

# FORMALDEHYDE

## HEALTH AND SAFETY GUIDE



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Health and Safety Guide No. 57

**FORMALDEHYDE  
HEALTH AND  
SAFETY GUIDE**

This is a companion volume to  
Environmental Health Criteria 89: Formaldehyde

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## INTRODUCTION

The Environmental Health Criteria (EHC) documents produced by the International Programme on Chemical Safety include an assessment of the effects on the environment and on human health of exposure to a chemical or combination of chemicals, or physical or biological agents. They also provide guidelines for setting exposure limits.

The purpose of a Health and Safety Guide is to facilitate the application of these guidelines in national chemical safety programmes. The first three sections of a Health and Safety Guide highlight the relevant technical information in the corresponding EHC. Section 4 includes advice on preventive and protective measures and emergency action; health workers should be thoroughly familiar with the medical information to ensure that they can act efficiently in an emergency. Within the Guide is a Summary of Chemical Safety Information which should be readily available, and should be clearly explained, to all who could come into contact with the chemical. The section on regulatory information has been extracted from the legal file of the International Register of Potentially Toxic Chemicals (IRPTC) and from other United Nations sources.

The target readership includes occupational health services, those in ministries, governmental agencies, industry, and trade unions who are involved in the safe use of chemicals and the avoidance of environmental health hazards, and those wanting more information on this topic. An attempt has been made to use only terms that will be familiar to the intended user. However, sections 1 and 2 inevitably contain some technical terms. A bibliography has been included for readers who require further background information.

Revision of the information in this Guide will take place in due course, and the eventual aim is to use standardized terminology. Comments on any difficulties encountered in using the Guide would be very helpful and should be addressed to:

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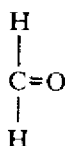
**THE INFORMATION IN THIS GUIDE  
SHOULD BE CONSIDERED AS A  
STARTING POINT TO A COMPREHENSIVE  
HEALTH AND SAFETY PROGRAMME**



# 1. PRODUCT IDENTITY AND USES

## 1.1. Identity

Common name: formaldehyde  
Chemical formula:  $\text{CH}_2\text{O}$  [HCHO]  
Chemical structure:



CAS registry number: 50-00-0  
RTECS registry number: LP 8925000  
UN numbers: 1198, 2209, 2213  
EC numbers: 605-001-01-2 (solution 5% to 25%)  
605-001-02-X (solution 1% to 5%)  
605-001-00-5 (solution 25%)  
IUPAC name: methanal  
Common synonyms: formic aldehyde, methyl oxide, methylene oxide, oxymethylene, methyl aldehyde, oxomethane, fannofom, formalith, karsan  
Common names for solutions of formaldehyde: formalin, formol  
Relative molecular mass: 30.03

## PRODUCT IDENTITY AND USES

### 1.2 Physical and Chemical Properties

Formaldehyde is a flammable, colourless, reactive, and readily polymerized gas at normal temperature and pressure. The heat of combustion for formaldehyde gas is 4.47 kcal/g. It forms explosive mixtures with air and oxygen at atmospheric pressure. Flammability is reported to range from 12.5 to 80% by volume, a 65–70% formaldehyde–air mixture being the most readily flammable.

Formaldehyde is present in aqueous solutions as a hydrate and tends to polymerize. At room temperature and with a formaldehyde content of 30% and more, the polymers precipitate, making the solution turbid.

Formaldehyde decomposes into methanol and carbon monoxide at temperatures above 150 °C, though uncatalysed decomposition is slow at temperatures below 300 °C.

Under atmospheric conditions, formaldehyde is readily photooxidized by sunlight to carbon dioxide. It reacts relatively quickly with trace substances and pollutants in the air, and its half-life in urban air, under the influence of sunlight, is short. In the absence of nitrogen dioxide, the half-life of formaldehyde is approximately 50 min during the day; in the presence of nitrogen dioxide, it is about 35 min.

### 1.3 Analytical Methods

The most widely used methods for the determination of formaldehyde are based on spectrophotometry. Depending on the method used, sensitivities of between 0.0036 and 0.3 mg/litre can be achieved.

Other available methods include colorimetry, fluorimetry, high pressure liquid chromatography (HPLC), polarography, gas chromatography, infrared detection, and gas detector tubes. HPLC is the most sensitive method. In all these methods, other inorganic and organic chemicals, such as sulfur dioxide, other aldehydes, and amines, cause interference.

The method of sampling and the treatment of the sample before analysis are important factors in the accuracy of the determination.

## PRODUCT IDENTITY AND USES

Gas detector tubes or infrared analysers are often used for monitoring workplace atmospheres, and the sensitivity of these is generally around 0.5–0.6 mg/litre.

### 1.4 Composition

Formaldehyde is most commonly available, commercially, as a 30–50% (by weight) aqueous solution. Methanol or other substances are usually added to the solution as stabilizers, to reduce intrinsic polymerization. The concentration of methanol can be as high as 15%, while that of other stabilizers is of the order of several hundred mg/litre. Concentrated liquid formaldehyde–water systems containing up to 95% formaldehyde are obtainable, but the temperature necessary to maintain solution and prevent separation of the polymer increases from room temperature to 120 °C, as the concentration in solution increases.

In solid form, formaldehyde is marketed as trioxane (CH<sub>2</sub>O)<sub>3</sub>, and its polymer, paraformaldehyde, with 8–100 units of formaldehyde. Paraformaldehyde is technologically important.

### 1.5 Uses

The uses of formaldehyde cover a wide spectrum. Some examples are given below:

#### *(a) Animal nutrition and agriculture*

In animal nutrition, formaldehyde may be added to feed to protect dietary protein from deamination by ruminal microorganisms in ruminants. In the USA, formaldehyde is used as a food additive, to improve the handling characteristics of animal fat and oilseed cattle food mixtures, by producing a dry free-flowing product. Urea-formaldehyde fertilizer is used in farming, as a source of nitrogen, to improve the biological activity of the soil.

#### *(b) Aminoplastics (urea formaldehyde resins and melamine formaldehyde resins)*

Reaction of formaldehyde with urea or melamine yields urea formaldehyde (UF) or melamine formaldehyde (MF) (condensation process).

## PRODUCT IDENTITY AND USES

Various concentrations of these synthetic resins are then used, in solution or powder form, for further processing.

In the Federal Republic of Germany, about 70% of the total amount of aminoplastics produced, i.e., 170 000 tonnes of formaldehyde per annum, is used as glue in the manufacture of particle boards. These boards are mostly manufactured from urea formaldehyde resins.

About 10% of the aminoplastic glues used are melamine-urea-formaldehyde resins, i.e., products in which melamine and urea are co-condensed with formaldehyde. Melamine resins are more damp-proof than urea resins, but they are also more expensive.

Condensed aminoplastics of very low relative molecular mass serve as textile treatments, to make cotton and fabrics containing synthetic fibres creaseproof and permanently pressed. In the USA, it is estimated that approximately 85% of all fabrics used in the clothing industry have been treated in this way. Extremely stable aminoplastics are used, in order to ensure that they will not degrade during the lifetime of the articles.

Compounds similar to those used in finishing textiles are used in the tanning of leather. Others are used in electrical engineering, e.g., in light switches, sockets, and in parts of electric motors, in mechanical engineering, in the motor-vehicle industry, for household articles, e.g., camping dishes, parts of electrical household appliances, lamps, and plumbing components.

Aminoplastics are used in the paint industry as binding agents in special types of lacquer and paint, e.g., for cars. In agriculture, they are used as preservatives. Aminoplastics in the form of foam resin are also used in carpet cleaning agents.

### *(c) Phenolic plastics (phenol formaldehyde resins)*

Phenolic plastics are synthetic resins in which formaldehyde is condensed with phenols. Phenol, resorcinol, and cresols are among the phenolic components. The wood-working industry is a major consumer.

## PRODUCT IDENTITY AND USES

Other major areas of application are: in the production of hard materials, similar to those produced from aminoplastics; as a moulding material; and as a binder in enamel, paints, and lacquers.

Phenolic plastics are used as binding agents in the production of insulating materials from rock-wool or glass fibres, in brake-linings, abrasive materials, and moulded laminated plastics. They also serve as binding agents for moulding sand in foundries.

### *(d) Polyoxymethylene (polyacetal plastics)*

Polyoxymethylenes (POM) are another group of plastics produced by polymerizing formaldehyde. They are used for parts of motor vehicles and machines that are subjected to mechanical or thermal stress, in precision and communication engineering, in household appliances, and in plumbing fixtures.

### *(e) Chemical intermediate*

Formaldehyde is an important raw material in the industrial synthesis of a number of organic compounds, e.g., 1,4-butane diol, pentaerythritol, methylenediphenyldiisocyanate, trimethylolpropane, neopentylglycol, hexamethylenetetramine, and chelating agents (NTA, EDTA). It is also used in the production of dyes, dispersion products, pesticides, perfumes, and vitamins.

### *(f) Pharmaceutical products*

Products containing formaldehyde are now rarely used for disinfecting the skin and mucous membranes, but formaldehyde may be added to some pharmaceutical products as a preservative.

Formaldehyde kills viruses, bacteria, fungi, and parasites, and has found wide use as a fumigant. It is a disinfectant with a broad efficiency, and its virucidal properties make it extremely useful for disinfection in the clinical field.

Root canal-filling sealants containing paraformaldehyde are used in dental surgery.

## PRODUCT IDENTITY AND USES

### *(g) Cosmetics*

Formaldehyde is used as a preservative in cosmetics and in nail-hardening agents. Traces can also be found in cosmetics resulting from the disinfection of apparatus used in their manufacture. Products containing formaldehyde are used for other purposes, e.g., antiperspirants, skin-hardening agents, dry-skin lotion, shampoos, and bubble bath oil.

### *(h) Other consumer goods*

Formaldehyde at a concentration of  $< 1\%$  is also used as a preservative in a variety of other consumer goods, such as household cleaning agents, dish-washing liquids, fabric softeners, shoe-care agents, car shampoos and waxes, and carpet-cleaning agents.

## 2. SUMMARY AND EVALUATION

### 2.1 Human Exposure

Air concentrations of formaldehyde, near the ground in coastal, mountain, and oceanic areas, were found to range from 0.05 to 14.7  $\mu\text{g}/\text{m}^3$ , the majority of concentrations being within the range of 0.1–2.7  $\mu\text{g}/\text{m}^3$ . In the presence of man-made sources of formaldehyde, but away from any industrial plants, mean values ranged from 7 to 12  $\mu\text{g}/\text{m}^3$ , with a few peaks up to 60–90  $\mu\text{g}/\text{m}^3$ . Data from different parts of the world were in good agreement.

Rain-water contains 110–174  $\mu\text{g}$  formaldehyde/litre, with peaks as high as 310–1380  $\mu\text{g}$ /litre.

Emissions of formaldehyde from industrial processes vary widely, according to the type of industry. A considerable amount of formaldehyde comes from the exhaust emission of motor vehicles, but this varies greatly, according to country and the quality of fuel.

There is some natural formaldehyde in raw food, levels ranging from 1 to 90 mg/kg. Accidental contamination of food may occur during fumigation. Formaldehyde is sometimes used as a preservative, or it may be produced during cooking.

Indoor air levels (non-industrial) depended on several factors, but mainly on the age of the building and the building materials, the type of construction, and the ventilation. Tobacco smoke as well as urea-formaldehyde foam insulation and formaldehyde-containing disinfectants are all important sources of indoor formaldehyde. Indoor levels varied widely in different situations, most being within the range of 10–4000  $\mu\text{g}/\text{m}^3$ . In some cases, low values were found in rooms with substantial sources of formaldehyde emission. Area disinfection in hospitals produced the highest levels of up to 20 000  $\mu\text{g}/\text{m}^3$ . However, persons carrying out such disinfection wear protective equipment and the areas are not occupied until the formaldehyde levels have fallen to 1200  $\mu\text{g}/\text{m}^3$  (1 ppm) or less. Levels in rooms in which there is tobacco smoking can exceed 100  $\mu\text{g}/\text{m}^3$ .

## SUMMARY AND EVALUATION

The contribution of various atmospheric environments to the average human daily intake has been calculated to be 0.02 mg/day for outdoor air, 0.5–2 mg/day for indoor conventional buildings, 1–10 mg/day for buildings with sources of formaldehyde, 0.2–0.8 mg/day for workplaces where formaldehyde is not used, 4 mg/day for workplaces in which formaldehyde is used, and 0–1 mg/day for environmental tobacco smoke. Smoking 20 cigarettes per day corresponds to an intake of 1 mg formaldehyde/day, through inhalation.

The formaldehyde concentration in drinking-water is generally about 0.1 mg/litre, resulting in a mean daily intake of 0.2 mg/day. The quantity of formaldehyde ingested in food depends on the composition of the meal and, for an average adult, may range from 1.5 to 14 mg/day.

### 2.2 Uptake, Metabolism, and Excretion

Formaldehyde is readily absorbed via the respiratory and gastrointestinal routes. Dermal absorption of formaldehyde appears to be very slight. Increases in blood concentrations of formaldehyde were not detected in rats or human beings exposed to formaldehyde through inhalation, because of rapid metabolism. Absorbed formaldehyde is metabolized rapidly to formate, or enters the one-carbon pool to be incorporated into other molecules. There are two pathways of final elimination, namely, in exhaled air or via the kidneys.

### 2.3 Effects on Organisms in the Environment

Formaldehyde is used as a disinfectant to kill viruses, bacteria, fungi, and parasites, but it is only effective at relatively high concentrations.

Algae, protozoa, and other unicellular organisms are relatively sensitive to formaldehyde, with acute lethal concentrations ranging from 0.3 to 22 mg/litre. Aquatic invertebrates showed a wide range of responses; some crustaceans were the most sensitive, with median effective concentration (EC<sub>50</sub>) values ranging from 0.4 to 20 mg/litre. In 96-h tests on several fish species, the LC<sub>50</sub> of formaldehyde for adults ranged from a minimum of about 10 mg/litre to a maximum of several hundred mg/litre; most species showed LC<sub>50</sub> values in the range of 50–100 mg/litre. The responses of various species of amphibians are similar to those of fish, with median acute



## SUMMARY AND EVALUATION

lethal concentrations (LC<sub>50</sub>) ranging from 10 to 20 mg/litre for a 72-h exposure.

No data are available on long-term aquatic studies.

Eggs and larvae of some cattle parasites are killed by formaldehyde solution (1–5%) and some nematodes by a 37% solution, whereas other nematodes are unaffected. In ruminant mammals, formaldehyde protects dietary protein from microbial proteolysis in the rumen and increases the efficiency of utilization of amino acids.

Few data are available on the effects of formaldehyde on plants. However, from the agricultural use of urea-formaldehyde fertilizers, it appears that, at recommended concentrations, formaldehyde does not alter nitrogen and carbohydrate metabolism in plants, but that high doses have negative effects on soil metabolism. Formaldehyde impairs pollen germination.

Formaldehyde undergoes rapid decomposition, and does not accumulate in the environment or in food chains.

### 2.4 Effects on Experimental Animals

Acute inhalation exposure of rats and mice to formaldehyde at very high concentrations (120 mg/m<sup>3</sup>) produced salivation, dyspnoea, vomiting, spasms, and death. At a concentration of 1.2 mg/m<sup>3</sup>, eye irritation, decreased respiratory rate, increased airway resistance, and decreased compliance appeared. Mice were more sensitive than rats.

Short-term, repeated exposures (7–25 mg/m<sup>3</sup>) of rats produced histological changes in the nasal epithelium, such as cell degeneration, inflammation, necrosis, squamous metaplasia, and increased cell proliferation.

There is evidence that it is the concentration rather than the dose that determines the cytotoxic effects of formaldehyde on the nasal mucosa of rats; concentrations below 1 mg/m<sup>3</sup> do not lead to cell damage and hyperplasia.

Dose-related lesions, observed with long-term, repeated inhalation exposure (2.4, 6.7, or 17.2 mg/m<sup>3</sup>), were dysplasia and squamous

## SUMMARY AND EVALUATION

metaplasia of the respiratory and olfactory epithelia, which regressed, to some extent, after cessation of exposure.

Formaldehyde is carcinogenic in rats and mice. It produced nasal squamous cell carcinomas in rats exposed to high concentrations ( $17.2 \text{ mg/m}^3$ ), which also caused severe tissue damage. The concentration-response curve was extremely non-linear with a disproportionate increase in tumour incidence at higher concentrations. A low, but not statistically significant, incidence of nasal tumours occurred at  $6.7 \text{ mg/m}^3$ . No tumours were found at other sites. Mice developed squamous cell carcinomas of the nasal cavity with long-term exposure to  $17.2 \text{ mg formaldehyde/m}^3$ , but this finding was not statistically significant. No tumours were found at other sites. No tumours were found in hamsters.

Long-term oral administration of formaldehyde (0.02–5% in the drinking-water) was found to induce papillomas in the forestomach of rats.

Several skin initiation/promotion studies on formaldehyde in mice did not produce evidence of skin carcinogenicity; the results, with regard to promotion, were either negative or inconclusive.

The International Agency for Research on Cancer has concluded that there is sufficient evidence for the carcinogenicity of formaldehyde in animals.

### 2.5 Effects on Human Beings

Formaldehyde has a pungent odour, detectable at low concentrations, and its vapour and solutions are known skin and eye corrosives or irritants (depending on the concentration) in human beings. The common effects of formaldehyde exposure are various symptoms caused by irritation of the mucosa in the eyes and upper airways. In the non-industrial indoor environment, sensory reactions are typical effects, but there are large individual differences in the normal population and between hyperreactive and sensitized people.

There are a few case reports of asthma-like symptoms caused by formaldehyde. However, none of these conformed to classical asthma, and were neither Type I nor Type IV reactions. Irritation of the airways was considered to be the primary cause. Skin sensitization is induced only by

## SUMMARY AND EVALUATION

direct skin contact with formaldehyde solutions at concentrations higher than 2%. The lowest patch-test challenge concentration in an aqueous solution, reported to produce a reaction in sensitized persons, was 0.05% formaldehyde.

Formaldehyde does not have any adverse effects on reproduction, and is not teratogenic.

In *in vitro* studies, formaldehyde interfered with DNA repair in human cells, but there are no data relating to mutagenic outcomes.

The International Agency for Research on Cancer has concluded that there is limited evidence for the carcinogenicity of formaldehyde in human beings.

## 3. CONCLUSIONS AND RECOMMENDATIONS

### 3.1 Conclusions

#### 3.1.1 *Exposure*

Formaldehyde occurs naturally and is a product of normal metabolic pathways in many species. It is a widely produced industrial chemical. Major sources of formaldehyde are automobile and aircraft exhaust emissions, tobacco smoke, natural gas, fossil fuels, waste incineration, and oil refineries.

Formaldehyde exposure varies widely, because of local variations in emissions from natural and man-made sources. Significant levels of formaldehyde have been reported in indoor air arising from tobacco smoking, building and furnishing materials, and the use of formaldehyde-containing disinfectants. In workplaces, exposure can occur during the production, or handling, of formaldehyde, or products containing formaldehyde.

#### 3.1.2 *Health effects*

The most prominent features of formaldehyde vapour are its pungent odour and its irritant effects on the mucosa of the eyes and upper airways. Odour-detection thresholds are in the range of 0.1–0.3 mg/m<sup>3</sup>. Thus, some individuals can smell formaldehyde at very low concentrations.

Eye and respiratory-tract irritation can occur at levels of about 1 mg/m<sup>3</sup>, but discomfort has been reported at much lower levels. Direct contact with formaldehyde solutions at

## CONCLUSIONS AND RECOMMENDATIONS

concentrations of 1–2% can cause skin irritation in some individuals. In general, solutions containing between 5% and 25% are irritant, those containing more than 25% formaldehyde are corrosive; below 5%, irritancy decreases with decreasing concentration. Long-term exposure of the skin can lead to allergic contact dermatitis, but this has been demonstrated only for formaldehyde solution and not for gaseous formaldehyde.

Reversible obstruction of the airways has been produced by irritant concentrations of formaldehyde, and long-term exposure to formaldehyde at levels as low as  $0.5 \text{ mg/m}^3$  may cause a slight elevation in airway resistance. Formaldehyde-related asthma is unusual, despite widespread population exposure to formaldehyde.

In dental surgery, in order to avoid adverse reactions, root canal sealants should not be extruded beyond the apex.

There is no convincing evidence that formaldehyde is teratogenic, in either animals or human beings; it has not produced any adverse effects on reproduction in test animals or in human beings.

Formaldehyde is positive in a wide range of mutagenicity test systems *in vitro*; results of *in vivo* test systems are conflicting. It has been shown to form DNA-protein cross-links *in vitro* and *in vivo* in rat nasal mucosa. *In vivo*, this occurred at an exposure concentration of  $1.1 \text{ mg/m}^3$ . Formaldehyde interferes with DNA repair in human cells *in vitro*.

## CONCLUSIONS AND RECOMMENDATIONS

Following inhalation exposure at levels causing cell damage, a significant incidence of squamous cell carcinomas of the nasal cavity was induced in two strains of rat. Nasal tumours in mice have also been reported, but the incidence was not statistically significant. There were no tumours at other sites.

A limited number of forestomach papillomas were reported in rats following the administration of formaldehyde in the drinking-water.

In human beings, though an increased risk for a number of cancers has been reported, the causal role of formaldehyde is considered likely only for nasal and nasopharyngeal cancer.

### **3.2 Recommendations**

#### *3.2.1 General*

Human exposure to formaldehyde should be controlled.

It is recommended that consumer goods containing formaldehyde should be labelled, in order to protect persons with a formaldehyde allergy.

#### *3.2.2 Workplaces*

Personal protective clothing should be required only under exceptional circumstances. Normally, plant design and operating procedures should make the use of personal protection unnecessary. Work procedures must always be planned so that skin contact with formaldehyde solutions is avoided. Washing facilities should be readily available so

## CONCLUSIONS AND RECOMMENDATIONS

that contaminated skin can be washed immediately with ample quantities of water.

Any work involving formaldehyde or paraformaldehyde should, whenever possible, be carried out using enclosed systems. Pipes carrying formaldehyde should be distinctly and durably marked. Flange connections should be equipped with a splash guard.

The release of formaldehyde into workplace atmospheres should be prevented during filling or emptying operations, for example, by the use of the gas pendulum method or suitable suction devices, and the introduction of formaldehyde via ports. Areas in which formaldehyde is handled must be well ventilated. Normally, mechanical ventilation is necessary.

For sampling, open contact with formaldehyde should be avoided by using sampling ports, closed sampling vessels, or vacuum samplers.

Work procedures must always be planned so that skin contact with formaldehyde solutions is avoided. Washing facilities should be readily available to enable contaminated skin to be washed immediately with ample quantities of water.

Where the release of formaldehyde from processes cannot be prevented by technical measures, suction devices at the release points or adequate ventilation should be used, to ensure the safe removal of gaseous formaldehyde.

## CONCLUSIONS AND RECOMMENDATIONS

When exhaust gases from equipment or rooms containing formaldehyde are vented to the atmosphere, the installation of purification or destruction units may be required.

### 3.2.3 *Cosmetics*

Cosmetics (creams) containing formaldehyde should be suitably labelled, giving the concentration. Levels in oral health products should be strictly limited.

The concentration of formaldehyde, used as a preservative agent in cosmetics, should not exceed 0.2%, except in the case of nail hardeners, which may contain up to 5% formaldehyde.

### 3.2.4 *Disinfection*

Because of the sensitizing potential, skin contact with formaldehyde-containing disinfectants should be avoided by wearing impermeable gloves. Thermal procedures are preferred for disinfection or sterilization. If instruments are disinfected using formaldehyde, closed containers should be used. Incubators for babies, endoscopes, and tubes (e.g., endotracheal, gastric) should not be sterilized with formaldehyde.

Appropriate laundering procedures are preferred for the disinfection of clothing. Any "tub-disinfection" of clothing in formaldehyde solution should be exceptional and, if used, the "tub" must be closed with a tight-fitting lid. Gloves (and, if necessary, respirators) should be worn for the initial handling of formaldehyde-disinfected clothing. Steam disinfecting is the method of choice for mattresses; spraying with



## CONCLUSIONS AND RECOMMENDATIONS

disinfectants is considered obsolete. However, mattresses covered with synthetic materials can be disinfected by wiping with formaldehyde solution, but this should only be performed under well-ventilated conditions.

Care should be taken when using formaldehyde solutions for area disinfection. Wiping or scrubbing is recommended and the spraying of formaldehyde solutions should be confined to inaccessible places. Direct contact with the formaldehyde solution should be avoided by the use of gloves and suitable protective clothing. Large-area disinfection, e.g., of laboratories, should be done after working hours. Good ventilation during and after disinfection is mandatory.

### *3.2.5 Pathology*

Fixation of tissues in formalin baths should be performed in closed containers, under an exhaust hood. Fixed tissue slices should then be washed with water to remove superfluous formaldehyde, before viewing them under the microscope.

### *3.2.6 Laboratories*

In all laboratories, any work using formaldehyde or paraformaldehyde should be carried out under an exhaust hood, using enclosed equipment.

## 4. HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

### 4.1 Main Human Health Hazards, Prevention and Protection, First Aid

#### 4.1.1 *Human health hazards, prevention, and protection*

Workers must be informed of the possible dangers associated with the handling of formaldehyde, and instructed on safety precautions. When a risk to workers handling formaldehyde cannot be ruled out by technical means, personal protective equipment must be made available and used.

Individuals with an allergy to formaldehyde should not work with it.

Some technical protective measures are described in section 3.2.

Working clothes and personal protective equipment, including protective clothing that has been contaminated with formaldehyde or paraformaldehyde, must be changed and either thoroughly cleaned or destroyed.

Storage of food, eating, drinking, and smoking, should not take place in workplaces where formaldehyde is used.

If there is a risk of inhaling toxic concentrations of formaldehyde, for example, during open sampling or repair work, under uncontrolled working conditions, or in emergencies, breathing masks should be worn. As the effectiveness of gas filters is extremely limited, they should only be used if the total atmospheric contaminant concentration, including formaldehyde, is 1% (by volume) or less, and the oxygen content of the air is not less than 17% (by volume).

At higher concentrations of formaldehyde, or with prolonged exposures to formaldehyde-containing atmospheres, or under uncertain conditions, self-contained breathing apparatus or an independent air supply must be used. A full face-mask provides additional eye and face protection.

When working with formaldehyde solutions or paraformaldehyde, safety glasses (framed spectacles with side protection) must be worn. If eye irritation is expected, full goggles must be used.

## HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

During work involving a risk of skin contact with formaldehyde solutions or paraformaldehyde, well-fitting full goggles, suitable protective gloves, boots, and, possibly, an impermeable safety suit should also be worn.

### 4.1.2 *First aid*

All persons handling formaldehyde or paraformaldehyde should be informed about the health risks and given instructions on the actions to take in case of accident.

If formaldehyde poisoning is suspected, the affected person must be removed from the danger area immediately. First-aid and rescue personnel must protect themselves against contact with formaldehyde (for example, breathing protection, protective gloves). Medical advice should be sought without delay and the physician given details concerning both the exposure and the first-aid measures applied.

Advice on first-aid measures is given in the Summary of Chemical Safety Information (section 6).

### 4.2 **Advice to Physicians**

There is no specific antidote. If formaldehyde has been ingested, a stomach lavage can be performed, providing that full precautions are taken against inadvertent inhalation. In all cases of formaldehyde poisoning, maintain electrolyte balance, treat pain, and combat shock.

### 4.3 **Explosion and Fire Hazards**

Formaldehyde gas is flammable with a flash-point of 50 °C. Formaldehyde and formaldehyde solutions will burn above the flash-point, if exposed to flames or sparks. The flash-point depends on the concentration of methanol, and can vary between 50 °C and 85 °C. When formaldehyde is heated above its flash-point, it explodes (autoignition temperature, 430 °C).

## HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

### 4.3.1 *Explosion hazards*

Work areas where formaldehyde is present, or can be present, in such quantities that the lower explosion limit (7% volume) is reached, should be considered as fire and explosion risk areas.

Rooms in which aqueous formaldehyde solutions and paraformaldehyde are stored or handled at normal temperature (below the flash-point) are not explosion risks.

### 4.3.2 *Fire hazards*

There is a fire risk in rooms in which aqueous formaldehyde solutions and paraformaldehyde are stored at normal temperature. Smoking, open flames, and lights are prohibited. Electrical installations must be explosion-proof. The same restrictions apply to rooms in which work is carried out using aqueous methanol-containing formaldehyde solutions or paraformaldehyde heated beyond the ignition point.

Foam, carbon dioxide, and water are suitable for putting out fires. Powder extinguishers are of limited use, except in the case of small fires. Keep drums or containers of formaldehyde cool by spraying with water.

## 4.4 Storage

Containers of stainless steel, pure aluminium, polyethylene, and polyester reinforced with glass fibre are suitable for the storage and shipping of formaldehyde solutions. Normal steel containers with a corrosion-proof lining, e.g., phenol-formaldehyde resin or asphalt varnish, or with a rubber inner coating can also be used. Aluminium is extremely prone to corrosion by formaldehyde, at temperatures above 60 °C. Containers made of ordinary steel, copper, nickel, or zinc compounds, with unprotected surfaces, are unsuitable.

To avoid precipitation of paraformaldehyde, minimum storage temperatures for formaldehyde solutions of various concentrations are specified by the manufacturers. Do not store at temperatures below 15 °C.

## HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

During the filling of containers, exhaust air should be purified or recycled, using the gas pendulum method. Hoses used for the transfer of formaldehyde should not be used for any other substances.

### 4.5 Road Transport

In case of accident, stop the engine. Remove all sources of ignition. Keep bystanders at a distance and mark the road.

In case of spillage or fire, use the methods advised in sections 4.6 and 4.3, respectively. In case of poisoning, follow the advice in section 4.1.2 and in the Summary of Chemical Safety Information (section 6).

### 4.6 Spillage and Disposal Advice (based on the IRPTC waste disposal file)

#### 4.6.1 Spillage

Before cleaning up spilled formaldehyde solutions, workers should put on breathing equipment and suitable protective clothing (protective goggles, protective gloves, rubber boots, safety suit).

Use absorbent paper to mop up spilled material. Follow by washing surfaces well with soap and water. Seal all wastes in vapour-tight plastic bags for eventual disposal. Larger quantities should be collected by pumping into containers, or by the use of sorbents (e.g., kieselguhr or exfoliated mica). Solutions containing formaldehyde are water-contaminating and should be disposed of safely. Formaldehyde-containing absorbents, or soil contaminated with formaldehyde, should be disposed of in a suitable manner.

Working clothes and personal protective equipment, including protective clothing contaminated with formaldehyde or paraformaldehyde, must be changed and either cleaned or destroyed.

If transported, formaldehyde waste should be clearly labelled.

## HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

### 4.6.2 *Disposal*

The International Register of Potentially Toxic Chemicals provides the following advice on waste treatment and disposal methods:

"Recommendable: incineration, oxidation, discharge to sewer.

Not Recommendable: evaporation, alkaline hydrolysis.

Dissolve in a combustible solvent, thence spray the solution into a furnace with afterburner.

Dilute formaldehyde waste with a large amount of water and treat the solution by hypochlorite solution. Concentration of formaldehyde on the solution should be below 2%, in order to avoid excess exothermic reaction heat.

Formaldehyde is a powerful reducing agency and many oxidants can be used but may react violently (must be diluted).

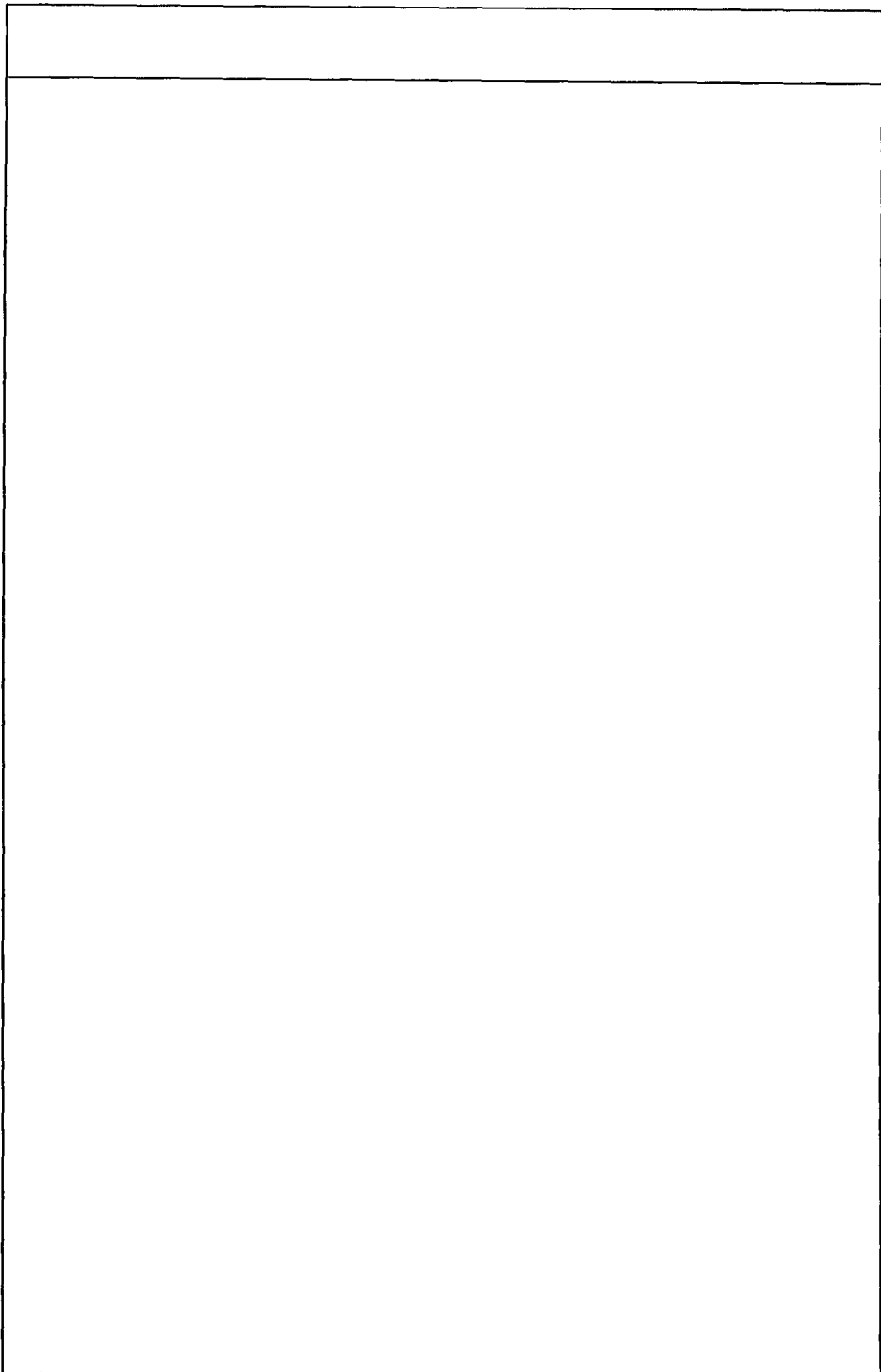
Alkaline hydrolysis may be dangerous because of exothermic reaction."

## 5. HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION

Formaldehyde is widely present in the environment, as a result of natural processes and from man-made sources. Most of the formaldehyde enters the atmosphere, where it is rapidly degraded by photolysis and photo-oxidation by hydroxyl radicals. Formaldehyde in soil and water is also biodegraded in a relatively short time. In water, one pathway of degradation is rapid hydration to methylene glycol.

Formaldehyde is toxic for several aquatic organisms, but its ready biodegradability, low bioaccumulation, and the ability of organisms to metabolize it indicate that the impact of formaldehyde on the aquatic environment is limited, except in the case of major pollution. Similar considerations apply to the atmosphere and the terrestrial environment where hazards will only occur when massive discharges or releases lead to major local pollution. The non-persistence of formaldehyde means that effects will not be permanent.

The main feature in the prevention of hazards for the environment is the control of the emissions, release, and disposal of formaldehyde.





## 6. SUMMARY OF CHEMICAL SAFETY INFORMATION

*This summary should be easily available to all health workers concerned with, and users of, formaldehyde. It should be displayed at, or near, entrances to areas where there is potential exposure to formaldehyde, and on processing equipment and containers. The summary should be translated into the appropriate language(s). All persons potentially exposed to the chemical should also have the instructions in the summary clearly explained.*

*Space is available for insertion of the National Occupational Exposure Limit, the address and telephone number of the National Poison Control Centre, and local trade names.*

## SUMMARY OF CHEMICAL SAFETY INFORMATION

### FORMALDEHYDE

Methanal, methylene oxide, oxymethylene, methylaldehyde, oxomethane, formalin (solution), formol (solution)

#### PHYSICAL PROPERTIES

##### Gas

Relative molecular mass	30.03	Colourless gas at normal temperature and pressure; pungent odour, detectable at low concentrations
Melting point (°C)	-118	
Boiling point (°C) at ambient pressure (3.33kPa or 25 mmHg)	-19.2	
Water solubility at 30 °C (g/100 ml water)	55	
Vapour pressure (kPa at -19 °C)	101.3	
	52.6	
Flash-point (°C)	300	
Explosivity range in air (g/m <sup>3</sup> )	87-910 (7-73%)	

##### Solution

Aqueous solution (37-50% formaldehyde with varying amounts of methanol)		
Boiling point (°C)	97	
Freezing point (°C) without methanol	-15	
Flash-point (°C) without methanol	85	
Flash-point (°C) with 15% methanol	50	

#### OTHER CHARACTERISTICS

## HAZARDS/SYMPTOMS

## PREVENTION AND PROTECTION FIRST AID

**Formaldehyde is a suspected human carcinogen by the inhalation route**

**SKIN:** Vapour is irritant; solutions may be corrosive or irritant, depending on formaldehyde concentration; redness of skin, burns, scaly and brittle nails

Handle mechanically, where possible, in proper enclosures or cabinets with exhaust ventilation; where appropriate, wear clean impervious gloves and apron to deflect splashes; wear freshly laundered clothes; remove and wash clothes thoroughly after contamination

Remove contaminated clothing immediately; wash contaminated skin thoroughly with running water and soap; continue for at least 10 minutes; protect from heat loss; obtain medical advice

**EYE:** Vapour is irritant and lacrimatory; solutions may be corrosive or irritant, depending on formaldehyde concentration

Ensure vapour concentrations are below occupational exposure limits; wear chemical goggles or face visor when handling solutions

Irrigate eyes with potable water or sterile eyewash solution for at least 15 minutes; obtain medical advice

**INGESTION:** Formaldehyde solutions may irritate the upper gastrointestinal tract or have corrosive effects, depending on formaldehyde concentration; abdominal pain, nausea, vomiting, diarrhoea, convulsions, coma

Do not eat, drink, or smoke while handling chemicals; use good work and personal hygiene practices

Do not induce vomiting; obtain medical advice; water can be sipped (dilution effect); milk can be sipped (protein binds with formaldehyde)

## SUMMARY OF CHEMICAL SAFETY INFORMATION (continued)

### HAZARDS/SYMPTOMS                      PREVENTION AND PROTECTION                      FIRST AID

**INHALATION:** Irritation, which may be severe, possibility of oedema; sore throat, shortness of breath, laboured breathing, congluing bronchospasm, nausea, dizziness, loss of consciousness

Remove from danger zone to the fresh air; absolute rest; if unconscious, maintain three-quarter prone position; protect against heat loss; give oxygen; if breathing stops, commence artificial respiration, if possible with respirator; obtain medical advice

**ENVIRONMENT:** Half-life in the environment is short; formaldehyde is toxic for aquatic organisms; should not pose an environmental risk, except in the case of major discharges, when there could be local, but not persistent, effects

Industrial emissions, discharges, and waste disposal should be minimized and regulated

FIRE AND EXPLOSION	
SPILLAGE	STORAGE
<p>SOLUTIONS: Wear rubber gloves and boots; absorb on paper, earth, sand, or equivalent, and shovel into a sealable container; dispose of drummed material as hazardous chemical waste</p> <p>Store in a cool dark place in light-proof containers</p>	
NATIONAL INFORMATION	
WASTE DISPOSAL	LABELLING
Incineration; oxidation	UN: Hazard Class 3 : Flammable liquid (applies to flammable formaldehyde solutions)
National Occupational Exposure Limit:	Hazard Class 9 : Miscellaneous dangerous substances; and
National Poison Control Centre:	Packing Class III : Substance presenting minor danger (applies to formaldehyde solutions)
Local trade names:	

## 7. CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

The information given in this section has been extracted from the International Register of Potentially Toxic Chemicals (IRPTC) legal file. A full reference to the original national document from which the information was extracted can be obtained from IRPTC. When no effective date appears in the IRPTC legal file, the year of the reference from which the data are taken is indicated by (r).

The reader should be aware that regulatory decisions about chemicals, taken in a certain country, can only be fully understood in the framework of the legislation of that country. The regulations and guidelines of all countries are subject to change and should always be verified with appropriate regulatory authorities before application

### 7.1 Exposure Limit Values

Some exposure limit values are given on pages 39 to 43.

### 7.2 Specific Restrictions

In the Federal Republic of Germany, emissions of formaldehyde are controlled. Formaldehyde is included in Class 1, in which the air emissions of organic compounds must not exceed (as the sum of all compounds in one class) a mass concentration of  $20 \text{ mg/m}^3$ , at a mass flow equal to, or greater than,  $0.1 \text{ kg/h}$ .

In the European Economic Community, formaldehyde, in quantities equal to, or greater than, 50 tonnes (at concentrations greater than 90%) is listed as a dangerous substance in the 1988 Directive on the Major Accident Hazards of Certain Industrial Activities.

In the United Kingdom, formaldehyde is classified as a poisonous substance and its sale is subject to restrictions.

The USA designates formaldehyde, and any isomers, hydrates, and solutions and mixtures containing formaldehyde, as hazardous substances for the purposes of discharge (including spillage and leakage), under the 1981 Federal Water Pollution Control Act. Unless in compliance with a

## CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

specified permit or procedure, the USA Government must be notified of any discharge of formaldehyde in, or on, navigable waters, adjoining shorelines, or the contiguous zone, in an amount equal to, or more than, 454 kg in any 24-h period. Permits are required for the discharge of formaldehyde from any point source into USA national waters. Formaldehyde in outfalls must be reported. Even if not required in the permit, discharge of formaldehyde must be reported, if it exceeds the highest concentration of 100 µg/litre, five times the maximum concentration reported in the permit application, or the level established by the US EPA Director. Any solid waste containing formaldehyde must be listed as hazardous waste and subject to handling, transport, treatment, storage, and disposal regulation, permit, and notification requirements, unless it is found that the waste cannot pose a threat to human health or the environment, when improperly managed. Certain specified industrial solid wastes containing formaldehyde are classified as hazardous wastes. According to the US EPA hazard-ranking system for the identification of hazardous waste facilities, formaldehyde is assigned a toxicity value of 3 (on a 0-3 scale), a persistence value of 0, an ignitability value of 2, and a reactivity value of 2.

### 7.3 Labelling, Packaging, and Transport

In the European Economic Community, formaldehyde is classified for labelling purposes in accordance with the concentration of the solution. Solutions containing 25% or more formaldehyde are labelled:

*Toxic by inhalation, in contact with skin and if swallowed; causes burns; possible risk of irreversible effects; may cause sensitization by skin contact.*

Solutions containing between 1% and 5% formaldehyde are labelled:

*Possible risk of irreversible effects; may cause sensitization by skin contact.*

In the United Kingdom, for road tankers transporting formaldehyde solutions with a flash-point below 60.5 °C, the required label is:

*Other hazardous substance..*

## CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

For the purposes of marine transportation, the International Maritime Organization (IMO) classifies formaldehyde in Hazard Class 3.3—Flammable Liquid—; Packing Group II—Substance Presenting Medium Danger (applies to solutions). For solutions of formaldehyde with a flash-point above 60 °C (closed-cup), the IMO classification is Hazard Class 9—Miscellaneous Dangerous Substances—; Packing Group III—Substance Presenting Minor Danger.

The United Nations transport classification for non-flammable formaldehyde solutions is Hazard Packing Group III—Substance Presenting Minor Danger; For flammable formaldehyde solutions, the classification is Hazard Class 3—Flammable Liquid.

In Canada, formaldehyde solutions with a flash-point greater than 61 °C are subject to transport restrictions in the category of miscellaneous dangerous goods. The maximum amount per package that may be transported on a passenger aircraft, train, or road vehicle, is 100 litres; on a cargo aircraft, the maximum amount per package is 200 litres. Solutions with a flash-point of less than 61 °C, in containers having a water capacity not greater than 454 litres, are in the category of flammable liquid, hazardous to the environment, and Packing Group II (Medium Danger). The maximum amount per package that may be transported on a passenger aircraft, train, or road vehicle is 5 litres; on a cargo aircraft, the maximum amount per package is 60 litres. Where the containers have a capacity greater than 454 litres, the maximum amount per package that may be transported on a passenger aircraft, train, or road vehicle, is 60 litres; on a cargo aircraft, the maximum amount per package is 220 litres.



## CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

### EXPOSURE LIMIT VALUES

Medium	Specification	Country/ organization	Exposure limit description	Value (mg/m <sup>3</sup> )	Effective date <sup>a</sup>
AIR	Occupational	Australia	Threshold limit value (TLV)	1.5	1985
			- Time-weighted average (TWA)	3.0	
			- Short-term exposure limit (STEL) (Suspected carcinogenic potential for man)		
		Belgium	Threshold limit value (TLV)	1.5	1989
			- Time-weighted average (TWA)	3.0	
			- Short-term exposure limit (STEL) (Suspected carcinogenic potential for man)		
		Brazil	Allowable limit (AL)	2.3	1982
			- Time-weighted average (TWA) (48 h/week)		
		Canada	Threshold limit value (TLV)	1.5	1980
			- Time-weighted average (TWA)	3.0	
			- Short-term exposure limit (STEL) (Suspected human carcinogen)		

## CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

### EXPOSURE LIMIT VALUES (*continued*)

Medium	Specification	Country/ organization	Exposure limit description	Value (mg/m <sup>3</sup> )	Effective date <sup>1</sup>
AIR	Occupational	Czechoslovakia	Maximum allowable concentration (MAC)	0.5	1985
			- Time-weighted average (TWA) - Ceiling value (CLV)	1.0	
		Finland	Maximum permissible concentration (MPC) - Short-term exposure limit (STEL)	1.3	1989 <sup>r</sup>
		Germany, Federal Republic of	Maximum worksite concentration (MAK) - Time-weighted average (TWA) - Short-term exposure limit (STEL) (5-min ceiling value) (local irritant; sensitization; suspected carcinogenic potential)	0.6 1.2	1989 <sup>r</sup>
		Hungary	Maximum allowable concentration (MAC) - Time-weighted average (TWA) - Short-term exposure limit (STEL) (30-min)	1.0 2.0	1985 <sup>r</sup>
		Italy	Threshold limit value (TLV) - Time-weighted average (TWA)	1.2	1985 <sup>r</sup>

AIR	Occupational	Japan	Maximum allowable concentration (MAC) - Ceiling limit value (CLV)	2.5	1988r
		Netherlands	Maximum limit (MXL) - Time-weighted average (TWA) - Short-term exposure limit (STEL)	1.5 3.0	1987r
		Poland	Maximum permissible concentration (MPC) - Time-weighted average (TWA)	2.0	1985r
		Romania	Maximum permissible concentration (MPC) - Ceiling limit value (CLV)	4.0	1985r
		Sweden	Hygienic limit value (HLV) - Time-weighted average (TWA) - Ceiling limit value (CLV) (sensitization)	0.6 1.2	1988
		Switzerland	Maximum worksite concentration (MAK) - Time-weighted average (TWA) (sensitizer)	1.2	1987r
		United Kingdom	Control limit (CL) - Time-weighted average (TWA) - Short-term exposure limit (STEL) (10-min)	2.5 2.5	1986

## CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

### EXPOSURE LIMIT VALUES (continued)

Medium	Specification	Country/ organization	Exposure limit description	Value (mg/m <sup>3</sup> )	Effective date <sup>1</sup>
AIR	Occupational	*USA (ACGIH)	Recommended threshold limit value (TLV)	1.2	1990
			- Time-weighted average (TWA)	2.5	
			- Short-term exposure limit (STEL) (Suspected carcinogenic potential)		
		(OSHA)	Permissible exposure limit (PEL)	3.7	1988
			- Time-weighted average (TWA)	6.1	
			- Ceiling value (CLV) - Peak value (30-min. during 8-h shift)	12.0	
		USSR	Maximum allowable concentration (MAC)	0.5	1989
			- Ceiling value (vapour) (CLV)		
		Yugoslavia	Maximum allowable concentration (MAC)	1.0	1985 <sup>r</sup>
			- Time-weighted average (TWA)		
*Notice of Intended Change, 1989-90					
		USA (ACGIH)	Recommended threshold limit value (TLV)	0.45	
			- Time-weighted average (TWA) (Suspected human carcinogen) (No short-term exposure limit - STEL)		

AIR	Ambient	USSR	Maximum allowable concentration (MAC)	0.035 (once/day) 0.003 daily average)	1984
SURFACE WATER	Environmental	USSR	Maximum allowable concentration (MAC)	0.05 mg/litre	1985
SURFACE WATER FOR FISHING	Environmental	USSR	Maximum allowable concentration (MAC)	0.25 mg/litre	1982 <sup>a</sup>
SOIL	Environmental	USSR	Maximum allowable concentration (MAC)	7.0 mg/kg	1980

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<sup>a</sup> r = year of last IRPTC update.

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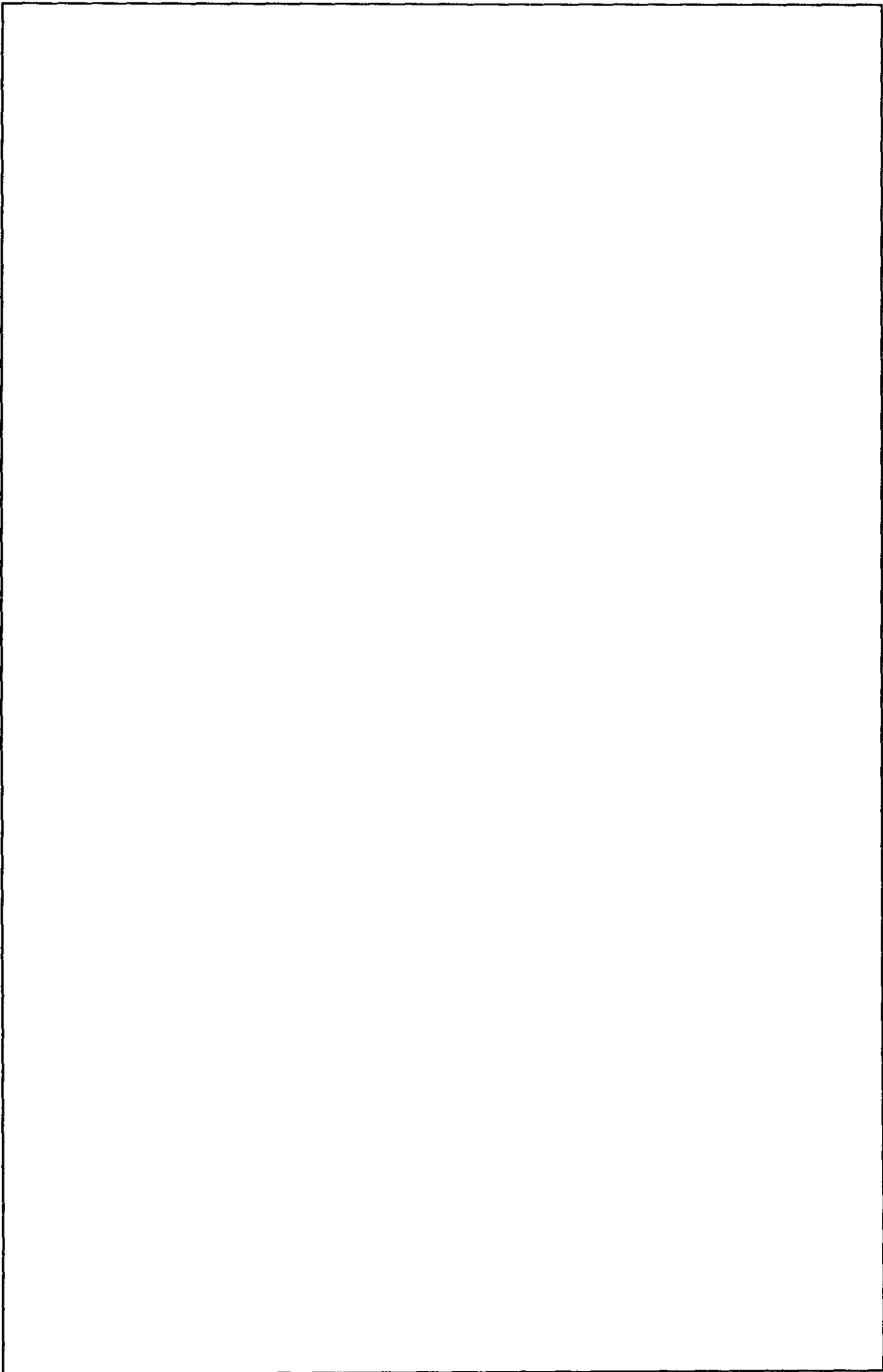
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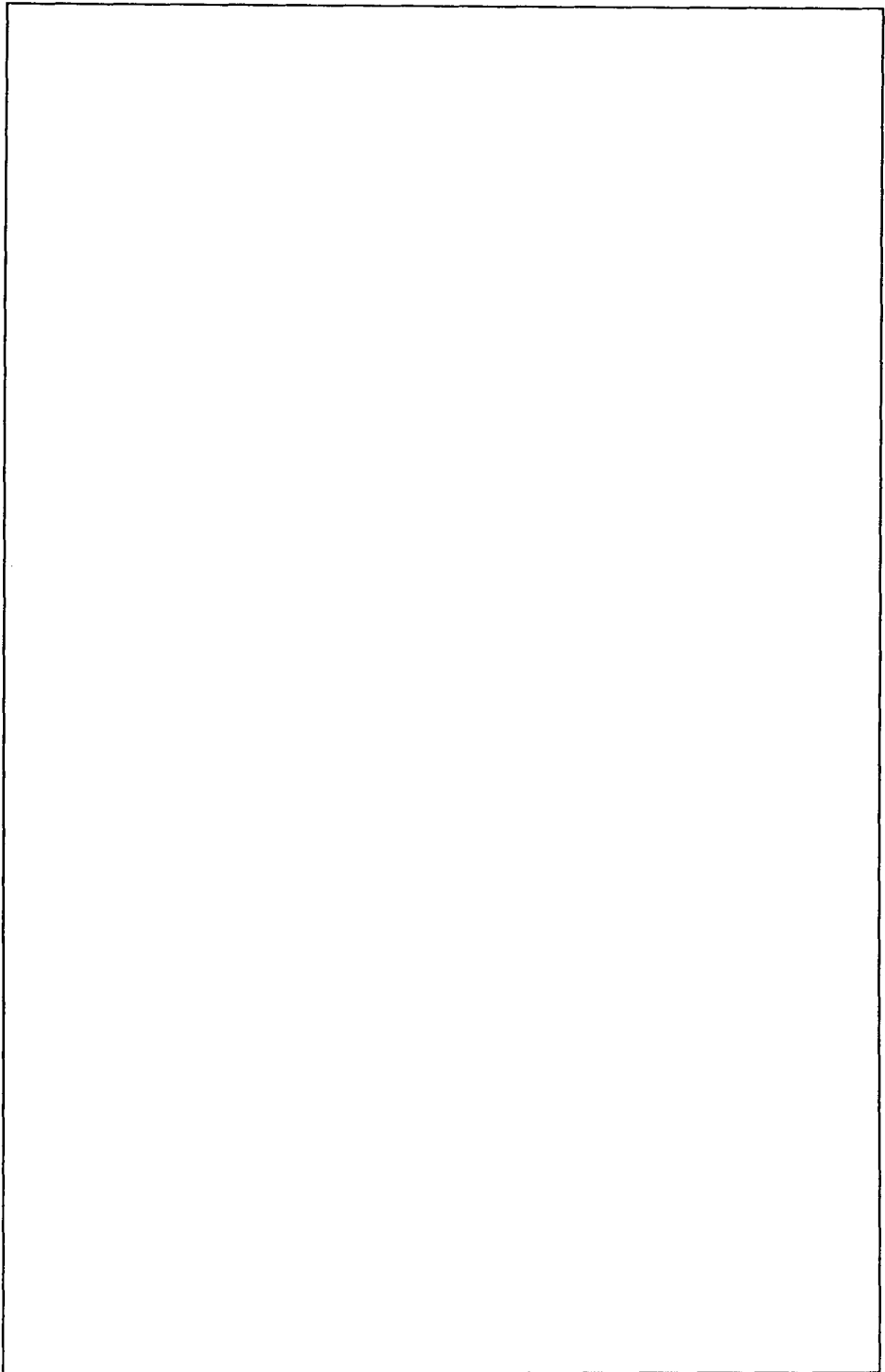
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