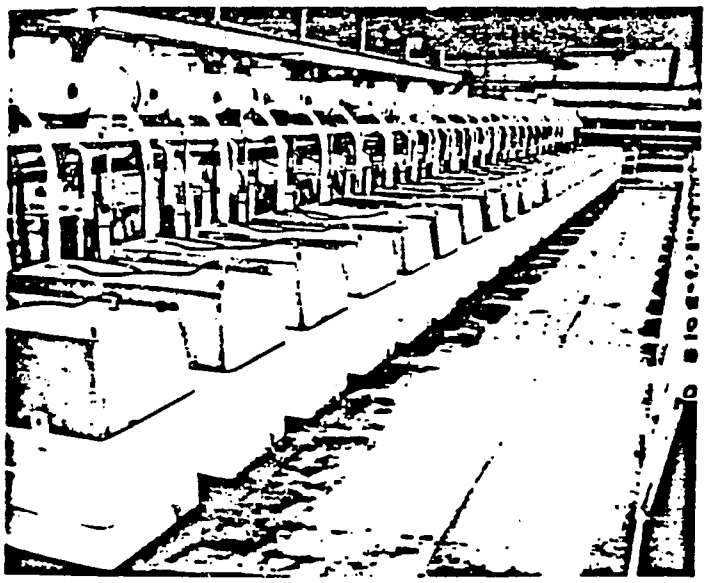


*Fig. 13.4* Typical Diamond-Shamrock cell installation. (*Diamond Shamrock Corp.*)

ized with hydrochloric acid (Ch). This brine is stored, heated, and fed to the cells through a float feed system designed to maintain a constant level in the anode compartments (Op).

*Brine electrolysis.* Typical cells employed were described in the preceding section. Each cell usually requires 3.0 to 4.5 V; consequently, a number of them are put in series to increase the voltage of a given group (Ch).

*Evaporation and salt separation.* The decomposition efficiency of the cells being in the range of only 50%, about half of the NaCl charged is in the weak caustic and is recovered by reason of its low solubility in caustic soda solutions after concentration. Hence the weak, about 10 or 12%, NaOH solution is evaporated to about 50% NaOH in a double- or triple-effect evaporator with salt separators and then passes through a settler and washing filter. The salt so recovered is again made into charging brine. In the evaporators, nickel tubes are generally used to lessen iron contamination. Since the caustic soda liquor from the evaporator contains 50% NaOH, it will dissolve only about 1% NaCl and other sodium salts after cooling. This liquor may be sold, after thorough settling, as liquid caustic soda in tank cars or drums.

*Final evaporation.* Either the cooled and settled 50% caustic or a specially purified caustic may be concentrated in a single-effect final or high evaporator to 70 or 75% NaOH, using steam at 75 to 100 psig. This very strong caustic must be handled in steam-jacketed pipes to prevent solidification. It is run to the finishing pots. Another method of dehydrating 50% caustic utilizes the precipitation of NaOH monohydrate. This monohydrate contains less water than the original solution. Precipitation is accomplished by the addition of ammonia to the 50% solution, and this also purifies the caustic. If the 50% caustic is treated with anhydrous ammonia,[9] particularly in a countercurrent system, free-flowing anhydrous crystals separate from the resulting aqueous ammonia. Naturally, this procedure should be carried out in pressure vessels (Ch).

*Finishing of caustic in pots.* Although 50% caustic was at one time finished in special close-grained, cast-iron, direct-fired pots, the heat efficiency is so low that good practice now handles only 70 or 75% NaOH in this fashion. The final temperature is 500 to 600°C and boils off all but about

[9]Muskat, Method for Producing Anhydrous Caustic, U.S. Pat. 2,196,593 (1940).

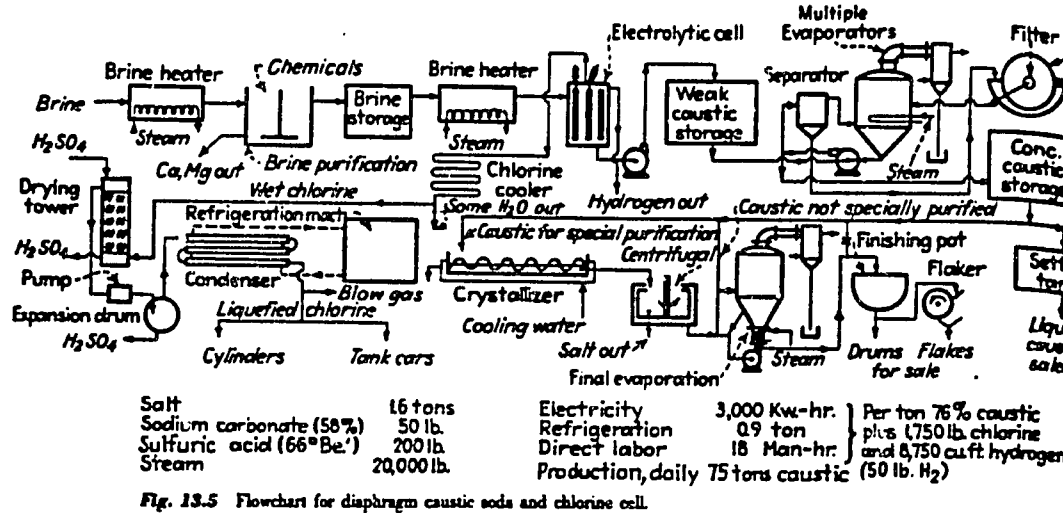



*Fig. 13.5* Flowchart for diaphragm caustic soda and chlorine cell.

1% or less of the water. These pots are now being replaced by Dowtherm heated evaporators for caustic evaporation above 50%. The hot anhydrous caustic is treated with sulfur to precipitate iron and settled. The product is pumped out by lowering into the molten caustic a centrifugal pump that discharges the caustic into thin steel drums holding about 700 lb. or into the flaking machine (Op).

*Special purification of caustic.* Some of the troublesome impurities in 50% caustic are colloidal iron, NaCl, and $NaClO_3$. The iron is often removed by treating the caustic with 1% by weight of 300-mesh calcium carbonate and filtering the resulting mixture through a Vallez filter on a calcium carbonate precoat. The chloride and chlorate may be removed by allowing the 50% caustic to drop through a column of 50% aqueous ammonia solution. This treatment produces caustic almost as free of chlorides and chlorates as that made by the mercury process. To reduce the salt content of the caustic necessary for certain uses, it is cooled to 20°C in equipment such as that outlined in Fig. 13.5. Another crystallization method used industrially, however, involves the actual separation of the compound $NaOH \cdot 3\frac{1}{2}H_2O$ or $NaOH \cdot 2H_2O$, leaving the NaCl in the mother liquor. Another procedure reduces the salt content of the caustic soda solution by formation of the slightly soluble complex salt $NaCl \cdot Na_2SO_4 \cdot NaOH$.[10]

A standard process for the continuous extraction of NaCl and $NaClO_3$ in 50% caustic solution is countercurrent extraction in vertical columns with 70 to 95% ammonia.[11] It should be noted that mercury cells furnish caustic soda free from salt. These purification or manufacturing methods give *high-grade* caustic with less than 1% impurities (anhydrous basis). The *standard grade* contains $2\frac{1}{2}$ to 3% impurities (anhydrous basis) (Ch).

*Chlorine drying.* The hot chlorine evolved from the anode carries much water vapor. It is first cooled to condense most of this vapor and then dried in a sulfuric acid scrubber or tower as shown in Fig. 13.5. Up to the sulfuric acid tower, the wet chlorine should be handled in polyester, polyvinyl chloride, or a similar resistant material; after drying, iron or steel can be employed (Op and Ch).

*Chlorine compression and liquefaction.*[12] The dried chlorine is compressed to 35 psi, or sometimes as much as 80 psi. For lower pressures the usual type of compressor employed is the liquid-piston rotary blower[13] constructed of iron, with concentrated sulfuric acid as the sealing liquid. For

[10] Hubel and Sweetland, Removal of Salt from Caustic Soda Produced by Diaphragm Cells, *Can. Chem. Met.*, 17, 52 (1933)
[11] Twichaus and Ehlers, Caustic Purification by Liquid-Liquid Extraction, *Chem. Ind. (N.Y.)*, 63, 230 (1948).
[12] Eichenhofer and Fedoroff, Chlorine Liquefaction, *Chem. Eng. (N.Y.)*, 58(12), 142 (1951).
[13] Perry, Fig. 6-47, Centrifugal Compressors in Chlorine Service, *Chem. Eng. Prog.*, 70(3), 69 (1974).

39

larger capacities and higher pressures, centrifugal and nonlubricated reciprocating compressors are chosen. Carbon piston rings or carbon cylinder liners are usually used in the reciprocating compressors, other parts being cast iron. The heat of compression is removed and the gas condensed. The liquid chlorine is stored in small cylinders, ton cylinders, pipeline, or the 55-ton tank cars that are shipped to large consumers. Barges carrying 600 or 1,100 tons are also employed. There is always some residue, or "blow gas," made up of an equilibrium mixture of chlorine and air. The blow gas is used to make chlorine derivatives, either organic or inorganic, especially bleaching powder (Op).

*Hydrogen disposal.* The hydrogen is frequently made into other compounds such as hydrochloric acid or ammonia or is employed for the hydrogenation of organic compounds (Ch).

**MERCURY CELLS**[14] The method of producing chlorine and caustic soda in an electrolytic cell with a mercury cathode was discovered simultaneously by H. Y. Castner, an American, and K. Kellner, an Austrian, in 1892. The Mathieson Alkali Works (now Olin Corp.) operated this cell, or modifications of it, from 1894 to recent years at Niagara Falls. In the mercury cell, continuously fed brine is partly decomposed in one compartment (called the electrolyzer) between a graphite anode and a moving mercury cathode, forming chlorine gas at the anode and sodium amalgam at the cathode. The reactions are:

| | |
|---|---|
| Anodic half-reaction: | $2Cl^-(aq) \longrightarrow Cl_2(aq) + 2e^-$ |
| | $Cl_2(aq) \longrightarrow Cl_2(g)$ |
| Cathodic half-reaction: | $2Na^+(aq) + Hg + 2e^- \longrightarrow 2Na(Hg)$ |
| Overall cell reaction: | $2NaCl(aq) + Hg \longrightarrow Cl_2(g) + 2Na(Hg)$ |

The average electrolysis temperature is about 65°C. and the average NaCl concentration is 290 g/l. The sodium amalgam flows continuously to a second compartment (called the amalgam decomposer, secondary cell, or denuder) where it becomes the anode to a short-circuited iron or graphite cathode in an electrolyte of NaOH solution. Purified water is fed to the cell countercurrent to the sodium amalgam: hydrogen gas is formed, and the NaOH increases to 40 or 50%. (The eutectic composition of 73% NaOH can be obtained if the temperature is kept above 100°C.) The reactions are:[15]

| | |
|---|---|
| Anodic half-reaction: | $2Na(Hg) \longrightarrow 2Na^+ + Hg + 2e^-$ |
| Cathodic half-reaction: | $2H_2O + 2e^- \longrightarrow 2OH^- + H_2(g)$ |
| Overall decomposition reaction: | $2Na(Hg) + 2H_2O \longrightarrow 2NaOH(aq) + H_2(g) + Hg$ |

Most modern cells, such as the DeNora cell (Figs. 13.6 and 13.7), are constructed with a flat-bottomed steel trough over which the mercury cathode flows uniformly. Parts of the trough not in contact with mercury are provided with a corrosion-resistive coating. The steel bottom of the cell, which in operation is electrically connected with the cathode bus bars, is covered with a sheet of mercury. The anodes are horizontal graphite plates (*L* in Fig. 13.6) that hang on insulated rods extending through the cover (*M*). The anodes are parallel and close to the mercury-brine interface and are perforated or grooved to facilitate release of chlorine in the cover. The vertical amalgam decomposer, or denuder, shown in Fig. 13.7, is characteristic of the DeNora[16] cell. This figure indicates the brine, chlorine, and hydrogen flows. No evaporation is necessary. The weak brine or anolyte is dechlorinated and resaturated with solid salt, purified, and returned to the cell.

The choice between the diaphragm and the mercury cell depends on whether solid salt or strong brine is cheaper and the purity of the caustic desired. The mercury cell produces superior-quality

[14] MacMullin, 1962, chap. 6 in Sconce (ed.), ACS Monograph 154; ECT, 2d ed., vol. 1, 1963, p. 686; MacMullin, *Chem. Eng. Prog.*, 46, 440 (1950).

[15] The Mercury Cathode Chlor-Alkali Process, Hampel, Electrochemical Encyclopedia, Reinhold, 1964.

[16] DeNora and Gallone, The Mercury Cathode Chlor-Alkali Process, and Hampel, Electrochemical Encyclopedia, Reinhold, 1964.

# Best Available Document

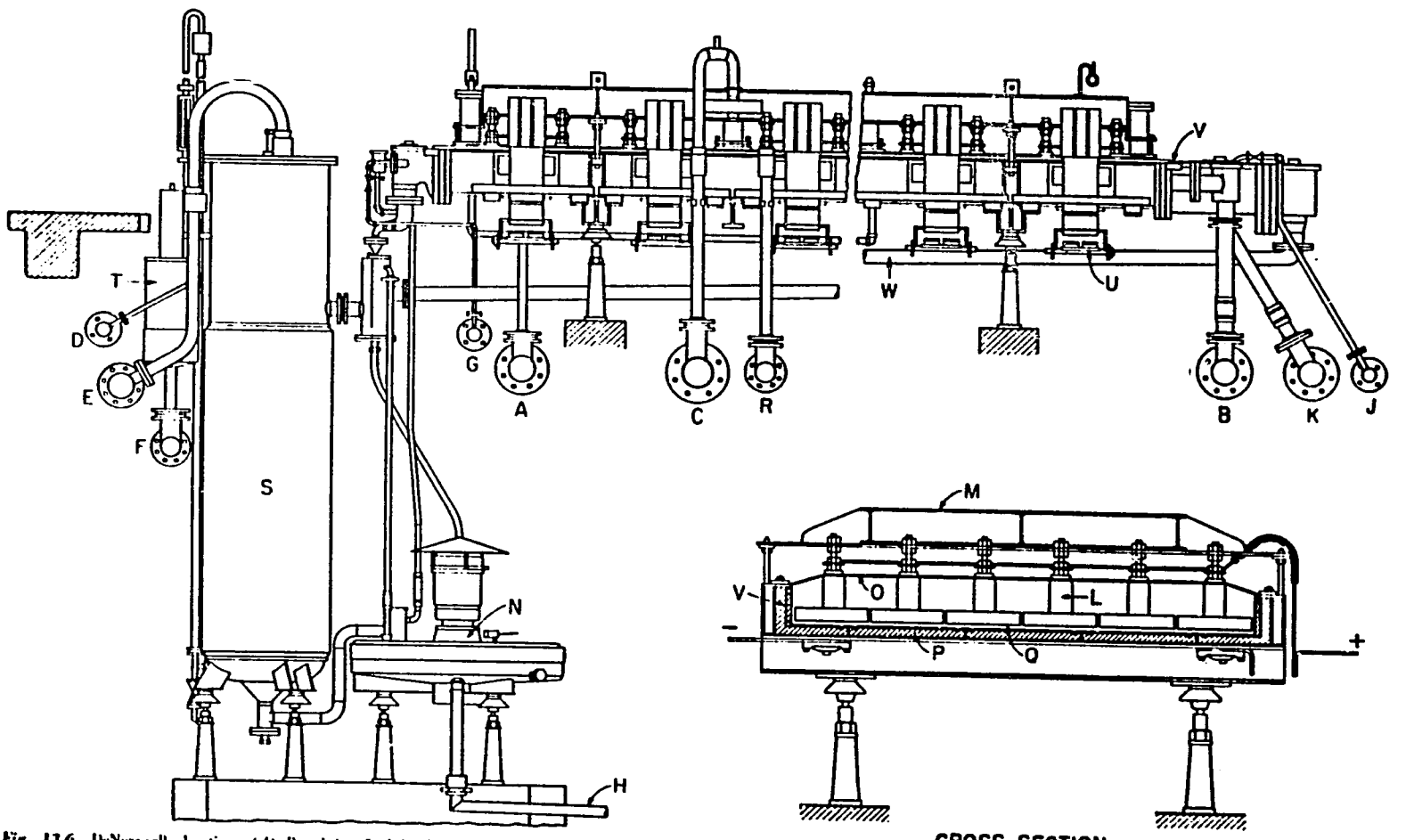
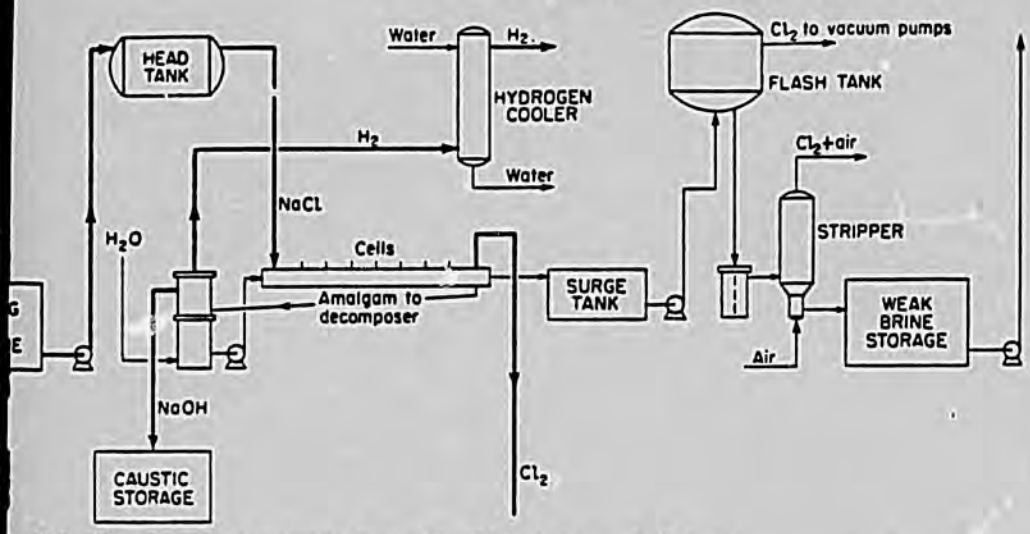



*Fig. 13.6* DeNora-cell elevation. (*A*) Pure-brine feed header; (*B*) depleted-brine collection header; (*C*) strong chlorine header; (*D*) pure-water feed header to decomposer; (*E*) hydrogen-collection header; (*F*) caustic-collection header; (*G*) pure-water feed header to inlet end; (*H*) to mercury trap and sewer; (*L*) anode post-and-plate assembly; (*M*) anode support structure; (*N*) mercury pump and sump; (*O*) rubber cover; (*P*) concrete grout; (*Q*) corrosion-resistant membrane; (*R*) dilute-chlorine header; (*S*) decomposer; (*T*) current breaker; (*U*) cell-charging cable; (*V*) [illegible]




g. 13.7 DeNora-cell operating arrangement. Compare Fig. 13.5 for diaphragm cell. (*DeNora.*)

% NaOH directly from the cell sembly through the decomposition of the mercury-sodium nalgam. The diaphragm cell produces a weak caustic liquor containing about 10% caustic and 15% nverted salt. On the other hand, the mercury cell requires about 15% more energy per ton of oduct than the diaphragm cell. The predominance of the diaphragm cell in this country is largely e to the availability of natural brines. In other countries, such as Germany and Italy, however, the ercury process is responsible for much of the total chlorine production.

Other processes for making chlorine include the Downs cell (for making sodium, Chap. 14), ydrogen chloride decomposition (Chap. 14), the Solvay nitrosyl chloride process, and the Allied emical process at Hopewell, Va., where common salt is treated with nitric acid to form sodium trate and chlorine with nitrosyl chloride (containing 4 to 10% nitrogen tetroxide) as a by-product. he nitrosyl chloride vapor placed in contact with oxygen to produce nitrogen tetroxide and chlorine: $NOCl + O_2 \longrightarrow N_2O_4 + Cl_2$. After liquefying and distilling the chlorine out, the nitrogen troxide is absorbed in water to make nitric and nitrous acids which are recycled: $N_2O_4 + {}_2O \longrightarrow HNO_3 + HNO_2$. The advantage of this process is that it produces chlorine but no caustic da. The limited demand for sodium nitrate regulates the amount of chlorine that can be made in is way. The overall reactions may be simplified as follows:

$$3NaCl + 4HNO_3 \longrightarrow 3NaNO_3 + Cl_2 + NOCl + 2H_2O$$

$$2NOCl + 3HNO_2 + 3O_2 + H_2O \longrightarrow 5HNO_3 + Cl_2$$

Du Pont has started up a 600 ton/day plant to recover chlorine from hydrogen chloride by the l-Chlor[17] process. This process accepts either gaseous or aqueous hydrogen chloride and converts to chlorine, using a four-step operation based on the Deacon process but involving nitrosyl sulfuric id ($HNSO_5$) as a catalyst. The development of oxychlorination technology has been the ma- factor in reducing the oversupply of by-product hydrogen chloride from organic chlorination ocesses.

[17]Hydrogen Chloride to Chlorine via the Kel-Chlor Process, *Chem. Eng.* (*N.Y.*), 69(4), 57 (1974); The Kel-Chlor Process, *Eng. Chem.*, 61(7), 23 (1969).

# Chlor-alkali membrane cell set for market

**Result of Du Pont-Diamond Shamrock cooperative effort, new method uses less energy than diaphragm cell process, doesn't pose pollution problem**

When Du Pont announced its development of Nafion membrane materials in the late 1960's, one of the obvious potential uses was as a membrane material in chlor-alkali cells. One of the obvious companies to test the membranes was Diamond Shamrock. A formal cooperative development program now has resulted in a proved chlor-alkali membrane technology that could well dominate the chlorine and caustic industry in the future.

Diamond Shamrock currently is operating a 12 ton-per-day demonstration plant at its facility in Muscle Shoals, Ala. According to George L. Fish, manager of Diamond's R&D electrochemicals division, two years of operation at Muscle Shoals have yielded the necessary commercial-scale operating data to permit intensive marketing of the membrane process in the U.S. He believes that the membrane cells now can compete favorably as the choice for new chlor-alkali plants over a wide range of product capacity.

Caustic solutions from the membrane cells are more concentrated than those from the older diaphragm cells and are essentially salt-free, as is the case with the product of mercury cells. This permits a considerable reduction in steam requirement for caustic evaporation, compared with that for diaphragm cells. Fish says that, because of the reduced steam requirement, the overall membrane process consumes less energy than does the diaphragm cell process.

The principal distinction between diaphragms and membranes reduces to a difference between porosity and permeability of the materials. The diaphragms now in use are porous, will pass all ions and molecules in solution, and are, in the last analysis, gas separators. The Nafion membranes are permselective and reject all negative ions because of the net negative charge on the membrane resulting from chemical substituents on the polymer backbone. The net negative charge does not result from any deliberate electrical bias.

At present, Diamond Shamrock has six active projects under way using membrane technology. Three are in Canada, and there is one each in Japan, Sweden, and Brazil. About 40 additional projects are in the discussion stage, many of them in the U.S. Fish estimates that from 500 to 700 tons per day of chlorine is now being produced, worldwide, from membrane cells, most of it in the Diamond Shamrock plants. The Japanese are said to be working on similar technology but little is known of the Japanese developments.

Other than economics, one of the prime considerations that evoke interest in membrane cells is pollution control. There has been little factual justification for indicting either asbestos-diaphragm or mercury cells for pollution, and the chlor-alkali industry doesn't anticipate any major future problems therefrom. However, with antipollution regulations becoming stricter, they could tip the balance in favor of membranes if the economics are marginal on other counts.

Diamond Shamrock has tested two basic designs for its membrane cells: a bipolar (series) cell and a monopolar cell. The monopolar cell was developed for high-amperage situations—an operating current load of 53,500 amp, compared to 3200 amp for the bipolar cell. The electrode area is 20% larger than that for the bipolar to more fully utilize the width of membrane as produced by Du Pont, but the design can be expanded in width and length to fit other amperage loads. For both bipolar and monopolar cells, titanium is used for wetted parts in contact with chlorine and brine, and carbon steel for those parts contacting hydrogen and caustic and for the structural frame.

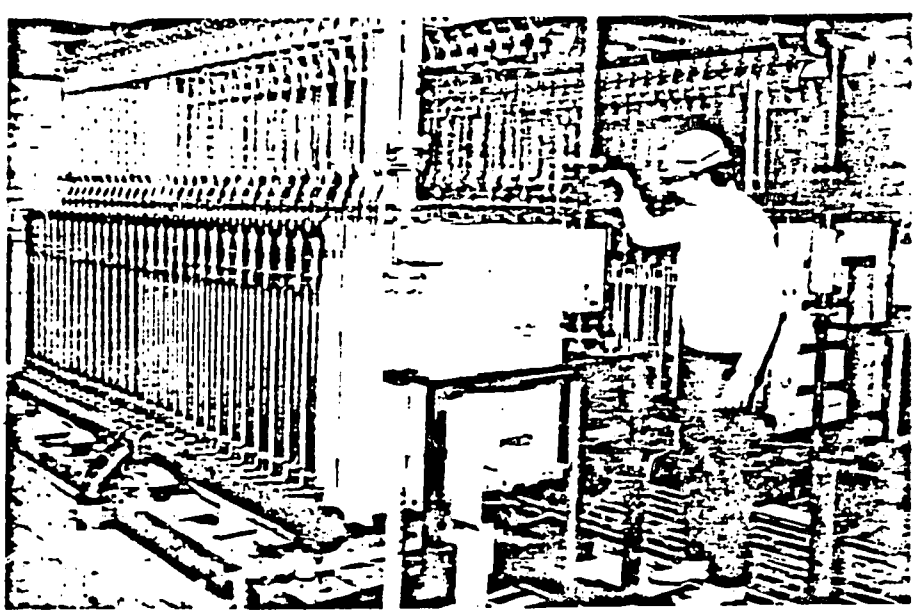
The bipolar cell normally would be used for small plants of up to 50 tons of chlorine per day. Larger plants normally would use the monopolar cells.

In both cases, cell cost is a significant factor. The bipolar cell costs more than the monopolar, and both are more expensive than diaphragm cells per unit of production. However, Diamond Shamrock currently is designing a new monopolar cell that it thinks will be able to compete on cost with diaphragm cells.

Membrane cells lead to some differences in the overall process. The brine loop is similar to that of a conventional mercury-cell plant, with solid salt normally used for the primary brine supply and conventional brine saturation and primary brine treatment systems used. However, a chemical treatment and filtration or ion exchange is employed downstream of the primary treatment to ensure extremely pure brine feed. To keep current efficiency high and voltage low, hardness of the brine feed must be reduced to 1 ppm or less and other heavy metals—particularly mercury—removed as completely as possible.

Diamond Shamrock uses a patented phosphoric acid addition step in the chemical treatment. Phosphoric acid and hydrochloric acid are metered into the brine stream. The phosphoric acid complexes trace amounts of calcium ions before they can penetrate into the membrane and cause deterioration in the performance. Hydrochloric acid neutralizes back-migrating hydroxyl ions.

For good cell performance, proper



*Membrane cell electrolyzer in Uddeholm chlor-alkali plant, Skoghall, Sweden*

## Three types of electrolytic cells dominate chlor-alkali business

Karl Scheele discovered dephlogisticated muriatic acid in 1774 and Sir Humphrey Davy named it chlorine in 1810. Chlorine has been an item of commerce even since. However, it was not a large-tonnage item until the electrolysis of brine became established. There have been dozens of types of brine cells used at one time or another and hundreds of variations. Today three types of electrolytic cells dominate the chlor-alkali business.

The diaphragm cell is physically the simplest but requires considerable product treatment, chiefly because of the high residual brine content of the caustic and the low concentration of the caustic itself. Because most diaphragms are fabricated from asbestos, the diaphragm cell recently has acquired the stigma of a potential polluter.

The mercury cell provides concentrated caustic with low residual brine concentrations—both great economic advantages. The mercury cell also requires great capital investment and has a high power consumption. Like the diaphragm cell, the mercury cell also has acquired the stigma of a potential polluter—probably undeserved in both cases.

The membrane cell is something of a compromise on technical grounds, and it offers certain economic advantages over diaphragm cells as well as mechanical simplicity over the mercury cell. Membrane cells had been sought for many years but their development had been stymied by lack of a suitable membrane material that would withstand the rigors of chlorine and caustic environments.

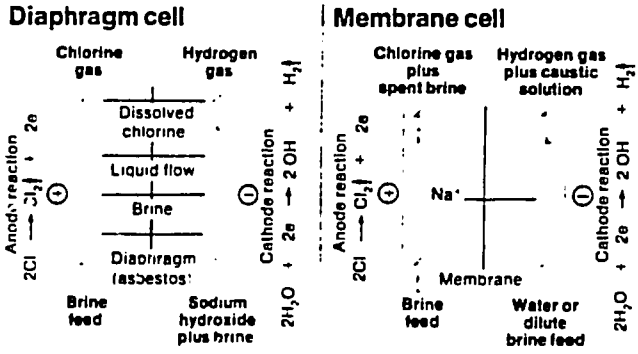
The development of Du Pont's Nafion materials in the early 1960's appears to have provided the material suitable for chlor-alkali membranes, and nearly all of the membrane cells now in service use Nafion materials. It now appears that the wave of the future in chlor-alkali technology could be the membrane cell.

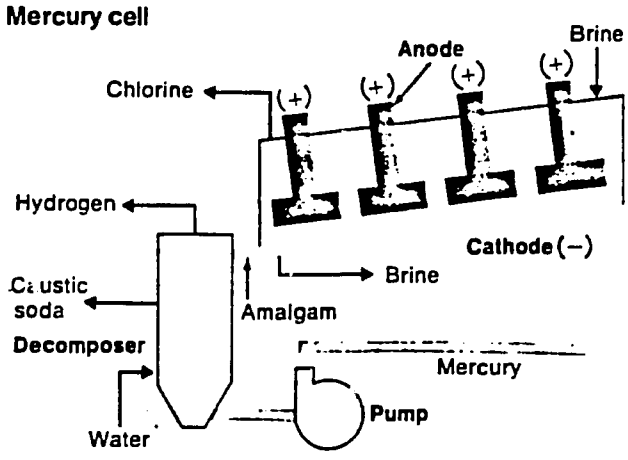
Whatever the process, there are basic similarities in chlor-alkali manufacture. In all cases it is necessary to pretreat the saturated brine feed with water conditioners to reduce water hardness, and to add hydrochloric acid to neutralize a portion of the back-migrating sodium hydroxide. This suppresses by-product formation of chlorates, hypochlorites, and oxygen. The treated brine is metered into the anode compartment of the cell. After electrolysis, the chlorine-saturated residual brine is dechlorinated. Chlorine is compressed and further processed into the various grades for sale. Residual brine is recycled. A weak caustic solution is metered into the cathode compartment where its concentration is increased by the cell reaction. A two-phase stream of concentrated caustic and hydrogen issues from the cathode compartment to a separator where the hydrogen is removed. The strong caustic goes to a holding tank where part of it is recycled to the cathode compartment after dilution and the remainder passed on to further processing, if necessary. The further processing, in the diaphragm and membrane processes, usually means concentration in a multiple-effect evaporator. Mercury-cell caustic does not require concentration.

Each of the processes has advantages, with marketing economics deciding which is preferable in a given location. The greatest single economic influence, other than the cost of electrical power, probably will remain the need (or lack of it) for caustic concentration.

Sources in the industry suggest that a continued strong showing of the membrane cell could gradually eliminate the diaphragm cell in the future. That would leave a two-horse race. If, as speculation suggests, a nonthermal caustic concentration method could be developed, the membrane cell might emerge the winner. Membrane dewatering is an obvious goal but is still far in the cloudy future.

### Chlor-alkali processes operate like this ...



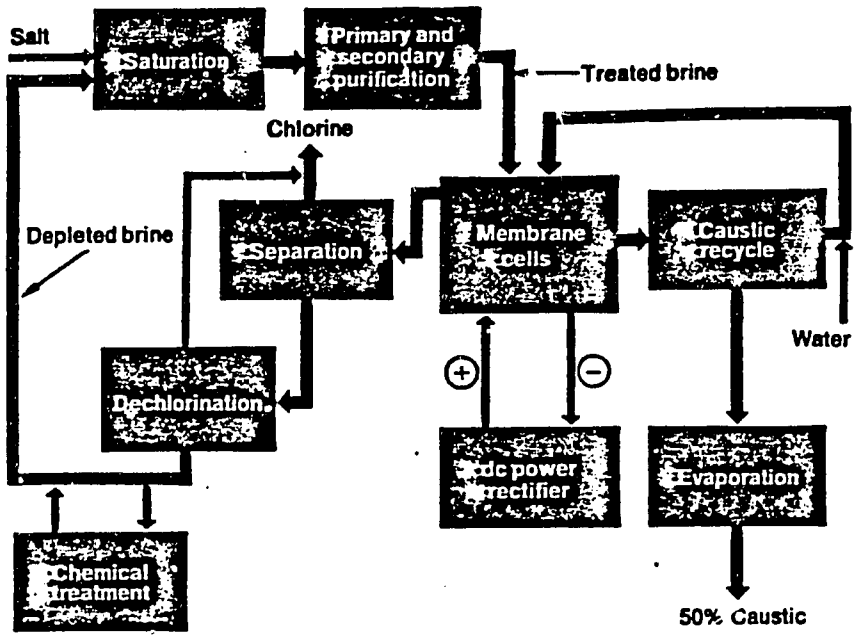




### ...and have these characteristics

| | Membrane cell | Diaphragm cell | Mercury cell |
|---|---|---|---|
| Cell separator | Nafion | Reinforced asbestos | None |
| Method of separator application | Hanging sheet | Vacuum deposition | — |
| Anode | DSA* | DSA (expendable) | DSA |
| Cell caustic Wt% NaOH Wt% NaCl | 28% 50 ppm | 11% 15% | 50% 30 ppm |
| Cell power consumption dc kw per ton NaOH | 2600 | 2180 | 2800 |
| Evaporation required lb $H_2O$ per ton 50% NaOH | 1570 | 5730 | 0 |

* DSA = Dimensionally stable anode, a patented development of Diamond Shamrock.
Source: Diamond Shamrock

## Membrane cell plant treats brine to maintain good membrane performance




caustic concentration must be kept, since current efficiency falls off rapidly if catholyte concentration rises too high. Caustic strength should be kept high to minimize the amount of energy required for evaporation, but not so high as to affect current efficiency adversely. Proper concentration can be maintained, by keeping caustic recycle ratio high enough so that a large amount of caustic flows through each cell.

Heat generated in the cell is removed in the caustic loop. The heat can be transferred to cooling water or used to raise caustic strength further. Commercial 50% grade is achieved readily with simple evaporation, the company says.

Diamond Shamrock has made a comparative economic analysis of grass-roots chlorine-caustic plants for those using membrane cells and those using the most modern diaphragm cell technology. Plant sizes studied ranged from 50 to 1 million tons per day. In its analysis, the company doesn't include absolute dollar figures, since, it explains, capital is as sensitive as it is to local philosophy, engineering practices, and accounting bases.

In its capital cost comparison, Diamond Shamrock found that at all capacities, the total investment for membrane cell plants is lower than for diaphragm cell plants. Electrolyzers and cell room systems for membrane cell plants are more costly than those for diaphragm cell plants, mostly as the result of cell costs. Membrane cell plants, on the other hand, have a "very respectable" cost advantage over diaphragm cells. Investment for brine treatment is larger for membrane plants but doesn't have a very large impact on capital for the total facility. Because of the newness of membrane cell technology, the assignment for contingencies is larger.

As for operating costs, electrolysis power is higher for membrane cells, although, Diamond Shamrock says, the difference is shrinking as membrane technology advances. Steam costs for caustic evaporation "overwhelmingly" favor membrane cells, and might, in some cases, be eliminated almost entirely.

Energy requirements of electricity and steam are considerably lower for membrane cell plants and are approaching those for mercury cell plants, the company says. Other differences are modest. Raw materials, for example, are higher for membrane cell plants but are offset by lower labor costs and fixed and service costs.

Getting to the bottom line, Diamond Shamrock finds that return on investment would be nearly the same for either type of plant. Membrane cell plants are more profitable, it says, at low plant capacities. Diaphragm cells still have a slight edge at high plant capacities. But the company believes that there is a larger margin for improvement in the use of membrane cells than is left in diaphragm cell technology.

Chemically, the Nafion membranes are made from Du Pont's XR Resin, a copolymer of tetrafluoroethylene and a perfluorosulfonylethoxy ether. Depending on the specific ether and chemical substituents on the polymer backbone a wide variety of properties can be achieved. The Nafion membranes used in Diamond Shamrock's chlor-alkali cells are reinforced with Teflon mesh.

Currently all of Du Pont's Nafion production emanates from Wilmington but a new plant, dedicated to Nafion products, is scheduled to go into production in 1979 at Fayetteville, N.C.

The high thermal stability of Nafion membranes, as well as their excellent wettability and ionic surface characteristics, has prompted Du Pont to look beyond chlor-alkali membrane applications. The regeneration of chromic acid plating solutions is one potential use. Another may issue from another joint project—between Du Pont and General Electric—in which the membranes are being evaluated for use in electrolyzers to produce hydrogen and oxygen. ◻

## Processes to refine ocean nodules assessed

ANAHEIM

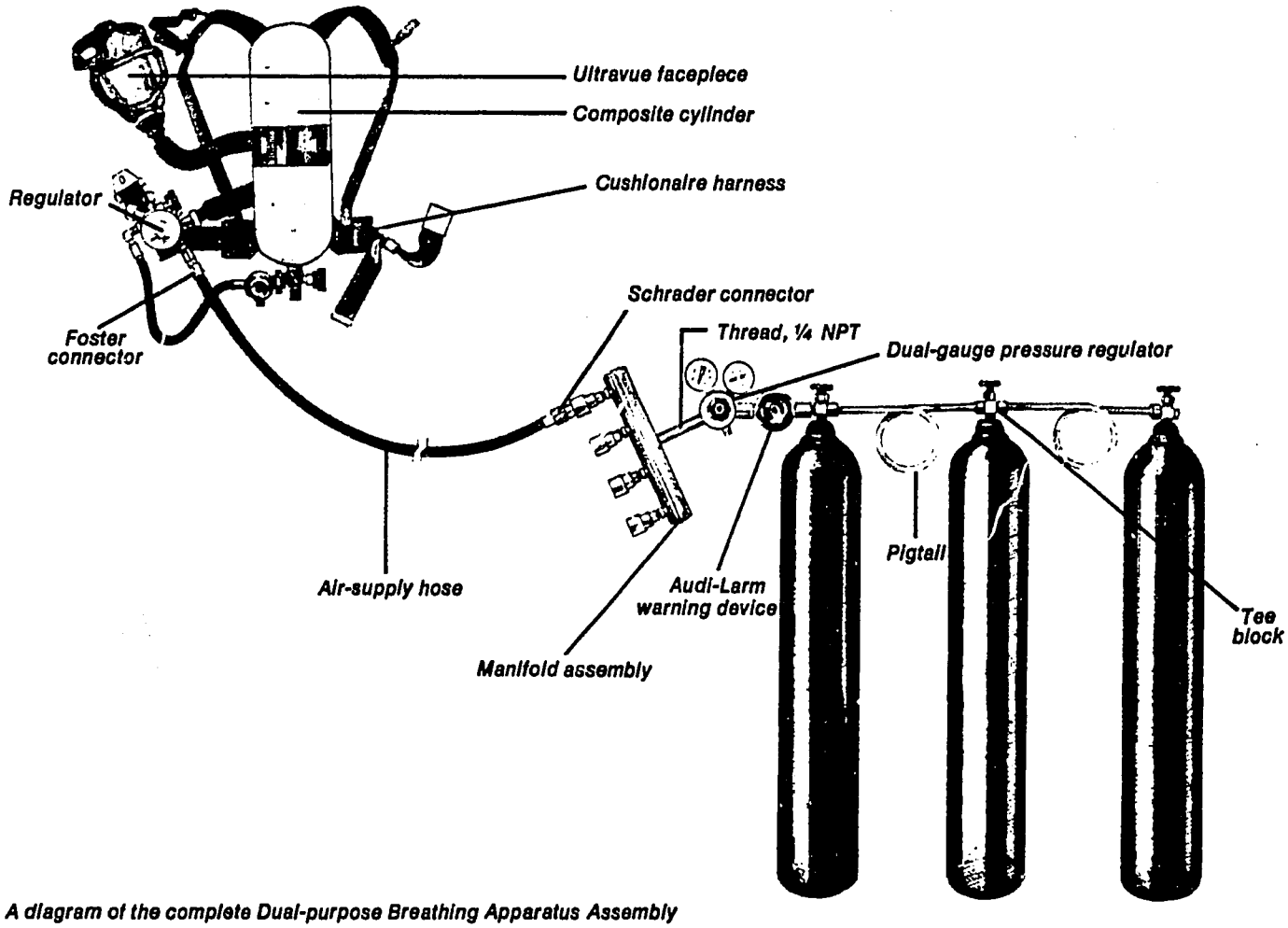
Since the discovery of nodules on the ocean floors, most attention has been devoted either to the legal problems associated with the Law of the Sea Conferences or to the technical problems of mining the nodules. The legal problems remain unsolved, but the mining problems appear to be well on the way to solution. The next step is what to do with the nodules once they have been mined.

Dr. N. Beecher of Kennecott Copper Corp. offered his assessment for the Division of Industrial & Engineering Chemistry of two possible processes for the recovery of metal values from the nodules. The cost of nodule mining is still debatable, but Beecher says that the capital investment for the onshore processing plant probably will be about twice that required for the mining operation. The decision on which process should be used is still open, as well, but two of the contenders have been described by their proponents. A Kennecott consortium has selected a hydrometallurgical process and an International Nickel consortium has selected a pyrometallurgical process.

In Kennecott's low-temperature ammoniacal leach process, the nodules are wet-ground to a fine mesh. Reduction is carried out on the slurry at low temperature and pressure. The reducing agent is carbon monoxide, which probably will be generated by partial oxidation of fuel oil. Copper, nickel, and cobalt values, which are partially released in the reduction, are further solubilized in a countercurrent decantation wash carried out in a series of thickeners. The solution from the decantation contains essentially all the copper, nickel, and cobalt values, while the solid tailings contain the manganese as manganese carbonate. Ammonia and carbon monoxide are stripped from the tailings and recycled. Liquid ion exchange removes the copper and nickel from solution while the cobalt is removed by sulfide precipitation.

In the pyrometallurgical process, the nodules are dried in a rotary dryer with pulverized coal as a fuel. The nodules are not ground. Gas from the dryer is passed

# Dual-purpose Breathing Apparatus Assembly




*A diagram of the complete Dual-purpose Breathing Apparatus Assembly*

## The Total Assembly

### Application

This assembly combines all of the capabilities of a 30-minute, pressure demand, self-contained breathing apparatus with the long duration of a supplied air respirator.

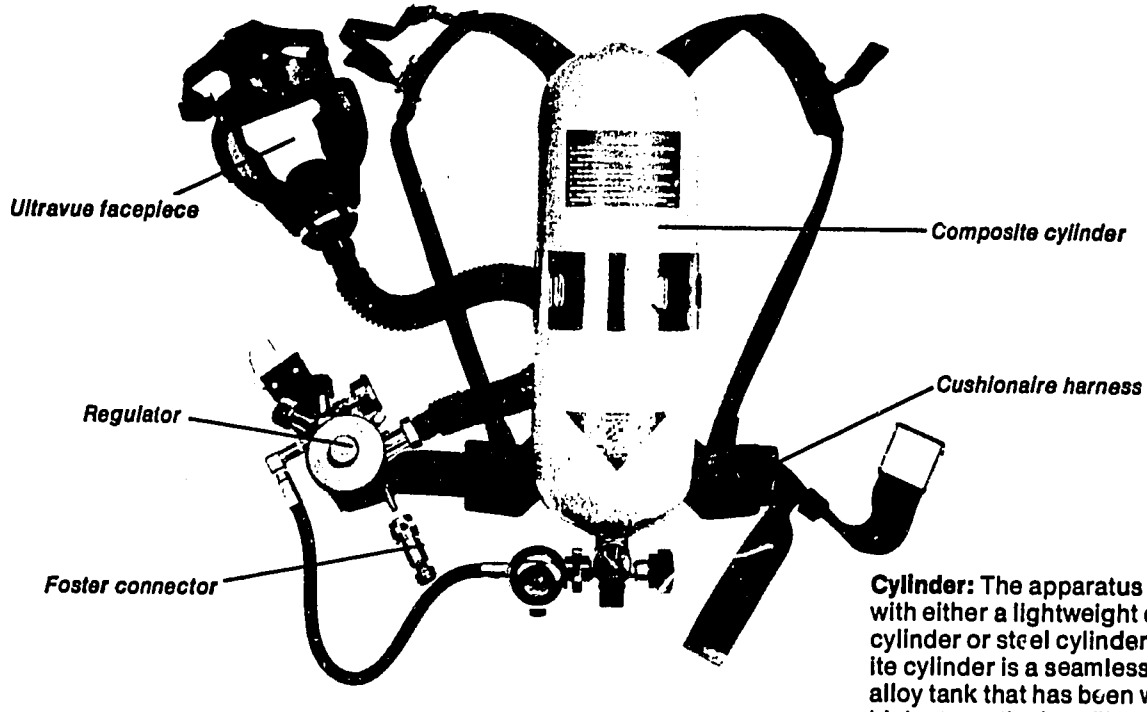
It is specifically designed for prolonged work in remote areas made hazardous by toxic gases or oxygen deficiency.

The self-contained breathing apparatus can be used in the routine manner for emergency or limited time work in dangerous areas by itself. With the assembly, however, it is also used for entry and connection to the supplied air respirator, or disconnection from that source and exit to fresh air in the event the low pressure supply of the respirator is interrupted.

### Approvals

The total assembly is approved by the U.S. Coast Guard under their Approval No. 160.011/53/0. The Dual-purpose Breathing Apparatus portion (the SCBA and up to 300 feet of air supply hose) bears the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) Approval Number TC-13F-90.

# Dual-purpose Breathing Apparatus




## Application

The MSA® Dual-purpose Breathing Apparatus combines all the capabilities of a self-contained breathing apparatus and a supplied-air respirator in one unit. The apparatus is approved by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) for use in oxygen deficient atmospheres or where dangerous concentrations of toxic gases or vapors are present. The NIOSH/MSHA approval allows:

(1) The wearer of the apparatus to enter or exit a dangerous area using only the cylinder air in applications such as emergency rescue;

(2) The wearer to work within the area for a limited time using the cylinder air;

(3) The wearer to work within the area for an extended time using air from a supply line.

Note particularly that 20 percent of the cylinder air may be used for entry and that the apparatus is not limited to escape. Of course, if the air from the supply line should fail, the wearer can escape the area using the cylinder air.

## Description

The Dual-purpose Breathing Apparatus portion of the installation is a pressure demand design. A slight positive pressure is maintained within the facepiece during both inhalation and exhalation. The slight positive pressure prevents a toxic atmosphere from leaking into the facepiece; this type of leakage can occur with a demand apparatus, due to the negative pressure developed in the facepiece. A pressure demand apparatus should, therefore, be used where the potential toxicity of the atmosphere is such that no back leakage can be tolerated.

**Regulator:** The regulator reduces the high pressure from the apparatus's compressed air cylinder to a breathable pressure. It also automatically monitors the flow of air into the facepiece so as to maintain a slight positive pressure within the facepiece. The regulator has two inlet ports—one for the cylinder and another for the supply line. A Foster connector allows the air supply to be semi-automatically switched from the cylinder to the air line. With no supply line connected to the regulator, the wearer receives air from the cylinder. When an air line is connected to the regulator through the Foster fitting, the wearer automatically receives air from the supply line. If the air supply from this line should be interrupted, the wearer must disengage the supply line in order to automatically receive air from the cylinder.

**Facepiece:** The Ultravue® facepiece has a large, panoramic lens and a speaking diaphragm. The facepiece is molded of a soft rubber compound that is comfortable to wear and resists facial oils. An exhalation valve in the facepiece enables a high exhalation flow rate at a low breathing resistance. A flexible breathing tube, corrugated to reduce the possibility of kinking, connects the facepiece to the regulator. A larger, wide-vision Clearvue® facepiece also is available to further broaden the range of effective face-to-facepiece fit.

**Cylinder:** The apparatus is available with either a lightweight composite cylinder or steel cylinder. The composite cylinder is a seamless, aluminum-alloy tank that has been wound with high-strength glass filaments and impregnated with epoxy resin. The composite cylinder has a rated service life of 30 minutes and weighs only 10.5 lb, about half the weight of a comparable steel cylinder—19 lb. Both the composite and steel cylinders feature a rubber guard for the pressure gauge on the cylinder valve. All cylinders have been tested to 5/3 of the rated pressure in accordance with Department of Transportation regulations.

**Audi-Larm™ Warning Device:** The Audi-Larm gives an audible warning when the cylinder pressure drops below a preset level. It warns the user that his air supply is nearing depletion and that he should leave the area.

**Harness and backplate:** The Cushionaire™ Harness has a foam-padded, two-inch-wide nylon strap at each shoulder. The bottom of the aluminum backplate is padded to protect the wearer's back.

## Ordering information

**30-Minute-Approved Pressure Demand Units**

**465205** Pressure Demand Apparatus with Ultravue facepiece and steel cylinder, complete in case—**465188** without case.

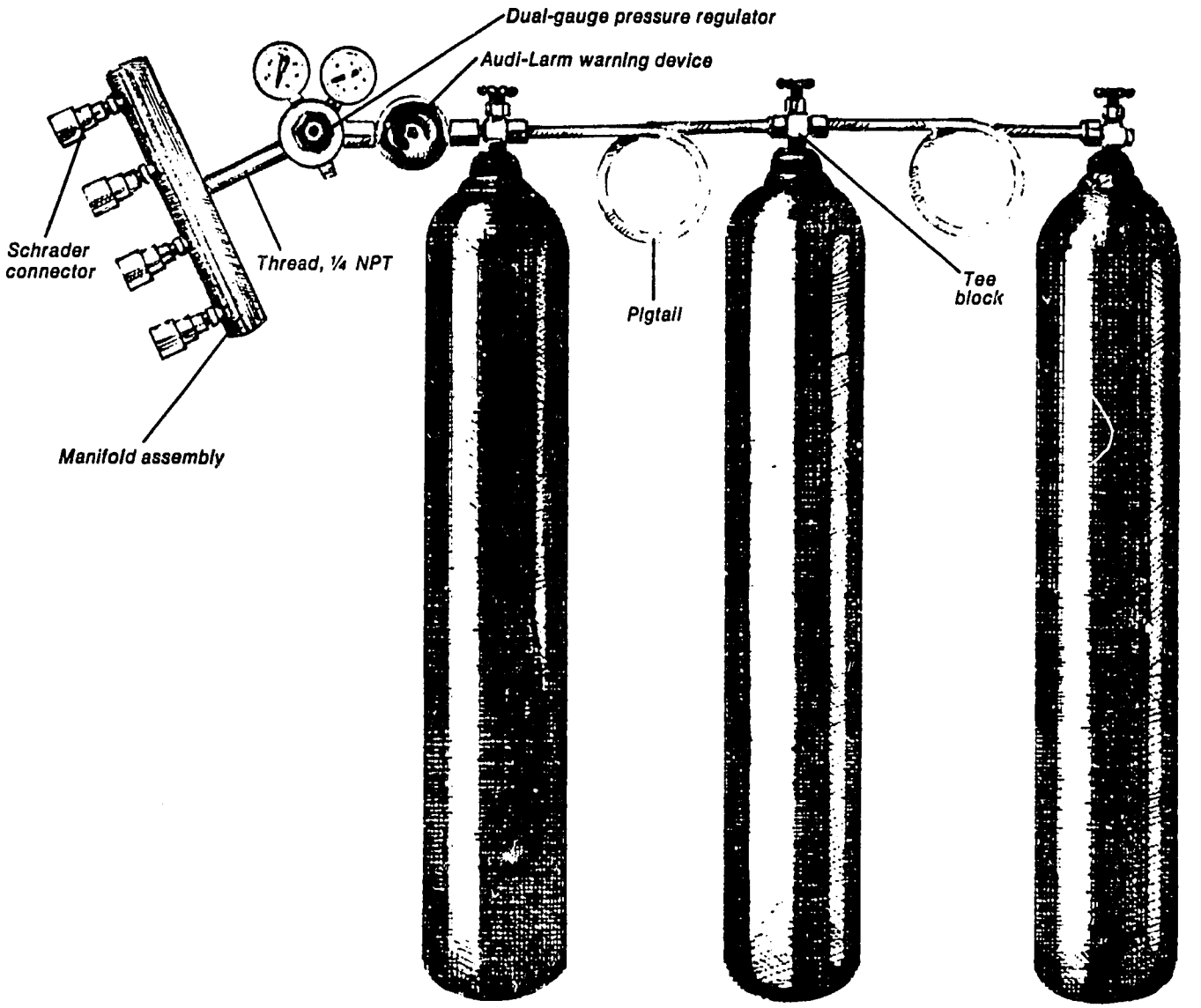
**465206** Pressure Demand Apparatus with Ultravue facepiece and composite cylinder, complete in case—**465189** without case.

**465208** Pressure Demand Apparatus with Clearvue facepiece and steel cylinder, complete in case—**465191** without case.

**465209** Pressure Demand Apparatus with Clearvue facepiece and composite cylinder, complete in case—**465192** without case.

4/1

# Low Pressure Supplied Air Apparatus




## Application

This arrangement will provide low pressure air for one to four men, each wearing a Dual-purpose Breathing Apparatus. It consists of the following:

## Description

**Cylinders:** Either three 244 cu. ft. or three 330 cu. ft. cylinders must be used as the source of air for the air-supplied respirator mode in this installation. These cylinders are joined together in a bank by means of coupler tees and pigtails. At the normal rate of consumption of one cubic foot of air per minute per man, these banks will provide either 12 or 16.5 man-hours of air. The user must supply the cylinders and also make certain that the purity of the air meets the requirements of the Compressed Gas Association Specification G-7 for Type 1, Class D Gaseous Air.

**Audi-Larm:** This alarm monitors the pressure in the bank of the three supply cylinders located on deck. It will ring when the pressure in the bank falls below 400 psi. On-deck personnel can then alert the men in the work area.

**Pressure Regulator:** The regulator reduces the high pressure from the bank to the breathable pressure required by the air-supplied respirator. The low pressure on the outlet side is preset but it can be readjusted. Both the inlet and outlet pressures have gauges—0-4000 for the inlet, 0-200 for the outlet.

**Outlet Manifold:** The outlet manifold allows up to four users to receive air from the bank of high pressure cylinders. Two- and four-outlet models are available. Both have quick-disconnect Schrader couplings and automatic shut-off outlets.

## Ordering information

**Air-supply Hose**

| | |
|---|---|
| **455021** | Air-supply Hose, 25-ft. length |
| **455022** | Air-supply Hose, 50-ft. length |

**Manifolds**

| | |
|---|---|
| **47370** | Four-outlet Manifold Assembly with Schrader couplers |
| **84416** | Two-outlet Manifold Assembly with Schrader couplers |

**Audi-Larm**

| | |
|---|---|
| **85078** | Audi-Larm Warning Device |

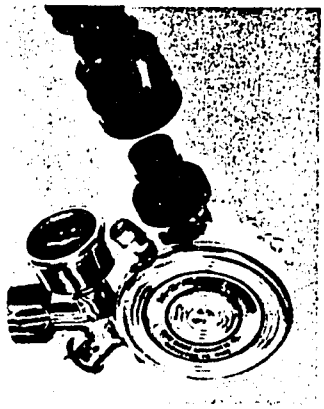
**Cylinder Connectors**

| | |
|---|---|
| **68850** | Air Coupler Tee |
| **68851** | Air Pigtail |

**Regulator**

| | |
|---|---|
| **68858** | Pressure Regulator, dual-gauge |

4



## Accessories

### Spectacle Kit

**Description:** Designed for use by those who must wear corrective lenses. A proper seal cannot be established if the temple bars of spectacles extend through the sealing edge of a full facepiece.

The Spectacle Kit consists of a retaining spring wire support, a rubber block guide, and one universal-bridge metal-frame spectacle front (S-7 shape, 44-mm lens size) with mounting prongs. Corrective lenses are not included.

The retaining spring wire support is inserted between the inturned peripheral lip of the facepiece and the facepiece lens.

Spectacles are adjusted by moving them in or out of the rubber guide and moving the rubber guide up or down the center wire support.

### Ordering information

| | |
|---|---|
| 454819 | Prescription Spectacle Kit, Universal Bridge, 44-mm lens size (less lenses); for use with Ultravue Facepiece |
| 83829 | Same for Clearvue Facepiece |

### Nosecup

**Description:** The nosecup is used to reduce the possibility of lens fogging. It is effective under conditions of high humidity and/or low temperatures by inhibiting contact of moist exhaled air with the facepiece lens. Molded from a soft rubber compound, the nosecup is resistant to facial oils. It can be attached to the facepiece without tools.

### Ordering information

| | |
|---|---|
| 457135 | Nosecup, for use with Ultravue Facepiece |
| 09863 | Nosecup, for use with Clearvue Facepiece |

### Cover Lens

**Description:** The cover lens is made of clear cellulose acetate and is designed to protect the polycarbonate facepiece lens from scratches or contamination. The cover lens is backed with a pressure-sensitive material to permit attachment to the facepiece lens.

### Ordering information

| | |
|---|---|
| 456975 | Cover lens, clear, for Ultravue Facepiece, package of 25 |
| 84773 | Cover lens, clear, for Clearvue Facepiece, package of 25 |

### Walkaway* Mounting Bracket

**Description:** This accessory is a storage unit that can be mounted on rescue or fire vehicles or any permanent wall or surface with screws.

The air mask is held in the bracket by two steel spring clips. The breathing apparatus cylinder valve rests on a foot plate base for support. Supplementing the clips is the quick-release hook and lever fastener.

The spring clips permit the user to strap on the apparatus unassisted. By stepping forward, the user snaps the breathing apparatus out of the bracket. The Air Mask is now on his back, strapped in position and ready for use.

*Trademark of Ziamatic Corp.

### Ordering information

| | |
|---|---|
| 39581 | Walkway Mounting Bracket |

### Quick Disconnect Assembly

**Description:** Specifically designed for use with the Air Mask, Model 401, and Air Cub, Model 502, the Pressure Demand Air Mask and Air Cub, and the Dual-purpose Apparatus.

The optional Quick Disconnect Assembly permits rapid and secure connection to or disconnection from the breathing tube outlet on the regulator if the user is wearing heavy gloves, or during other difficult conditions.

The Quick Disconnect Assembly has two components—a nipple, which is attached to the outlet of the demand regulator, and a coupler, which is attached to the breathing tube. These parts are supplied as a kit, with instructions for attachment of the components to breathing units with the standard coupling unit assembly.

### Ordering information

| | |
|---|---|
| 458734 | Quick Disconnect Assembly |

**Note:** This bulletin contains only a general description of the Dual-purpose Breathing Apparatus Assembly. While uses and performance capabilities are described, under no circumstances should the products be used except by qualified, trained personnel and not until the instructions, labels, or other literature accompanying them have been carefully read and understood, and the precautions therein set forth followed. Only they contain the complete and detailed information concerning these products.

MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 · Telex 812453

Worldwide service: Branch offices throughout the United States. Subsidiaries in: Amsterdam · Barcelona · Berlin · Calcutta · Glasgow · Johannesburg · Lima · Mexico City · Milan · Ndola · Paris · Santiago · Sao Paulo · Singapore · Sydney · Tokyo · Toronto. Representatives in principal cities throughout the world.

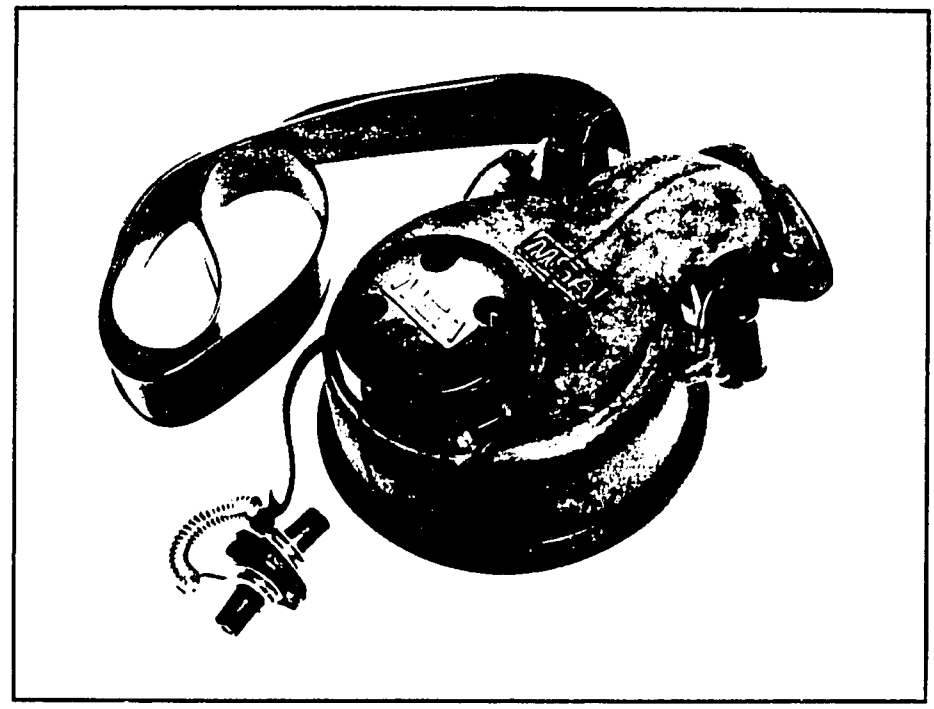
Bulletin No. 01-0555

Printed in U.S.A. 8012 (L)

MSA

Data Sheet
10-00-11

# Mouthpiece Respirator



## Application

The MSA® Mouthpiece Respirator is an escape device that enables personnel to make quick, protected getaways from areas suddenly contaminated by not more than 10 ppm chlorine or 50 ppm hydrogen chloride by volume.

## Description

The Mouthpiece Respirator has a soft, natural rubber mouthpiece which allows a positive lip seal to be maintained without uncomfortable jaw pressure. A nose clip, attached to the respirator body by a flexible cord, exerts just enough clamping pressure for positive closure of nasal passages without discomfort. A replaceable chemical cartridge and the exhalation valve are housed in the rubber body. An integral neckstrap lets worker wear the respirator at chest level, ready for immediate use when needed; an optional belt clip and clamp assembly is available for those who wish to wear the respirator on their belts.

Operation is simple. When chlorine gas or hydrogen chloride is present, the user removes the mouthpiece cover, inserts the mouthpiece in his mouth, places the nose clip over his nostrils, and breathes through the mouth until he is clear of the contaminated area.

It is recommended that the device be kept clean and sanitary with MSA Cleaner-Sanitizer, a water-soluble powder which will not deteriorate the rubber, plastic or metal parts.

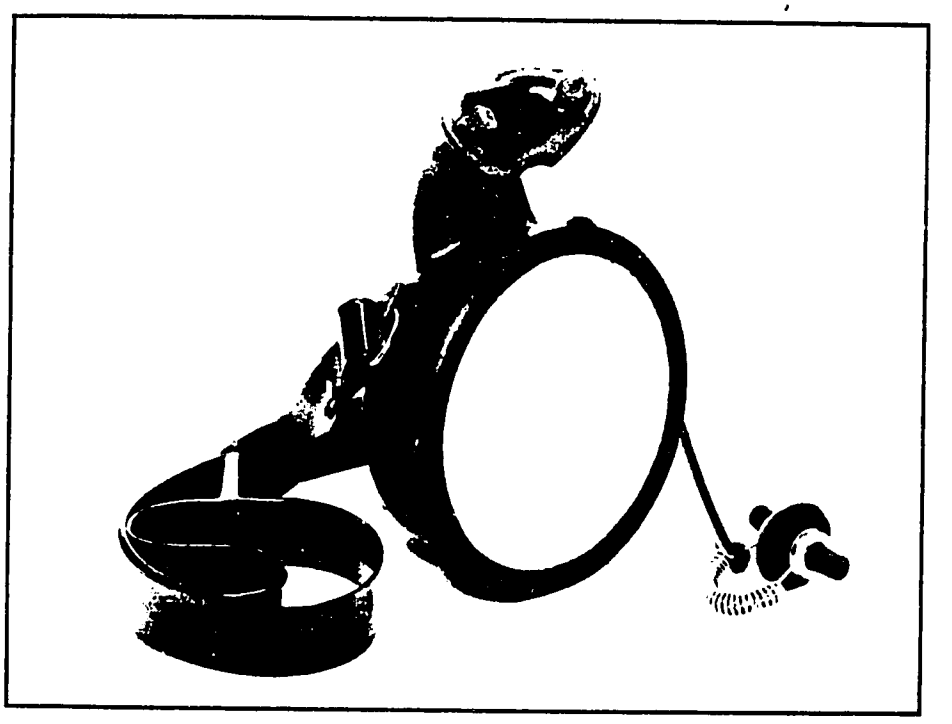
## Approvals and standards

The MSA Mouthpiece Respirator has been granted NIOSH/MSHA Approval TC 23C-108 which covers escape only from atmospheres containing not more than 10 ppm chlorine or 50 ppm hydrogen chloride by volume.

## Ordering information

**Catalog numbers**

| | |
|---|---|
| **460400** | MSA Mouthpiece Respirator |
| **465089** | Mouthpiece Respirator, less cartridge |
| **463078** | Mouthpiece Respirator with belt clip and clamp assembled |
| **465090** | Mouthpiece Respirator with belt clip and clamp, less cartridge |
| **468319** | Chemical Cartridge for Mouthpiece Respirator, pkg of 10 |
| **94601** | Belt Clip |
| **462756** | Belt Clip and Clamp Kit (optional) |
| **462755** | Conversion Kit |
| **34337** | MSA Cleaner-Sanitizer II, 12 2-oz packages |



**Note:** This Data Sheet contains only a general description of the MSA Mouthpiece Respirator. While uses and performance capabilities are described, under no circumstances should the product be used except by qualified, trained personnel and not until the instructions, labels, or other literature accompanying it have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning this product.

MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 · Telex 812453

Worldwide service: Branch offices throughout the United States. Subsidiaries in: Amsterdam · Barcelona · Berlin · Calcutta · Glasgow · Johannesburg · Lima · Mexico City · Milan · Ndola · Paris · Santiago · Sao Paulo · Singapore · Sydney · Tokyo · Toronto. Representatives in principal cities throughout the world.

Data Sheet 10-00-11

Printed in U.S.A. 8012 (L)

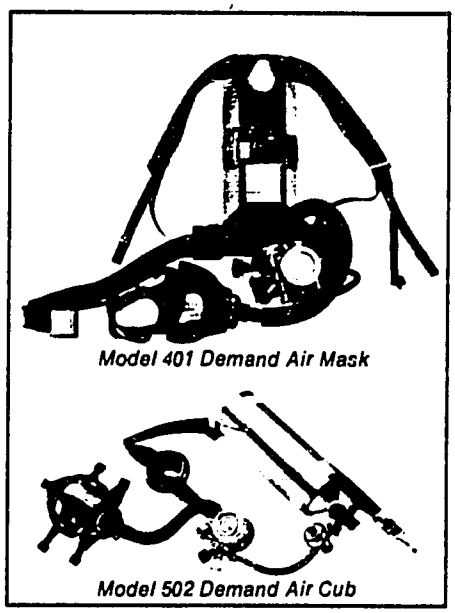
MSA

**Data Sheet**
**01-00-10**

# Demand Air Mask and Demand Air Cub™

*Model 401 Demand Air Mask*

*Model 502 Demand Air Cub*


*Model 401 Demand Air Mask*

*Model 502 Demand Air Cub*

## Application

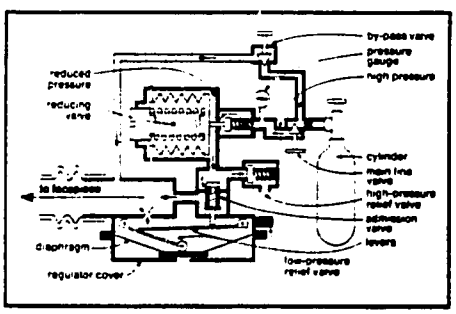
The Model 401 Demand Air Mask is designed for use where oxygen deficiency or toxic gas concentrations present a danger. The Model 502 Demand Air Cub™ apparatus supplements the Model 401 for shorter-time activity and should not be used in its place.

Pressure demand versions of both models are available for extremely toxic atmospheres, where even minute levels of inward leakage into the facepiece would be dangerous. (A slight positive pressure within the facepiece prevents leakage.)

## Description

### Apparatus

The Model 401 Demand Air Mask Breathing Apparatus and the Model 502 Demand Air Cub Breathing Apparatus are demand-type, self-contained units. Air is supplied on demand at ambient atmospheric pressure. As the user inhales, air is drawn from the supply cylinder in the quantity necessary to satisfy breathing requirements. Both models are open-circuit systems that release exhaled air to the surrounding atmosphere without reuse.




*This diagram of a demand-type breathing apparatus traces the flow of air from the cylinder through the regulator to the facepiece.*

The Demand Air Mask has a 45-cubic-foot (1274-liter) capacity air-storage cylinder with a rated service life of 30 minutes. The Demand Air Cub has a 26-cubic-foot (736-liter) capacity air-storage cylinder with a rated service life of 15 minutes. See the section on Service Life.

Both the MSA Demand Air Mask and Air Cub consist of five major components:

- Ultravue® facepiece equipped with headbands, exhalation valve, speaking diaphragm, and breathing tube. Because facepiece fit is so important in a demand mask to minimize the possibility of inward leakage of contaminants, MSA offers the larger Clearvue® facepiece in addition to the standard Ultravue facepiece to provide a broader range of effective face-to-facepiece fit with MSA demand apparatus. The two facepieces are interchangeable on MSA Demand Air Mask and Air Cub apparatus;
- Demand regulator capable of air delivery of more than 400 liters per minute with built-in high-pressure and low-pressure relief valves;
- Audi-Larm™ warning device that sounds an audible alarm when the cylinder air pressure drops below a preset level;
- High-pressure cylinder to store the supply of compressed air;
- Harness for mounting the assembly on the body. Model 401 has the Cushionaire™ harness with foam-padded shoulder straps, a backplate of ⅛-inch-thick anodized aluminum. The Air Cub apparatus does not use a backplate. Instead, the cylinder is mounted with a stainless-steel cylinder holder which is held by a simple harness designed to allow the user to don the apparatus quickly.

### Cylinders

Two types of high-pressure cylinoers are available for use with the Model 401 Air Mask:

1. a lightweight Composite aluminum-fiberglass cylinder (approximately 10.5 pounds, empty, without valve);
2. the standard steel cylinder (18-20 pounds, empty, without valve).

The Composite Cylinder and steel cylinder are interchangeable on the MSA Demand Air Mask and the Pressure Demand Air Mask.

Both Air Mask cylinders have a capacity of approximately 45 cubic feet of air when they are charged to a pressure of 2216 psig, and are also refilled with the same equipment. The cylinder for the Model 502 Air Cub apparatus has a capacity of approximately 26 cubic feet of air when charged to 2216 psig. MSA cylinders are hydrostatically tested to 5/3 of the 2015 psig rated pressure, in accordance with Department of Transportation (DOT) Specification 3AA.

Cylinders are equipped with a flush-mounted pressure gauge. A removable rubber guard protects the gauge if the cylinder is dropped. The cylinder valve handwheel, mounted at a right angle to the valve stem for ease of operation and protection from damage, controls the flow of high-pressure air to the demand regulator.

## Approvals and Standards

The Model 401 Air Mask is jointly approved by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA), formerly the Mining Enforcement and Safety Administration (MESA), under Subpart H, 30 CFR, Part 11 for a 30-minute service life. The NIOSH approval number is TC-13F-29.

The Model 502 Air Cub apparatus is jointly approved by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA), formerly the Mining Enforcement and Safety Administration (MESA), under Subpart H, 30 CFR, Part 11, for a 15-minute service life. The NIOSH approval number is TC-13F-46.

The Model 401 Demand Air Mask meets the requirements of the National Fire Protection Association (NFPA) Standard 19B-1971 (Respiratory Protective Equipment for Firefighters); both also meet guidelines for self-contained breathing apparatus contained in the American National Standards Institute (ANSI) Standard Z88.2-1969 (Practices for Respiratory Protection) and ANSI Z88.5-1973 (Practices for Respiratory Protection for the Fire Service).

MSA steel cylinders meet the requirements of the Department of Transportation Specification 3AA. The Composite Cylinder has received Department of Transportation Exemption 7277 for shipment in interstate commerce.

## Service Life

Approvals from NIOSH-MSHA for duration of use (30 minutes for the Model 401 Air Mask and 15 minutes for Model 502 Air Cub). are based on tests conducted by NIOSH. These apparatus were tested with a breathing machine at a use rate of 40 liters per minute and were able to supply air for the rated service life or longer.

However, because work performed by the user may be more or less strenuous than the work level of the test procedure, actual service life may be affected. During extreme exertion, for example, service life may be reduced as much as 50 percent.

Service duration of each unit depends on such factors as:

- The degree of physical activity by the user;
- The physical condition of the user;
- Emotional conditions such as fear or excitement (which may increase the user's breathing rate);
- The degree of training or experience the user has had with such equipment;
- Whether or not the cylinder is fully charged at the beginning of use;
- Possible presence of carbon dioxide ($CO_2$) in the compressed air supply at levels greater than the 0.4 percent found in normal air;
- Atmospheric pressure, e.g. use in a pressurized tunnel or caisson. At two atmospheres (15 psig) the duration will be one-half as long as the rated service life; at three atmospheres the duration will be one-third as long as the rated service life;
- Condition of the breathing apparatus.

## Inspection and Maintenance

The Demand Air Mask and Demand Air Cub should be inspected and maintained in accordance with OSHA regulations 1910.134(f) and ANSI Standards Z88.2 and Z88.5 (for the fire service) which recommends that self-contained breathing apparatus be inspected routinely, before and after each use, and at least monthly.

MSA offers a bulletin that outlines Inspection and Maintenance Procedures for Self-Contained Breathing Apparatus. In addition, inspection tags are available from MSA for the Model 401 Demand Air Mask and Model 502 Demand Air Cub. MSA also can supply a permanent log for recording weekly, after-use, and monthly inspections.

## Caution

Repairs of breathing apparatus must never be attempted beyond the scope of the manufacturer's recommendations.

Regulators must be sent to the manufacturer or an authorized MSA Air Mask Service Center for adjustment or repair.

Parts must not be interchanged among self-contained breathing devices from different manufacturers.

MSA demand regulators must not be interchanged with MSA pressure demand regulators; MSA demand facepieces must not be interchanged with MSA pressure demand facepieces.

Cylinders must be filled to required pressure before use: 2216 psig on both the Model 401 Air Mask and Model 502 Air Cub.

Only respirable air, free of all organic substances and other contaminants should be used to refill the cylinder. Refill air should be at least Grade D, gaseous air, as described in the Compressed Gas Association Commodity Specification for Air, G-7.1, ANSI Z86.1-1973.

Proper cleaning agents, such as MSA Cleaner-Sanitizer II, must be used to sanitize the unit after each use so that rubber components do not deteriorate. NEVER use alcohol as a germicide, because it may deteriorate the rubber. Do not apply heat to the rubber parts to speed drying.

Lubricants MUST NEVER BE USED on any part of the apparatus and all parts must be kept free of grease and oil.

Respiratory protection only is provided by self-contained breathing apparatus. For protection of skin exposed to toxic gases which can irritate or penetrate the skin, other precautions must be taken.

Unless an emergency exists, personnel should not enter a foam-filled building, enclosure, or become completely covered with foam, because hearing becomes difficult, vision is blocked, and breathing becomes uncomfortable. Where rescue work or firefighting requires entry into a foam-filled building or enclosure, use only positive pressure self-contained breathing apparatus for proper respiratory protection. The condensation of foam inside the regulator housing can cause the pressure demand self-contained breathing apparatus to flow continuously. Should this occur, return at once to fresh air, even if the end-of-service-life alarm has not sounded.

## Ordering Information

**Catalog numbers**

**Model 401 Demand Air Mask**

**463830** Model 401 Demand Air Mask, complete with lightweight Composite Cylinder in case
**463827** Model 401 Demand Air Mask, complete with lightweight Composite Cylinder, less case
**457153** Model 401 Demand Air Mask with steel cylinder, complete in case
**457152** Model 401 Demand Air Mask with steel cylinder, less case
**460320** Air Mask Composite Cylinder (45 cubic feet) with valve
**94007** Air Mask steel cylinder (45 cubic feet) with valve

**Model 502 Air Cub**

**457151** Model 502 Demand Air Cub, complete in case
**457150** Model 502 Demand Air Cub, less case
**456104** Air Cub steel cylinder (26 cubic feet) with valve

**Clearvue Demand Facepiece**

**95940** Clearvue Demand Facepiece (black) for Demand Air Mask and Air Cub

**Accessories**

**457135** Nosecup for Ultravue Facepiece
**454819** Prescription Spectacle Kit for Ultravue Facepiece
**34337** Cleaner-Sanitizer II (dispenser box of 12 2-oz packages)

**Note:** This Data Sheet contains only a general description of the Model 401 Demand Air Mask and Model 502 Demand Air Cub apparatus and accessories. While uses and performance capabilities are described, under no circumstances should the products be used except by qualified trained personnel and not until the instructions, labels, and other literature accompanying them have been read, understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning these products.

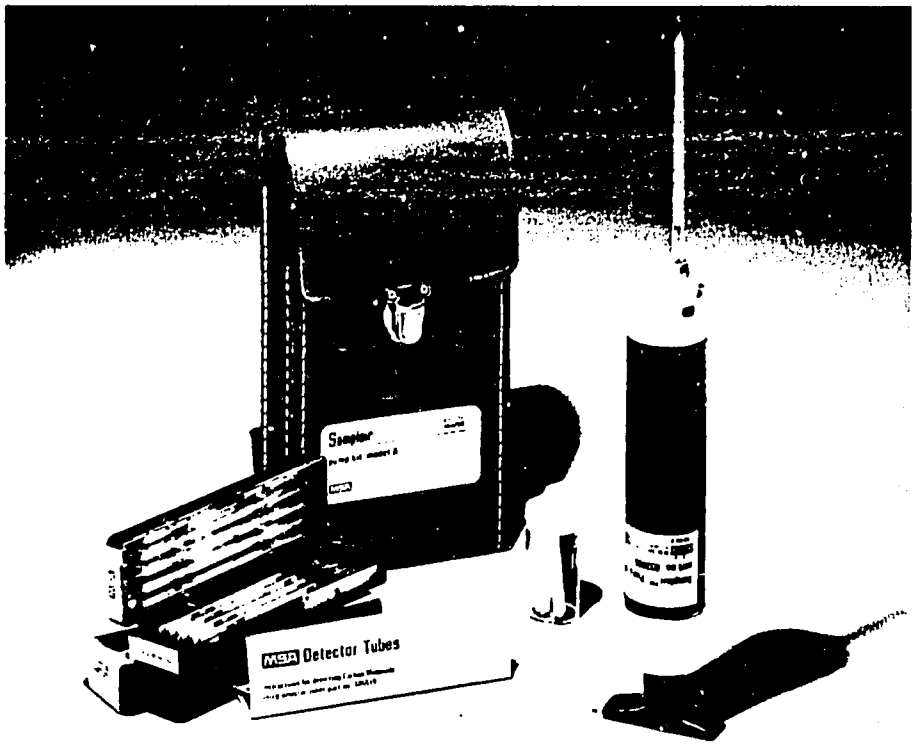
MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 · Telex 812453

Worldwide service: Branch offices throughout the United States. Subsidiaries in: Amsterdam · Barcelona · Berlin · Calcutta · Glasgow · Johannesburg · Lima · Mexico City · Milan · Ndola · Paris · Santiago · Sao Paulo · Singapore · Sydney · Tokyo · Toronto. Representatives in principal cities throughout the world.

MSA

Data Sheet
08-02-02

# Samplair™ Pump, Model A




*Samplair Pump, Model A, with carrying case and accessories*

## Application

The Samplair Pump, Model A, provides an economical method for manual sampling of a broad range of toxic gases, vapors, and mists in the threshold limit ranges. It is designed for use with the majority of MSA detector tubes and can be used for testing atmospheres for toxics in accordance with OSHA procedures.

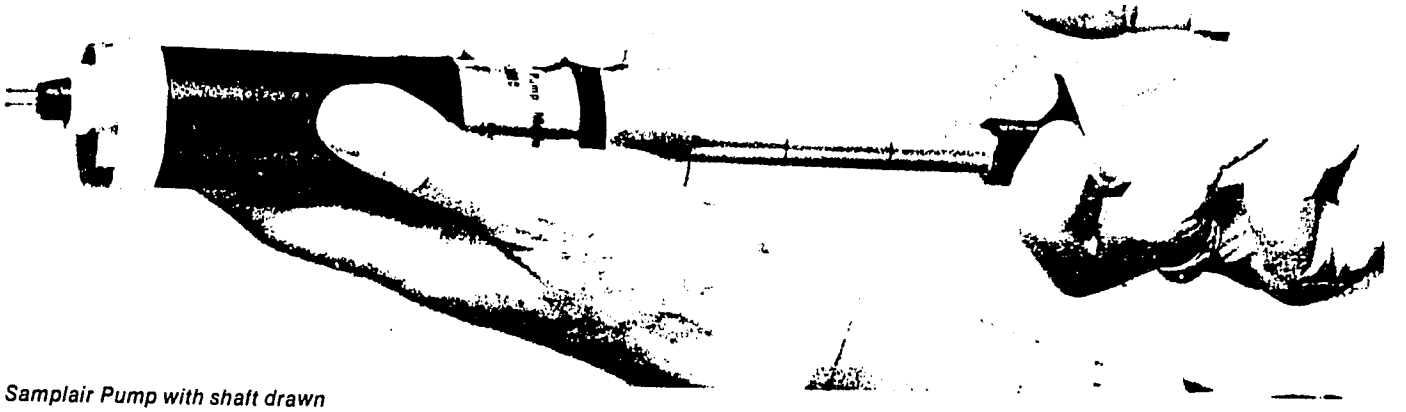
## Description

The Samplair Pump, Model A, a simplified, economical version of the MSA Universal Tester, is a variable-volume piston-type pump which draws an accurate sample of ambient air through a detector tube affixed to its intake end. The operator draws the handle of the pump to the preset position which controls volume at four levels (25, 50, 75, or 100 cc), and notes the reaction in the detector tube being exposed. The Samplair Pump Kit includes: pump, carrying case, spare parts vial, and maintenance sheet. Sufficient space is provided in the case for two packages of detector tubes.

MSA detector tubes are chemically filled glass tubes with break-off tips. They are packaged in boxes of 10 and have a minimum two-year shelf life. Detector tubes indicate the presence of the gas being tested for by the length of a color change resulting from the reaction of chemical in the tube with the compound of interest. Tubes have been calibrated for gases and/or vapors listed on their packing box, such as carbon monoxide, hydrogen sulfide, sulfur dioxide, etc.

Sampling lines of various lengths can be used with the Samplair Pump, Model A, to test for the presence of toxic atmospheres in hard-to-reach areas.

**Precision calibrated shaft accurately indexes the intake volume at 25, 50, 75, or 100 cc. Spring-loaded stop locks shaft in desired position.**



*Samplair Pump with shaft drawn*

## Approvals

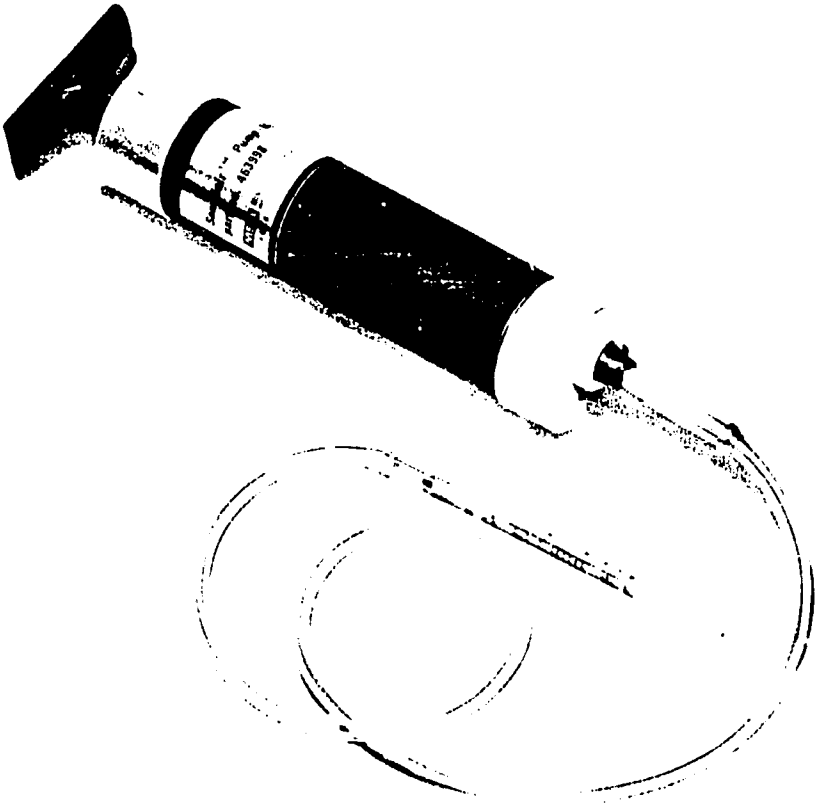
The Samplair Pump, Model A, is certified by NIOSH when used with selected MSA detector tubes.

## Ordering information

**Catalog numbers**

| | |
|---|---|
| **464080** | Samplair Pump, Model A, complete with carrying case, spare parts kit, and remote sampling connecting tube. |
| **73067** | Sampling line, 10 ft. |
| **73068** | Sampling line, 25 ft. |
| **73069** | Sampling line, 50 ft. |

**Note:** Detector Tubes and Accessories for use with the Samplair Pump are listed in Data Sheet 08-01-02.



*Samplair Pump, Model A, with adapter and sampling line for remote sampling.*

**Note:** This data sheet contains only a general description of the Samplair Pump, Model A. While uses and performance capabilities are described, under no circumstances should the product be used except by qualified, trained personnel and not until the instructions, labels, or other literature accompanying it have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning this product.

MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 · Telex 812453

Worldwide service: Branch offices throughout the United States. Subsidiaries in: Amsterdam · Barcelona · Berlin · Calcutta · Glasgow Johannesburg · Lima · Mexico City · Milan · Ndola · Paris · Salisbury Santiago · São Paulo · Singapore · Sydney · Tokyo · Toronto. Representatives in principal cities throughout the world.



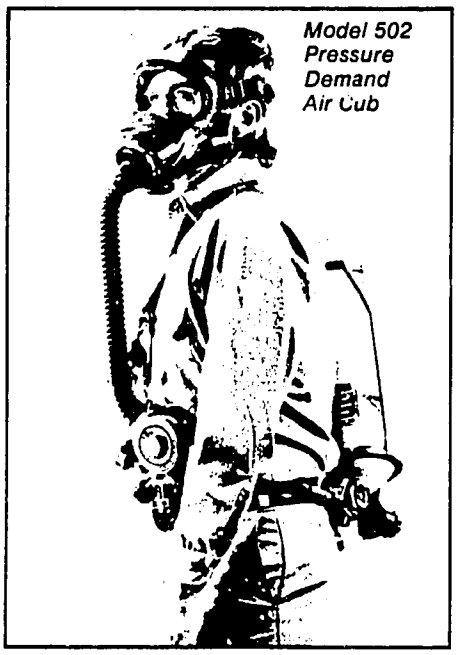
Printed in U.S.A. 8112 (L)

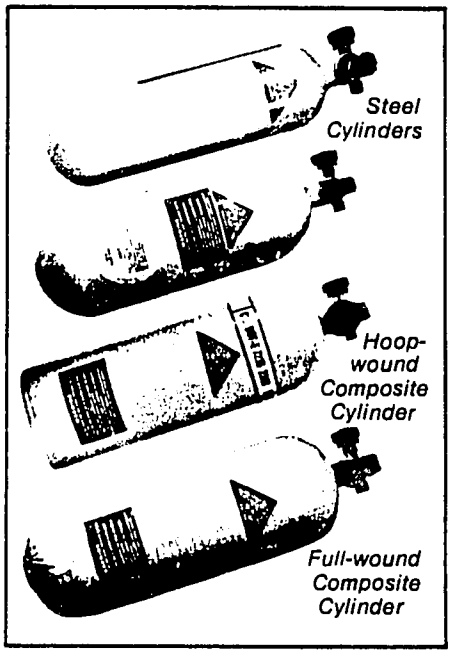
55

MSA

Data Sheet
01-00-11

# Pressure Demand Air Mask and Air Cub™




## Description

The **Pressure Demand Model 401 Air Mask Breathing Apparatus** and the **Pressure Demand Model 502 Air Cub Breathing Apparatus** are pressure-demand type self-contained breathing apparatus that provide respiratory protection under conditions of oxygen deficiency or in concentrations of toxic gases. Both models are open-circuit systems that release exhaled air to the surrounding atmosphere without reuse.

The Model 401 Pressure Demand Air Mask and Model 502 Pressure Demand Air Cub consist of an Ultravue® facepiece assembly equipped with a spring-loaded exhalation valve and breathing tube; a pressure demand regulator that supplies air to the facepiece under positive pressure; a high-pressure hose that links the regulator to the Audi-Larm™ audible low-pressure warning device; a high-pressure cylinder to store the compressed air; and a harness assembly for carrying the apparatus on the wearer's body.

## Application

The MSA Pressure Demand Air Mask and Pressure Demand Air Cub provide respiratory protection in toxic atmospheres where it is necessary to avoid potential inward leakage that could result from negative pressure that is developed in a demand-type apparatus. These MSA Pressure Demand Apparatus maintain a slight positive pressure inside the facepiece during inhalation and, through a spring-loaded exhalation valve, provide low exhalation resistance while maintaining the positive pressure *inside the facepiece.*

Recent OSHA standards specify the use of *only* pressure demand apparatus for fire-fighting or emergency entry into unknown concentrations of toxic gases.

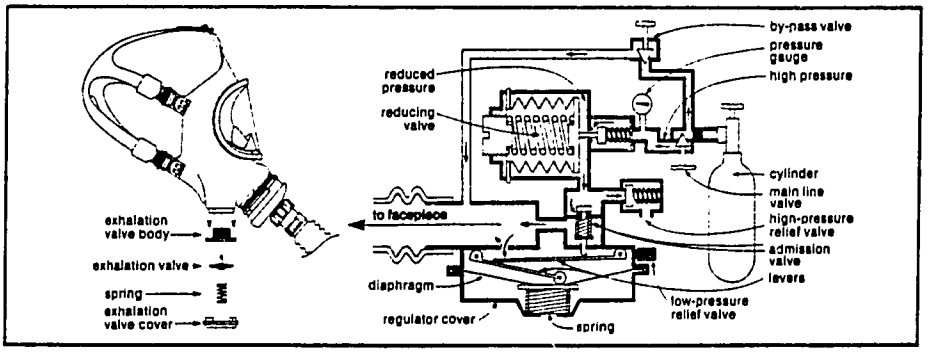
Both units are approved for entry into and escape from irrespirable atmospheres. Both can be used in extremely toxic atmospheres where even minute levels of inward leakage into the facepiece would be dangerous.

The Model 401 Pressure Demand Air Mask has a rated service life of 30 minutes. The Model 502 Air Cub, with a rated service life of 15 minutes, is designed to supplement the Pressure Demand Air Mask for shorter periods of time in irrespirable atmospheres, and should not be used in its place.

Service life ratings are based on the results of tests conducted by the National Institute for Occupational Safety and Health. See the section on Service Life.

## Operation

Demand-type units adjust automatically to deliver the air supply necessary to satisfy breathing requirements, with air pressure inside the facepiece the same as outside (so under some circumstances there is a possibility of inward leakage of air). With the Pressure Demand Air Mask and Pressure Demand Air Cub apparatus, air is delivered to the facepiece at a pressure of approximately 1.0 inch of water. This slight positive pressure is controlled by a spring on the regulator diaphragm. Flow stops during exhalation because the exhalation valve opens at approximately 1.5 inches of water, positive pressure. The pressure inside the facepiece, therefore, remains positive during both inhalation and exhalation. With this pressure demand arrangement, the danger of potential inward leakage is minimized, yet breathing resistance is low. Because of these operating differences, pressure demand regulators must never be interchanged with demand regulators; pressure demand facepieces must never be interchanged with demand facepieces.






56

## Components of MSA Pressure Demand Air Mask

### Ultravue® Facepiece

The **Ultravue Facepiece** is supplied with both the Model 401 Pressure Demand Air Mask and Model 502 Pressure Demand Air Cub units. This facepiece has a one-piece replaceable **lens** that is molded out of polycarbonate plastic, five adjustable **headbands**, and a **speaking diaphragm** to project the sound of the user's voice through the mask. The plastic lens is treated with a coating which resists scratching and chemical attacks. Rubber components are made out of a compound that is soft and resistant to facial oils. An internal **baffle** controls lens fogging by deflecting exhaled air away from the lens. The baffle also directs the sound of the user's voice into the speaking diaphragm. Exhaled air vents to the surrounding atmosphere through an **exhalation valve.**

Ultravue facepiece accessories include: a **spectacle kit** for mounting prescription lenses inside the facepiece without disturbing the facepiece seal; a **nosecup assembly** to reduce the possibility of lens fogging (NIOSH requires the use of this accessory when the apparatus is used at temperatures below 32°F); a **cover lens** to provide additional facepiece-lens protection.

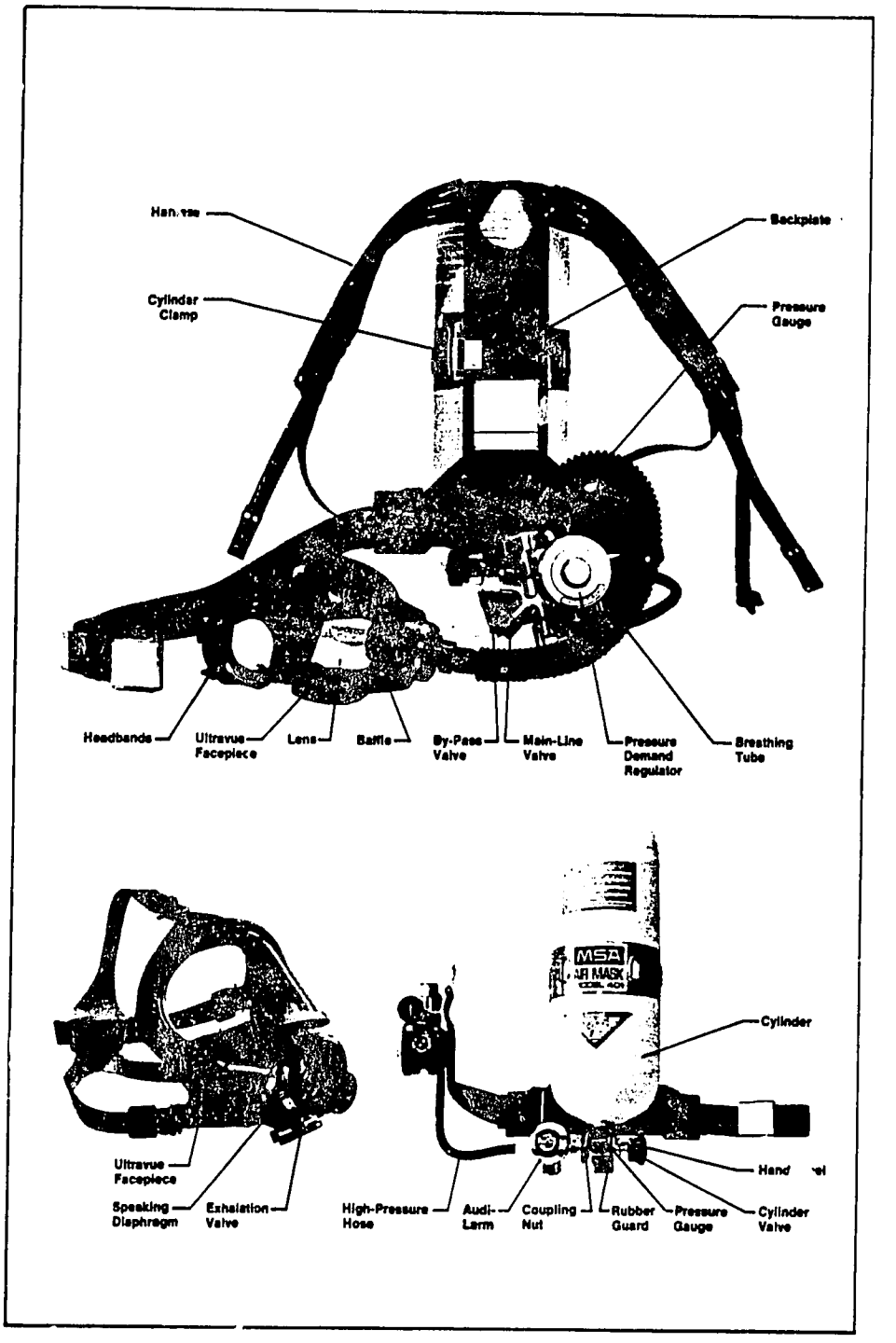
### Two facepieces available

Because facepiece fit is so important in a pressure demand apparatus to conserve the air supply, MSA offers the larger Clearvue® pressure demand facepiece in addition to the standard Ultravue pressure demand facepiece to provide a broader range of effective face-to-facepiece fit with MSA pressure demand apparatus. The two pressure demand facepieces are interchangeable on MSA Pressure Demand Air Mask and Air Cub apparatus.

### Pressure demand regulator

The **pressure demand regulator** supplied with all MSA Pressure Demand Air Masks, can deliver high volume air flow to meet breathing demands during periods of extreme exertion while maintaining a positive pressure in the facepiece. The regulator reduces the high pressure of the cylinder air to a breathable pressure, and automatically meters the flow of air to the facepiece during inhalation and exhalation, maintaining a slight pressure of approximately 1.0 inch of water above ambient atmospheric pressure. The MSA regulator design incorporates both high-pressure and low-pressure relief devices which preclude the possibility of damage to the regulator's internal components or diaphragm cover in case of a buildup of excessive pressure. The regulator is connected to the facepiece by the **breathing tube.**

Under normal operating conditions, air flow through the regulator is controlled by a **main-line valve** that is equipped with a round yellow knob. However, should the automatic regulator mechanism be damaged or fail to operate, a **by-pass valve** with a six-sided red knob provides a controlled, direct, constant flow of air from the cylinder. The difference in shapes of the main-line and by-pass knobs permits identification by touch in a smoke-filled or dark area. A **pressure gauge** on the regulator indicates remaining air pressure in the cylinder. High-pressure air is delivered to the regulator by a length of **high-pressure hose.**




## Audi-Larm™ Warning Device

The **Audi-Larm** supplied on both the Model 401 Pressure Demand Air Mask and Model 502 Pressure Demand Air Cub gives an audible warning when the cylinder air pressure drops below a preset level. It alerts the user that the air supply is nearing exhaustion, and warns the user to leave the toxic area. The assembly is installed between the high-pressure hose and the cylinder-valve outlet. It is joined to the cylinder valve by a hand-tightened **coupling nut.** The Audi-Larm is automatically made ready to operate when the user opens the cylinder valve.

When the cylinder pressure reaches approximately 540 psig, the warning device's piston begins to strike the 2½-inch-diameter nickel-plated-brass bell. The ringing continues until the cylinder pressure drops below approximately 200 psig. The operating pressures are preset at the factory.

Total ringing time depends on cylinder capacity. When connected to a 45-cubic-foot capacity cylinder (as on the Air Mask), the bell will ring for approximately six minutes. When connected to a 26-cubic-foot capacity cylinder (as on the Air Cub), the bell will ring for approximately three minutes. When ringing, the Audi-Larm consumes less than two liters of air per minute (a small fraction of the total remaining air supply).

## Cylinders

The Model 401 Pressure Demand Air Mask can be furnished with one of three types of cylinders: a lightweight, fully wrapped composite (aluminum-fiber glass) cylinder which weighs approximately 10.5 pounds, a hoop-wound composite cylinder weighing approximately 11.75 pounds, or the standard steel cylinder weighing 18-20 pounds. These weights are for unvalved cylinders. The cylinders have an air-storage capacity of 45 cubic feet (1274 liters) for the full-wound and the steel cylinders, and 45.5 cubic feet (1288 liters) for the hoop-wound cylinder when all are charged to a pressure of 2216 psig and are refilled with the same equipment.

The Model 502 Pressure Demand Air Cub is supplied only with a steel cylinder having an air-storage capacity of 26 cubic feet (736 liters) and a rated service life of 15 minutes when charged to a pressure of 2216 psig.

The steel cylinders (both sizes) are made of high-strength chromium-molybdenum steel. The Air Mask full-wound composite cylinder is a seamless aluminum-alloy tank wound over its entire surface with high strength S-glass filaments impregnated with epoxy resin. The hoop-wound cylinder is an aluminum cylinder with a resin-impregnated filament wrapping over the side walls. All cylinders are hydrostatically tested to 5/3 of the rated pressure in accordance with Department of Transportation regulations.

Both composite cylinders have a cadmium-plated valve and the steel cylinder has a nickel-plated valve. All cylinders are equipped with a flush-mounted **pressure gauge.** A removable **rubber guard** protects the gauge if the cylinder is dropped. The cylinder-valve **handwheel**—mounted at a right angle to the valve stem for ease of operation and protection from damage—controls the flow of high-pressure air to the pressure demand regulator.

**NOTE:** To ensure that the cylinder remains free of organic substances and other contaminants, it must be filled only with respirable air that conforms to the Compressed Gas Association Commodity Specification for Air, G-7.1, ANSI Z86.1-1973, for Grade D or better gaseous air.

## Harness and backplate

The **Cushionaire™ Harness** of the Model 401 Pressure Demand Air Mask has a foam-padded, two-inch-wide nylon strap at each shoulder, and a padded strap across the bottom of the backplate where contact is made with the wearer's back. The **backplate** is made of ⅛-inch-thick aluminum and is painted black.

The **cylinder clamp** installed on the Model 401 Pressure Demand Air Mask is an adjustable mechanism that compensates for small variations in outside cylinder dimensions. It consists of a cam-type latch that can engage any of six slots in the stainless-steel spring clip. The cylinder is changed by opening the cam latch, slipping out the empty cylinder, slipping in the recharged cylinder, and twisting the cam latch to locking position.

## Carrying case

Pressure demand self-contained breathing apparatus is supplied in a molded plastic case to facilitate carrying the apparatus and to protect it in storage. The Pressure Demand Air Mask case is approximately 27x18x11 inches and weighs approximately 12 pounds (empty). The Pressure Demand Air Cub case is approximately 23x12x6 inches and weighs approximately 7 pounds (empty).

## Model 502 Pressure Demand Air Cub

The Model 502 Pressure Demand Air Cub is equipped with the same facepiece, pressure demand regulator, Audi-Larm, and cylinder valve as the Model 401 Pressure Demand Air Mask.

The major physical differences are the capacity of the cylinder and the design of the harness assembly. The Air Cub cylinder has a capacity of approximately 26 cubic feet of air, when filled to a pressure of 2216 psig. It has a rated service life of 15 minutes.

The Pressure Demand Air Cub does not have a backplate harness. Instead, the cylinder rests in a stainless steel cylinder holder. A single cushioned shoulder strap runs from the cylinder holder to a 4-inch-diameter steel ring. In turn, an adjustable nylon strap leads from the ring to the demand regulator and an under-the-arm strap extends between the ring and the cylinder holder. This harness holds the cylinder at an angle across the wearer's back.

*To don the Pressure Demand Air Cub, the user grasps the large round ring with his right hand and the shoulder pad with his left hand, and swings the harness over his head so the shoulder pad is on the right shoulder. The regulator strap is adjusted to the desired tightness and the loose strap is snapped to the ring and tightened.*

## Service life

Approvals from NIOSH-MSHA for duration of use (30 minutes) for the Model 401 Pressure Demand Air Mask and 15 minutes for Model 502 Pressure Demand Air Cub are based on tests conducted by NIOSH. Both apparatus were tested with a breathing machine at a use rate of 40 liters per minute and were found able to supply air for the rated service life or longer.

However, work performed by an actual user may be more or less strenuous than the work level simulated in the test procedure, and this difference will affect service life. During extreme exertion, for example, service life may be reduced as much as 50%. Service duration of each unit depends on such factors as:

- degree of physical activity by the user;
- the physical condition of the user;
- emotional conditions such as fear or excitement (which may increase the user's breathing rate);
- the degree of training or experience the user has had with such equipment;
- whether or not the cylinder is fully charged at the beginning of use;
- possible presence of carbon dioxide ($CO_2$) in the compressed-air supply at levels greater than the 0.4 percent found in normal air;
- atmospheric pressure—if used in a pressurized tunnel or caisson, at two atmospheres (15 psig) duration will be half as long; at three atmospheres (30 psig), duration will be one-third as long;
- condition of the apparatus.

## Approvals and standards

The Model 401 Pressure Demand Air Mask and Model 502 Pressure Demand Air Cub apparatus are jointly approved by the National Institute for Occupational Safety and Health (NIOSH) and Mine Safety and Health Administration (MSHA), under Subpart H, 30 CFR, Part 11. The Model 401 has Approval TC-13F-30 for 30-minute service, and the Model 502 has Approval TC-13F-47 for 15-minute service.

The Model 401 Pressure Demand Air Mask meets the requirements of the National Fire Protection Association (NFPA) Standard 1981 (Self-Contained Breathing Apparatus for Firefighters); both also meet guidelines for self-contained breathing apparatus contained in the American National Standards Institute (ANSI) Standard Z88.2-1980 (Practices for Respiratory Protection) and ANSI Z88.5-1973 (Practices for Respiratory Protection for the Fire Service).

MSA Steel Cylinders meet the requirements of the Department of Transportation Specification 3AA. The MSA Composite Cylinder has received DOT Exemption 7277 for shipment in interstate commerce, and the hoop-wound cylinder has Exemption 7235.

## Inspection and maintenance

The Pressure Demand Air Mask and Pressure Demand Air Cub should be inspected and maintained in accordance with OSHA regulations 1910.134(f) and ANSI Z88.2 and Z88.5 standards (for the fire service) which recommend that self-contained breathing apparatus be inspected routinely before and after each use. Apparatus not used routinely but kept ready for emergency use should be inspected after each use and at least monthly.

MSA offers a bulletin that outlines Inspection and Maintenance Procedures for Self-Contained Breathing Apparatus. In addition, MSA has available inspection tags for the Model 401 and Model 502 and a permanent log for recording the weekly, after-use, and monthly inspections.

## Caution

Repairs of breathing apparatus must never be attempted beyond the scope of the manufacturer's recommendations.

Regulators must be sent to the manufacturer or an authorized MSA Air Mask Service Center for adjustment or repair.

Parts must not be interchanged among self-contained breathing devices from different manufacturers.

Cylinders must be filled to required pressure before use: 2216 psig on both the Model 401 Air Mask and Model 502 Air Cub.

Only respirable air, free of all organic substances and other contaminants, should be used to refill the cylinder. Refill air should be at least Grade D, gaseous air.

Proper cleaning agents, such as MSA Cleaner-Sanitizer II, must be used to sanitize the unit after each use so that rubber components do not deteriorate. NEVER use alcohol as a germicide, because it may deteriorate the rubber. Do not apply heat to the rubber parts to speed drying.

MSA pressure demand regulators must not be interchanged with MSA demand regulators; MSA pressure demand facepieces must not be interchanged with MSA demand facepieces.

Unless an emergency exists, personnel should not enter a foam-filled building, enclosure, or become completely covered with foam, because hearing becomes difficult, vision is blocked, and breathing becomes uncomfortable. Where rescue work or firefighting requires entry into a foam-filled building or enclosure, use only positive pressure, self-contained breathing apparatus for proper respiratory protection. The condensation of foam inside the regulator housing can cause the pressure demand self-contained breathing apparatus to flow continuously. Should this occur, return at once to fresh air, even if the end-of-service-life alarm has not sounded.

## Weight specifications

**Model 401 Pressure Demand Air Mask**

- Complete apparatus with full-wound Composite Cylinder, approximately 25 pounds.
- Complete apparatus with full-wound Composite Cylinder, in case packed for shipment, approximately 37 pounds.
- Complete apparatus with hoop-wound Composite Cylinder. Approximately 26.5 pounds. Packed for shipment, approximately 38.5 pounds.
- Complete apparatus with steel cylinder, approximately 33 pounds.
- Complete apparatus with steel cylinder, in case packed for shipment, approximately 45 pounds.
- Full-wound Composite Cylinder only, with valve, fully charged, approximately 15 pounds.
- Hoop-wound Composite Cylinder only, with valve, fully charged, approximately 16.5 pounds.
- Steel cylinder only, with valve, fully charged, approximately 23 pounds.

**Model 502 Pressure Demand Air Cub**

- Complete apparatus, approximately 22 lb.
- Complete apparatus, in case, packed for shipment, approximately 29 pounds.
- Steel cylinder only, with valve, fully charged, approximately 14 pounds.

## Ordering information

**Catalog numbers**

**Pressure Demand Air Mask**

| | |
|---|---|
| 463831 | MSA Pressure Demand Air Mask, Model 401, with full-wound Composite Cylinder, with Ultravue Facepiece, complete in carrying case |
| 463814 | MSA Pressure Demand Air Mask, Model 401, with full-wound Composite Cylinder, with Ultravue Facepiece, less case |
| 470448 | MSA Pressure Demand Air Mask, Model 401, with hoop-wound Composite Cylinder, with Ultravue Facepiece, complete in case |
| 470444 | MSA Pressure Demand Air Mask, Model 401, with hoop-wound Composite Cylinder, with Ultravue Facepiece, less case |
| 461704 | MSA Pressure Demand Air Mask, Model 401, with steel cylinder, with Ultravue Facepiece, complete in carrying case |
| 461696 | MSA Pressure Demand Air Mask, Model 401, with steel cylinder, with Ultravue Facepiece, less case |
| 460320 | Full-wound Composite Cylinder, 45-cubic-foot capacity, complete with valve, for Model 401 Air Mask |
| 469619 | Hoop-wound Composite Cylinder, 45-cubic-foot capacity, complete with valve, for Model 401 Air Mask |
| 94007 | MSA Steel Air Cylinder, 45-cubic-foot capacity, complete with valve, for Model 401 Air Mask |

**Pressure Demand Air Cub**

| | |
|---|---|
| 461703 | MSA Pressure Demand Air Cub, Model 502, with Ultravue Facepiece, complete in carrying case |
| 461697 | MSA Pressure Demand Air Cub, Model 502, with Ultravue Facepiece, less case |
| 456104 | MSA Steel Air Cylinder, 26-cubic-foot capacity, complete with valve; for Model 502 Air Cub |

**Clearvue Pressure Demand Facepiece**

| | |
|---|---|
| 96057 | Pressure Demand Clearvue Facepiece (black) for Pressure Demand Air Mask and Air Cub |

**Accessories**

| | |
|---|---|
| 457135 | Nosecup for Ultravue Facepiece |
| 454819 | Prescription Spectacle Kit for Ultravue Facepiece |
| 34337 | Cleaner-Sanitizer II (dispenser box of 12 2-oz packages) |

**Note:** This Data Sheet contains only a general description of MSA Model 401 Pressure Demand Air Mask, Model 502 Pressure Demand Air Cub, and accessories. While uses and performance capabilities are described, under no circumstances should these products be used except by qualified, trained personnel and not until the instructions, labels or other literature accompanying them have been carefully read and understood and the precautions set forth therein followed. Only they contain the complete and detailed information concerning these products.

MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 · Telex 812453

Worldwide service: Branch offices throughout the United States. Subsidiaries in: Amsterdam · Barcelona · Berlin · Calcutta · Glasgow Johannesburg · Lima · Mexico City · Milan · Ndola · Paris · Salisbury Santiago · São Paulo · Singapore · Sydney · Tokyo · Toronto. Representatives in principal cities throughout the world.

Data Sheet 01-00-11

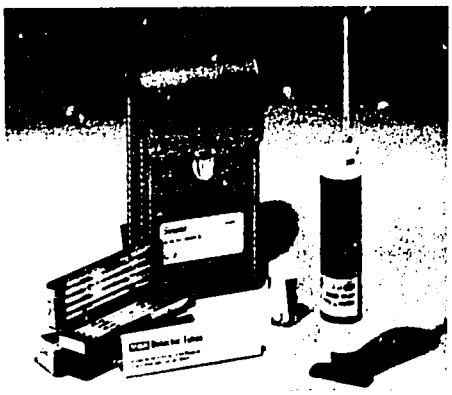
Printed in U.S.A. 8110 (L)

MSA

Data Sheet
08-01-02

# Detectors, Reagents, and Accessories for Samplair™ Pump and Testing Kit.

## Also for Universal Tester.



Using the Samplair Pump with appropriate tubes, filter paper and reagent kits, some 140 toxic gases, vapors, and mists in the threshold limit ranges can be detected.

MSA® detector tubes are regularly submitted for certification by National Institute for Occupational Safety and Health. The tubes which at the time this list was printed have been certified by NIOSH as meeting the requirements of 42 CFR Part 84 when used with these pumps, are indicated by "NIOSH" and Testing & Certification number following the listed detectable hazard. The tubes are a direct-reading type. Those tubes calibrated for a single compound have the concentration scale printed on the tube for direct reading. Multiple-use tubes have a millimeter scale printed on the tube and concentrations are determined from a table supplied with the package. Tubes are supplied in packages of ten.

Note: Shelf life of Detector Tubes and Reagent Kits, minimum of 30 months after packaging.

For information on the Samplair Pump, Model A, see Data Sheet 08-02-02.

## Key

Ⓐ Refers to Threshold Limit Values as established by the American Conference of Governmental Industrial Hygienists—1980. (TLVs refer to time-weighted-average concentrations for a 7- or 8-hr workday and 40-hr workweek.) Threshold Limit Values are reviewed annually by the Conference. For current TLV data, contact: Secretary-Treasurer, American Conference of Governmental Industrial Hygienists, P.O. Box 1937, Cincinnati, Ohio 45201.

Ⓑ Interferences and temperature correction data shown on individual instruction sheets.

Ⓒ Also order #81316 Package of Pre-Filter Discs to remove interfering $H_2S$ and $SO_2$ (if present). A pre-filter effectively absorbs these gases in concentrations up to 100 ppm.

Ⓓ Also order #58238 Pinch Clamp (necessary to restrict contents of reactor tube).

Ⓔ Also order #82389 Vial of Charcoal (required for filling filter retainer of Accessory Kit to protect Sampling Pump from reagent vapors and/or droplets).

Ⓖ Order Sample Conditioning Kit #87028. When measuring CO content of flue gases or in presence of $NO_2$ in concentrations from 7 to 100 ppm, also order #73139 Gasorbent Refill (sufficient for 10 refills of Sample Conditioning Kit "prescrubber").

Ⓗ If remote sampling is desired, also order a sampling line of the desired length:
- #73067 Sampling Line, 10 ft long
- #73068 Sampling Line, 25 ft long
- #73069 Sampling Line, 50 ft long

Note: when sampling point is remote from pump, detector tube should be placed in remote end of sampling line.

Ⓘ If desired, a gas-sampling collecting kit is available for measuring the mercaptan content of a sample taken from a natural gas line. Order #454500 Gas-Sample Collecting Kit.

Ⓙ Accessory Kit #87030 required for detecting Chromic Acid Mist, Decaborane, Diborane, Lead Dust/Fume, and Pentaborane. Accessory Kit #87031 required for Arsine, Phosphine, and Stibine.

Ⓚ Requires adapter (#467063) when using Samplair Pump.

Ⓛ Flue Gas Test Kit #470321 is available for reducing sample temperature (max. 1000° F) to less than 125° F.

## Detector, Reagents, Accessories for Universal Tester and Samplair Pumps and Testing Kits

*DENOTES TRADENAME ( )TLV FIGURES IN PARENTHESES ARE 1980 PROPOSED

| Detectable Hazard | | Measurable Range (PPM) | Ⓐ 1980 ACGIH TLVs (PPM) | Ⓗ Pkg of Detector Tubes | Reagent Kit | Box of Filter Papers | Required Pyrolyzer | Ⓑ Interferences |
|---|---|---|---|---|---|---|---|---|
| Acetaldehyde | | 25–1000 | 100 | 93963 | | | | Turpentine, other Aldehydes |
| Acetic Acid | | 0–50 | 10 | 460022 | | | | $SO_2$ |
| Acetone | NIOSH (TC-84-54) | 125–6500 | (750) | 460423 | | | | Ethanol |
| Acetonitrile | | 10–200 | 40 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Acetylene | | 3–600 | | 82802 | | | | Ammonia, $H_2S$, CO, Hydrocarbons |
| Acrylonitrile | | 1–150 | (2) | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Ammonia | | 10–400 | 25 | 92115 | | | | Acid gases & other Amines |
| | NIOSH (TC-84-034) | 5–1600 | 25 | 90103 | | | | Acid gases & other Amines |
| n-Amyl alcohol (pentanol 1) | | 25–2000 | | 95097 | | | | Other Alcohols |
| sec-Amyl alcohol (pentanol 2) | | 25–2000 | | 95097 | | | | Other Alcohols |
| tert.-Amyl alcohol (2 methyl-butanol 2) | | 25–2000 | | 95097 | | | | Other Alcohols |
| n-Amyl mercaptan (pentanethiol–1) | | 0.5–100 | | 454206 Ⓘ | | | | $H_2S$ |

*DENOTES TRADENAME

( )TLV FIGURES IN PARENTHESES ARE 1980 PROPOSED

| Detectable Hazard | Measurable Range (PPM) | (A) 1980 ACGIH TLVs (PPM) | (H) Pkg of Detector Tubes | Reagent Kit | Box of Filter Papers | Required Pyrolyzer | (B) Interferences |
|---|---|---|---|---|---|---|---|
| Arsine (I) (R) | 0.025–1.0 | 0.05 | | 81101 (E) | 81220 (C) | | Stibine, Phosphine |
| Benzene | 5–200 | 10 | 93074 | | | | Aromatic, Aliphatic Hydrocarbons |
| | 0–150 | 10 | 467050 | | | | Aromatic, Aliphatic Hydrocarbons |
| Bromine | 5–175 | 0.1 | 82399 | | | | $H_2S$, $NH_3$, $NO_2$, Ethylene, Halides |
| Bromobenzene (Mono) | 10–800 | | 93074 | | | | Aromatic, Aliphatic Hydrocarbons |
| Butadiene (1, 3-butadiene) | 100–4000 | 1000 | 93962 | | | | ——— |
| 2-Butoxyethanol (butyl Cellosolve*) | 30–900 | (25) | 95097 | | | | Other Alcohols |
| n-Butyl alcohol (butanol 1) | 50–4000 | 50 | 95097 | | | | Other Alcohols |
| sec-Butyl alcohol (butanol 2) | 50–4000 | (100) | 95097 | | | | Other Alcohols |
| tert.-Butyl alcohol (2 methyl propanol 2) | 100–1000 | 100 | 95097 | | | | Other Alcohols |
| n-Butylamine | 2–100 | 5 | 92115 | | | | Acid gases |
| Butyl mercaptan (butanethiol-1) | 0.5–100 | 0.5 | 454206 (I) | | | | $H_2S$ |
| tert.-Butyl mercaptan (2-methyl propanethiol-2) | 0.5–100 | | 454206 (I) | | | | $H_2S$ |
| Carbon dioxide NIOSH (TC-84-025) | 200–120,000 | 5000 | 85976 | | | | ——— |
| Carbon disulfide | 0–100 | 10 | 463527 | | | | ——— |
| Carbon monoxide NBS Color Change (G) | 10–1000 | 50 | 47134 | | | | $NO_2$, Ethylene, Acetylene |
| | 5–3000 | 50 | 91229 (L) | | | | Hydrogen, $H_2S$, Acetylene |
| NIOSH (TC-84-067) | 0–3000 | 50 | 465519 (L) | | | | Hydrogen, $H_2S$, Acetylene |
| Carbon tetrachloride | 10–200 | (5) | 885[illegible]3 | | | 460325 | Other Halogen Compounds & Halogens |
| | 0–70 | (5) | 460548 | | | 460325 | Other Halogen Compounds & Halogens |
| Chlorine | 0.5–100 | 1 | 82399 | | | | $H_2S$, $NH_3$, $NO_2$, Ethylene, Halides |
| NIOSH (TC-84-042) | 0.1–25 | 1 | 460225 | | | | $H_2S$, $NH_3$, $NO_2$, Ethylene, Halides |
| Chlorine dioxide | 0.05–16 | 0.1 | 82399 | | | | $H_2S$, $NH_3$, $NO_2$, Ethylene, Halides |
| Chlorobenzene (Monochlorobenzene) | 10–200 | 75 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| | 10–800 | 75 | 93074 | | | | Aromatic, Aliphatic Hydrocarbons |
| Chlorobromomethane | 50–400 | 200 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| | 25–500 | 200 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| 1-Chloro-1, 1-difluoroethane (Genetron* 142B) | 100–4000 | | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| | 100–2500 | | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Chlorodifluoromethane (Freon* 22) | 200–2000 | 1000 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Chloroform (trichloromethane) | 25–400 | 10 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| 1-Chloro-1-nitropropane | 2–75 | (2) | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Chloropentafluoroethane (Freon* 115) | 200–2000 | | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Chlorotrifluoromethane (Freon* 13) | 250–2500 | | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| | 200–3500 | | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Chromic acid mist (I) (R) | 0.05–1.4 mg/m³ | 0.1 | | 79014 (E) | 79010 | | ——— |
| Cumene | 0–1000 | 50 | 460422 | | | | Butyl Mercaptan & Unsaturated Hydrocarbons |
| Cyanogen | 2–100 | 10 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Cyclohexanol | 25–1000 | 50 | 95097 | | | | Other Alcohols |
| Cyclohexylamine | 5–100 | 10 | 92115 | | | | Acid gases |
| Decaborane (I) (R) | 0.01–1.0 | 0.05 | | 82099 (E) | 82388 | | Hydrazine, UDMH, $H_2S$ |
| Diborane (I) (R) | 0.1–3.0 | 0.1 | | 82099 (E) | 82388 | | Hydrazine, UDMH, $H_2S$ |
| 1,2-Dibromoethane (ethylene dibromide) | 10–200 | 20 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| | 5–100 | 20 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| O-Dichlorobenzene | 10–200 | 50 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| Dichlorodifluoromethane (Freon* 12) | 25–3000 | 1000 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| 1,1-Dichloroethane | 25–400 | 200 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| 1,2-Dichloroethane | 25–400 | 10 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| Dichloroethylene (CIS-1-2) | 10–300 | 200 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| | 100–500 | 200 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Dichloroethylene (trans.-1,2) | 50–400 | 200 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| | 25–1000 | 200 | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Dichloroethyl ether | 5–75 | 5 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| 1,1-Dichloro-1-nitroethane | 2–75 | 2 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Dichlorotetrafluoroethane (Freon* 114) | 200–2000 | 1000 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Diethylamine | 10–200 | 3 | 92115 | | | | Acid gases |

*DENOTES TRADENAME ( )TLV FIGURES IN PARENTHESES ARE 1980 PROPOSED

| Detectable Hazard | Measurable Range (PPM) | (A) 1980 ACGIH TLVs (PPM) | (H) Pkg of Detector Tubes | Reagent Kit | Box of Filter Papers | Required Pyrolyzer | (B) Interferences |
|---|---|---|---|---|---|---|---|
| Diethyl sulfate | 5–50 | | 95300 | | | | ——— |
| Dimethyl acetamide | 5–80 | 10 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Dimethylamine | 5–100 | 10 | 92115 | | | | Acid gases |
| Dimethylformamide | 5–150 | 10 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Dimethyl sulfate | 1–50 | 0.1 | 95300 | | | | ——— |
| Dimethyl sulfoxide | 10–250 | | 95739 | | | 460325 | $SO_2$, Organic Sulfur Compounds |
| Di-n-propylamine | 5–100 | | 92115 | | | | Acid gases |
| 2-Ethoxyethanol | 50–1000 | (50) | 95097 | | | | Other Alcohols |
| Ethyl alcohol (ethanol) | 200–10,000 | 1000 | 95097 | | | | Other Alcohols |
| Ethylamine | 10–300 | 10 | 92115 | | | | Acid gases |
| Ethyl benzene | 10–500 | 100 | 463202 | | | | Aromatic, Aliphatic Hydrocarbons |
| Ethyl bromide | 25–400 | 200 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| Ethyl Chloride | 100–2000 | 1000 | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| | 100–2000 | 1000 | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Ethylene | 0.5–100 | | 82802 | | | | $NH_3$, $H_2S$, CO, Hydrocarbons |
| Ethylene dichloride | 25–450 | 10 | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| 1,2-Dichloroethane NIOSH (TC-84-058) | 0–600 | 10 | 461863 (D) | | | | Other Halogen Compounds & Halogens |
| Ethylenimine | 2–100 | 0.5 | 92115 | | | | Acid gases |
| Ethyl mercaptan | 0.5–100 | 0.5 | 454206 (I) | | | | $H_2S$ |
| N-Ethylmorpholine | 5–100 | 5 | 92115 | | | | Acid gases |
| Fluorotrichloromethane (Freon* 11) | 250–2000 | 1000 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| | 250–2000 | 1000 | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Formaldehyde | 1–100 | 2 | 93963 | | | | Turpentine, other Aldehydes |
| Furfuryl alcohol | 25–500 | 10 | 95097 | | | | Other Alcohols |
| Hexane | 25–5000 | 50 | 463838 | | | | Aliphatic and some Aromatic Hydrocarbons |
| Hydrazine | 0.5–40 | 0.1 | 460425 | | | | Acid gases & other Amines |
| Hydrogen chloride | 0–300 | 5 | 91636 | | | | $HNO_3$ |
| | 2–170 | 5 | 466612 | | | | $HNO_3$ |
| Hydrogen cyanide | 0–80 | 10 | 93262 | | | | Ammonia, $H_2S$ |
| Hydrogen fluoride | 0–25 | 3 | 462019 | | | | ——— |
| Hydrogen sulfide NIOSH (TC-84-022) | 1–1000 | 10 | 460058 | | | | $SO_2$ |
| | 10–2000 | 10 | 463875 | | | | $SO_2$ |
| Isoamyl alcohol (2 methyl-butanol 4) | 50–1000 | 100 | 95097 | | | | Other Alcohols |
| Isobutyl alcohol (2 methyl propanol) | 50–4000 | 50 | 95097 | | | | Other Alcohols |
| Isopropylamine | 5–100 | 5 | 92115 | | | | Acid gases |
| Lead Dust/Fume (J) (K) | 0.05–6.3 mg/m³ | 0.15 mg/m³ | | 78399 (E) | 78693 | | ——— |
| Mercury, except alkyl | 0.05–2.0 mg/m³ | 0.05 mg/m³ | 83089 | | | | ——— |
| Methacrylonitrile | 10–80 | | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Methyl alcohol (methanol) | 100–10,000 | 200 | 95097 | | | | Other Alcohols |
| Methylamine | 10–100 | 10 | 92115 | | | | Acid gases |
| Methyl bromide | 10–100 | (5) | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| | 2.5–90 | (5) | 462135 | | | | Other Halogen Compounds & Halogens |
| | 10–100 | (5) | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Methyl chloride | 25–1000 | (50) | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Methyl chloroform (1,1,1-trichloroethane) | 100–700 | 350 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Methylcyclohexanol | 25–800 | 50 | 95097 | | | | Other Alcohols |
| Methylene chloride (dichloromethane) | 100–2000 | (100) | 85834 (D) | | | | Other Halogen Compounds & Halogens |
| | 0–3000 | (100) | 462516 | | | | Other Halogen Compounds & Halogens |
| | 100–1000 | (100) | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| | 50–2000 | (100) | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Methyl isobutyl carbinol | 25–1000 | 25 | 95097 | | | | Other Alcohols |
| Methyl mercaptan | 0.5–100 | 0.5 | 454206 (I) | | | | $H_2S$ |
| Monomethyl hydrazine | 0.5–50 | 0.2 | 460425 | | | | Acid gases & other Amines |
| Nitric oxide NIOSH (TC-84-059) | 1–150 | 25 | 460424 | | | | $H_2S$ & Halogens |
| Nitrogen dioxide NIOSH (TC-84-040) | 0–30 | (3) | 83099 | | | | $H_2S$, Halides |
| Nitroethane | 10–300 | 100 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |

*DENOTES TRADENAME

( )TLV FIGURES IN PARENTHESES ARE 1980 PROPOSED

| Detectable Hazard | Measurable Range (PPM) | Ⓐ 1980 ACGIH TLVs (PPM) | Ⓗ Pkg of Detector Tubes | Reagent Kit | Box of Filter Papers | Required Pyrolyzer | Ⓑ Interferences |
|---|---|---|---|---|---|---|---|
| Nitromethane | 5–300 | 100 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| 1-Nitropropane | 2–100 | (15) | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| 2-Nitropropane | 5–150 | 25 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Ozone | 0.05–5.0 | 0.1 | 93865 | | | | $NO_2$, $SO_2$ |
| Pentaborane Ⓙ Ⓚ | 0.01–1.0 | 0.005 | | 82099 Ⓔ | 82388 | | Hydrazine, UDMH, $H_2S$ |
| Perchloroethylene NIOSH (TC-84-065) | 25–350 | 50 | 85834 Ⓓ | | | | Other Halogen Compounds & Halogen |
| | 0–800 | 50 | 460467 | | | | Other Halogen Compounds & Halogen |
| | 25–400 | 50 | 88536 | | | 460325 | Other Halogen Compounds & Halogen |
| Phosgene (carbonyl chloride) | 0.1–10 | 0.1 | 89890 | | | | ——— |
| Phosphine Ⓙ Ⓚ | 0.025–1.0 | 0.3 | | 81101 Ⓔ | 81220 Ⓒ | | Arsine, Stibine |
| Propyl alcohol (propanol-1) | 100–10,000 | 200 | 95097 | | | | Other Alcohols |
| iso-Propyl alcohol (propanol-2) | 100–10,000 | 400 | 95097 | | | | Other Alcohols |
| n-Propyl mercaptan (propanethiol-1) | 0.5–100 | | 454206 Ⓘ | | | | $H_2S$ |
| n-Propyl nitrate | 10–100 | 25 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Propylene | 1–400 | | 82802 | | | | $NH_3$, $H_2S$, CO, Hydrocarbons |
| Propylene dichloride (1,2-dichloropropane) | 25–250 | 75 | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| | 25–500 | 75 | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Propylene imine | 2–300 | 2 | 9211F | | | | Acid gases |
| Pyridine | 2–50 | 5 | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Stibine Ⓙ Ⓚ | 0.025–1.0 | 0.1 | | 81101 Ⓔ | 81220 Ⓒ | | Arsine, Phosphine |
| Styrene, monomer (phenylethylene) | 0–500 | (50) | 461781 | | | | ——— |
| Sulfur dioxide NIOSH (TC-84-046) | 1–400 | 2 | 92623 | | | | Acetic Acid |
| 1,1,2,2-Tetrabromoethane | 2–50 | | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| 1,1,2,2-Tetrachloroethane | 2–50 | 1 | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| 1,1,3,3-Tetrachloropropene | 5–100 | | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| Toluene (toluol) NIOSH (TC-84-057) | 12.5–700 | 100 | 461371 | | | | Aromatic, Aliphatic Hydrocarbons |
| | 10–800 | 100 | 93074 | | | | Aromatic, Aliphatic Hydrocarbons |
| 1,1,2-Trichloroethane (beta) | 25–700 | 10 | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| | 50–500 | 10 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Trichloroethylene NIOSH (TC-84-055) | 50–600 | (50) | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| | 25–600 | (50) | 460328 | | | | Other Halogen Compounds & Halogens |
| | 25–400 | (50) | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| 1,2,3-Trichloropropane | 10–500 | 50 | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon* 113) | 100–2000 | 1000 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| | 100–4000 | 1000 | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Triethylamine | 5–100 | 25 | 92115 | | | | Acid gases |
| Trifluoromonobromomethane (Freon* 13B1) | 100–4000 | 1000 | 88536 | | | 460325 | Other Halogen Compounds & Halogens |
| Trimethylamine | 5–200 | | 92115 | | | | Acid gases |
| Unsymmetrical Dimethylhydrazine | 0.5–50 | 0.5 | 460425 | | | | Acid gases & other Amines |
| Vinyl chloride (chloroethylene) | 25–250 | 5 | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| | 0–100 | 5 | 462534 | | | | $HNO_3$, Hydrocarbons |
| | 100–2000 | 5 | 92030 | | | 460325 | $HNO_3$, Hydrocarbons |
| Vinylidene chloride | 10–300 | 10 | 85834 Ⓓ | | | | Other Halogen Compounds & Halogens |
| Vinyl pyridine | 1–100 | | 91624 | | | 460325 | $H_2S$, Halogen, Nitrogen & Hydrocarbon Compounds |
| Xylene (o-, m-, p-isomers) | 10–500 | 100 | 463201 | | | | Aromatic, Aliphatic Hydrocarbons |
| Xylene | 10–800 | 100 | 93074 | | | | Aromatic, Aliphatic Hydrocarbons |

**Note:** This Data Sheet contains a general description of certain detectors, reagents and accessories for use with the Universal Tester™ and Samplair Pumps from MSA and includes a list of representative hazards that can be detected; however, under no circumstances should the products be used except by qualified, trained personnel and not until the instructions, labels, or other literature accompanying them have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning these products.

MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 · Telex 812453

Worldwide service: Branch offices throughout the United States. Subsidiaries in: Amsterdam • Barcelona • Berlin • Calcutta • Glasgow Johannesburg • Lima • Mexico City • Milan • Ndola • Paris • Salisbury Santiago • São Paulo • Singapore • Sydney • Tokyo • Toronto. Representatives in principal cities throughout the world.

Data Sheet 08-01-02 (Part No. 994098) Printed in U.S.A. 8111 (L)

# Gas Masks

*MSA Type N Gas Mask with Ultravue Facepiece*

*MSA Super Size Gas Mask with Ultravue Facepiece (back-mounted harness)*

*MSA Industrial Size Gas Mask with Ultravue Facepiece*

*MSA Chin Type Gas Mask with Ultravue Facepiece*

## Application

MSA® Gas Masks are used for respiratory protection against certain gases, vapors, and particulate matter which otherwise might be harmful to life or health.

Because gas masks are air-purifying devices, designed solely to remove specific contaminants from the air, it is essential that their use be restricted to atmospheres which contain sufficient oxygen to support life (at least 19.5 percent by volume) and which contain generally no more than 2 percent concentrations of toxic gases and vapors by volume. It is imperative that the user assess the exposure conditions carefully before selecting a specific mask for respiratory protection. It is recommended that instruments be used to measure the concentration of oxygen and harmful gases and vapors present in the atmosphere under the various exposure and operating conditions.

**If the specific exposure concentrations are suspected of exceeding the specific limitations—only a self-contained breathing apparatus should be used.**

From a practical standpoint, gas masks are generally suitable for ventilated areas with relatively stable concentration levels. They should never be used in confined spaces or where oxygen deficiency and high gaseous concentrations may occur.

**WARNING: DO NOT USE FOR FIREFIGHTING**

## Description

Each MSA Gas Mask is a protective system consisting of the facepiece, breathing tube, harness, and a chemical-sorbent canister, specifically labeled and color coded to indicate the type of protection afforded.

## Facepieces

**Ultravue® Facepiece:** Has a wide-vision lens and a speaking diaphragm. Lightweight (17 oz), easy to don. Facepiece is molded from a soft rubber compound which has high resistance to facial oils. It has a soft inturned peripheral lip and chin stop for good fit and tight seal. Headbands of the same rubber are attached to the facepiece by stainless steel quick-adjust roller buckles; the replaceable buckles are attached to the facepiece without rivets.

Lens is rugged polycarbonate and fits close to the eyes to afford unobstructed vision. Each lens is treated with a coating which resists scratching and chemical attack. The lens is securely sandwiched between a flexible, formed rubber groove in the periphery of the facepiece and the lens retaining ring.

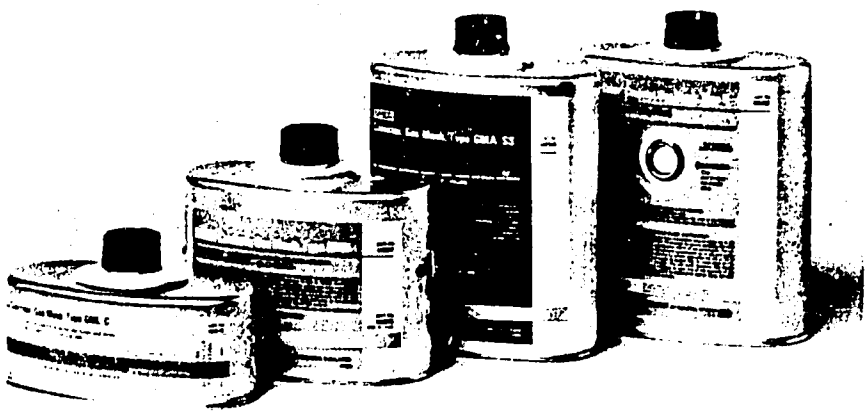
A molded-in baffle serves as a deflector for exhaled air to reduce lens fogging; it also directs the voice to the speaking diaphragm to permit clear short-range conversation.

The facepiece has a universal coupling nut which permits quick disassembly for cleaning and also allows the facepiece to be interchanged with other MSA respiratory protection equipment. Most parts, including the lens, can be replaced in the field without special tools.

**Clearvue® Facepiece:** This wide-vision facepiece with speaking diaphragm is available on special order. Unit may be equipped with an MSA ClearCom Amplifying unit or a Maskfone™ Sound Powered Communications device for communications in high-noise areas.

Accessories are available for use with either facepiece: a spectacle kit for prescription lenses, a nosecup to reduce the possibility of lens fogging under low temperature and/or high humidity conditions, and a welders adapter which permits the attachment of large welding plates.

The Ultravue Facepiece and Clearvue Facepiece are NIOSH/MSHA approved with most types of MSA respiratory protection equipment.



*MSA Gas Mask Canisters: Chin Type, Industrial Size, Super Size, and Type N*

## MSA Gas Mask Canisters

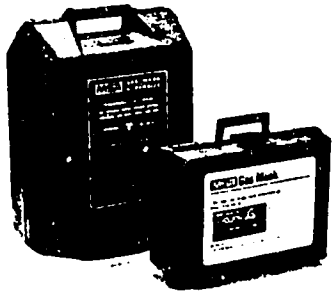
MSA manufactures four canister models: Type N, Super Size, Industrial Size, and Chin Type. The model to use depends upon type and concentration of contaminant and length of service life required.

MSA canisters are seamless to prevent potential leakage or channeling of gases or vapors past the chemical sorbents. The compact oval shape makes the canister easy to use and store. Canister connector is threaded, and a sealing tape seals the bottom air intake to assure fresh chemical sorbents by preventing moisture from entering the canister before use.

An adjustable universal-size harness consisting of webbing and a cover shell is used to support Type N, Super Size, and Industrial Size Canisters. Tubular nylon webbing resists chemicals and moisture, is easily cleaned and sanitized, and keeps its snug fit indefinitely.

The rigid, injection-molded nylon shell fits over the top of the seamless canister and is held in place by the harness webbing; it is easily removed for canister change. Harnesses for either front or back mounting are available.

A series of Industrial Size Canisters with D-rings attached to the canister shell for wear with a single webbed strap are available on special order.



*Carrying cases for Industrial, Super Size, and Type N Gas Masks (left) and Chin Type Gas Masks (right)*

**Gas mask carrying cases:** All Industrial and Super Size Gas Masks are supplied in one-piece molded plastic carrying cases. Cases have no metal parts. Two canisters are supplied with Super Size masks; one canister is supplied with Industrial and Chin-type masks. The Chin-type mask is supplied in a more compact case.

**Canister selection:** Each canister is specifically labeled as to type and limitations and is color coded for fast and accurate recognition.

The gas masks are tested and approved by NIOSH/MSHA or Bureau of Mines for respiratory protection against specific gases and vapors in concentrations up to 2 percent by volume (3 percent ammonia) or as specified on the canister label. NIOSH/MSHA has plans to extend its gas-mask testing and certification program in the future. **Chin Type Canisters, because of their smaller size, should be limited to concentrations not in excess of 0.5 percent by volume.**

Most MSA canisters contain particulate filters for the removal of dust and certain other particulate matter, as indicated by a gray or orange stripe around the top of the canister. This makes the mask dual purpose—protects against both gaseous and particulate contaminants, and eliminates stocking canisters for special use in situations where toxic aerosols may be present. Certain canisters also have a high-efficiency Ultra Filter® element which protects against more toxic and finely divided matter, indicated by a magenta stripe.

The following chart shows the MSA canisters and gas masks available for various contaminants.



65

| MSA canister identification (SS indicates Super Size) | Color coding | Protects against | Canister sizes available (Catalog numbers in parentheses) |
|---|---|---|---|
| SW | Red | ††2% acid gases, organic vapors, or carbon monoxide; 3% ammonia, or 2% total when more than one class is present | Type N (465363) |
| HW | Red | ††Same as above with the addition of hydrogen fluoride gas | Type N (85956) |
| VCM-SS | Light Olive | Not more than 25 ppm vinyl chloride | Super Size (461480) |
| GMA & GMA-SS | Black | †2%* organic vapors | Industrial Size (449888; with D-ring, 448969), Super Size (448965), and Chin Type (448974) |
| GMB | White | †2%-by-volume acid gases | Industrial Size (84494; with D-ring, 84498) |
| GMC & GMC-S | Yellow | †2%* organic vapors and acid gases | Industrial Size (84493; with D-ring, 84497), Super Size (460117), and Chin Type (466222) |
| GMC-SS-1 | Yellow with orange stripe around bottom | †2% hydrogen sulfide, organic vapors, 0.5% phosphine | Super Size (77713) |
| GMD & GMD-SS | Green | †3%* ammonia | Industrial Size (448967; with D-ring, 448968), Super Size (448964), and Chin Type (448973) |
| GMEO-SS | Olive | †0.1% ethylene oxide | Super Size (469256) |
| GMEO-C | Olive | †0.001% (10 ppm) ethylene oxide | Chin Type (470504) |
| GMK & GMK-SS | White with green stripe around bottom | †2% hydrocyanic acid gas | Industrial Size (77709; with D-ring, 95194), and Super Size (84499) |
| GML | White with yellow stripe around bottom | †Chlorine not more than 1%* by volume | Industrial Size (77711; with D-ring, 84492), and Chin Type (460113) |
| GMDL-C | Brown | †0.5% ammonia, chlorine, organic vapors | Chin Type (469041) |
| GMN-SSW | Orange | ††2% rocket fuels and oxidizers | Super Size with window (92372) |
| GMP | Yellow | ††Pesticides, organic vapors not more than 2%* by volume | Industrial Size with D-ring (448966) |
| GMP | Olive | ††0.5% pesticides and organic vapors | Chin Type (448972) |
| GMR | Magenta | ††0.5% iodine vapors, hydrogen fluoride, and radioactive particulate matter | Chin Type (466221) |
| GMR-I | Magenta | ††0.5% organic iodides, organic vapors, iodine vapors, and radioactive particulate matter | Chin Type (466220) |
| GMV-SS | White | †Acid gases, such as sulfuryl fluoride (Vikane), not more than 2% by volume | Super Size (87080) |

***Note:** Chin Type Canisters, because of their small size, should be used in concentrations not in excess of 0.5 percent. Canisters marked with a (†)—GMA, GMB, GMC, GMD, GMDL, GMEO, GMK, GML, and GMV—contain a particulate filter, identified by a gray or orange stripe on canister, effective against dusts and mists having a Threshold Limit Value (TVL) not less than 0.05 mg/m³. Canisters marked with (††)—SW, HW, GMN, GMP, and GMR—contain an Ultra Filter with initial efficiency of 99.97% against 0.3-micron DOP smoke, and provide respiratory protection against more toxic and more finely divided dusts, mists, and fumes having a TLV less than 0.05 mg/m³.

**Service life:** Canister service life of an air-purifying device depends on the following factors:

**1.** The design, including the quality and amount of chemical fill, packing uniformity, and density.

**2.** Variable exposure conditions, including concentration of contaminants in the air, breathing rate of the wearer, temperature, and humidity. Generally, higher concentrations, breathing rates, and humidity conditions adversely affect service life. Since the exposure conditions are subject to wide variation, it is most difficult to estimate the service life of a gas mask canister. However, for guidance purposes, actual man tests performed under Bureau of Mines Schedule 14F stipulate the following minimum service requirements at an average breathing rate of 25 liters per minute in concentrations of 2 percent for most gases and vapors or 3 percent ammonia:

Industrial Size Canisters . . 30 minutes

Type N Canisters
- Acid gases . . . . . 15 minutes
- Organic vapors . . . . . 25 minutes
- Ammonia . . . . . 15 minutes
- Carbon monoxide . . . . . 30 minutes

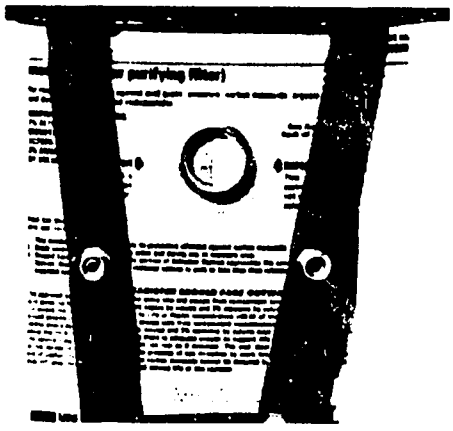
MSA Industrial and Super Size Canisters exceed these minimum performance requirements. Super Size Canisters, because of their greater volume of chemical fill, will last approximately twice as long as the equivalent Industrial Size Canister. **Chin Type Canisters, because of their small size, should be used in concentrations not in excess of 0.5 percent.**

**Warning: Because the work level of the wearer may be more or less than that used in the test, a shorter or longer service period may actually be obtained. Hence, the above times are guides only and cannot be relied upon for minimum performance time.**

## Type N Gas Mask with Ultravue Facepiece

**The MSA Type N, Model SW Gas Mask is approved for respiratory protection in atmospheres containing at least 19.5 percent oxygen and not more than 2 percent acid gases, organic vapors, or carbon monoxide; 3 percent ammonia; or 2 percent total when more than one class is present. Also approved for respiratory protection against dusts, mists, fogs, and smokes having a Threshold Limit Value (TLV) of less than 0.05 milligram per cubic meter. The Model HW Canister contains a special filter making it resistant to hydrogen fluoride gas.**

**Impermeable protective clothing should be worn during exposures to gases and vapors which can poison by skin absorption.**



The Type N Gas Mask has a Window-Cator® Canister which contains a moisture indicator. This small, round window in the front of the canister has two half-circles—one shows a light blue reference color; the other, a darker blue indicating color. As the sorbent is penetrated during use and absorbs moisture, the indicator color gradually grows lighter—closer to the reference color. When the colors match, the canister is losing its effectiveness against carbon monoxide and should be replaced. **Note:** A Type N Canister exposed to carbon monoxide can be expected to get quite warm due to the oxidation reaction; however, if the inhaled air becomes extremely hot, it is an indication that high gas concentrations have been encountered and the wearer should return to fresh air immediately.

The Type N Model SW canister has a high-efficiency particulate filter approved by NIOSH/MSHA for toxic dusts, smoke, fumes, mists, and fogs. This particulate filter is designed for high filtration with low breathing resistance. The large shielded port at the canister base also contributes to the low breathing resistance.

## Ordering information

**Catalog numbers** (NIOSH Approval Number in parentheses)

**MSA Type N Gas Mask with Ultravue Facepiece**

| | |
|---|---|
| **465331** | Model SW, front mounted; complete with two 465363 Window-Cator Canisters; in carrying case (TC-14G-96) |
| **457075** | Model HW, front mounted; complete with two 85956 Window-Cater Canisters; in carrying case |
| **465327** | Model SW, Type C, back mounted; complete with two 465363 Window-Cator Canisters; in carrying case (TC-14G-96) |
| **465363** | Replacement Canister, Model SW Window-Cator; for Type N Mask (TC-14G-96) |
| **85956** | Replacement Canister, Model HW Window-Cator; for Type N Mask |

**Note:** Type N Gas Masks are also available with Clearvue Facepieces on special order.

**WARNING: DO NOT USE FOR FIREFIGHTING**



61

## Super Size Gas Mask with Ultravue Facepiece

**The MSA Super Size Gas Mask with Ultravue Facepiece is designed for respiratory protection against a specific gas or group of gases, as indicated by canister identification, in areas where there is sufficient oxygen to sustain life (19.5 percent by volume) and where the total toxic-gas concentration does not exceed 2 percent by volume or as specifically indicated on the canister label.**

As indicated by its name, the Super Size Gas Mask has an extra-large canister which will last for longer periods than Industrial Size Canisters because of a larger volume of chemical fill.

A filter in the canister removes certain particulate contaminants. See canister selection chart for details.

## Ordering information

**Catalog numbers** (NIOSH or USBM Approval Number in parentheses)

**MSA Super Size Gas Mask with Ultravue Facepiece**

**461483** Vinyl chloride; front mounted; complete with two 461480 VCM-SS canisters; in carrying case (TC-14G-84)

**448923** Organic vapor; front mounted; complete with two 488965 GMA-SS canisters; in carrying case (TC-14G-97)

**460122** Organic vapor/acid gas; front mounted; complete with two 460117 GMC-S canisters; in carrying case (TC-14G-100)

**457069** Organic vapor/hydrogen sulfide/phosphine; front mounted; complete with two 77713 GMC-SS-1 canisters; in carrying case (14F-61)

**448929** Ammonia; front mounted; complete with two 448964 GMD-SS canisters; in carrying case (TC-14G-101)

**457073** Hydrocyanic acid; front mounted; complete with two 84499 GMK-SS canisters; in carrying case (14F-63)

**449732** Rocket propellant, in pouch, with one 92372 GMN-SSW canister

**461970** Rocket propellant, in case

**469430** Ethylene Oxide; front mounted; complete with two 469256 GMEO-SS canisters; in carrying case

**457097** Front-mounted gas mask; canisters to be specified; in carrying case

**461484** Vinyl chloride; Type C back mounted; complete with two 461480 VCM-SS canisters; in carrying case (TC-14G-84)

**461486** Vinyl chloride; Type D back mounted; complete with two 461480 VCM-SS canisters; in carrying case (TC-14G-84)

**448924** Organic vapor; Type C back mounted; complete with two 448965 GMA-SS canisters; in carrying case (TC-14G-97)

**457087** Organic vapor/hydrogen sulfide/phosphine; Type C back mounted; complete with two 77713 GMC-SS-1 canisters; in carrying case (14F-61)

**457095** Type C back-mounted gas mask; canisters to be specified; in carrying case

**457067** Organic vapor/hydrogen sulfide/phosphine; Type D back mounted; complete with two 77713 GMC-SS-1 canisters; in carrying case (14F-61)

**457133** Sulfuryl fluoride (Vikane); Type D back mounted; complete with two 87080 GMV-SS canisters; in carrying case

**461480** Replacement Canister, VCM-SS, vinyl chloride; for Super Size Gas Mask

**448965** Replacement Canister, GMA-SS, organic vapors; for Super Size Gas Mask

**77713** Replacement Canister, GMC-SS-1, hydrogen sulfide/organic vapors/phosphine; for Super Size Gas Mask

**448964** Replacement Canister, GMD-SS, ammonia; for Super Size Gas Mask

**460117** Replacement Canister, GMC-S, organic vapors/acid gases; for Super Size Gas Mask

**84499** Replacement Canister, GMK-SS, hydrocyanic acid gas; for Super Size Gas Mask

**87080** Replacement Canister, GMV-SS, sulfuryl fluoride (Vikane); for Super Size Gas Mask

**92372** Replacement Canister, GMN-SSW—rocket propellants; for Super Size Gas Mask

**469256** Replacement Canister, GMEO-SS, ethylene oxide; for Super Size Gas Mask

**Note:** Type C back-mounted masks have one breathing tube, Type D back-mounted masks have two tubes. Super Size Gas Masks are also available with Clearvue Facepieces on special order.

**WARNING: DO NOT USE FOR FIREFIGHTING**

68

## Industrial Size Gas Mask with Ultravue Facepiece

**The MSA Industrial Size Gas Mask with Ultravue Facepiece is approved for respiratory protection against a specific gas or group of gases, as indicated by canister identification, in areas where there is sufficient oxygen to sustain life (19.5 percent by volume) and where the total toxic-gas concentration does not exceed 2 percent by volume or as specifically indicated on the canister label.**

This gas mask is similar to the Super Size mask described previously, except it has a smaller canister.

See canister selection chart for details.

## Ordering information

**Catalog numbers** (NIOSH or USBM Approval Number in parentheses)

**MSA Industrial Size Gas Mask with Ultravue Facepiece**

**448934** Organic vapor; front mounted; complete with a 449888 GMA canister; in carrying case (TC-14G-97)

**448938** Ammonia; front mounted; complete with a 448967 GMD canister; in carrying case (TC-14G-101)

**457083** Chlorine; front mounted; complete with a 77711 GML canister; in carrying case (14F-60)

**457084** Hydrocyanic acid; front mounted; complete with a 77709 GMK canister; in carrying case (14F-62)

**448942** Pesticides; front mounted; complete with a 448966 GMP canister; in carrying case (TC-14G-99)

**457100** Front-mounted gas mask; canister to be specified; in carrying case

* * *

**448935** Organic vapor; Type C back mounted; complete with a 449888 GMA canister; in carrying case (TC-14G-97)

**448939** Ammonia; Type C back mounted; complete with a 448967 GMD canister; in carrying case (TC-14G-101)

**457080** Chlorine; Type C back mounted; complete with a 77711 GML canister; in carrying case (14F-60)

**448943** Pesticides; Type C back mounted; complete with a 448966 canister; in carrying case (TC-14G-99)

**457090** Type C back mounted; canister to be specified; in carrying case

**449888** Replacement Canister, GMA, organic vapors; for MSA Industrial Size Gas Mask

**84494** Replacement Canister, GMB, acid gases; for MSA Industrial Size Gas Mask

**84493** Replacement Canister, GMC, organic vapors/acid gases; for MSA Industrial Size Gas Mask

**448967** Replacement Canister, GMD, ammonia; for MSA Industrial Size Gas Mask

**448966** Replacement Canister, GMP, organic vapors/acid gases/toxic particulates; for MSA Industrial Size Gas Mask

**77709** Replacement Canister, GMK, hydrocyanic acid gas; for MSA Industrial Size Gas Mask

**77711** Replacement Canister, GML, chlorine; for MSA Industrial Size Gas Mask

**Note:** Type C back-mounted masks have one breathing tube, Type D back-mounted masks have two tubes. Industrial Size Gas Masks with Clearvue Facepieces and a series of Industrial Size Canisters with D-rings attached are available on special order.

**WARNING: DO NOT USE FOR FIREFIGHTING**

## Chin Type Gas Mask with Ultravue Facepiece

**The MSA Chin Type Gas Mask is recommended for respiratory protection against gases and vapors in concentrations not in excess of 0.5 percent by volume where there is sufficient oxygen to sustain life (19.5 percent by volume). Specific protection afforded by each type of canister is shown on canister label.**

The Chin Type Gas Mask gives face and respiratory protection against particulate matter, vapors, and gases by means of a lightweight, replaceable canister. The small, oval-shaped aluminum canister and facepiece are designed to permit downward head movement.

When equipped with the GMR canister, the chin-type mask is particularly adaptable for use in ERDA installations because of its highly efficient Ultra Filter element (for radioactive aerosols) and the special chemical bed which efficiently absorbs hydrogen fluoride, radioactive iodine vapors, acid gases, and organic vapors. The GMR-S canister is equally applicable, except that its Ultra Filter element is not designed for exposure to HF. The GMR-I canister is very effective against organic iodides and iodine vapors.

## Ordering information

**Catalog numbers** (NIOSH Approval Number in parentheses)

**MSA Chin Type Gas Mask with Ultravue Facepiece:**

**448975** Organic vapor; complete with a 448974 GMA canister; in carton (TC-14G-87)

**448976** Organic vapor; complete with a 448974 GMA canister; in carrying case (TC-14G-87)

**466228** Organic vapor/acid gas; complete with a 466222 GMC canister; in carton (TC-14G-107)

**466350** Organic vapor/acid gas; complete with a 466222 GMC canister; in carrying case (TC-14G-107)

**448979** Ammonia; complete with a 448973 GMD canister; in cardboard carton (TC-14G-88)

**448980** Ammonia; complete with a 448973 GMD canister; in carrying case (TC-14G-88)

**460133** Chlorine; complete with a 460113 GML canister; in cardboard carton (TC-14G-89)

**460134** Chlorine; complete with a 460113 GML canister; in carrying case (TC-14G-89)

**448983** Pesticides; complete with a 448972 GMP canister; in carton (TC-14G-86)

**448984** Pesticides; complete with a 448972 GMP canister; in carrying case (TC-14G-86)

**448974** Replacement Canister, GMA, organic vapors; for MSA Chin Type Gas Mask (TC-14G-87)

**466222** Replacement Canister, GMC, organic vapors/acid gases; for MSA Chin Type Gas Mask (TC-14G-107)

**448973** Replacement Canister, GMD, ammonia; for MSA Chin Type Gas Mask (TC-14G-88)

**460113** Replacement Canister, GML, chlorine; for MSA Chin Type Gas Mask (TC-14G-89)

**448972** Replacement Canister, GMP, Pesticides; for MSA Chin Type Gas Mask (TC-14G-86)

**466221** Replacement Canister, GMR, iodine vapors/hydrogen fluoride/radioactive particulate matter; for MSA Chin Type Gas Mask (TC-14G-105)

**466220** Replacement Canister, GMR-I, organic iodides/organic vapors/iodine vapors/radioactive particulate matter (TC-14G-108)

**469041** Replacement Canister, GMDL-C, ammonia/chlorine/ organic vapors; for MSA Chin Type Gas Mask (TC-14G-112)

**470504** Replacement Canister, GMEO, ethylene oxide; for MSA Chin Type Gas Mask

**Note:** Chin Type Gas Masks are available with Clearvue Facepiece on special order.

**WARNING: DO NOT USE FOR FIREFIGHTING**

## Warning

Never use a gas mask without carefully assessing exposure conditions. Use suitable instruments to determine concentration of oxygen and air contaminants, if possible. If in doubt about exposure conditions, use self-contained breathing apparatus only. Always use strictly in accordance with canister labels, gas mask instructions, and limitations. Safety is the responsibility of the user of the mask. DO NOT USE GAS MASKS FOR FIREFIGHTING. When a chin type canister is used in the maximum 0.5 percent (by volume) concentration, its useful life may be extremely short (as low as 12 minutes). As the concentration is reduced, the useful life will increase correspondingly. **Note:** Do not use canisters where the contaminant vapor does NOT possess good warning properties such as odor, taste, eye, nose or throat irritation that are readily detectable at or below the Threshold Limit Value.

*Gas mask canisters used for **emergency purposes** should be replaced after each use. Specific indications for canister replacement and/or return to fresh air are:*

*1. If the window indicators of the Type N or GMN-SSW Canisters show the specified color changes.*

*2. If any leakage is detected by smell, taste, or eye, nose, or throat irritation.*

*3. If high breathing resistance develops.*

*4. If the canister shelf life is exceeded.*

*Specific warning signs which require immediate return to fresh air are:*

*1. Uncomfortable heat in the inhaled air. (A properly operating canister will become warm on exposure to certain gases or vapors, but a canister which becomes extremely hot indicates that concentrations above the canister limit have been encountered.)*

*2. If any feeling of nausea, dizziness, or ill-being develops.*

## Approvals and standards

Many MSA Gas Masks have been approved by NIOSH/MSHA or Bureau of Mines (specific numbers shown under Ordering Information for each mask type), and all Chin Masks to date have received NIOSH/MSHA approval. Certain MSA Gas Masks also meet U.S. Coast Guard Specifications under Subpart 160.011.

## Accessories

**MSA Nosecup:** Molded from a soft rubber compound that is resistant to facial oils. Reduces possibility of lens fogging. The nosecup, which is easily affixed to the facepiece without tools, is particularly effective under conditions of high humidity and/or low temperatures by inhibiting contact of the moist exhalation with facepiece lens.

**MSA Spectacle Kit:** For use by workers who must wear corrective lenses, easily inserted into the facepiece. Spectacle kit includes wire support, rubber guide, and one pair of metal-frame spectacles. Desired adjustment is obtained by moving the spectacles in and out of the rubber guide and moving the rubber guide up and down the wire support. One size of spectacle frame is used (S7 shape, 44-mm lens size) with a Universal Bridge. Corrective lenses may be obtained from MSA or local sources. Spectacle Kit may be worn in conjunction with nosecup.

**MSA Welders Adapter:** Provides eye protection for welding in areas where a gas mask is required. Made of polycarbonate. Large 4½" x 5¼" lens area with lift front.

**Cover lens:** The MSA Ultravue Facepiece may be equipped with a replaceable clear cellulose acetate cover lens. This inexpensive cover lens protects the polycarbonate facepiece lens from scratches and contamination, thus prolongs its useful life. Replacement cover lenses are sold in packages of 25.

## Ordering information

**Catalog numbers**

| | |
|---|---|
| **457126** | Replacement Ultravue Facepiece |
| **457135** | Nosecup; for use with Ultravue Facepiece |
| **464358** | Lens ring kit assembly |
| **454819** | Prescription Spectacle Kit, Universal Bridge, 44-mm lens (less lenses); for use with Ultravue Facepiece |
| **449646** | Welders Adapter, for Ultravue Facepiece, complete with cover lens, less welding lens |
| **456975** | Cover lens, clear (pkg of 25 lenses); for Ultravue Facepiece |
| **92876** | Carrier, canvas, for rocket propellant gas mask |
| **84874** | Case for hydrocyanic acid industrial mask |
| **449996** | Case for GMA-SS mask |
| **460099** | Case for GMC-S mask |
| **449995** | Case for GMD-SS mask |
| **86114** | Case for GMK-SS mask |
| **84888** | Case for Super Size Gas Mask (canister to be specified) |
| **460322** | Case for Chin Type Gas Mask |
| **465313** | Case for Type N Model SW Window-Cator |
| **449998** | Case for ammonia industrial mask |
| **84876** | Case for industrial mask (canister to be specified) |
| **84872** | Case for chlorine industrial mask |
| **449999** | Case for organic vapor industrial mask |
| **84880** | Case for GMC-SS-1 gas mask |
| **86239** | Case for model HW Type N mask |
| **449997** | Case for pesticide industrial mask |
| **34337** | MSA Cleaner-Sanitizer II, 12 2-oz packages in carton/dispenser |

**Note:** This Data Sheet contains only a general description of MSA Gas Masks. Although the Data Sheet describes uses and performance capabilities of the gas masks, under no circumstances should these products be used except by qualified, trained personnel and not until the instructions, canister labels, or other literature accompanying the products have also been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning these products.

MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 · Telex 812453

Worldwide service: Branch offices throughout the United States. Subsidiaries in: Amsterdam · Barcelona · Berlin · Calcutta · Glasgow Johannesburg · Lima · Mexico City · Milan · Ndola · Paris · Salisbury Santiago · São Paulo · Singapore · Sydney · Tokyo · Toronto. Representatives in principal cities throughout the world.

Data Sheet 05-00-01

Printed in U.S.A. 821 (L)