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**FORMALDEHYDE EXPOSURE HAZARDS AND HEALTH EFFECTS:
A COMPREHENSIVE REVIEW FOR EMBALMERS**

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Abstract: A comprehensive examination of formaldehyde exposure hazards, dangers during use and health effects is covered in depth. The implications for embalmers and the overall impact of exposure during embalming is considered. Both short-term and long-term effects of formaldehyde exposure are delineated. Techniques and commentary regarding embalming use of formaldehyde and strategies for drastic reduction of use and exposure are presented. Alternatives for effective embalming without significant use of formaldehyde are discussed and encouraged.

SAPERE AUDE.

-Horace

INTRODUCTION: Formaldehyde is truly an ancient friend of embalmers, it seemingly has been around forever. Embalming without formaldehyde is, to most embalmers, just a meaningless historical footnote. Formaldehyde has been purported to be used as early as 1899 for cadaver embalming. It missed the Civil War and most of the Wild West Era, but very little else. Modern embalmers cannot perceive of embalming that is not formaldehyde based. Formaldehyde is so much an ancient friend that most embalmers judgements regarding this hazardous chemical are clouded at best. So sacred is the concept of formaldehyde that a formaldehyde-apology mindset pervades the industry. As far as formaldehyde is concerned: nothing on the face of the earth is usable for embalming cadavers, except formaldehyde. Formaldehyde must be safe and not a concern, otherwise how could it have been used all these years? Formaldehyde must never be questioned as to exposure problems, health effects or em-

balming efficacy. Embalmers manage to meet the legal requirements of OSHA mandated monitoring, therefore everything must be fine. Everybody condemns the possible alternatives to formaldehyde as either useless or too dangerous to use, or both. There is formaldehyde and there is nothing else – period.

There's only one problem — all the modern chemical, scientific and medical research on formaldehyde flies directly in the face of the above liturgy. The voluminous and ponderous amount of modern scientific research is extremely condemning and paints a bleak picture, as regards formaldehyde and its dangers, hazards during use and long-term health effects.

Everything in the embalming room is hazardous one way or another, otherwise it would be basically useless for embalming and preserving dead tissue and destroying pathogens and arresting putrefaction and decomposition. The question is — how hazardous comparatively to alternatives, how indispensable the chemical is for embalming and whether necessity of use counterpoised to dangers of use, exposure and health consequences justifies the use. The goal in embalming should be a chemical mix that effectively achieves embalming and minimizes the overall total exposures to the embalmer with the least resultant health effects and longterm sequelae resulting therefrom. This goal is eminently achievable by embalmers by careful and judicious selection of readily available modern embalming chemicals.

The bad news is that formaldehyde has the most serious exposure concerns, health effects and hazards of use of virtually all the chemicals used in embalming. The good news is that about 90% of formaldehyde can be eliminated in embalming use without any illtoward consequences of embalming results. In fact, an embalmer won't even notice that it is missing, except for the lack of fumes. Formaldehyde will probably never be eliminated from embalming rooms, but its quantity of use can easily be a small fraction of what it currently is, with no significant impact on embalming results.

The following, then, is a comprehensive, disturbing and exhaustive look at the scientific/medical research regarding formaldehyde and the implications for embalmers of these findings.

FORMALDEHYDE USES: The U.S. manufacture of formaldehyde easily exceeds 8.2 billion pounds per year and that doesn't count what we import from other countries. Worldwide production is well over 16 billion pounds per year. 60% of all formaldehyde used ends up in wood and construction related industries as urea-formaldehyde, phenol-formaldehyde and melamine-formaldehyde glues, resins and stiffeners. 30% is used as a chemical intermediate (e.g. pentaerythritol, hexamethylenetetramine, butanediol) to manufacture another chemical of commerce. 7% is accounted for by use in specialty thermoplastic resins. 2% ends up in the textile/apparel industry as a whitener/finisher/stiffener for shirts and other items of clothing and an additive for wrinkle-resistance and crispness of appearance. 1%, or less, is used as preservative additives (usually as derivatized releaser chemicals) in soaps, lotions, shampoo, etc. The worst recorded exposure problems occur in the wood product/construction industry and the textile/apparel industry because of the quantities used and the long exposure scenarios associated with these industries.

Notice in the above statistics that there is no mention of quantities used in the embalming industry. Quite simply, the quantities are so miniscule, that the embalming industry has no impact on formaldehyde usage in the U.S. All embalming could cease tomorrow and no one in the chemical industry would notice.

Our impact is, at best, 2-3/100th of 1% of U.S. production, which is less than one days manufacture in the U.S. and about equal to what the State of California reports as accidental atmospheric loss through off-gassing at chemical facilities in a year. Nobody cares about formaldehyde use in embalming except embalmers.

EARLY RESEARCH: By this, I refer to exposure investigations that were conducted specifically in the funeral industry prior to the 90's (mostly the 70's and early 80's). Most of these reports and conclusions were conducted when exposure limits were skyhigh and the methodologies used are decidedly dated. You will constantly see these early papers floated around the embalming industry and cited and reproduced in various textbooks. Consequently, I will not devote any time and effort to reviewing this early research. Some of it is now over 3 decades old and the conclusions to be drawn are very limited and of marginal utility. If you wish an exhaustive overview of this early period for historical curiosity, I have a full bibliography available.

CURRENT RESEARCH: From the 1990's on, a massive amount of research regarding health effects and exposure hazards of formaldehyde has been conducted. The amount is truly voluminous, confusing and basically damning. Very little, if any, of this research focuses on embalming, however, as basically researchers assume this is an exposure scenario of little societal or economic impact. Consequently, we must derivatize and extrapolate from exposure studies regarding other industries and exposure scenarios that mimic exposures that would occur in embalming.

A comprehensive investigation into formaldehyde exposure during embalming was conducted by me in 1991 and is published in the Champion Encyclopedia. This research answered what I felt had not been answered in any of the earlier research — how much formaldehyde was actually used in embalming and at what strength, what precautions for exposure control were used, and when during the embalming did the worst exposures occur? Also investigated, was reduced and drastically-reduced formaldehyde embalming and its effects on total overall exposures to the embalmer and embalming results. My conclusions were that formaldehyde exposures were marginally controllable and eminently controllable if formaldehyde concentrations were moderated and substitute chemicals were used. Looking back, I can see that I was overly optimistic regarding my hopes and aspirations that the embalming industry would succeed in controlling formaldehyde exposure.

A followup study was conducted by me and published in the next Champion Encyclopedia, wherein the exposure impact of glutaraldehyde in embalming rooms was examined. Being a low volatility chemical, not surprisingly, exposure levels were low or not detectable under almost all scenarios of use in embalming. This study verified that incredibly low exposure impact embalming could be conducted by judicious selection of chemical mix in embalming, with no noticeable adverse embalming results.

A very comprehensive investigation of formaldehyde exposure during embalming was published in the early/mid 90's that showed formaldehyde exposure monitorings in a range of .31 ppm to an unbelievable 8.72ppm. STEL's were reported as high as 21 ppm during certain scenarios and autopsied bodies and spills created the greatest exposure problems. Average formaldehyde exposures were 1.4ppm during the actual embalming which equates to a .33ppm TWA (8 hour average) if no other exposures occurred. Many peaks during the embalmings exceeded 6.6ppm of formaldehyde exposure and, not surprisingly, monitorings for glutaraldehyde, phenol, methanol and isopropanol were very low, insignificant or not detectable. Most all students that were involved in these embalmings reported nasal irritation, breathing difficulties, and skin irritation. Additionally, as a followup to this investigation, embalming students were monitored before and after the 10 week, or so, practical embalming class. Nasal/buccal epithelial tissue scrapings and blood samples were taken from each student before and after the practical embalming course and compared. Results demonstrated fundamental and observable mutative effects noted in the nasal/buccal tissues and significant changes in blood lymphocytes, both indicative of significant formaldehyde-induced changes.

EXPOSURE LIMITS: The myth is, that if you meet the OSHA standards for formaldehyde monitoring, then you are supposedly safe. The OSHA standards are almost 3 TIMES the ACGIH standards and aren't even noted as a CEILING. So, therefore, the ACGIH standards are 3 times more stringent than necessary and all their research and documentation is faulty? No, the OSHA standards are 3 times more lenient than they probably should be because of political and economic factors regarding society, industry, commerce and manufacture. OSHA standards are invariably always higher than all other agencies because of this governmental mandate to balance risk versus economics. If you meet OSHA standards, you are LEGAL and not necessarily anything else. The ACGIH standards are based on a massive amount of sophisticated medical/scientific investigation, taking into account numerous factors of exposure impact and documentable health effects, with the publication of a well-reasoned, defensible and documented realistic exposure limit.

The problem with formaldehyde is that the ACGIH standard is .3PPM (Ceiling), which is very difficult to achieve in the great majority of embalming rooms. Studies in Canada in the mid-90's verified that it was not possible 83% of the time to conduct embalmings that met the Canadian .3PPM limit (which has been in effect for years). The NIOSH limits are shockingly low at .016PPM (8hr)/.1PPM (STEL), which is essentially the NOAEL for formaldehyde (No Observed Adverse Effects Level). It is impossible to embalm with formaldehyde and meet these limits of exposure. The impact of formaldehyde exposures in embalming rooms is far more serious than previously assumed when looked at realistically with ACGIH standards.

MORE CURRENT RESEARCH: There are ways other than industry and occupational to have formaldehyde exposure. Sick buildings, freshly manufactured mobile homes and even newly constructed conventional homes are notorious for formaldehyde exposure problems and related health effects. Conventional new homes typically show .03-.1PPM monitorings while mobile homes are .2-.5PPM, which is a significant exposure. Sick buildings weigh in at .1-.3PPM and formaldehyde is almost

always implicated in the exposure cocktail in these unhealthy buildings. HUD (Housing and Urban Development) in the U.S. has set mandatory emission limits for formaldehyde from new lumber at .2PPM for plywood and .3PPM for particle board. People, and especially children, show significantly reduced PEF's (Peak Expiratory Flows) from living in formaldehyde infected homes. Children have demonstrated health problems at dosages as low as 29 PPB (parts per billion)!

Anatomy students at medical colleges, through several studies, show significant negative health effects from the dissecting of formaldehyde-embalmed cadavers. These students were exposed to .5PPM-1PPM formaldehyde for 3 hours, 1 day per week for 10 weeks. Breathing ability as measured by PEFs (Peak Expiratory Flows) was lower after the class and required 10 weeks of recovery time before PEF's returned to the pre-class values. This is an example of a short-term/high-dose scenario, where exposure is over a short time frame but significant in exposure value. These scenarios appear recoverable, as your exposure is eliminated at some time and recovery thus ensues. The alternative scenario is long-term/low-dose, which is indicative of what an embalmer would subject himself to over his lifetime in the profession. Health effects are not immediate at these lower doses, but insidiously accumulate over time and cause irreversible and significant symptomology, manifested as major health problems, as time progresses.

Another big problem for embalmers is because of their familiarity with and inability to adequately smell formaldehyde at other than excessively high exposure values. A typical embalmer or regular user of formaldehyde cannot detect the chemical at less than 1PPM or more. At this level, you are hopelessly over-exposed before you can even smell the chemical. Most people that do not work with formaldehyde can smell the chemical at approximately .5PPM, which is still at or above the action level as specified in the OSHA regulations. Either of these levels is above the ACGIH safety values of .3PPM.

The No-Effects-Level for formaldehyde is .018PPM with minimal effects evident at exposure values approaching .05PPM. Above .05PPM, eye irritation, tearing, and nasal distress manifest up to .2PPM. Upper airway irritation becomes obvious at .1-.3PPM, with lower airway and pulmonary effects occurring at 5PPM. The IDHL (Immediately Dangerous to Health and Life) level is 20PPM, with edema/pneumonia occurring at 50PPM and death at 100PPM, which is the typical concentration when formaldehyde is used as a gas-bomb rodent/pesticide fumigant.

Numerous other examples of chronic health effects from long-term/low dosage exposure scenarios are reported in anatomy assistants, autopsy pathologists, dissectors, morgue workers and wood plant workers. Health sequelae of formaldehyde exposure include neurobehavioral impairment, seizures, memory loss, tremors and neurotoxic symptomology. A 2001 study placed formaldehyde as #4 on a list of environmental-impact chemicals with significant brain damage effects. #1 on the list was hydrogen sulfide, a toxic gas, followed by PCP's, arsenics and behind formaldehyde, chlorine gas, chlorpyrifos, nickel carbonyl and ammonia gas.

FORMALDEHYDE AND WOOD DUST: Formaldehyde and wood dust is an explosively deadly combination that combines, accelerates and exacerbates the serious exposure hazards of both these

substances. Wood dust has a myriad of serious health effects and exposure dangers associated with it, which is only made worse by the inclusion of formaldehyde into the chemical mix. Formaldehyde in the wood and construction industry is such a serious problem that solutions to reduce or eliminate formaldehyde are being actively pursued. Johns-Manville, a Berkshire-Hathaway company, will eliminate formaldehyde from its insulation products in 2003/2004 and completely eliminate formaldehyde in all its construction materials by 2010. When this massive industry is seeking ways to reduce or eliminate the formaldehyde in its wood products, the funeral industry is voluntarily adding formaldehyde to wood dust and other particulates and calling it autopsy/hardening compound — unbelievable. This problem has been extensively investigated and researched by me and is reported in an earlier Champion Encyclopedia article. Formaldehyde/wood dust exposures are insidious and unnecessary and second only to concentrated formaldehyde cavity fluid use in exposure danger. There are effective solutions and alternative autopsy/hardening compounds that virtually eliminate the exposure dangers with no loss in embalming effectiveness.

CARCINOGENICITY: Formaldehyde is classified as carcinogenic by about every agency there is. The warning signs posted in embalming rooms are the result of The Formaldehyde Act and OSHA's classification of formaldehyde as a carcinogen. ACGIH classifies formaldehyde as an A2, with NTP assigning a (R) designation. EPA, IARC and NIOSH all classify formaldehyde as a carcinogen. Formaldehyde is on 8 regulatory lists and is ranked in EPA's worst 10% list of chemicals for overall hazard to human health and overall environmental and ecosystem impact by an Environmental Defense Fund study. Formaldehyde is one of only a couple of dozen chemicals for which OSHA has mandated additional controls, monitoring and reporting. Unfortunately, formaldehyde seems to be on about every short list there is. Basically, formaldehyde is the only carcinogen in embalming, virtually all the other chemicals that might be used in embalming have not been indicted for cancer-causing potential. Actually, wood dust itself, is a stand-alone carcinogen and this ends up in embalming rooms, mixed with formaldehyde and called autopsy/hardening compounds. TCE (trichloroethylene) and PERC (perchloroethylene) are both carcinogenic and unfortunately are appearing in drywash/cleaning solvents in embalming rooms. The carcinogenic impact from exposure in embalming rooms, however, resides essentially on exposure to the various forms of formaldehyde encountered during embalming.

ALLERGIC SENSITIZATION: Formaldehyde is a documented allergic contact dermatitis sensitizer and inhalation sensitizer and producer of asthma and asthmatic-like symptomology in humans. A significant proportion of the population is allergic and sensitized to formaldehyde from early previous exposure due to the ubiquitousness of the chemical in leaching or off-gassing products available to consumers. Formaldehyde is actively being eliminated in all dental applications due to the serious allergic reactions from the glues, resins and hardeners used in dental work and appliances. Formaldehyde is a true, serious causative agent of full-blown asthma, which is IgE (immunoglobulin E) immune-mediated hypersensitivity with serious systemic health effects possible. Formaldehyde is in the first-line patch testing protocol for allergens and sensitizers that dermatologists use to document and confirm allergic reactions and sensitization. The reports of contact dermatitis and inhalation sensitization in the medical literature are voluminous and unassailable.

PREGNANCY AND FORMALDEHYDE: The verdict is, if you are a female embalmer and are pregnant or wish to become pregnant, you should not embalm. If it is imperative that you embalm, then you should limit it as much as possible and use a formaldehyde respirator and adequate impervious protection. There are numerous research articles pointing to the dangers and illtoward health effects of formaldehyde and organic solvents on pregnancy, including birth defects, fetal abnormalities, spontaneous abortions, short term miscarriages, and reduced fertility and other negative pregnancy outcomes and difficulties. I have devoted an entire previous Champion Encyclopedia article regarding this issue of serious concern to all female embalmers.

COMPARISONS: In comparison to other very toxic and lethal gases, formaldehyde appears to have an extremely low exposure level. This is exactly opposite to what most embalmers feel, in that formaldehyde is relatively safe and you can breath plenty of it and suffer no ill effects. When was the last time anybody stumbled out of an embalming room, gasping for breath and collapsed into a coma? — so say most formaldehyde apologists. The fallacy is, that exposure limits are predicated on both short-term and long-term adverse health effects and not immediately distressing symptomology. The long-term/low dose insidious and chronic effects of formaldehyde exposure are formidable and factored into the consideration when exposure standards and safe limits are established. The only reason embalmers are comfortable with exposures to formaldehyde is due to familiarity and the absence of serious immediate effects resulting from use. Consequently, a false mindset of safety and security results if monitorings and exposures are anywhere in the ballpark.

Would anybody reading this lock themselves in an embalming room and breath hydrogen cyanide gas at 10PPM? Nobody would. Why not? Everyone knows cyanide gas is deadly and must be treated with respect and any exposure minimized. The OSHA exposure limits for hydrogen cyanide are 10PPM for an 8 hour workday — 10 times the limits for formaldehyde! So what's your problem? — you respect it for what it is — a dangerous but sometimes necessary toxic chemical that must be controlled, guarded against and exposure reduced or eliminated, if at all possible. Why doesn't the embalming industry feel the same about formaldehyde? How about H₂S, hydrogen sulfide at 10PPM — over ten times the limit for formaldehyde, according to OSHA. Hydrogen sulfide is a poisonous stenchy gas emanating from artesian wells and crude oil factories. Health effects are anoxia and CNS damage, to name a few. What about exposure to CO (carbon monoxide) at 50PPM, fifty times the limits for formaldehyde, also legal according to OSHA? Of course not. Carbon monoxide poisoning can be deadly, but if not severe, is usually recoverable and no serious long term effects remain. That information, however, does not change your respect and caution you would exercise if you were exposed to this deadly chemical. Can you say the same about formaldehyde? Unfortunately, embalmers treat formaldehyde as a familiar and practically harmless, old friend. Perhaps formaldehyde is not as harmless as everyone in the embalming industry would hope.

ALTERNATIVES AND SOLUTIONS: There are alternatives to formaldehyde and numerous techniques and procedures that can drastically reduce or eliminate formaldehyde usage and exposure during embalming. It is easy to reduce formaldehyde exposure up to 90% without an embalmer even noticing any

changes in embalming results. There will probably always be some formaldehyde used in embalming — it does some things very well such as rapid firming of bodies, extreme stiffening and hardening, dehydration reaction, tissue and skin shrinkage and effective edema reduction. The key is to replace formaldehyde where and when it is not essential, or of dubious value or where an alternative of lower exposure impact would function just as good.

Formaldehyde is just not needed in cavity fluid formulations. High-index formaldehyde cavity fluids generate very high exposures and are the most dangerous formaldehyde chemicals to use in the embalming room. Glutaraldehyde based cavity chemicals with numerous accessory preservatives and penetrants, in addition to additional higher molecular weight mono- and dialdehyde mixes, are equal or superior in preservation and embalming ability of the most powerful formaldehyde cavity fluids available. The volatilities of the alternative glutaraldehyde/complex aldehydes are a fraction of what formaldehyde chemical mixes are and the monitorings verify a significant reduction in total overall exposure impact. These alternative cavity chemicals exhibit extreme levels of preservation approaching the definition of mummification/petrification with astoundingly low exposure values.

There is absolutely no need for formaldehyde in autopsy/hardening compounds in embalming. The dual lethality of formaldehyde coupled with wood dust is totally unnecessary and a needless exposure danger to embalmers. Glutaraldehyde based chemicals that are predicated on coarse/granular wetted-type formulations are excellent preservative autopsy/hardening compounds with very low exposure impact. Numerous embalmers have been using formaldehyde-free compounds for over a decade with excellent results.

Eliminate the use of spray forms of formaldehyde. This is an absurdity and flies in the face of logic. Why ventilate and attempt to control airborne formaldehyde and then purposefully aerosolize it? The formaldehyde sprays are an anachronism from an earlier time and are of dubious value at best. There are superior alternatives that are EPA registered, tested and approved with confirmed label-stated disinfection/killing ability and are incredibly low impact exposure risks. I have devoted an earlier entire Champion Encyclopedia to just this topic alone.

If you can manage the above three scenarios for formaldehyde elimination in cavity fluid, particulate compounds and sprays you have reduced formaldehyde exposures by 80-90%! And you haven't even noticed the difference. Now, if you want to inject formaldehyde-based arterial chemicals — go right ahead. Arterial injection is the lowest exposure procedure in the embalming operation and has the least impact on total overall exposure values. It is, however, extremely easy to moderate or nearly eliminate the formaldehyde in arterial injection and still get good embalming results. It is shocking, actually, how little formaldehyde is required and how late in the injection it can be introduced to replicate acceptable, traditional, stiffening/hardening results. It's scary, but about an ounce, or so, of formaldehyde late in the injection is sufficient. This calculates out to about 4-6 ounces of a moderate index formaldehyde arterial chemical — unbelievable! Bodies can be infused with alternative based glutaraldehyde solutions with a small final hit of formaldehyde in the last gallon, to replicate the rock

-firming and drying of a traditional embalming. The final spike with formaldehyde is optional, and most of the time I dispense with it. If you are not comfortable with this concept, then eliminate formaldehyde in your cavity fluid, compounds and don't use sprays and then stop there. Then, arterially inject formaldehyde to your hearts' content. You will have drastically reduced your exposures in the embalming room and you will still have traditional formaldehyde results after embalming. What do you have to lose by trying these alternatives? — nothing. What do you have to gain? — an excellent embalming result with drastically reduced exposures resulting in a much safer environment to work in for the rest of your life.

For edema style embalming, formaldehyde appears to be essential. There is just no other good way to rapidly and effectively get dehydration/tissue shrinkage from alternative preservatives. There are, however, injection solutions and mixes that can drastically reduce the total formaldehyde used and still achieve excellent results. An extremely effective and potent edema fluid is comprised of glutaraldehyde/formaldehyde and high concentrations of alternative high-solubility salts in a hypertonic mixture for arterial injection. I have devoted an entire earlier Champion Encyclopedia article to the concept of edema embalming and modern low-exposure alternative solutions.

So, after reading all this you intend to embalm traditionally, with large amounts of formaldehyde and only formaldehyde, as the industry has done for over 100 years — well, whatever, not a problem, I guess. Be warned, be aware, be careful, ventilate like there is no tomorrow, be protected with impervious apparel (not latex gloves and a disposable plastic apron, I hope) and wear a formaldehyde respirator at least during autopsies and compound use, cavity treatment, when you spill formaldehyde and when spraying formaldehyde in the air. I wish you the best of luck. You'll need it.

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