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Prevention guide: Formaldehyde in the workplace

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PREVENTION GUIDE
FORMALDEHYDE IN THE WORKPLACE

prepared by **Nicole Goyer, Denis Bégin, Charles Beaudry, Michèle Bouchard, Gaétan Carrier, Jérôme Lavoué, Nolwenn Noisel et Michel Gérin**—October 2006

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STUDIES AND RESEARCH PROJECT

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FORMALDEHYDE IN THE WORKPLACE

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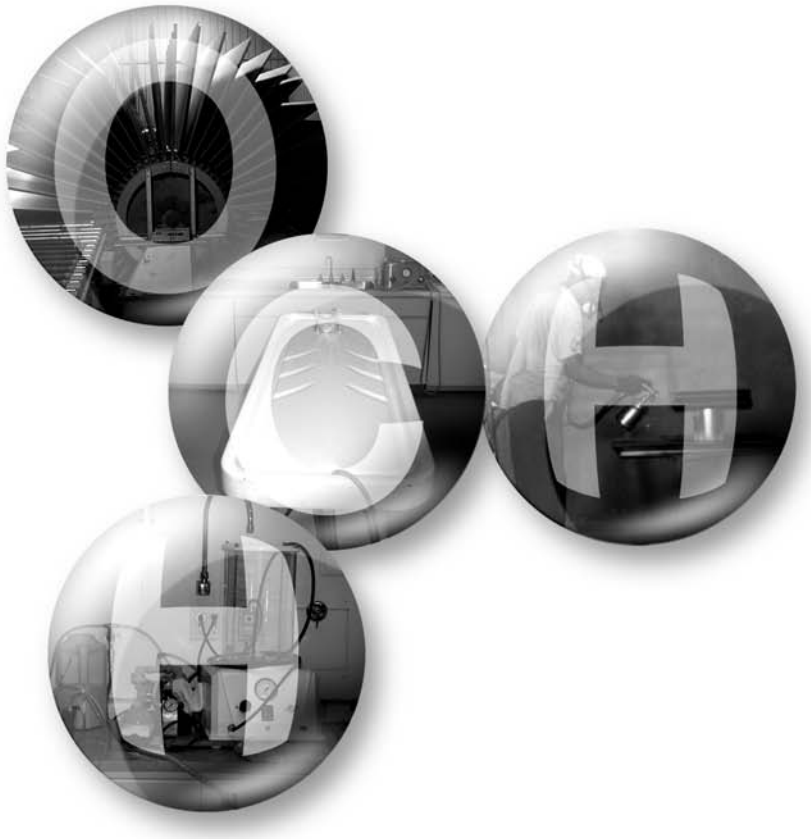
PREFACE

Research on the health and economic impact of lowering the permissible exposure value for formaldehyde in Quebec resulted in data being collected on various aspects: exposure of Quebec workers in several sectors of economic activity, sources of emission, hazardous tasks and the available control measures. The outcome was a final report that presents all the data that document this research.(1)

Twelve appendices comprising 12 separate documents have also been published, 10 of which are on the main activity sectors involved.(2-13)

For the panel, veneer and plywood manufacturing, embalming, wood furniture varnishing, and pathology laboratory sectors, specific prevention fact sheets have also been developed.(14-17)

This guide and the prevention fact sheets are intended as a practical summary of the research. They have been produced to provide occupational health and safety practitioners (preventionists members of health and safety committees, health and safety managers), employers and workers, with a better understanding of the risks associated with formaldehyde and to help them make informed decisions regarding the means of prevention that can be implemented.



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CHAPTER 1 GENERAL INFORMATION

Under normal temperature and pressure conditions, formaldehyde is a colourless gas with an acrid and pungent odour. Depending on the concentration, it may irritate the eyes and respiratory mucous membranes.

Table 1 presents some important physicochemical characteristics and properties from the standpoint of preventing exposure.

TABLE 1 MAIN PHYSICOCHEMICAL CHARACTERISTICS OF FORMALDEHYDE

Chemical formula	HCHO
CAS number	50-00-0
Synonyms	Methanal Formic aldehyde Formol or formalin (aqueous solutions)
Boiling point	- 19°C (1 atm))
Autoignition temperature	424 °C
Explosive limits in air	7 % – 73 %
Odour detection limit	0.05 ppm – 1.00 ppm
Concentration representing an immediate danger to life or health	20 ppm (24.6 mg/m^3)
Molar mass	30.03 g/mol
Flash point of aqueous solutions of 37% formaldehyde Without methanol 15% methanol	 83 °C (closed cup) 50 °C (closed cup)
Air concentration conversion factors (20°C)	1 ppm = 1.23 mg/m^3; 1 mg/m^3 = 0.81 ppm

SOURCES OF FORMALDEHYDE IN THE ENVIRONMENT

Formaldehyde is practically everywhere in the environment. It comes from natural sources and sources related to human activity. The combustion of plants is the main source of so-called "natural" formaldehyde. Exhaust gases from motor vehicles (diesel and gasoline) generate most of the emissions of human origin. Although the overall associated quantities of formaldehyde are small, the use of wood stoves, cigarette smoke, and some cooking methods constitute sources of indoor air contamination. In the same way, the degradation and degassing of some products containing formaldehyde such as particleboard and crease-resistant fabrics can increase its concentration in the indoor air.

Formaldehyde is rapidly and completely broken down in air and water. In the soil, it tends to remain in an aqueous solution. It does not bioaccumulate in living organisms.

Formaldehyde does not contribute to the depletion of the ozone layer or to climate warming. It does not pose a significant risk for flora and fauna. Formaldehyde does, however, contribute significantly to urban smog.(18)

CONCENTRATIONS OF FORMALDEHYDE MEASURED IN THE ENVIRONMENT

In Canada, the maximum concentrations of formaldehyde measured in the outdoor air between 1989 and 1998 were 0.024 ppm in the urban environment and 0.007 ppm in the rural environment. In the 1970s and 1980s, high concentrations of formaldehyde were found in the indoor air of residences containing urea formaldehyde foam insulation (UFFI, banned in Canada in 1980). Once the resins used in the manufacture of construction materials were modified, formaldehyde emission rates dropped significantly. Recent average concentrations of formaldehyde in residential indoor air are estimated at 0.04 ppm. Indoor contamination is on average 10 times higher than outdoors. Formaldehyde is found in the water and soil at respective concentrations of a few dozen mg/L and mg/kg.(18)

INDUSTRIAL USES OF FORMALDEHYDE

Formaldehyde is mainly stored and sold as an aqueous solution at concentrations varying between 30% and 56% by mass. These solutions contain various percentages of methanol (up to 36%), which is added to inhibit the spontaneous polymerization of formaldehyde. In general, the most concentrated solutions do not contain inhibitors but are stored and transported at high temperature (~ 60°C).

Formaldehyde is mainly produced by the oxidation of methanol, itself obtained from natural gas. It is primarily used to produce glues used in the manufacture of particleboard, veneers, wood furniture and other wood products. Formaldehyde is also used in the manufacture of various plastics, some fertilizers, resins used in foundry sand moulds, and some paints and varnishes. The textile industry uses these resins as finishers to make fabrics crease-resistant. The substance is also used in the synthesis of other chemical products and for its bactericidal properties in many formulations of disinfectant products, cosmetics, embalming fluids and solutions for preserving biological tissues. In Canada, approximately 92% of the consumption of formaldehyde is intended for the manufacture of formaldehyde-based glues and the synthesis of other chemicals. Fertilizer manufacture and disinfection-related uses represent respectively 6% and 2% of Canadian consumption.(18)

Occupational exposure to formaldehyde by inhalation is mainly from three types of sources: thermal or chemical decomposition of formaldehyde-based resins, formaldehyde emission from aqueous solutions (for example, embalming fluids), or the production of formaldehyde resulting from the combustion of a variety of organic compounds (for example, exhaust gases).

CHAPTER 2 HEALTH EFFECTS AND FIRST AID

In the workplace, exposure to formaldehyde occurs in various ways. In its gaseous form, it is absorbed by the respiratory tract; in aqueous solution, it is absorbed through skin contact.(1,2) The health effects associated with exposure to this substance vary with the exposure route and the concentration or dose absorbed. The Quebec Regulation respecting occupational health and safety establishes the limit as a ceiling exposure value (meaning a value never to be exceeded during any length of time whatsoever) at 2 ppm in the air.(19)

In extreme situations such as accidents, formaldehyde may be present at high concentrations in the air, representing a considerable immediate danger. Concentrations equal to or greater than 20 ppm can cause serious pulmonary oedema and eventually death.(20)

In the case of direct skin contact, formaldehyde may produce skin lesions such as irritation, irritant contact dermatitis and allergic contact dermatitis. The symptoms are itching, tingling and redness. Skin sensitization is likely to appear after contact with aqueous solutions of formaldehyde at concentrations equal to or greater than 2%,(21) or even solids or resins containing free formaldehyde.(22) When someone is sensitized, skin allergy (erythema) symptoms may occur at every contact with solutions of increasingly lower concentration (starting at 0.5% formaldehyde).(21) These effects are easily avoidable by protecting exposed skin for example, by wearing gloves.

Following exposure to contaminated air, the first effect is irritation of the mucous membranes of the eye and upper respiratory tract (nose and throat). The related symptoms are tingling, redness or burns to the nose and throat, nasal discharge and watery eyes. These symptoms are generally negligible to slight for formaldehyde concentrations below 1 ppm. They can become bothersome and even intolerable at higher concentrations mainly when they exceed 2 to 3 ppm.(1, 2)

In rare cases, formaldehyde causes sensitizing or allergic type changes in lung function.(23,24) These are manifested by a decrease in lung capacity and by asthma attacks likely to recur at decreasing concentrations. These effects were observed with asthmatic and non-asthmatic subjects exposed to more than 2 ppm.(2) Nevertheless, there is no consensus in scientific literature that asthmatics have a more severe reaction to formaldehyde exposure than non-asthmatics. The allergenic effect of formaldehyde can be worsened by the presence of particles or dust (for example, wood dust), that trigger bronchial reactions even at concentrations below 2 ppm.

The Commission de la santé et de la sécurité du travail (CSST) considers formaldehyde to be a causal agent for occupational asthma.(24,25) However, the documented concentrations that cause such pathologies often exceed the current standard of 2 ppm, and formaldehyde is generally not the only trigger. The simultaneous presence of some other chemical compounds, dusts or particles helps induce the same type of reaction.

In the case of occupational exposure over several years, formaldehyde has been related to causing cancer of the nasopharynx. Furthermore, the International Agency for Research on Cancer (IARC) has classified it as a human carcinogen since June 2004.(26) In Quebec, considering the concentrations present in the workplace and the number of exposed workers, the number of cases of cancer of the nasopharynx related to this exposure should remain very low. According to conservative estimates, less than one Quebec worker per year would develop a cancer attributable to formaldehyde following daily exposure for 40 years.(2) As for other types of cancers (of the sinuses, oro- and hypopharynx, pancreas, larynx, lung, brain and leukemias), epidemiological studies have not established with certainty any cause-effect relationships with formaldehyde.(26)

Currently in Quebec, approximately 150,000 workers are potentially exposed, but the number of reported cases recognized by the CSST as occupational injuries involving formaldehyde as a causal agent remains very low. Between 1994 and 1997, there were 11 cases among six codes in the Classification des activités économiques du Québec (CAEQ, classification of economic activities of Quebec). They were distributed as follows: five eye irritations, three respiratory system changes, two bronchial and lung damage, and one dermatitis.(27) Furthermore, according to the same register (Surveillance médico-environnementale de la santé des travailleurs (SMEST) or Medico-Environmental Surveillance of Workers' Health from 1994 to 1997), 403 women were the subject of a request for preventive reassignment recommended for a pregnant or breastfeeding worker under the "For a danger-free pregnancy" program.(27) However, it is rather unlikely that formaldehyde reaches the foetus since it is rapidly metabolized at the site of contact(21,28) and, to date, no effect on reproduction has been clearly demonstrated.(28)

As with many other chemical substances that affect human health, the extent of the effects of a given concentration varies from one person to the next (inter-individual variability) and in a given individual over time (intra-individual variability). The effects attributed to exposure to formaldehyde are not specific. Many factors can induce the same ailments. Irritation of the eye and upper respiratory tract can also be caused by other chemical substances, particles and dusts, dry air, tobacco and a lack of sleep, to mention only a few examples.(2)

FIRST AID

In rescue, first aid or emergency action situations, and before performing any direct intervention on the casualty, the person providing assistance must first ensure that they will not be exposed to the formaldehyde. Depending on the circumstances, the first step should be to remove the victim from the contaminated zone. When formaldehyde is in gaseous form, there is no risk of secondary contamination. However, if the formaldehyde is in solution and on the victim's clothes or skin, there is a possibility that the responder will be exposed either by direct contact or by inhalation. There is no antidote to counter the effects of formaldehyde. Treatment is based primarily on mitigating the symptoms.(29-31)

In the event of skin exposure, the responder must make sure that contaminated skin and hair are rinsed thoroughly with water for at least 15 minutes.(28) If the eyes are affected, they must be rinsed for 15 minutes with water or a saline solution. Contact lenses may be removed if it does not cause additional injury. Following exposure to the eye, the injury must be treated as a burn, and an ophthalmologist must be consulted as soon as possible. Casualties who have suffered severe eye or skin irritation must be reexamined after 24 hours.

In the case of inhalation at levels exceeding 3 ppm, it is recommended that the worker be transferred to a hospital emergency ward for medical follow-up.(29-31)

If the formaldehyde is ingested, vomiting should not be induced and gastric washing not performed. The casualty must be transferred to a hospital emergency ward.(29-31)

CHAPTER 3 REGULATIONS

The regulatory aspects are discussed in relation to the protection of workers' health and safety and the protection of the environment.

PROTECTION OF WORKERS' HEALTH AND SAFETY

In Quebec, the Regulation concerning occupational health and safety (RROHS) establishes the permissible exposure value for formaldehyde in the air at 2 ppm (3 mg/m^3) as a ceiling value (meaning a value that must never be exceeded during any length of time whatsoever).(19)

According to Schedule II of this regulation, formaldehyde solutions are dangerous substances that are flammable, combustible and toxic, and as such, must be handled and stored in accordance with the sections in division X "Storage and handling of dangerous substances".

The Service du répertoire toxicologique of the Commission de la santé et de la sécurité du travail (CSST), in accordance with the Workplace Hazardous Materials Information System (WHMIS), has assigned to formaldehyde the classifications A "compressed gas", B1 "flammable gas", D1A "very toxic substance causing immediate serious effects for its acute toxic effects", D2A "toxic material causing other toxic effects" for its carcinogenicity, and D2B "toxic material causing other toxic effects" for eye irritation in humans and mutagenicity in animals.(32) Formol (defined as a 37% aqueous solution of formaldehyde) has been assigned the classifications B3 "flammable solution", D1A, D2A, D2B, and E "corrosive material".(32)

Quebec workers under federal regulatory authority are subject to the Canadian standard (0.3 ppm ceiling).(33)

Table 2 presents the current regulatory standards for formaldehyde in various jurisdictions as well as the recommendations of independent or governmental organizations that are interested in workers' health and safety.

TABLE 2 EXPOSURE LIMIT VALUES FOR FORMALDEHYDE

JURISDICTION	EXPOSURE LIMIT VALUE
Canada	0.3 ppm, ceiling
Alberta	0.75 ppm, TWA 8 h 2 ppm, ceiling
British Columbia	0.3 ppm, TWA 8 h 1 ppm, ceiling
Manitoba	1 ppm, TWA 8 h 2 ppm, STEL 15 min
New Brunswick	0.5 ppm, TWA 8 h 1.5 ppm, STEL 15 min
Nova Scotia **Prince Edward Island** **Saskatchewan** **Newfoundland**	0.3 ppm, ceiling
Ontario	1 ppm, TWA 8 h 2 ppm, STEL 15 min
Quebec	2 ppm, ceiling, designations C2, EM and RP
United States (Occupational Safety and Health Administration (OSHA))	0.75 ppm, TWA 8 h (intervention: 0.5 ppm) 2 ppm, STEL 15 min
American Conference of Governmental Industrial Hygienists (ACGIH)	0.3 ppm, ceiling (since 1992)
National Institute of Occupational Safety and Health (NIOSH)	0.016 ppm, TWA 8 h 0.1 ppm, ceiling
Germany (Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area)	0.3 ppm, TWA 8 h 1 ppm, ceiling
Sweden (Swedish National Board of Occupational Safety and Health)	0.5 ppm, TWA 8 h 1 ppm, ceiling

TWA = Time-weighted average exposure value

STEL = Short-term exposure value

C2: suspected carcinogen

EM: substance whose exposure must be reduced to a minimum

RP: substance whose recirculation is prohibited

In Canada, formaldehyde is a "controlled product" according to the Controlled Products Regulation under the Hazardous Products Act,(34) and appears on the Act's Disclosure List. According to this List, the material safety data sheet for any commercial preparation containing more than 0.1% by mass of formaldehyde must mention its presence.(35)

PROTECTION OF THE ENVIRONMENT

In Canada, several regulations to protect the environment relate to chemical substances.

Persistence and Bioaccumulation Regulations

According to the Persistence and Bioaccumulation Regulations, formaldehyde is not classified as a "bioaccumulative" or "persistent" substance according to the Canadian Environmental Protection Act (CEPA) (36).

Domestic substances list (DSL)

Formaldehyde is on the DSL.(37) This inventory was created to respond to one of CEPA's requirements. It groups substances that, between January 1, 1984, and December 31,1986, were manufactured in or imported into Canada at a rate of at least 100 kg per year or that were used for commercial manufacturing purposes in Canada.

Transportation of Dangerous Goods Regulations (TDGR)

Two shipping names in the TDGR refer to formaldehyde.(38) Corrosive materials: solutions containing more than 25% by mass of formaldehyde (UN number of the regulatory name UN2209) are included in class 8 of the TDGR. Their transportation is subject to the rules of the TDGR corresponding to this category; and, flammable liquids: flammable solutions of formaldehyde (flash point below 60.5°C using the closed cup method or UN number of the regulatory name UN1198) belong to class 3.

A substance can belong to two categories. For example, a solution of 37% formaldehyde and 15% methanol in water that has a flash point of 50°C in a closed cup would be subject to the requirements of class 8 of subsidiary class 3 of the TDGR.

Priority Substances List

CEPA requires that federal environment and health ministers establish a priority list of substances whose toxicity must be evaluated. Formaldehyde has been on this list since 2001.(39) It is considered "toxic" as defined in Section 64 of CEPA.(18)

Briefly, the evaluation report concludes that formaldehyde is not hazardous for the environment but is a health hazard for Canadians due to its contribution to the formation of urban smog and its carcinogenic potential.

National Pollutant Release Inventory (NPRE)

Created in 1992 under CEPA, the NPRE requires that industries report their releases and transfers of pollutants annually to the Canadian government.(40) Environment Canada makes this information available to citizens in an annual report and manages a detailed inventory that can be consulted on-line. Formaldehyde is on this list of substances subject to the requirements of the NPRE. As such, any industry that, in the course of a year, accumulates 20,000 hours of remunerated work (~10 full-time workers) and manufactures, processes or uses more than 10 tonnes of formaldehyde (concentration >1% by weight) must report to the NPRE. In Quebec, in 2003, 626 tonnes of formaldehyde were reported as being released into the immediate environment by the companies, while 114 tonnes were eliminated off-site. Releases from particleboard plants represented 80% of the on-site releases.

In Quebec, two regulations relate to the emissions of chemical products into the environment.

Regulation concerning the quality of the atmosphere

No provision of the Regulation concerning the quality of the atmosphere applies to formaldehyde.(41) All the measures should soon be replaced by the Air Quality Regulation, currently under evaluation and revision (Gazette officielle du Québec, Partie 2 137(46): 6465-6519, November 16, 2005).

Furthermore, a draft regulation was recently published in the Gazette officielle du Québec pronouncing that companies operating in Quebec will have to report their atmospheric releases of formaldehyde to the ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) as stated in the NPRE (Gazette officielle du Québec, Partie 2 138(9): 1222-1227, March 1, 2006).

Regulation respecting hazardous materials

The Quebec Regulation concerning hazardous materials and amending various regulatory provisions indicates that a substance is considered a "toxic material" if it bears this name under the Controlled Products Regulation (Canadian).(34,42) Formaldehyde is classified D1A "very toxic material with serious immediate effects" according to the Workplace Hazardous Materials Information System (WHMIS). According to Section 3 in the Quebec regulation, this substance must therefore be considered as a "toxic material". According to Section 8, it is prohibited to release waste solutions of formaldehyde into the sewage system without obtaining a permit beforehand.

HANDLING AND STORAGE

Formaldehyde solutions must be stored in well-ventilated locations, away from sunlight, and away from all ignition sources, flammable materials, oxidants and bases.(28) The minimum storage temperature for a formaldehyde solution to limit its polymerization depends on its concentration and the presence of an inhibitor such as methanol. Therefore, a 50% solution of formaldehyde without an inhibitor must be stored at 60ºC while a 37% solution with an inhibitor can be stored at 15ºC.(43) It is recommended that respiratory protective equipment, a source of water at a high flow rate, safety showers and eye showers be available nearby, outside the storage area.(28)

As for chemical incompatibilities, formaldehyde, a strong reducing compound, will react violently (explode, catch fire, etc.) with strong oxidants (examples: hydrogen peroxide, potassium permanganate), acrylonitrile, caustic soda, magnesium carbonate, nitrogen oxides and peroxyformic acid. Formaldehyde is also incompatible with strong acids, amines, ammonia, aniline, disulfides, gelatine, iodine, magnesite, phenol, tannins, and copper, iron and silver salts. Also, formaldehyde solutions attack ordinary steel.(44)

As much as possible, formaldehyde and its solutions must be used in a closed circuit to avoid any exposure through skin contact or inhalation.

ACCIDENTAL LEAKS

In the event of a leak or spill, all skin contact with formaldehyde must be avoided and an attempt made to minimize exposure by inhalation. Personal protective equipment may be required. In addition, since formaldehyde is flammable, all ignition sources must be eliminated from the contaminated area. Water can be sprayed to eliminate formaldehyde in gaseous form. In the same way, the application of a foam of fluorocarbons and water will limit gaseous emissions and fire risks. In the event of a spill on the ground, the formaldehyde can be neutralized with sodium bicarbonate or ammonium hydroxide once it has been confined. Treatment with sodium sulfite is also recommended. Commercial formulations to neutralize formaldehyde spills (waste solutions or spill) are available from major suppliers of laboratory equipment, and equipment for hygiene and safety. The proposed "kits" contain substances that react with formaldehyde to form solid or viscous compounds that are easily cleaned up.(43) The compounds must be recovered according to the suppliers' recommendations.

The reader must refer to the guides published by Transport Canada and the CSST for more general instructions on emergency response planning.(45,46)

CHAPTER 4 METHODS AND STRATEGIES FOR MEASURING EXPOSURE

The quality of the evaluation of workers' exposure to chemical substances depends on the strategy applied in the workplace as well as on the precision, accuracy and limit of linearity of the sampling and analytical method. For information on the strategies to be favoured in relation to the objectives, and on the aspects of statistical treatment of the data, refer to the IRSST's Sampling Guide for Air Contaminants in the Workplace.(47) The methods for measuring formaldehyde exposure are described in the following sections.

MEASURING THE TIME-WEIGHTED AVERAGE EXPOSURE CONCENTRATION

Two standard methods are available for evaluating compliance with the time-weighted average exposure value (TWA) over eight hours. The first method consists of sampling formaldehyde on XAD-2 polymer tubes impregnated with hydroxymethyl piperidine and analyzed by gas phase chromatography with a nitrogen phosphorus detector according to IRSST method 295-1.(48) The limit of detection for this technique is 2 µg. The coefficient of variation of the analytical method is 0.045; the estimated coefficient for the pump is 0.05, which gives a coefficient of total variation of 0.067 or 6.7%. Sampling is done in the workers' breathing zone using a sampling pump operating at a flow rate between 0.1 and 0.3 litres per minute. The second method consists of using a passive dosimeter impregnated with 2.4 dinitrodiphenylhydrazine to sample the formaldehyde, also in the worker's breathing zone. The limit of detection is 0.21 µg and the sampling rate is estimated at 0.286 litres per minute.

The sampling periods must be representative of the work performed during the shift; it is therefore important that the workers' tasks be properly understood. For a majority of the workers, samples can be collected 2-4 hours each before and after the noon break. When the expected concentrations are low, the same sampling system can be used throughout the day. Shorter duration tests can be used for some specific short-duration tasks that are likely to release formaldehyde.

Samples can also be collected at stationary workstations considered representative of the workers' exposure, namely during specific tasks or close to emission sources where they have to work in the context of their jobs. The sampling time then varies according to the targeted task and the expected formaldehyde concentration.

The average exposure concentrations (AEC) over eight hours, which are then compared to TWA, are calculated as follows:

$$AEC = \frac{C1T1 + C2T2 + \ldots + CnTn}{T1 + T2 + \ldots + Tn} \quad \text{where}$$

Cn: concentration measured in the breathing zone or at the workstation

Tn: time in minutes of the sampling period

1,2,...n: indication of the sampling period

T1 + T2 +…+ Tn = 480 minutes (eight hours)

For periods not sampled, the arithmetic mean obtained for the sampling period corresponding to the same task is applied.

MEASUREMENT OF THE CEILING EXPOSURE CONCENTRATION

Standard method IRSST-39A for measuring the ceiling exposure to formaldehyde consists of reading the concentration directly on an infrared instrument equipped with an Innova model 1312 photoacoustic detector.(49) With the parameters set on the instrument for this analysis, the response time is 60 seconds and the lower limit of linearity is 0.12 ppm (although it can read lower values). The precision reported by the manufacturer is 1%. Due to its size, a worker cannot wear this instrument. A reading can, however, be taken using a sensor in the breathing zone.

As with any direct-reading method for gases, the presence of other substances may interfere with the analyzer's response. With the Innova 1312, some interference can be eliminated by using filters. In the case of formaldehyde, the instrument usually operates in crossed compensation with three filters of different wavelengths, namely the UA 0986 for formaldehyde detection, the UA0936 for methanol, and the UA0527 for water vapour. The data are saved every minute and the data processing software reports the minimum, maximum and mean values.

Other commercial direct-reading instruments measure formaldehyde. Three of them were evaluated in the IRSST's laboratory at the same time as the photoacoustic analyzer. They were the Miran series SapphIRE infrared spectrometer, the Drager CMS colorimetric reader, and the PPM series Formaldemeter 400 electrochemical cell analyzer. The precision, accuracy, effects and interference attributable to other chemical substances were considered. Although these instruments generally provide acceptable precision and accuracy, they are all subject to the effects of other chemical substances.(50) Before taking any formaldehyde reading in a workplace, it is important to know the processes and the chemical products that may be found in the air and that may affect the result. Only the Miran infrared spectrometer has an intrinsically safe classification, meaning it is explosion-proof.

Measuring the ceiling exposure to formaldehyde remains problematic in workplaces where other chemical substances are present in the air.

CHAPTER 5 CONTROLLING THE EXPOSURE

The goal of the requirements in Quebec's occupational health and safety Act is to eliminate hazards at their source. To do this, it is important to properly identify the emission sources and exposure determinants, namely the parameters that establish the intensity, duration and frequency of the exposure.

The first level in controlling exposure is to eliminate formaldehyde from the workplace air. This can be achieved through substitution, work in a closed circuit, modification of work methods, isolation and local ventilation. General ventilation can reduce concentrations through dilution. In some cases, using personal protective equipment is the only effective solution available. These control solutions are grouped in each appendix of the report on the impact of lowering the permissible exposure value for formaldehyde.(4-13)

SUBSTITUTION AND WORK METHODS

Substitution of one product by another requires a structured approach that must be technically applicable in the workplace and acceptable from the standpoint of performance, cost and equipment.(51) Due to the particular characteristics and inherent challenges of substitution, it was not systematically studied with respect to formaldehyde. However, various scenarios can be considered in relation to its use. They are briefly documented in the appendices relating to sectors of activity.(4-13) Here are a few examples:

- In the manufacture of panels and other wood products where formaldehyde is used as glue, the use of resins without or at lower formaldehyde emission rates is one option to be considered for particleboard and beams. A few plants use isocyanate-based products. Their toxicity is high, however, and a risk analysis is necessary.
- In wood furniture varnishing, different types of coatings exist: cellulose nitrate, acrylic, ultraviolet drying, polyester, polyurethane, and powder coatings. Several factors affect the choice, such as the type of furniture, the desired finish, the cost of equipment replacement, current environmental regulations, etc.
- In foundries, some moulding techniques release less formaldehyde.
- As a fixation agent in pathology, embalming fluid or crease-resistant finish for fabrics, other commercial products are available, but the data on their performances are incomplete. The possibility of using a less concentrated solution should also be studied.

Work methods and habits are to be considered in identifying exposure determinants. This aspect is even more important if the formaldehyde is to be handled in many tasks. In pathology and embalming laboratories, several tasks could be reconsidered to minimize or avoid formaldehyde exposure.

LOCAL AND GENERAL VENTILATION

The purpose of local ventilation is to collect a pollutant as it is emitted to prevent its dispersion in the work environment. Ventilation must be the preferred method of control when the emission source is well identified. It is even more effective when the source is contained and isolated. Local ventilation must also be available (for example, when using fume hoods) or any tasks that expose workers to short emissions. In all cases, the ventilation must be designed in such a way as to carry the pollutant away from the workers' breathing zone. A collection system at source must be designed and installed by industry professionals.

The purpose of general ventilation is to dilute the pollutants by introducing a sufficient flow of outdoor air. This requires a large quantity of air that will itself be dependent on the homogeneity of the mixture of fresh air with polluted air. As with local ventilation, the design of an efficient system requires a good understanding of the air-flow patterns in the building. It is also important to consider that flow rates and air flows (velocity, direction, temperature, etc.) will vary with the ambient conditions (temperature, door opening, etc.) and can reduce dilution. General or dilution ventilation is recommended in zones adjoining those containing the emission sources and in buildings such as warehouses where the emission sources are diffused. Please note that the recirculation of formaldehyde is prohibited by the RSST.(19)

PERSONAL PROTECTIVE EQUIPMENT

Due to the irritant effects of formaldehyde, personal protective equipment must protect the respiratory tract and eyes.(52)

- For concentrations above 20 ppm, causing an immediate danger to life or health (IDLH), a self-contained breathing apparatus (SCBA) must be worn.
- For formaldehyde concentrations below 20 ppm and up to the permissible value, wearing a filter cartridge mask is recommended. Depending on the necessary protection factor*, a full mask (protection factor of 100) or a half-mask (protection factor of 10) should be used. In the case of a half-mask, safety goggles must also be worn.

* The protection factor of a respirator indicates its effectiveness. It represents the theoretical relationship between the concentration in the work environment and the concentration inside the respiratory protective equipment. A factor of 10 therefore means that the concentration inside the mask is 10 times lower than in the work environment.

Formaldehyde can also cause skin irritations. Wearing protective gloves is recommended. The choice of model must take into account the nature of the chemicals used, the length of time they are used, and the dexterity required to perform the task. Nitrile, neoprene and butyl gloves offer good resistance to formaldehyde. When there is a risk of spraying or splashing, protective clothing must be worn.

EXPOSURE EVALUATION PROGRAM AND EMPLOYEE TRAINING

By monitoring the concentrations of formaldehyde in a company, it is possible to ensure that the environment is healthy and to identify leaks. Any technological change, or process or task modification justifies a new evaluation to determine that the work environment remains acceptable. The Regulation concerning occupational health and safety specifies in Section 43 that "in any establishment that employs 50 workers or more where the concentration of gases, dusts, fumes, vapours or mists at a work location exceeds or could exceed the standards prescribed, the concentration of such gases, dusts, fumes, vapours or mists emitted into the work environment concerned shall be measured at least once a year."(19) In addition, Section 42 stipulates that "when a worker is exposed to a substance identified as having a known or suspected carcinogenic effect on humans, such exposure shall be reduced to a minimum, even when it remains within the standards provided." Formaldehyde belongs to this category.

Information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

CHAPTER 6 INFORMATION AND RECOMMENDATIONS BY SECTOR OF ECONOMIC ACTIVITY

For each sector of economic activity studied, the main information and the means of prevention were identified, namely the uses of formaldehyde in the sector, the exposure determinants (the main factors that affect formaldehyde emission), the main emission sources, the workers' exposure concentrations measured for different tasks and professions, and the means of control. More information is available in the appendices of the report on the impact of lowering the permissible exposure value.(4-13)

6.1 MANUFACTURE OF CHIPBOARD

USE OF FORMALDEHYDE

The manufacture of chipboard includes particleboard; low, average and high density fibreboard; and oriented strandboard, called OSB. Regardless of the type of boards, the pieces of wood are bonded with urea formaldehyde (UF), melamine-formaldehyde (MF), melamine-urea-formaldehyde (MUF) or phenol-formaldehyde (PF) resins, and then formed into the mat. Hot pressing, where the mat is compacted to the desired density and thickness, allows the resin to be polymerized to bind the particles and stabilize the panel. Presses are single-stage, multi-stage or continuous. The boards are then transferred to a cooling system, and left for a period of time to mature. The different stages of finishing, storage and shipping follow.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Types of resins (UF, MF, MUF, PF) and molar ratio: UF resin has the highest emission rate, and PF resin the lowest.
- Process operating conditions: temperature, pressing time, panel thickness, and maturation time.
- Presence and efficiency of fume hoods or local collection systems at source.
- Efficiency of the general ventilation.

EXPOSURE SOURCES

The following table presents the maximum measured concentration ranges for the different hazardous tasks and the emission sources.

EMISSION SOURCES AND HAZARDOUS TASKS	MAXIMUM CONCENTRATIONS (PPM)
Gluing machine: glue preparation glue application	< 0.3 to > 2.0
Board press: board pressing: opening of the press (stage press) board pressing: board outfeed (continuous press) stacking of boards repair and maintenance quality control test	< 0.3 to > 2.0
Cooler (carrousel): collection of boards stacking of boards	< 0.3 to 1.2
Maturing, drying and storage area: finishing operations packaging operations transportation by lift truck	< 0.3 to 1.5
Laminating: impregnation tank feeding the press	< 0.3 to 1.7

EXPOSURE DATA

The following table presents the measured concentration ranges for the workers in 12 establishments.

PROFESSION	EXPOSURE RANGE (PPM)	
	WEIGHTED AVERAGE – 8 HOURS	CEILING
Reception		
Receiver	< 0.3	< 0.3
Chip preparer/wafer preparer	< 0.3	< 0.3
Manufacture of panelboard		
Resin preparer	< 0.3	< 0.3 – 0.8
Press operator	< 0.3	< 0.3 – > 2.0
Assistant press operator	< 0.3	< 0.3 – > 2.0
Misc. tasks – press	< 0.3 – 0.6	< 0.3 – > 2.0
Finishing		
Finisher	< 0.3	< 0.3 – 0.8
Lamination – impregnation		
Laminator	< 0.3	< 0.3 – 0.9
Operator	< 0.3	< 0.3
Shipping		
Shipper	< 0.3	< 0.3 – 1.5
Related tasks		
Laboratory technician	< 0.3	< 0.3 – > 2.0
Electrician/mechanic	< 0.3	< 0.3 – > 2.0
Cleaner	< 0.3	< 0.3 – > 2.0
Foreman	< 0.3	< 0.3 – 0.8
All-around hand	< 0.3	< 0.3 – > 2.0
Other (office)	< 0.3	< 0.3

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling exposure to formaldehyde are:

- Substitution: isocyanate-based products are used in one plant. However, these products have a high toxicity, and a risk analysis is necessary.
- Use of resins with a lower emission rate.
- Confinement of formaldehyde emission steps and installation of fume hoods above the sources (press, cooler).
- General ventilation in the board finishing and storage areas to dissipate the formaldehyde that could still be released. Confinement of these areas will limit the dispersion and reduce the flow necessary for general ventilation.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

NOTE: A prevention fact sheet specific to this sector is available on the IRSST Web site.(14)

6.2 MANUFACTURE OF WOOD PRODUCTS

USE OF FORMALDEHYDE

This activity sector includes the veneer, plywood, laminated wood and panel coating industries. For veneers, the only step requiring formaldehyde-based resin is bonding wood sheets in the longitudinal or transverse plane. Veneers and laminated veneers consist of different layers (panels, sheets of veneer, boards) bonded and hot pressed. Coating also involves gluing a laminated or melamined décor paper on the panels, followed by hot pressing. The pieces of wood are bonded with urea-formaldehyde (UF), melamine-formaldehyde (MF), melamine-urea-formaldehyde (MUF) or phenol-formaldehyde (PF) resins.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Types of resins and molar ratio.
- Process operating conditions: temperature, pressure, duration of pressing, panel thickness, type of coating.
- Presence and efficiency of fume hoods or local collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the measured maximum concentration ranges for the different hazardous tasks and the emission sources.

SECTOR	EMISSION SOURCES AND HAZARDOUS TASKS	MAXIMUM CONCENTRATIONS (PPM)
VENEERS	**Gluing machine:** glue preparation glue application	< 0.3
PLYWOOD	**Gluing machine:** glue preparation glue application	< 0.3 to 0.6
	Panelboard press: manual feed outfeed and stacking repair and maintenance **Drying and storage area:** finishing operations packaging operations transportation by lift truck	< 0.3 to 0.8
LAMINATED WOOD	**Gluing machine:** glue preparation glue application	0.8 to 1.7
	Panelboard press: manual feed outfeed and stacking transportation by lift truck	0.7
	Drying and storage area: finishing operations packaging operations transportation by lift truck	< 0.3 to 0.9
COATING	**Resin preparation**	> 2.0
	Impregnation tank: paper feed press infeed **Drying and storage area:** finishing operations packaging operations transportation by lift truck	1.7 < 0.3 to 0.5

EXPOSURE DATA

The following table presents the concentration ranges measured for the workers in 10 establishments

PROFESSION	EXPOSURE RANGE (PPM)	
	WEIGHTED AVERAGE – 8 HOURS	CEILING
Guillotine operator	< 0.3	< 0.3
Gluing machine operator	< 0.3 – 0.5	< 0.3 – 1.7
Jointer operator	< 0.3	< 0.3 – 0.8
Finisher	< 0.3	< 0.3 – 0.4
Press operator	< 0.3	< 0.3 – 0.8
Lift truck operator/shipper	< 0.3 – 0.4	< 0.3 – 0.9
Stacker	< 0.3 – 0.9	< 0.3 – 1.0
Office	< 0.3	< 0.3

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling exposure to formaldehyde are:

- Substitution: the use of isocyanate-based products is being tested for some processes such as beam manufacture. However, these products have a high toxicity, and a risk analysis is necessary.
- Use of resins with a lower emission rate.
- Confinement of formaldehyde emission steps and installation of fume hoods above the sources: preparation of resins, gluing machine, glue spray nozzle, transfer rollers, press.
- General ventilation in the parts finishing and storage areas to dissipate the formaldehyde that could still be released. Confinement of these areas will limit the dispersion and reduce the flow rate necessary for general ventilation.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

NOTE: A prevention fact sheet specific to this sector is available on the IRSST Web site.(14)

6.3 MANUFACTURE OF WOOD FURNITURE

USE OF FORMALDEHYDE

Furniture is manufactured from chipboard or hardwood. The manufacture itself can be summarized in four major steps: 1) processing (sawing, sanding, assembly, inspection); 2) painting, staining and varnishing (mixing, application, drying, sanding, repair); 3) upholstery and installation of hardware; 4) packaging and shipping.

Most of the adhesives used do not emit formaldehyde. Chipboard emits small quantities. The main source of formaldehyde originates from varnishes containing aminated resins.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Types of varnishes.
- Process operating conditions: nature of the spraying systems, drying time and location.
- Work method (for example, position of the painter in the paint booth).
- Presence and efficiency of varnishing booths or local collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the measured maximum concentration ranges for the different hazardous tasks and the emission sources.

SOURCES OF EXPOSURE	MAXIMUM CONCENTRATIONS (PPM)
HAZARDOUS TASKS	
Paint preparation	< 0.3 to > 2.0
Application of primers/varnishes	0.5 to > 2.0
Sanding between coats of varnish	0.4 to > 2.0
Unloading of furniture (from oven)	< 0.3 to > 2.0
Repair of imperfections	0.5 to 1.7
Installation of hardware	< 0.3 to 1.8
Cleaning of guns	Not measured
EMISSION SOURCES	
Storage of varnishes	Not measured
Paint booth	0.6 to > 2.0
Drying of furniture	< 0.3 to > 2.0
Storage of furniture	< 0.3 to 1.8

EXPOSURE DATA

The following table presents the concentration ranges measured for the workers in nine establishments.

PROFESSION	EXPOSURE RANGE (PPM)	
	WEIGHTED AVERAGE – 8 HOURS	CEILING
Day labourer - manufacture	< 0.3	< 0.3 – 0.8
Colourman	< 0.3 – 0.4	< 0.3 – > 2.0
Preparation painter	< 0.3	< 0.3 – > 2.0
Finishing painter	< 0.3 – 0.9	0.6 – > 2.0
Finishing operator	< 0.3 – 0.6	0.4 – > 2.0
Repairman	< 0.3 – 0.4	0.6 – 1.7
Labourer	< 0.3 – 0.6	< 0.3 – > 2.0
Finishing man/shipper	< 0.3 – 0.4	< 0.3 – 1.8
Maintenance man	< 0.3	0.5
Supervisor	< 0.3	< 0.3 – > 2.0
Office	< 0.3	< 0.3

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling exposure to formaldehyde are:

- Substitution: different types of formaldehyde-free coatings exist: varnish in the aqueous phase, with ultraviolet drying, in powder form, polyurethane.
- Confinement of emissions steps: preparation and spraying of paints and varnishes should be done in a ventilated booth.
- Ventilation at source: exhaust ventilation above the drying area (oven).
- General ventilation: in the furniture finishing and storage areas to dissipate the formaldehyde that could still be released. Confinement of these areas will limit dispersion and reduce the flow necessary for general ventilation.
- Work method: in the paint booth, the painter must not be between the part to be varnished and the polluted air outlet.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

NOTE: A prevention fact sheet specific to this sector is available on the IRSST Web site.(15)

6.4 MANUFACTURE OF FORMALDEHYDE AND FORMALDEHYDE-BASED RESINS

USE OF FORMALDEHYDE

Formaldehyde manufacture in Quebec uses only one industrial process: catalytic oxidation of methanol. Done continuously in a closed circuit, it is completely automated. The starting material, methanol, is fed and the formaldehyde solution transferred through pipes, and storage is in bulk in tanks. In Quebec, the only resins manufactured are aminated and phenolic thermoset materials. Production is done by the batch. As the polymerization reaction progresses, samples for analysis are collected through a specific tap and used to measure the progress of the reaction. Except for the maintenance, drum filling and bagging activities, all the other tasks mainly require the inspection and monitoring of production in the control rooms.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Condition of the piping and equipment.
- Presence and efficiency of fume hoods or local collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the measured maximum concentration ranges for the different hazardous tasks and the emission sources.

EMISSION SOURCES AND HAZARDOUS TASKS	MAXIMUM CONCENTRATIONS (PPM)
Reactor: collection of samples opening the hatch maintenance and repairs	< 0.3 to 0.7
Pump room: filter replacement maintenance and repairs	< 0.3 to 0.9
Loading system: bagging filling of trucks and barrels	< 0.3 to 1.4

EXPOSURE DATA

The following table presents the concentration ranges measured for the workers in four establishments.

PROFESSION	EXPOSURE RANGE (PPM)	
	WEIGHTED AVERAGE – 8 HOURS	CEILING
Operator – formaldehyde	< 0.3	< 0.3 – 0.7
Operator – resin	< 0.3	< 0.3 – 0.7
Reception/shipping clerk	< 0.3	< 0.3 – 1.4
Maintenance man	< 0.3	< 0.3 – 0.7
Laboratory technician	< 0.3	< 0.3 – 0.7
Foreman	< 0.3	< 0.3 – 0.5
Office	< 0.3	< 0.3

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling the exposure to formaldehyde are:

- Confinement of formaldehyde emission steps and installation of hoods above the sources: collection of samples, barrel filling, filter cleaning, filling of tank trucks.
- General ventilation: ensure that the fresh air in the control rooms originates from outside the building.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

6.5 FOUNDRIES

USE OF FORMALDEHYDE

The foundry process consists of pouring molten metal into a mould to obtain a product or a part of a specific shape and dimension. The mould can be equipped with a core that determines the dimensions of any internal cavity of the final product. The mould and the cores are sometimes made of sand bonded with a formaldehyde-based resin. The important manufacturing steps can be summarized as: 1) the manufacture of the mould and the cores and assembly of the mould; 2) melting of the metal; 3) pouring of the metal into the mould; 4) cooling of the moulded part; 5) removal of the mould and core removal (shake-out); 6) dressing and deflashing.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Types of production: moulding-coremaking processes and metals, types of hardening.
- Types of binders and percentage of free formaldehyde used in the binder.
- Size of the moulds and manufactured cores.
- Presence and efficiency of fume hoods or collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the maximum concentration ranges reported in the literature for the different hazardous tasks and the emission sources.

EMISSION SOURCES AND HAZARDOUS TASKS	MAXIMUM CONCENTRATIONS (PPM)
Moulds and cores: manufacture shake-out	< 0.3 to > 2.0

EXPOSURE DATA

The following table presents the concentration ranges reported in the literature.

PROFESSION	EXPOSURE RANGE (PPM)	
	WEIGHTED AVERAGE – 8 HOURS	CEILING
Moulding sand preparer	< 0.3	> 2.0
Moulder/coremaker	< 0.3	> 2.0
Foundryman	< 0.3	> 2.0
Shake-out operator	< 0.3	> 2.0
Technical personnel	< 0.3	> 2.0

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling exposure to formaldehyde are:

- Substitution: some moulding-coremaking processes do not use a binder containing formaldehyde. Replacement of hot processes by cold hardening would reduce emissions.
- Use of resins with a lower emission rate.
- Confinement of formaldehyde emission steps and installation of fume hoods above the sources: preparation of moulding sand, pouring of the hot metal, mould and core recovery, baking oven.
- General ventilation: confinement of these areas will limit the dispersion and reduce the flow necessary for general ventilation.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

6.6 PATHOLOGY LABORATORIES

USE OF FORMALDEHYDE

Pathology laboratories receive organ, tissue, or cell specimens collected from humans by health specialists to study their structural modifications and to serve as support in the diagnosis and prognosis. The main steps are the preparation of formaldehyde solutions (dilution from 37% to 10%); macroscopy, (the description of the specimen visible to the naked eye); placing the samples in cassettes (for the tissue preparer), and microscopic observation. The tasks related to the laboratory's proper operation are the emptying and maintenance of the parts preparer, elimination of specimens, recycling, neutralization or the elimination of the waste formaldehyde solution.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Concentration of the formaldehyde solution.
- Size and number of anatomical parts.
- Work methods.
- Number of workstations in the same location.
- Presence and efficiency of fume hoods or local collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the measured maximum concentration ranges for the different hazardous tasks and the emission sources.

SOURCES OF EXPOSURE	MAXIMUM CONCENTRATIONS (PPM)
HAZARDOUS TASKS **Handling of formaldehyde:**	
Solution preparation	1.0 – 2.0
Filling of jars	1.0 –2.0
Decanting of waste formaldehyde into the recycling equipment	0.3 – 0.75
Neutralization of the formaldehyde	Not measured
Handling of specimens:	
Placing of anatomical specimens in jars	Not measured
Handling of specimen during macroscopy	> 2.0
Emission from tasks not carried out under an efficient fume hood	> 2.0
Insertion of cassettes into the tissue preparer	1.0 – 2.0
Use of mercuric stain	Not measured
Handling of waste:	
Draining of specimens and waste solutions	> 2.0
Handling of bags of medical waste	Not measured
Handling and rinsing of used jars	Not measured
Equipment maintenance:	
Maintenance of tissue preparer	> 2.0
Maintenance of the recycling equipment	0.3 – 0.75
EMISSION SOURCES **Equipment:**	
Tissue preparer (leaks)	Not measured
Formaldehyde recycler (leaks)	Not measured
Specimen storage	0.3 – 0.75
Storage of new and waste formaldehyde solutions	Not measured
Garbage pail containing the emptied jars, gloves and dirty paper	Not measured
Medical waste garbage pail	> 2.0

EXPOSURE DATA

The following table presents the concentration ranges measured for the workers in 10 pathology laboratories.

PROFESSION	EXPOSURE RANGE (PPM)	
	WEIGHTED AVERAGE – 8 HOURS	CEILING
Pathologist	< 0.3 to 0.92	0.5 to >2.0
Technician	< 0.3 to 0.76	< 0.3 to >2.0
Technical assistant	< 0.3 to 0.81	< 0.3 to >2.0
Secretary	< 0.3	< 0.3

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling the exposure of formaldehyde are:

- Substitution: different substitution products are mentioned in the literature but none is the subject of consensus, although some are used successfully in the United States.(53)
- Use of less concentrated formaldehyde solutions.
- Modifications of work procedures: they must minimize formaldehyde emissions (closing of unused jars, immediate disposal of impregnated cloths, periodic checking of equipment). The possibility of using disposable plastic containers with the specimens could also be evaluated as well as that of using solution jars ready to receive the specimens, with these being prepared by an outside company.
- Work under an efficient chemical fume hood: preparation of formaldehyde solutions, filling of jars, draining of specimens, and neutralization of formaldehyde.
- Macroscopy work with lateral slot-type ventilation allowing an air flow that carries the contaminant away from the worker's breathing zone. A layout of the macroscopy workstation is described in the fact sheet produced by ASSTSAS. (54)
- Ventilation at source by fume hoods above the equipment: recycling equipment, tissue preparer, garbage pail.
- General ventilation: as specified in the air quality guide from the Corporation d'hébergement du Quebec, there must be a total of six air changes per hour, and two for outdoor air.(55)
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

NOTE: A prevention fact sheet specific to this sector is available on the IRSST Web site.(16)

6.7 FUNERAL SERVICES INDUSTRY

USE OF FORMALDEHYDE

Embalming includes the processes intended to delay the decomposition of a cadaver and prepare it for funeral rites. To prevent the decomposition of the body, the embalmer injects aqueous solutions of formaldehyde the concentration of which depends on how much the body has changed. This work is done on a table equipped with a system for evacuating the waste fluid. The concentrated formaldehyde solution is added to the dilution water in the injection equipment tank. The concentration of the formaldehyde solution is 1.25% to 32%. Several litres of more or less dilute solutions are injected. When the cadaver is in normal condition, embalming is completed within 1 to 1.5 hours, with 10 to 35 minutes spent using formaldehyde. In the case where the cadaver is in an advanced state of putrefaction or has undergone an autopsy, embalming can take up to three hours. For autopsied cases, the use of formaldehyde can take up to two hours. The embalmer can also use formaldehyde-based or paraformaldehyde-based jellies or powders to treat the wounds.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Concentration of the formaldehyde solution.
- Number of workstations and bodies handled daily in the same location.
- Embalming steps.
- Physical characteristics of the cadaver: condition, size, time since death.
- Presence and efficiency of fume hoods or local collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the measured maximum concentration ranges for the different hazardous tasks and the emission sources.

EMISSION SOURCES	MAXIMUM CONCENTRATIONS (PPM)
Body: embalming	< 0.3 to > 2.0
Injection instrument: solution preparation during use	0.4 to > 2.0

EXPOSURE DATA

The following table presents the concentration ranges measured for 13 embalmers in four establishments.

PROFESSION	EXPOSURE RANGE (PPM)	
	Weighted average – 8 hours	**Ceiling**
Embalmer	< 0.3 – 0.4	0.4 - > 2.0

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling exposure to formaldehyde are:

- Substitution: different substitution products are mentioned in the literature but none is the subject of a consensus.
- Use of less concentrated formaldehyde solutions.
- Modification of workstation layout and work organization: positioning the body to reduce the path of the fluids as much as possible, confining the difficult cases, physically separating the preservation tasks (solution injection) from the restoration tasks (esthetic care and dressing).
- Ventilation at source: exhaust system above the injection equipment, concept of ventilation by vertical displacement above the embalming table or use of a table with integrated ventilation combined with general ventilation.
- General ventilation: confinement of tasks will limit dispersion and reduce the flow necessary for general ventilation.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

NOTE: A prevention fact sheet specific to this sector is available on the IRSST Web site.(17)

6.8 TEXTILE FINISHING INDUSTRY

USE OF FORMALDEHYDE

Finishing includes all of the physico-chemical treatments that the fabric undergoes to change its characteristics: thermosetting, napping, embossing, pressing, calendering, chemical finishing. Formaldehyde emissions can originate from this last category in the case of cellulose fibre-based fabrics, namely cotton and viscose. Chemical treatments in the form of finishes are used to make the fabric crease-resistant, prevent shrinkage, or increase its resistance to slow combustion. Finishes are applied by padding, impregnating the fabric lying flat in an aqueous solution, and passing it between two cylinders to remove the excess solution.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Types of processes and products used.
- Presence and efficiency of fume hoods or local collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the measured maximum concentration ranges for the different hazardous tasks and the emission sources.

EMISSION SOURCES AND HAZARDOUS TASKS	MAXIMUM CONCENTRATIONS (PPM)
Finish: preparation application	< 0.3 to > 2.0
Impregnator: unjamming and maintenance	> 2.0

EXPOSURE DATA

The following table presents the concentration ranges measured for the workers in three establishments.

PROCESS / JOB	EXPOSURE RANGE (PPM)	
	Weighted average – 8 hours	**Ceiling**
Crease-resistance:		
Resin preparer	< 0.3	> 2.0
Operator	< 0.3	< 0.3 – > 2.0
Printing:		
Colorist	< 0.3	< 0.3
Operator	< 0.3	< 0.3
Wadding:		
Operator	< 0.3	< 0.3 – 0.5

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling exposure to formaldehyde are:

- Product substitution: formaldehyde-free finishes exist.
- Ventilation at source: exhaust system above installations where formaldehyde comes in contact with the fabric.
- General ventilation: increase in efficiency.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the formaldehyde concentration is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of controlling exposure.

6.9 PLASTICS PROCESSING INDUSTRY

USE OF FORMALDEHYDE

Plastics processing is different from the resin manufacturing industry in that the finished product is a manufactured object (pulley, printer gear wheel, plate, etc.) and not something that will be used in another processing process. Various starting materials and manufacturing processes are used in this industry, and the technologies are evolving. The processes considered likely to release formaldehyde are the injection moulding of polyacetals, compression moulding of phenolic or aminated resins, and the manufacture of laminates. Heating is the step with the most significant emissions.

EXPOSURE DETERMINANTS

The main factors affecting the workers' exposure to formaldehyde concentrations are:

- Types of processes and resins used.
- Presence and efficiency of fume hoods or local collection systems at source.
- Efficiency of the general ventilation.

SOURCES OF EXPOSURE

The following table presents the measured maximum concentration ranges for the different hazardous tasks and the emission sources.

EMISSION SOURCES AND HAZARDOUS TASKS	MAXIMUM CONCENTRATIONS (PPM)
Mould: degassing	< 0.3 to 1.7
Impregnator	< 0.3 to > 2.0

EXPOSURE DATA

The following table presents the concentration ranges measured for the operators in two establishments.

PROFESSION	EXPOSURE RANGE (PPM)	
	Weighted average – 8 hours	**Ceiling**
Operator	< 0.3 – 1.5	< 0.3 – > 2.0

The RROHS establishes the ceiling exposure limit (meaning a value that must never be exceeded during any length of time whatsoever) at 2 ppm.(19)

CONTROLLING THE EXPOSURE

The main means of controlling formaldehyde exposure are:

- Confinement of the formaldehyde emission steps and installation of fume hoods above the sources: moulding, degassing, impregnator, press.
- General ventilation: confinement of these areas will limit dispersion and reduce the flow necessary for general ventilation.
- Development and follow-up of prevention procedures including wearing personal protective equipment for tasks where the concentration of formaldehyde is high.

Employee information and training on the risks associated with formaldehyde, on emission sources, the most polluting tasks, the means of control (including work techniques and methods) and personal protective equipment are key aspects of exposure control.

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