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A COMPREHENSIVE GUIDE TO DEODORIZATION USING OZONE

HOW TO USE OZONE SAFELY
HOW TO DEODORIZE URINE ODORS
HOW TO BUILD A DEODORIZATION ROOM
HOW TO CHARGE FOR DEODORIZATION
DEODORIZING PROCEDURES
OZONE GENERATION EXPLAINED

A COMPREHENSIVE GUIDE TO DEODORIZATION USING OZONE

The Ozone Experts, would like to express thanks to the following people for their knowledge, experience, research, and input m preparing this training manual.

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PREFACE

Deodorizing is a subject that has confused and perplexed cleaning and disaster restoration technicians for many years. The basic problem, in past years, has arisen from our attempts to permanently neutralize a wide variety of odor types with only one water-based product that just happens to be pleasant to our individual sense of smell. If we were successful, it was most likely the result of luck, time or other natural phenomena, which we were hard pressed to explain to our customer or coworkers in reasonably accurate terminology. We developed a wide range of plausible sounding excuses to cover our lack of knowledge and crossed our fingers the next time we were called upon for deodorizing services.

Obviously, this process lacked professionalism, and it added to the frustration of the conscientious cleaning/restoration technician - not to mention the problems it created for our customers and insureds!

Today a great deal of research and effort to unravel the mystery surrounding the subject of deodorizing has been expended, and this book proposes to serve as an overview for professional cleaning and restoration technicians who desire more precise knowledge in this highly specialized field. All references used will be in generic terms, and it will be up to the individual technician or manager to locate various companies that provide the specific products referenced herein.

Note that in this most recent revision, we have included "Comprehension Quizzes" at various intervals. The idea is for a designated individual to read the chapter, present the information in a company meeting, and then run copies of the Comprehension Quiz to test the retention of knowledge by all involved in deodorization work.

In this manner, professionalism, through education, becomes a serious pursuit.

WARNING

Reference is made in this manual to the use of other products and/or equipment in conjunction with or in addition to the The Ozone Experts products. Prior to the use of any such products and/or equipment, it is critical that the user become thoroughly familiar with and precisely follow all directions contained in the users manual pertaining to the use of the product and/or equipment. The failure to specifically follow the directions for use of the product and/or equipment could and I may likely result in personal injury and/or property damage. The Ozone Experts a division of Newaire, Inc., assumes no liability for the use of any product and/or equipment referred to in this manual which is not marketed and/or manufactured by The Ozone Expert. In addition thereto, The Ozone Experts, a Division of Newaire, Inc, provides no warranty, either express or implied, including any warranty of fitness for particular purpose for any product I and/or equipment referred to in this manual which is not marketed and/or manufactured by The Ozone Experts®.

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BASIC

DEODORIZATION

CONCEPTS AND

PROCEDURES

I - GENERAL DISCUSSION

Welcome to the world of the professional deodorizing technician! It's a world filled with pleasant and not-so-pleasant odors; with chemicals that work miraculously and not-so-miraculously; with fantastic, space age machines that perform rapidly and perfectly in most situations, and not-so-perfectly in others.

And therein lies the challenge!

It's not a world for the faint of heart, or for those who view most situations as problems rather than exciting challenges. It isn't a world filled with precise answers, because we encounter new questions daily. But it is a rewarding world filled with opportunity for those few who are willing to seize it and move forward.

Walk with me now (yes, even struggle a little with me) into the world of the ultimate problem solver: the professional deodorizing technician.

With all the prefacing and preceding remarks in mind, there are several general concepts that must be understood by professional deodorization technicians, before they I can begin to tackle effectively various deodorization situations. These six points must be I analyzed carefully if technicians are to be successful in understanding where odor comes from, how odors are amplified or made more persistent, and when you should begin the I deodorizing process.

A. ODOR DETECTION: The sense of smell is one of the most primitive and I complicated senses possessed by human beings. Although scientists have developed machines to quantify the concentrations of gases in the air that contribute to odor, still the nose is the only instrument capable of detecting the *presence* and *intensity* of odor, and to date scientists have a hard time explaining exactly how this system functions. Actually, all parts of what we call the olfactory sensory system are involved in the sense of smell.

The sequence of events in discerning an odor occurs something like this:

1. Odor enters the air in the form of a volatile organic compound (VOC, usually water soluble) or tiny, airborne particle to which moisture or gases are attached.
2. The odor is breathed into the nose where it contacts mucus that coats the mucous membranes of the nose and mouth.
3. Interspersed throughout the mucous membranes are nerve endings called olfactory hairs, or technically, the olfactory epithelium. Odor molecules interface with the receptors on olfactory nerve endings and the sensation of smell (odor detection) has its beginning.
4. From there, the pure sensation of odor (hopefully fragrance) is transmitted to the brain by the olfactory nerve (see figure 1).

5. This sensation of smell terminates in the olfactory lobe, which is located on the lower surface of the brain's frontal lobe. The olfactory lobe interprets the sensation as odor, placing it into one of seven categories: camphoraceous, musky, floral, peppeminty, ethereal (solvent), pungent and putrid.
6. Now things start to get complicated. From here the sensation of pure odor is combined with a variety of past experiences, minute impressions and suggestions to form a judgement as to whether the actual smell sensed is good or bad. The fact that this interpretation process differs with each individual is what makes deodorizing an inexact and challenging science - to say the least! Further, some people (and animals) have more sensitive olfactory systems than others; i.e., some may smell odors vividly which are below the sensory threshold of others.

   It also brings us to our next point . . .

Figure 1.1 - The Sense of Smell

B. ODOR TYPES: Therefore, *there are two distinct types of odor - real and* *imagined or psychological odor.* **Real odor** consists of the sensation of smell as interpreted only by olfactory sensory mechanisms. It begins when odor vapors or gases are absorbed into the mucus coating the mucous membranes, and progresses through the interfacing of odor molecules with, and transmission up, the olfactory nerve. That sensation culminates in the olfactory lobe. We'll call this odor the pure sensation of smell or "real" odor. Real odor varies in different people depending on the genetic development of their olfactory system - particularly the olfactory lobe.

Psychological odor, on the other hand, consists of what people think they smell based on the present situation, what they have been taught, or some strong impression they have in a given set of circumstances. And here is where the challenge for the professional deodorizing technician begins! You see, all noses are different, and no two people will judge a given odor in exactly the same way. Often, an odor that is distinctly unpleasant to one person may be quite pleasant to another. To further complicate the situation, the psychological factor may cause odor that does not, in fact, even exist to become the major point of attack in the deodorizing job.

For example, some whose homes have been devastated by fire will be left with an indelible impression when they first view their blackened structure, furnishings and other precious possessions. Part of that impression is the awful "real odor" associated with that traumatic event. Weeks or months later, when they walk into a newly restored structure, no matter how perfect your restoration and deodorization effort may have been, memories of their earlier encounter with the devastation may come flooding back - along with intense psychological odor perception.

Now don't fall into the trap of labeling odors that you can't smell as psychological odor. Remember that some people simply are much more sensitive in detecting odor than you may be. Same's true with certain animals, such as rabbits and foxes, that are famous for their keen sense of smell. A smart deodorizing contractor will consider the effect of both real and psychological odor and plan to provide services to eliminate both.

C. ODOR AMPLIFICATION: Odor is amplified by humidity and temperature. Most odor is highly volatile. Therefore, it is dissolved and carried to the nose when humidity and temperature levels are high. The higher the temperature, the more humidity may be absorbed into the air. Then, humidity-borne odor vapors reacting with the mucous membranes of the nose cause a much stronger sensation of odor than that I detected in a dry air situation. For example, many an unsuspecting carpet cleaner has I gone into a home where animals are present. Everything smells fine until a quantity of water (cleaning solution) is introduced, at which time latent urine odor in carpet is activated and becomes very noticeable. Very! Without proper knowledge and a thorough customer briefing, the poor, innocent carpet cleaner now becomes the victim of one of the general considerations regarding odor - humidity amplification!

Another example of this problem involves odor from any fabric made of wool. This protein fiber contains approximately 4% sulphur which, when exposed to moisture, creates the characteristically musty odor associated with wool. Of course, when the wool is dried, this odor "mysteriously" disappears. Again, increased humidity and elevated temperature amplifies odor, while reduced humidity and temperature creates a corresponding reduction in odor.

Often, a problem may arise on a relatively non-humid or very cold day when an insured in a fire restoration situation thinks that deodorization is not necessary. This is especially true when smoke odor may be covered up temporarily by the odor of sealers, paints, varnishes, or even new materials used in the reconstruction or decorating effort. A few days or even months later, when the weather becomes warm and humid again, the odor seems to "come out of the woodwork." Because the areas that are the real sources of that odor (interior wall studs, for example) may have been sealed up so that gaining access to them is extremely difficult, the odor elimination process becomes infinitely more complicated and expensive. Conscientious technicians will anticipate this problem and brief customers accordingly. They also will make their deodorizing "presence" known and initiate procedures for deodorizing as quickly as possible at the *outset* of a situation, in order to avoid having someone consider the possibility, during periods of reduced temperature and humidity, that deodorization may not be required.

Compounding the odor amplification problem associated with humidity and elevated temperature is the fact that bacteria and fungi grow rapidly in a warm, moist environment. Even relative humidity in the air above 70% is sufficient to cause fungal or bacterial spores to germinate or become active growths. Likewise, the odor associated with these microorganisms are not only produced in greater quantity due to higher humidity, but it also makes those odors more noticeable to the human olfactory system.

Heads we lose; tails we lose!

D. PARTICLE SIZE AND PENETRATION: Odor particles and gases come in very small, microscopic, or even submicroscopic (molecular) sizes. Therefore, many surfaces are penetrated or impregnated to an extent that most technicians simply cannot believe. One of our problems in past years has been to develop a deodorant droplet of small enough size to seek out the malodor in its various "hiding places," combine with that malodor, and then, neutralize it.

This problem of *malodor penetration* is compounded noticeably when substantial heat associated with fire or extremely warm weather causes surfaces (porous or finished) to swell, allowing odor to penetrate inward. For example, in a fire restoration situation, several factors that affect the penetration of odor are:

1. Most odor gases and particles are extremely small and are measured in microns-1/1,000,000 th of a meter.
2. Odor particles range from atomic size to much larger particles. The Mass Median Diameter (MMD) of smoke (carbon), for example, is from one-tenth to four (0.1 to 4) microns MMD. For a perspective on what four microns looks like, consider that the period at the end of this sentence is about 500-800 microns in size (one inch = 25,400 microns).
3. Therefore, odor can penetrate surfaces to an unbelievable degree!
4. Odor penetration is facilitated or enhanced by several factors:
    a. the *absorptive (porous) nature of* surfaces contacted.
    b. *heavy residue* or vapor (obviously) coupled with sufficient dwell time for residual chemicals to penetrate. Excessive exposure time allows odors to penetrate all but the toughest surfaces (glass, stainless steel). Even so-called"durable" plastic surfaces (Formica, plastic freezer components, vinyl tile, synthetic fibers) or finishes (lacquer, polyurethane) eventually can be penetrated by malodorous chemicals and gases.
    c. rapid *thermal expansion of air* contributes substantially to odor penetration. *For every 10°F increase in air temperature, air volume doubles.* This air volume must go somewhere, carrying with it odor vapors or particles with odor molecules attached. Therefore, the velocity of air movement, when thermal expansion occurs, has a pronounced effect on odor penetration.
    d. prolonged exposure to heat eventually *expands porous surfaces,* facilitating the entry and deeper penetration of malodor. Upon cooling, when surfaces contract, odor is trapped inside where penetration with odor counteractants is difficult to achieve.

    In these situations, generating extremely small *deodorant* particles of the proper type, and creating the thrust necessary for deodorant penetration into affected surfaces is critical, though somewhat difficult, to achieve.

E. OVERKILL!: Because of the unusual and complicated nature of many deodorizing situations, a technician qualified to handle every malodor situation would have to have doctorates in microbiology and both organic and inorganic chemistry (a couple of advanced engineering degrees wouldn't hurt either!). Hardly practical! The fifth point of general discussion is brought out in the little catch-phrase *"overkill is the key to elective deodorization."*

This phrase implies that it will be necessary to plan to use multiple techniques, though not necessarily higher quantity, in most deodorizing situations - even when there seems to be no specific reason to do so. Don't apologize for this fact, because if you did have all the advanced degrees required to scientifically analyze the chemical and physical properties of all odors, along with the chemical and physical properties of all the surfaces contaminated, no one could afford to hire you to correct their malodor situation! The primary point here is that your education, although not all-encompassing, combined with experience in a wide variety of malodor situations, is the best bet the distressed client has. That, along with the use of multiple procedures and persistence in employing those procedures ("overkill"), will produce results **EVEN THOUGH YOU MAY NEVER KNOW EXACTLY WHAT ACTUALLY PERFORMED THE *PRIMARY* JOB OF ODOR ELIMINATION.**

The second point here is that your procedures, along with the chemical odor generated by other subcontractors (painters, for instance), will often cover up real odors to the point that they seem to be gone. Later, when the structure re-acclimates to normal conditions, odors return seemingly out of nowhere. Had you employed multiple procedures and, above all, had you been *patient, persistent and* <u>*meticulous*</u> in your application of those procedures (again, "overkill"), the recurring odor problem would not have arisen.

This sounds strange, perhaps even a little unprofessional, but overkill is the key!

F. DECONTAMINATION AND SAFETY: Finally, today more than ever, technicians must be aware that malodors tell us that something is wrong with the environment. And it's not just the smell that must be considered in our deodorizing efforts, it's also the potentially health threatening pathogenic biological organisms that must be considered. The odor generated by these microorganisms is merely a signpost to a more significant threat to our and our customer's health and safety.

Further, conscientious technicians consider not only the biological threat, but also, the threat of respiratory irritation or impairment, when breathing particles associated with matador in quantity for prolonged periods. Of course always use knowledge coupled with common sense in any potentially hazardous situation; but when your body reacts strangely to an odor, listen to it! It may be trying to tell you something important.

Therefore, when approaching any deodorizing situation, professionals will consider aeration and decontamination procedures required to render the environment safe for processing and eventually for re-occupancy by users of the structure. It is for this reason that a section on bloodborne pathogens and decontamination procedures is included in this edition of *Comprehensive Deodorization* for the first time.

Comprehension Quiz: I - General Discussion

1. The _______ is the only instrument capable of detecting the presence and intensity of odor.
2. The _______ sensory system is involved in providing the sense of smell.
3. Most odor is ________ soluble.

4. The sensation of smell begins when airborne odor vapors or gases are absorbed by the ________ ________ in the nose.

5. The sensation of smell is transmitted from the nose to the brain by way of the ________ ________ ________.

6. The ________ ________ is responsible for the initial interpretation of the sensation of smell.

7. ________ odor is the pure sensation of smell as interpreted by the __________ lobe of the brain.

8. Odor produced by thoughts, impressions, past experiences and suggestions from others is called ______ odor.

9. Odor is amplified by _________ and _________.

10. ________ animal urine odor that lies unnoticed in carpet may be activated by cleaning compounds.

11. The characteristic odor of damp wool comes from its _________ content.

12. Odor is far less noticeable on __________ days.

13. ________ and _______ grow rapidly in a warm, moist environment, thus contributing to malodor odor problems.

14. Odor particles and gases come in very small, ________ and even ________ sizes.

15. The small size of odor particles contributes to their ability to ______ various surfaces.

16. A _________ is 1/1,000,000 of a meter.

17. The Mass Median Diameter of an average smoke odor particle is from_____to ___________ microns in size.

18. Odor penetration is greatly facilitated by ______ surfaces, and by________.

19. Odor penetration is also a function of ______ residues or vapors, coupled with prolonged _______ ________.

20. For every 10°f increase in temperature. air volume _________, thus forcing airborne odor to penetrate further.

21. The speed or __________ of air in the thermal expansion process causes greater odor penetration.

22. Eventually, heat expands ________ surfaces, allowing for deeper penetration of malodor.
23. Upon cooling, expanded surfaces _________, _________ matador inside.
24. ________, _______, and _________ application of deodorizing procedures leads to successful odor removal.
25. Today, more than ever, health threatening __________ microorganisms must be considered in deodorizing procedures.

II - BASIC DEODORIZING PRINCIPLES

Frequently, deodorizing technicians, regardless of their level of experience, are called by upset home or business owners with some positively unique, never-before-heard-of odor problem. Their initial reaction usually is to exclaim, "How should I know what to do about this problem?!"

If all odors had exactly the same source and they required exactly the same chemicals, equipment and procedures, our job would be much easier - and anyone could do it, so we'd be out of business in no time! In fact, *oversimplification* of the problem is still the major pitfall that traps many an unsuspecting deodorization technician. "Just splash a little Super Duper Deodorant in the corner of the back bedroom and all your odor problems will be solved forever!" says the untrained amateur.

However, experience soon teaches you that, in order to assure **rapid, effective** and **permanent** deodorization, several specific and sequential steps must be taken. Failure to consider each step results in incomplete deodorizing. Eventually, it also results in many complications that may arise from a standpoint of customer complaints, inconvenience and loss of money, when you finally realize that you must now go back to the beginning and start over with the proper steps - in sequence! Unfortunately, when a contract is negotiated at a specific price, based on overly simplified procedures, it becomes difficult, if not impossible, to back-track and institute proper procedures at an elevated price. Usually, the deodorizing contractor will absorb the loss brought about by the extra work required to do the job properly.

Four specific principles or procedures always should be **considered** in approaching any deodorizing job. In fact, these principles are so important, I would suggest that they be committed to memory. They are: *remove the contaminant residue; clean; recreate the conditions of penetration with an odor counteractant,* and *consider sealing surfaces to encapsulate odor.*

Inevitably clients will ask questions about odor situations that are unique, which you've never encountered, which aren't covered in this book! By recalling these four basic procedural considerations, you can actually sound intelligent, while brainstorming through the situation and arriving at a conclusion that seems logical - whether it actually works or not. Never fear! Usually, it will!

Now, let's discuss these four basic principles or procedures in more detail.

A. REMOVE THE CONTAMINANT OR DEBRIS: It's foolish to expend time, chemicals and money in deodorizing excess source materials or items that are damaged beyond use, which eventually will be removed from the structure anyway. Thus, our first offensive maneuver would be to remove as much of the excess contaminant, destroyed material or debris, as practical.

A rather obvious, although distasteful, example of this principle would be a situation involving animal feces. Upon discovering the offensive pile in the corner of a room, you would never begin the deodorizing procedure by rushing back out to your vehicle for a chemical to pour on top of that little brown pile. Heavens no! Your initial, logical, procedural step here would be to use a "poop scoop" prior to applying a large quantity of expensive deodorant.

Hopefully, this is just common sense and requires no further elaboration. By extension of this logic, it would be impractical to expend time and money attempting to deodorize a fire-gutted residence before substantial quantities of charred structural materials have been removed. Never make the deodorizing job more complicated than necessary (it's already complicated enough!). Always begin with this simple step for rapid odor reduction.

A related problem involves odor infiltration from an external source. For example, suppose employees within a building complain of an intermittent rancid odor coming from the heating, ventilation and air conditioning (HVAC) system. A deodorizing technician might jump to the conclusion that the duct system must be torn apart and inspected, or that elaborate ductwork cleaning and decontamination procedures must be undertaken. In fact, the source of the malodor maybe something as simple as a dead bird decomposing on the roof near the HVAC system's fresh air intake, or a relocated dumpster filled with malodorous garbage with prevailing winds carrying the odor to the system's air intake. In either case simple source removal or relocation will solve the majority of the problem.

Bottom line, think. analyze, inspect and accomplish the simple things relating to the odor source first.

B. CLEAN SURFACES EXPOSED TO MALODOR RESIDUE: *Cleaning is basic to deodorizing!* In a minor grease fire, for example, the stove, vent hood (and filter), surrounding counter tops, cabinets, walls, ceiling and floor (usually the entire kitchen), all require cleaning to remove significant concentrations of malodorous residue. Cleaning excess residue is a critical part of the deodorizing process, even though a separate unit charge may be placed on each item or surface requiring cleaning. From there, conscientious deodorizing contractors begin physically testing and "sniffing out" adjacent rooms to see if further cleaning is required in them. In fire situations with rapidly expanding, odor carrying gases, often cleaning must extend to the entire structure and all its contents - even though no appreciable physical residue may be visible!

For another example, when deodorizing refrigeration units subjected to severe protein contamination, if cleaning isn't accomplished carefully and meticulously, even small quantities of residue left in gaskets or in cracks and crevices will generate considerable ongoing odor. Even if the remaining organic material does not create the odor itself, your deodorizing or disinfecting agents may expend themselves reacting with this organic material, so that their effect on odor-causing fungi or bacteria will be substantially reduced. This residue, which could have been cleaned off surfaces easily, now causes the deodorizing process to be greatly prolonged. Had the cleaning step been

accomplished properly in the first place, much time and effort would have been saved.
Remember, *cleaning is basic to deodorizing!*

C. NEUTRALIZE MALODOR BY RECREATING CONDITIONS OF PENETRATION: In other words, if smoke has created the odor problem, we must create a deodorizing "smoke" (deodorant fog or ozone gas) that will follow the matador wherever it has penetrated into fabrics, surfaces or materials, and combine with and neutralize it. Similarly, if animal urine is the case in point, we must literally flood the contaminated areas (layers of carpet and cushion) with deodorizing chemicals (sanitizers or digesters) in much the same manner as the animal "flooded" the carpet with his urine. To suggest that this odor problem can be permanently neutralized with one drop of deodorant in the vicinity of the spot, is utterly ridiculous! In many cases, a combination of distribution systems must be used, since physical residue in one area may produce fumes or gases which, when they become airborne through evaporation, further contaminate fabrics or other areas of the structure.

A good illustration of this point involves the prolonged "death scene" situation. It isn't sufficient to "flood" the area of contamination with disinfectant/deodorant solutions, since vapors and gases rising from the unsanitary source causes severe malodor in many other areas of the structure - particularly during hot, humid weather. Here we must recreate the conditions of penetration in the area of direct contamination by body fluids (i.e., saturation spray application), followed by fogging or ozone gas generation to seek out and combine with vapors and gases that have penetrated into other areas and components of the structure.

Effective deodorizing **always seeks** to reach the odor at its source!

D. SEAL SURFACES EXPOSED TO MALODOR: (not required in all circumstances): This technique is normally required only in severe situations. It involves sealing malodor into surfaces when complete odor removal is impractical, too expensive, or requires multiple treatments over an excessively prolonged time period. It simply isn't practical to expend time, chemicals and effort deodorizing severely contaminated, especially highly porous surfaces that may require days or weeks of repetitious effort, when sealing can eliminate the problem in minutes.

Examples of the sealing procedure involve painting scorched or heavily smoked drywall with alcohol-based sealers or shellacs. Sealing surfaces not only improves their appearance, but it also speeds up the progress of overall deodorization considerably! The heavier the residue or the more porous the surface (the higher the degree of penetration), the more consideration of surface sealing is required. And don't forget, cleaning always precedes the sealing process, if at all practical, in order to remove loose or gummy contaminant that may cause the sealer to fail to cover or encapsulate the odor.

In summary, on every deodorizing job, conscientious restoration technicians will consider:

1. **debris or excess contaminant removal**
2. **cleaning surfaces** exposed to significant residue
3. **recreating the conditions** of penetration
4. **sealing heavily contaminated or highly porous surfaces as the** situation dictates

Short-cutting basic procedural considerations only results in upset customers, as well as the loss of time and money. Although it is necessary to monitor progress and stop when you're sure that permanent deodorization has been accomplished, true professionals almost always go a little beyond that which is merely satisfactory. Remember the "overkill" technique discussed in Chapter I. They not only prevent re-occurrence of odor in unusual places or at a later date (along with complaints), but they also address the psychological barriers that must be overcome.

Comprehension Quiz: Chapter II - Basic Procedures

1. ________ of the problem is the major pitfall for many deodorizing technicians.
2. In order to assure _______, ________ and _______ deodorization, several steps must be considered.
3. You must consider ___________ specific principles or procedures in any deodorizing situation.
4. The first step to consider in effective deodorizing is to remove the ________or ________.
5. The second step in effective deodorizing is to _________ the surfaces exposed to significant contaminant.
6. Odor may be carried throughout the structure in the form of a _________ or .
7. In order to assure permanent deodorizing, you must recreate the conditions of ___________.
8. If smoke odor has permeated a structure, you must create a _______ or _____to seek out and neutralize that odor.
9. A final procedure that should be considered in all deodorizing situations is to ________ the surfaces exposed to intense heat and/or odor.
10. Short-cutting the basic procedures may result in the loss of ____________ and ________.

III - CLASSES OF DEODORANTS

The concept of one "jug of juice" for all situations is quite erroneous, and is the cause of many customer complaints, as well as much contractor frustration. In this chapter we'll examine the types of deodorants available to both consumers and professionals, with the objective of selecting the appropriate chemical or process needed to accomplish the deodorizing job effectively. Using a quality chemical that is not matched to the demands of the matador situation is simply a matter of pouring money down the drain - *literally!*

Odors associated with carbon, protein, bacteria - even psychological odor problems
- all require different agents to accomplish effective odor removal. Your job eventually becomes one of finding a reputable supplier who provides the appropriate counteractant for each type of deodorizing problem you're likely to encounter.

A third point to understand is that ventilation strategies are quite valid in reducing malodor, though not destroying it, while creating a safer area in which to work. Ventilation should not be used as a substitute for *total odor elimination,* but it is a good strategy for *positive odor management.*

The following discussion covers the basic classes of agents used in deodorizing. A summary chart is provided at the end of the chapter.

A. MASKING AGENTS (Time Release Deodorants): Masking agents are simply perfumes or fragrances that cover malodor with a stronger, more pleasant odor. Often, masking agents are packaged in a time-release form (wick, solid cake, saturated wood block) in order to prolong their useful effect. Many a contractor has disdained using a fragrance to "cover an odor problem"; however, masking agents are still one of our best weapons against the psychological effect of odor. They should never be thought of as the primary eliminator in *real* odor situations; but they sure are helpful in providing something pleasant with which to cover malodor, while the job of neutralizing the *real* odor source is being accomplished.

Frequently a deodorant formulator will compound a fragrance that both technicians and clients simply love to smell. That fragrance (citrus, floral, spice, baby powder, even apple potpourri!) becomes the only ingredient in their wick or time release deodorant. These may create a more tolerable atmosphere, but they certainly do nothing to remove the real source of odor. The products are often found in restrooms, kitchens, or as stickup type deodorizers.

Probably a more appropriate name would be *"re-odorizer."*

Of course, that's not to say that adding a re-odorant to a deodorant - one that actually deals with the source of odor - isn't a valid concept. A simple fact of life is that customers want to smell something pleasant while the real job of deodorizing is ongoing. That's what true deodorization is all about!

B. ABSORPTION OR FILTRATION AGENTS: This class of deodorants consists of those products designed to absorb humidity or provide filtration of air, often while "re-odorizing" the airspace within the structure with an added fragrance. Basically, there are two types of products used in this area:

1. **Sorbents -** First, what about those products purchased from the grocery store, generally classified as carpet deodorizers, which are designed to be sprinkled on the carpet, and which advertise the ability to make the odor completely disappear?

   What are they made of? . . .

   If you'll read the labels, you'll find three primary ingredients: an inexpensive, inert carrier in powdered form (sodium sulfate); highly absorptive compounds (sodium bicarbonate, corn starch), and a fragrance or perfume. Baking soda (sodium bicarbonate) works on the absorption principle only and has no ability to destroy odor. In other words, other than the sorbent's ability to temporarily absorb humidity (perhaps even a few oils) that amplify and carry odor to your nose, there is nothing to attack the *real* odor problem. These products are a tribute to modern marketing, and the fact that they sell so well indicates how sensitive consumers are to odor problems within their homes and businesses.

   The drawback to frequent or improper use of these products relates to a buildup that almost inevitably occurs. Most homes today have cut-pile carpet in stalled, usually in a saxony or sculptured saxony pile design. When powdered carpet deodorizers are sprinkled liberally onto the carpet's surface (and especially when worked into the pile), it is virtually impossible to vacuum it all out. The deeper or more dense the pile, the faster the buildup. In time, this buildup of powdery residue will form impacted areas. In turn, these hard-packed areas produce accelerated wear and tear on the fibers comprising the carpet yarn.

2. **Activated Charcoal -** The second type of absorbent (actually adsorbent) compound is activated charcoal. While absorbents *draw* liquids (moisture, humidity) *within* their chemical structure, adsorbents *adhere* molecules to their exterior surfaces. Anyway, activated charcoal is simply a high-grade wood product that has been subjected to super-heated air (600°f/316°c of heat and steam) to cause the charcoal to expand its surface area tremendously. This thermal expansion process provides an almost infinitely larger number of surface

areas that can **<u>ad</u>**sorb odor molecules carried by humidity or oily vapors. The effect of adsorption by activated charcoal is far greater and far more long-lasting than the effect produced by corn starch based **<u>ab</u>**sorbent products.

Activated charcoal is, for the most part, used in filtration deodorization. With this system, deodorizing is achieved by drawing air through filters of activated charcoal where VOCs. containing malodors are removed by the principle of adsorption. Often this is followed by re-odorization of that filtered air by exposing it to a time-release fragrance incorporated into the system. Filtration deodorization is limited to airspace, rather than surface or fabric deodorizing and is not generally practical in large-area situations. The major drawback to filtration deodorization is that activated charcoal filters are expensive, if large enough to do a quality job, and they must be replaced when saturated with contaminant.

C. PAIRING AGENTS: A pairing agent is a chemical that combines with (thus the term "pairing") malodorous molecules or substances. Pairing agents work in two ways: Some are humectants (glycol derivatives that have a high affinity for moisture) and will combine with airborne odor molecules carried by humidity or particles, causing these "droplets" or particles to become heavier than air. At that point the combined materials precipitate from the air onto surfaces (carpet or other flooring materials) that will be physically cleaned later. Usually, a wet fogger is used in the process, and you can think of this procedure as "washing the air" of odor.

On the other hand, some pairing agents combine with malodor molecules, imparting some of their chemical properties to that malodor in order to change its chemistry. Theoretically, at that point, a new, non-odorous compound is formed. Of course, direct contact in the airspace and on a variety of surfaces is necessary for a pairing agent to be effective.

Others paring agents have an attraction for moisture in the air that may be carrying odor-causing bacteria or fungi. When fogged into the air, these pairing (sanitizing) agents
attack microorganisms and chemically destroys them. Usually, a pairing agent will be combined with a pleasant fragrance in order to attack both real and psychological odor problems simultaneously.

D. DISINFECTANTS AND SANITIZERS: A disinfectant or sanitizer accomplishes deodorization by destroying or controlling microorganisms (bacteria and fungi) that cause malodor when they produce gases in their normal life cycle, or as a result of their effect on organic host materials (putrefaction). Realistically, there are four general classifications of antimicrobial agents: Most common is nature's inexpensive and effective use of *sunlight and fresh air!* These two are followed by *extremes in temperature,* either hot or cold, especially when combined with *reductions in relative humidity* (it seems that fungi and bacteria lose a considerable portion of their ability to attack organic hosts at relative humidity/temperature levels below 50% and 68°f/30°c). There are also *electrical appliances,* such as ultraviolet lamps or ozone generators; however, the agents with which deodorizing technicians are most familiar are the *chemical compounds* of various types.

The only reason all these agents are even mentioned is so you won't forget that the simple ones are still available. When combined with professional chemicals, they can be used to considerably speed up and simplify your deodorizing efforts.

Most cleaning technicians are familiar with several categories of **disinfecting or sanitizing** agents. Several of these are safe and useful to us. Some are downright hazardous to fabrics or surfaces, and should be considered health hazards as well.

Technically, to **sanitize** means to clean to a generally healthy state (though not microorganism free) as defined by public health agencies. To **disinfect** means to free from microorganisms, though not necessarily all their spores. The Federal Insecticide, Fungicide and Rodenticide Act of 1947 (FIFRA), as amended, is the basic law requiring formal registration of disinfectants. An Environmental Protection Agency (EPA) registration is required for a product to claim *disinfecting* capabilities. The requirements for assuring safety when used as directed have undergone many revisions. At present, minimum data to support application for registration must include data for eye, dermal and oral toxicity.

These terms are used interchangeably so often in our industry that they have almost come to mean the same thing. However, the term "disinfectant" generally describes a more powerful agent that is capable of killing a wider variety of fungal, bacterial and viral microorganisms. Remember, however, that although *disinfectants* may be called *sanitizers, sanitizers* should not be called *disinfectants.*

Finally, to **sterilize** means to kill all microorganisms and their spores. Seldom will a professional deodorizing technician encounter the conditions under which sterilization can be achieved, nor is this level of antimicrobial activity necessary for our purposes.

There are a wide variety of these antimicrobial compounds readily available on the market that destroy the fungi and bacteria associated with odor problems. For this reason, it's necessary to discuss these agents in several categories in order to understand their desirable as well as undesirable characteristics. Generally, limited-spectrum sanitizers are described by the suffix **"-stat,"** meaning to control, limit or regulate (fungistat, bacterio*stat*); while disinfectants are described by the suffix **"-cide,"** meaning to kill *(fungicide,* bacter*icide*, germ*icide*).

In discussing disinfection research in his book, *"Disinfection, Sterilization and Preservation,"* Dr. Seymour S. Block has aptly stated, "Our future guideline seems clear, and although it is not as simple as ABC, it is as simple as two other three-letter combinations, namely, EPA and FDA." How true!

An ideal disinfectant should have several properties: in use dilution it should be non-toxic and harmless to human skin; it should be non-corrosive to metals; it should act quickly and be effective at high dilutions. It's important (especially in cleaning), that it not be affected adversely by organic matter, or extremes of acidity or alkalinity. Finally, it should be stable, odorless, colorless and non-staining. Of paramount importance it must be accepted in use dilutions and applications by government regulators who now, more than ever, specify what we can and can't use safely and without liability in customers' homes and businesses.

Well, that's quite a demanding list of requirements! So let's look at some of the sanitizing and disinfecting products (in generic terms) with which you may have become familiar in recent years:

1. **Pine Oil -** Pine oil has been used as the basis of many household products (19.9-30% pine oil, depending on brand), which provide safe, effective (though limited) sanitizing properties. It is an effective germistatic agent that is usually clear amber in color, but which produces a snowy-white emulsion when mixed with water. It is non-corrosive and non-toxic to humans, and it leaves a fragrance that disassociated with cleanliness.

   Pine oil is safe and pleasant to use, but its lack of broad-spectrum *disinfecting* capabilities, along with the exposure time required, limits its use by professional cleaners and deodorizing technicians. Also, since dilution rates necessary for sanitizing call for use at anywhere from about 1:4 to undiluted use, it is not economically feasible for extensive use by professional deodorizing technicians.

2. **Alcohol -** Alcohol is a colorless, volatile, flammable dry solvent. There are three types that professional technicians may encounter: methyl, ethyl and isopropyl alcohol. As a group alcohols possess many desirable features for use as an antiseptic or disinfectant. They have bactericidal rather than bacteriostatic action against vegetative (growing) forms of bacteria and fungi; although they are much less effective against spores. They are relatively inexpensive, readily available and relatively non-toxic when used properly.

   This category includes anything from mouthwashes to rubbing alcohol used for medicinal purposes. Seldom are deodorizing technicians tempted to use these forms of antiseptics in malodor situations. However, technicians often may consider household "disinfectant cleaners" (Lysol®, for example) containing alcohol as good alternatives to commercial products. Read the labels. The active antimicrobial ingredient in many household sanitizers or deodorizers is simply alcohol (as much as 60-90% isopropyl or ethyl alcohol), occasionally mixed with pine oil or a phenol derivative (o-phenylphenol). Another thing you'll notice is that many of these labels specify that the product be used in its concentrated form for deodorizing (especially disinfecting) purposes. This means that the concentration of alcohol may be sufficient to cause dye bleeding, or to damage adhesives or other components of the materials we're treating, while at the same time creating a potentially toxic environment. Some products even contain dyes that could stain nylon or natural fibers. Although in concentrated form these products do work effectively, the lack of dilution makes them 10-30 times more costly than well-formulated, commercial deodorants!

Alcohols work by denaturing proteins found in active (vegetative) bacteria; however, in the absence of water, proteins are not denatured as readily as they are when water is present. Methyl alcohol has the weakest bactericidal action and is seldom considered for use as an antimicrobial compound. Most products contain from 60-90% of either ethyl or isopropyl alcohol, the bactericidal action of isopropyl alcohol being somewhat greater than that of ethyl alcohol. Both are also effective against a variety of viruses. The human immunodeficiency virus (HIV) is readily inactivated by most chemical disinfectants, including alcohols.

3. **Bleaches** - Various bleaches (hydrogen peroxide, HOOD, and sodium hypochlorite, Nacho) also serve as sanitizing or disinfecting agents. Their activity results in oxidation of the odor-causing material. For our purposes, oxidation refers to the ability of a chemical compound to impart an atom of oxygen to another compound to produce a change in the structure of that compound (oxidation), the change usually being permanently destructive.

For **example, hydrogen peroxide** (HP) is a clear colorless liquid with a characteristic slightly acidic odor. It has low toxicity and is not a systemic poison. HP is water, H_2O, plus an extra atom of oxygen, O. forming H_2O_2. When peroxide contacts a microorganism, the extra atom of oxygen is imparted, an oxidation reaction (chemical burning) takes place, the byproduct of which is water, H_2O, plus a few other gases (e.g., oxygen, nitrogen dioxide). Drug stores carry 3% hydrogen peroxide for medicinal (antiseptic) use, and barber and beauty shop suppliers carry 30% peroxide for bleaching color from hair, the most common form being "20 Volume" (6%) Clairoxide®, which is packaged in opaque brown or white quart bottles. To reduce 6% HP to a 3% use solution, simply mix it 1:1 with water.

According to research scientist Seymour S. Block, Ph.D.,

> "Hydrogen peroxide is regarded as nature's own disinfectant and preservative. It is naturally present in milk and in honey . . . it is a normal resident of tissues as a result of cellular metabolism. Further, it protects us from infections by invading pathogenic microorganisms . . . The hydroxyl radical is said to be the strongest oxidant known, and by this mechanism, HP is believed to do the actual killing of bacteria. The hydroxyl radical, being highly reactive, can attack [cell] membrane lipids, DNA, and other essential cell components."

Hydrogen peroxide is active against a wide range of microorganisms: bacteria, yeasts, fungi and viruses. HP, when diluted to a 3% use solution, is safe on all fibers and surfaces, and on most fabric dyes as well, and it is highly bactericidal. Its activity is greatest at an acid pH, and it's also non-residual. Its antimicrobial activity is accelerated by heat (increases spore sensitivity) and ultraviolet light (sunlight), and it decomposes rapidly in the presence of those accelerants. It is an effective biocide, and in high concentrations (10-25%) may even serve as a sporicide, especially in hot acid solutions (pH of 3). Commercial preparations of peroxide are relatively stable, however, when exposed to extremes of heat or sunlight, HP will decompose rapidly. Concentrated HP solutions are irritating to the skin, mucous membranes and particularly to the eyes. It should be washed off immediately if splashed onto the skin or in the eyes. The vapors can cause inflammation of the respiratory tract, but it is not a carcinogen or mutagen. Because of its volatile nature, ability to remove dyes from fabrics, and effect on skin, it has few practical applications for professional deodorizing technicians.

Peracetic acid is another peroxygen compound that has effective germicidal activity. However, it is less stable than hydrogen peroxide, and has been found to be a potent tumor promoter and weak carcinogen.

Chlorine is not found in a free state in nature, but is found in commercial products in combination with sodium, potassium, calcium and magnesium. It is a heavy gas that is greenish-yellow in color, with an irritating and penetrating odor. Most stable commercial products have the following characteristics: low chlorine concentrations (5.25%-6%); low concentrations of catalysts; relatively high alkalinity; absence of organic contaminants; prolonged storage at moderate temperatures (cool) in closed, dark containers. Ph has the greatest influence in antimicrobial activity: i.e., increased ph substantially reduces activity and decreased pH increases activity. Bactericidal activity is diminished considerably when chlorine is added to ammoniated water or amino compounds. Heavy organic contamination consumes available chlorine and reduces its bactericidal activity; however, water hardness has little effect on chlorine. Various types of bacteria, fungi and viruses display different levels of resistance to chlorine. This resistance may be compensated for by increasing chlorine concentrations, decreasing pH or increasing temperature.

The household bleach with which technicians probably are most familiar is **sodium hypochlorite** (NaC10) or chlorine bleach (trade names Clorox®, Purex®, Javex®, etc.). Hypochlorites are available in liquid (5.25-6% concentrate) or powdered form and are: powerful germicides that control a broad spectrum of microorganisms; deodorizers; non-poisonous to people at use concentrations (1/2-1%); free of toxic residues; and economical to use.

This information on oxidizing bleaches is mentioned merely to confirm the fact that these bleaches do have disinfecting properties; however, generally they are *not* recommended for use in professional deodorizing procedures, except in rare circumstances - and then primarily for *decontaminating* durable, colorfast surfaces directly contaminated with extremely persistent malodorous or contaminated substances. Side effects such as color loss, fiber destruction (particularly, dissolving protein fibers, such as wool and silk) and corrosion (rusting) of metals, is far too great a price to pay for any disinfecting benefits that may be achieved. Further, chlorine bleaches are not very cost effective when used in quantity, and they can easily create a toxic environment (chlorine gas), especially if mixed indiscriminately with acids or amrnoniated cleaners.

Some household products for cleaning (particularly when cleaning shower walls for mildew growths; e.g., Tiled) and disinfecting may contain chlorine bleach. Generally, they are to be used undiluted, and they normally contain around one to two percent (1-2%) sodium hypochlorite. They tend to be quite expensive, and, used in the wrong places, they're certainly strong enough to create the problems mentioned above!

4. **Phenolic Disinfectants -** Phenol (carbolic acid) no longer plays a significant role as an antibacterial agent. Phenol derivatives, however, make up one of the major classes of disinfectants used institutionally and commercially. The only phenolic derivative found in hospital, institutional and household deodorization and disinfecting products today is **o-phenylphenol.** Phenol derivatives display broad spectrum antimicrobial activity, acting as a bactericide (against both gram-positive and negative), fungicide, virucide (against lipophilic viruses), and tuberculocide. Phenol derivatives, at high concentrations, act on cells as a protoplasmic poison, penetrating and disrupting the cell wall and precipitating cell proteins. At lower concentrations they inactivate essential enzyme systems of

cells. Generally, the addition of alkali to phenol derivatives decreases antimicrobial action. When applied to surfaces, phenolics leave a residue that often inhibits the growth of fungi and molds. They have a tolerance for organic loads and hard water; they are biodegradable and should present no significant problem of accumulation. Phenol derivatives are considered low to intermediate level disinfectants. They are not a sporicide and should not be used when sterilization is required.

Viral contaminants can be divided into three broad categories: *lipophilic* - those surrounded by a lipid (fatty) envelope that combines with lipids; *hydrophilic* - those that do not have a lipid envelope; and *intermediate* - those that do not have a lipid envelope but do have the ability to combine with some lipids. A 5% phenol solution inactivates both hydrophilic and lipophilic viruses, but the phenolic derivative, o-phenylphenol, is effective only against lipophilic viruses, being 10 times more active against lipophilic viruses than phenol. Now here's the point. During the '80s a new disease, acquired immunodeficiency syndrome (AIDS), was discovered. The principle agents responsible for this disease are human immundeficiency virus (HIV) types 1 and 2. Both are lipophilic by nature, and phenol derived disinfectants show a high degree of virucidal activity against them when the need for positive decontamination is required.

They should be used only in "last-resort" situations involving: first, durable surfaces; second, unoccupied areas; and third, with careful protection of the technician providing the treatment. The primary hazard involves safety. If phenolics contact the skin, they should be washed with quantities of water immediately and for several minutes. They should never be fogged, since inhalation could cause damage to respiratory system tissues. If splashed into the yes, label directions normally require you to seek medical attention at the nearest hospital emergency room. In all these situations, useful bacteria on the skin, eyes, or lungs are destroyed by phenol derivatives and their residual effect.

And that's not to mention the harsh odor that remains after disinfecting is completed! In summary, concentrated phenolic disinfectants are simply too toxic and too harsh to be used in the various applications required by the professional deodorizing technician.

A few popular household disinfectant sprays contain some o-phenylphenol for disinfecting (less than one percent o-phenylphenol); however, most will be combined with a substantial quantity of alcohol as well (as high as 90% isopropyl or ethyl alcohol!). Again, these products are designed to be used straight and, therefore. are hardly cost effective for the professional. Some household product formulators have switched from a pine oil or phenol base, to an ammonium chloride base (2-3% dimethyl benzyl ammonium chloride).

When you read the label of many disinfecting products on the market today, you probably will be confused by the term "Phenol Coefficient," followed by a number. Does this mean that all these products contain phenol and, therefore, should be used with extreme caution, if at all? The answer is no; the products don't necessarily contain phenol. The primary idea behind the phenol coefficient concept is to determine what is the greatest dilution of a material that will kill a certain species of microorganisms, within a certain time, at a certain temperature. Then that data is compared with similar tests made with solutions of carbolic acid (phenol). The Phenol Coefficient, then, refers to the number of times the disinfectant being tested is stronger than carbolic acid against that same bacteria.

Now, you don't need to remember all that; just remember that the Phenol Coefficient doesn't necessarily refer to the chemical content of the product you're using. It was simply a standard test of product effectiveness. Fortunately, the term "Phenol Coefficient" is obsolete and is rarely seen on labels anymore. Today, the Phenol Coefficient Method has been replaced by the Association of Official Analytical Chemists (AOAC) by the AOAC Use-Dilution Method.

5. **Iodine and Iodine Compounds** - Most technicians recognize this nonmetallic, essential element as the general antiseptic, iodine (I_2). Its limited spectrum use as a bactericide or fungicide, not to mention its ability to stain fabrics a violet or orange-brown color, renders it impractical for use in the cleaning and deodorizing industry. Further, iodine has an unpleasant odor, it combines with iron and other metals, solutions are not stable, it is irritating to animal tissues, and it is a poison.

An *iodophor is* a complex of iodine or triiodide with a carrier that: increases solubility in water; provides for sustained release of halogen; and reduces the equilibrium concentration of free molecular iodine. Iodophors are used in medicine for disinfecting skin without unwanted side reactions, such as staining, irritation and absorption of iodine. There also are preparations of iodine used for disinfecting water, but again, they have few applications for the technician in terms of odor or contamination control or elimination.

6. **Aldehydes** are derived from hydrocarbons (petroleum by-products) and are used for a variety of purposes including disinfecting. The most familiar chemical derived from this group is **formaldehyde** that is used as a disinfectant, as a preservative, in the synthesis of plastics, and in the production of pressed or laminated wood products - not that you'd be tempted to use formaldehyde in a disinfecting function, since strong odor and toxicity would be overriding considerations. Since formaldehyde has been labeled by the U.S. EPA as a carcinogen, its use in disinfectants has been all but eliminated.

However, there are other aldehydes that may be recommended to you from time to time by those familiar with their use in the medical or food processing industries, particularly as a substitute for formaldehyde. **Glutaraldehyde** displays a broad spectrum of biocidal activity and rapid rate of kill against most microor ganisms. Glutaraldehyde in a 2% solution is capable of destroying all forms of microbial life including bacterial (gram-negative and positive) and fungal spores, tubercle bacilli and viruses, including human immunodeficiency virus (HIV) and hepatitis B virus (HBV). It is an excellent sporicide, perhaps its most important property, and will not corrode most materials. It continues to be active in the presence of organic materials. In an acid solution, the activity of glutaraldehyde is increased by heat; whereas, in an alkaline solution (the most common) heat reduces activity, a distinct advantage when sterilizing heat-sensitive medical instruments. Shelf life is a consideration for alkaline glutaraldehyde solutions.

Disadvantages include increased oral and skin contact, and inhalation toxicity (toxic fumes), along with elevated eye and skin irritation. The increase in number of reports of occupational sensitivity reactions has resulted in growing concern about glutaraldehyde's use, and safety precautions (gloves, splash goggles, ventilation) are required to minimize risk of toxicity for technicians. Glutaraldeyde also is more expensive.

In summary, more research in the area of toxicity is required before technicians can expect to see glutaraldehyde available in formulations for deodorization and decontamination.

7. **Quaternary Ammonium Chloride** - The first references to quaternary ammonium chloride compounds ("quats" for short) used as germicides appeared as early as 1915. However, by far the products of greatest commercial significance today are the advanced generations of quaternary ammonium compounds, the "dual" or "twin-chain" quats, whose development began in 1955. The dual quats contain equal proportions of alkyldimethylbenzyl ammonium chloride and alkyldimethylethylbenzyl ammonium chloride. How's that for a mouth full! Just check the label of the product you're using and you'll find these terms.

If it's an EPA-registered quat (a requirement for disinfectant claims), you'll find the formula listed. If not, start looking for another product. The EPA recommends methods to determine the sanitizing activity on inanimate, nonfood contact surfaces, the initial and residual *bactericidal* and *bacteriostatic* activity of treated laundry fabrics, the *sanitizing* activity on carpet, the *virucidal* activity on environmental surfaces and the initial and residual *fungicidal* and *fungistatic* activity on inanimate surfaces.

The result of testing with quats is summarized as follows: The active quaternary ammonium compounds sold commercially are algistatic, bacteriostatic, tuberculostatic, sporostatic and fungistatic at low concentrations (0.5-5 ppm). They are algicidal, bactericidal, fungicidal and virucidal (against lipophilic viruses, including HIV) at medium concentrations of 10-50 ppm. They are not tuberculo cidal, sporicidal or virucidal against hydrophilic viruses even at high concentrations. They are bactericidal against gram-positive and gram-negative bacteria with greater activity against gram-positive types. Remember that gram-negative bacteria, as a group, are more resistant to all antimicrobial compounds currently available, and contact time of at least ten (10) minutes is the general recommendation. Further, as with most chemical reactions, elevated temperature increases product activity.

The synergistic combination of dual quats not only has increased biocidal activity, along with increased detergency (cationic), but it reduces oral toxicity as well. Continual changes and improvements in advancing and broadening the spectrum of biocidal activity enables quaternary ammonium disinfectants to work under adverse conditions and produce safer, more economical products.

These disinfectants (like the phenolics) act upon odor producing microorganisms by denaturing protein, or by interfering with cell metabolic functions, such as respiration or the synthesis of carbohydrates (glycolysis). Quats also attack cell walls creating lesions, which can lead to leakage of metabolites and coenzymes and the subsequent disruption of metabolite concentrations within the cell.

Quaternary ammonium chloride disinfectants are the product of choice in many food service establishments for sanitizing. They are heavily depended upon in restaurants and other eating establishments to protect against bacteria and fungus growth, following cleaning, on various food-contact surfaces. Treatment of large area environmental surfaces is accomplished by mop-and-bucket procedures (hard surfaced flooring), by mechanical flooding and wet pick-up vacuuming (carpet), by sponge or cloth hand-wipe procedures (walls and other non-porous surfaces), or with spray application alone to clean surfaces. The reason quats are so important is that they are odorless and highly effective against a broad spectrum of bacteria, fungi and viruses. They simply represent the ultimate in safety.

In other forms, quats are used as fungistats for exterior latex paints and as moth-proofing agents for wool fabrics. They may be added to water in cooling towers to prevent the formation of algae slime.

Virtually no fibers or surfaces are harmed in the least by the application of properly diluted quats. Also, in proper use dilution, they are relatively safe when in contact with the skin (although repeated or prolonged contact, especially in a concentrated form, is not advised and chemical-resistant gloves are specifically recommended). Quats should not be fogged, except when overall decontamination is called for, and even then, technicians must be wearing skin, respiratory and eye protection. Breathing the vaporized product will cause respiratory irritation for several hours, and if gotten under contact lenses, useful bacteria may be destroyed, causing severe irritation for many days.

Always keep in mind, however, that quats are cationic; in other words, they are positively charged solutions. Therefore, they cannot be mixed indiscriminately with anionic (negatively charged) solutions without destroying the properties of both chemicals. Also, the same effect is experienced when cationic quats are applied to the anionic surface agents that provide acid dye resistance in stain-resist carpet. Moreover, quats are adversely effected by heavy organic loads on fabrics or surfaces being treated. Therefore, following initial decontamination procedures using quats, cleaning (physical removal) of heavy organic residues is required before overall sanitizing or disinfecting of surfaces can be accomplished.

In short, quats are great products when used properly by conscientious technicians who are constantly concerned with their own health and safety, as well as that of anyone else in the area being treated. *The effectiveness of the product is determined by five critical factors: concentration; the nature of microorganism's cells; time of contact; temperature; pH; and the presence of foreign matter.* Again, the presence of an Environmental Protection Agency (EPA) registration may be helpful in assuring consistent quality in the product purchased (supplier reputation being another critical consideration). These products, like the pairing agents mentioned previously, are often combined with a pleasant fragrance that addresses the psychological side of the odor problem, while the "quat" neutralizes the real odor.

Supplemental reading on microorganisms may be found in *"Flood Damage Restoration - Part II, the Procedures,"* published by Clean Care Seminars.

E. ENZYME DEODORANTS: Many odors produced by decaying organic material such as urine, feces, meat, fish, milk, egg, body fluids or other protein materials may be effectively eliminated using enzyme deodorants. Before discussing how deodorization with enzymes is achieved, it is first necessary to elaborate on why these odors are so difficult to completely and permanently neutralize.

Urine, for example, leaves the dog or cat as a relatively sanitary, though toxic, chemical compound. Very quickly, however, due to bacterial action, decaying of urine protein begins to occur. Bacterial growths develop, along with their associated amino acids and gases. Amino acids are complex organic compounds that make up all living matter. In much the same way as formic acid dissolves nylon fiber, but to a far lesser extent, amino acids may actually penetrate and combine with fibers. Therefore (because the odor may be part of the fiber itself), it may be extremely difficult to accomplish **complete** urine deodorization without permanent damage to the fiber or dye pigment. More on this subject later.

Once again we see that the problem is more complicated than we realize.

Enzyme digesters have been used for many years in the sewage treatment and dairy products industries. They have found their way into the cleaning industry as spotting agents and, more recently, as deodorants and additives to cleaning compounds. Most of the enzyme compounds used as deodorizers today come directly from the dairy products industry where they have been used for years as deodorizers and sanitizers of equipment and surfaces contacted by milk protein.

Enzyme deodorants consist of bacteria that produce a combination of two or more classes of enzymes in a mildly alkaline solution (pH approximately 9). Usually, the enzymes produced are protease for starch degradation, and amylase for protein degradation. They also include a pleasant fragrance. They perform their function by breaking down insoluble, complex starch and protein molecules into simpler, soluble substances or gases, many of which dissipate or evaporate completely without even the requirement for rinsing. Best results, however, are achieved with rinsing.

Some of the enzyme digesters used by cleaners in the past, particularly in spotting, have produced, as a byproduct of the digestive process, a rather foul smell similar to rotten eggs. In addition, the digestive action was relatively short-lived when substantial quantities of protein were present (as in the case of urine-saturated carpet). For this reason, and because we failed to understand the parameters in which enzymes were used, the results obtained were not impressive.

Today, modern science has given us new products that contain living bacterial organisms that actually provide ongoing production of protease, amylase and lipase enzymes, as long as the proper environment for their production is maintained. These are actual odor digesters, which perform their function in the fabrics on which we are working. As long as there are organic contaminants present on which the bacteria may feed, the production of enzymes is an ongoing function, until the food source is completely gone. At that point, the bacterial strain dies, and enzyme production ceases.

These bacteria-based compounds are safe and effective, when used according to manufacturers' label directions, on urine as well as a variety of other protein contaminants. The by-product of the bacteria-based digestion process is carbon dioxide (CO_2), water (H_2O) and ammonia (NH_3) - all of which are volatile substances. Two of the chief advantages derived from the newer compounds are: there is no unpleasant odor (hydrogen sulfide) produced; and, in fact, a pleasant residual fragrance is combined with, and left by, most of these products. Also, the newer compounds even digest other microbial by-products of the protein contamination situation, such as those produced by mold, mildew and bacteria.

There are limitations to the use of enzyme deodorants. Some enzymes used as cleaning aids have been found to be skin and respiratory irritants, causing some products to be withdrawn from the market. In deodorizing, proper application procedures and protective clothing should overcome this problem. Additionally, however, most enzymes function in limited temperature, light, time and pH ranges. Therefore, it may be extremely difficult or impossible to produce the conditions necessary for maximum effectiveness in every situation where enzyme deodorants are employed. Use considerations for enzyme deodorants will be discussed in detail in a later chapter on "Chemical Requirements."

F. RESIDUAL OR BONDED ANTIMICROBIALS: For years man has searched for a way to make fibers and fabrics - all sorts of materials in fact - resistant to the ravages of microorganisms and other pests. The thrust of this effort has been to make materials more resistant to wet or dry rot and other forms of degradation, and to make them more sanitary for the user who will be in contact with them.

Several questions have arisen in attempts to achieve these goals. Foremost, what is the immediate and prolonged effect of antimicrobial treated fabrics on human beings, particularly children? Will the treatments adversely affect friendly microorganisms that ward off invading bacteria and pathogens? Second, how safe are the concentrated formulations? What's the potential for harm for the one making the application; moreover, what dangers are present if concentrates fall in the wrong hands? Third, what is the long-range impact on the environment when treated fabrics are discarded? How long will it take for biodegradation to occur?

There are two classes of persistent antimicrobial treatments that have received attention from the professional cleaning/restoration industry in recent years.

1. **Residual Antimicrobials** - For years man has known about the antimicrobial properties of various metals, such as copper, zinc, tin and mercury. In this same category, products generally known as "residual antimicrobials" should be mentioned because most are inorganic compounds linked chemically with organic materials to form organomaleates.

    The first organotin compounds were prepared in the mid-19th century, but it wasn't until the 1950s that their biocidal properties were systematically explored. The organotin compounds were first used broadly in agricultural applications as fungicides and insecticides. To a lesser extent, they also are used to treat wood products to prevent damage from fungi and pests, and as exterior paint additives to prevent the growth of mold and mildew. In the '70s organotins were added as antifouling agents to paints and varnishes used on the hulls of boats and ships. They replaced the old copper-based paints that required restoration every two years or so and extended the time between repainting up to five years. Organotins, combined with quaternary ammonium chloride compounds, have been used to treat recirculated water in cooling towers as well to control slime produced by bacteria, algae and fungi.

In the fabric manufacturing industry, organotins (tributyltin maleate) have been used to provide antimicrobial properties to fibers and fabrics. In the cleaning and restoration industry, products such as UltraFresh® get the name "residual" from the fact that, after being applied to the face yarns of the carpet, they remain on the fibers comprising face yarns. There, they continue to have a "residual," or long-lasting, antimicrobial or biostatic effect.

2. **Bonded Antimicrobials** - Bonded antimicrobial compounds (e.g., Dow Corning's Sylgard®) have been under development for some time, but only in recent years have carpet applications been attempted. Originally, they have been applied to surgical gowns, surgical drapes (used to cover patients during operations), camping tents for mildew resistance, and socks and underwear for odor reduction. Eventually, applications were made to carpet to achieve reduced odor during its use life and to aid in the reduction of allergy aggravating fungus growths, such as mold and mildew. Note that only bacteriostatic and fungistatic claims are made for these products. If broad spectrum *disinfecting* capabilities were present, the terms "bactericide" or "fungicide" would be claimed.

   Bonded antimicrobial compounds combine a binding mechanism with the microorganism killing ability of conventional antimicrobial compounds. The bonded antimicrobials used on carpet are based on halogenated phenol derivatives, halogenated salicylic acid anilides, organotin (tributyltin maleate) compounds, quaternary ammonium compounds, quaternary ammonium sulfonamide derivatives, or a combination of several chemical technologies. If all that chemical terminology escapes you, just remember that the resulting treatments are generally durable to repeated cleanings, have broad-spectrum microorganism suppression capabilities, are compatible with other finishes, and are safe to man and animals, *when used as directed.*

   Bonded antimicrobials tend to be long lasting in their microbe suppression role. Once applied and properly bonded, they can withstand several cleanings without losing their effectiveness. Residual antimicrobials are more easily removed with cleaning and therefore, for ongoing microbe suppression, reapplication of the compound at least every other cleaning should be considered.

Both *residual and bonded* antimicrobials are primarily designed to be used in a preventative role, rather than as a corrective treatment. Although they may be used to a limited extent in a corrective role, generally this procedure is less effective and much more expensive than would be the case with the use of standard, non-residual quaternary ammonium chloride compounds.

Perhaps more importantly, be aware that both residual and bonded antimicrobials do not produce a permanent sanitizing effect under all soiling conditions. Basically, the organism causing the odor or fungus growth must come in close contact with the antimicrobial remaining on, or bonded to the fiber, in order for the compound to kill it. Therefore, when fibers are heavily coated with soil and grease, you may correctly assume that the residual antimicrobial is rendered marginally effective at best. Of course, you now have another reason to recommend yearly cleaning to homeowners who desire effective microbe suppression in their treated carpet. However, to suggest that this treatment will completely suppress odor development in urine-saturated carpet or carpet subjected to flood damage, will only result in disappointment for you and your client. Also, as you will see in later discussions about the quantity of chemical required to penetrate all areas of contamination (carpet, cushion, sub floor), it is questionable as to whether residual antimicrobials are cost effective to use in a saturation application role.

Again, the purpose of a residual antimicrobial treatment is to suppress odor and fungus development in **normal** use situations. Abnormal situations, the reason for this book, will require the other compounds and procedures that are to be discussed. This is the reason residual antimicrobials are not discussed as an agent normally used by the deodorizing technician in a corrective role.

It is extremely important to note that urine-saturated carpet treated with residual antimicrobial compounds may not respond to deodorizing with enzyme digesters. The antimicrobial simply kills the enzymes (themselves microorganisms) that produce the digestive action required. In this situation, quaternary ammonium chloride or alcohol/phenol derivative disinfectants are specifically recommended as a substitute for enzyme deodorants.

Somewhere in this discussion of residual and bonded antimicrobials, a few words of caution are in order, especially regarding the organomaleate classification. They should not be gotten in your eyes or on your skin or clothing. In spray application procedures, an .04 jet orifice, or larger, is recommended to prevent the misting effect caused by smaller jet sizes, which might cause you to inhale quantities of the airborne compound. Similarly, wet fogging of the compound is discouraged in order to avoid inhalation. The product should be mixed prior to leaving the plant each morning, since the small container in which the material may be packaged represents an inviting toy for small children when left lying around by thoughtless technicians. If a child drinks any antimicrobial compound, circulatory shock, respiratory depression, convulsions and damage to mucous membranes may result. Like any useful chemical, residual antimicrobial compounds are only as safe as the person using them.

Unfortunately, silicone-based, quaternary ammonium chloride bonded antimicrobials (Dow Chemical Corporation's Sylgard®) have all but disappeared from the market. This is because of increased pressure from the EPA regarding toxicity testing. This testing is time consuming and very expensive, and the market for the treatment simply doesn't justify the effort.

Regardless, residual and bonded antimicrobials have created opportunities for the use of these products following fabric cleaning in homes where odors or allergies are a continuing problem, or where animal odor is assured. Again, the key is prevention rather than correction.

Before closing this subject, it should be noted most of our current EPA-registered disinfectants as well as the bonded antimicrobial, Sylgard®, are cationic and will neutralize stain resistance (thus voiding the five-year warranty) on fifth-generation carpet. Theoretically, the only products that are compatible with the anionic stain-resist barrier are the enzyme deodorants and some alcohol-based antimicrobials in anionic solutions. Although the organotin-based residual antimicrobial compound, UltraFresh® is anionic, it too will void the warranty on stain-resist carpet. It seems that the tributyltin maleate attracts dyes in staining materials, which makes the carpet appear to be stained.

The bottom line is that today, odor problems in stain-resist carpet aren't covered the warranty, and second, homeowners have one of two choices: smelly carpet or stain resistance. Your job is to identify and present those choices; not to have perfect answers to problems you didn't create!

There is one practical application for residual or bonded antimicrobials in the final phase severe animal urine correction. After non-residual disinfectants or enzyme deodorants are used, a topical application of residual or bonded antimicrobial creates a more pleasant and long-lasting impression for carpet owners. Of course, it continues to suppress odor (at least in the carpet's nap) for months, if not years, to come, or until the carpet becomes substantially soiled. Then recleaning and retreatment is called for.

Comprehension Quiz: CHAPTER III - Classes of Deodorants

1. Masking agents are also referred to as ______- _______ deodorants.
2. Masking agents contain a ________ or ________ that covers or "masks" a matador with a stronger, more pleasant odor.
3. Masking agents are useful in attacking ________ odor.
4. ________ work by attracting or progressively removing odor carrying humidity from the air.
5. Powdered household carpet deodorants simply contain ________ materials and ________.
6. Activated charcoal employs the principle of ______.
7. Activated charcoal is wood product subjected to extreme ___ and _______.
8. Some pairing agents combine with airborne odor particles carried by _______, causing them to become _________ than air.

9. Some pairing agents combine with malodor in order to change its __________composition.
10. Disinfectants and sanitizers deodorize by attacking ______ that cause odor.
11. Nature's most effective deodorants are ________, _______ and _________.
12. Extremes of _____, or reducing ________ ________ also aids in reducing odor naturally.
13. The suffix "-stat" means to _______; the suffix "-cide" means to ______.
14. Bleaches disinfect based on the principle of ______.
15. Although effective disinfectants, chlorine bleach will remove ___________from fabrics, _______ protein fiber and _______ metals.
16. Phenolic disinfectants are also known as _________ __________.
17. Phenolics are too _______ or too ________ for extensive use in the cleaning and restoration industries.
18. The _______ ________ is a standard test of the effectiveness of a disinfectant.
19. The ideal disinfectant, particularly in food service situations, is ______ _____ _____ - _________.
20. EPA stands for ______ ________ ________.
21. EPA registration is helpful in assuring ___________ __________, when selecting a disinfectant.
22. Never fog quats without ______, _______ and _______ protection.
23. Quats are _____ and should never be mixed with anionic compounds, such as those in many cleaners, or those applied to create stain-resistant carpet.
24. Enzyme deodorants are used primarily on ________ odors, such as those caused by heavy urine, meat, fish, milk, blood, or body discharge.
25. Bacterial enzyme deodorants work through a process called _______.
26. Residual antimicrobials remain on, or bonded to, fibers for a ______ ________ _____ antimicrobial or biostatic effect.
27. Residual antimicrobials are used primarily in a _________ role, rather than in a ___________ role.
28. Residual antimicrobials are ideal for use as an after-treatment in places where people are extremely ______ sensitive, in ___________ facilities, or in areas

when ______ odors are unavoidable.

IV - PROFESSIONAL CHEMICAL OPTIONS

A professional technician should realize by now that no one system for deodorization is perfect under all circumstances. The type of odor (real or psychological), the source of odor (smoke, bacteria, protein, fungi), the heat associated with odor penetration and the surfaces permeated (fabric, hard surface, porous surface, etc.) all combine to determine the chemicals and equipment required to achieve optimum results.

For these reasons the following list of chemicals should be included in your arsenal of "weapons" for use in combating a wide range of odor problems. Basic chemical requirements are:

A. TIME RELEASE DEODORANTS (BLOCK, WICK OR GEL):

This item consists of some type of highly absorbent or slow-evaporating, time-release material that is saturated with oils of fragrance. It is purely a masking agent and, as such, has no odor-destroying capability. However, deodorant blocks are extremely useful to the professional technician in "re-odorizing" an area to produce the positive psychological impression that will bring the job to a successful conclusion. Masking agents should not be used in lieu of positive odor neutralization, but rather as a supplement that assists in resolving psychological odor problems.

B. ODOR ABSORBING GRANULES: The purpose of this product is to enable the technician to erect an odor absorbing barrier at the source of the odor or within the structure's air handling system. Odor absorbing granules consist of an absorbent bulking agent that is impregnated with masking fragrances. Its second basic component is activated charcoal granules which, in theory, adsorb odor as air is passed over it.

Activated charcoal consists of high-grade wood charcoal that has been subjected to steam and super-heated air (above 600°f/316°c). It is normally found in granular or powdered form in order to maximize the surface area available for adsorption. Again, adsorption refers to the ability of the charcoal to adhere malodor to itself when passing contact is made. Ordinary charcoal briquettes, coffee grounds, or baking soda are of little or no value as a substitute for activated charcoal.

Although it is extremely questionable whether fragrance-saturated charcoal particles can actually adsorb malodor, these compounds do create a pleasant fragrance when placed at the odor's source; they considerably heighten the aura of professionalism.

C. GENERAL PURPOSE DEODORANT: This chemical combines a highly effective pairing agent with a pleasant, though non-specific, fragrance. It is an inexpensive deodorant used in combination with cleaning chemicals in all surface-cleaning applications (walls, fixtures, floors furniture, etc.). It may also be used as a wet-fogging compound for general, light-duty deodorizing in, for instance, a smoke-filled conference room, or to achieve rapid deodorization of a very lightly smoked home.

A general purpose deodorant with a non-specific fragrance is recommended in order to minimize customer complaints. As mentioned previously, judging the quality of an odor is a highly subjective process. Therefore, we can conclude that any specific fragrance such as lemon, cherry, floral, spice, etc., which may be very pleasing to you, invariably will be offensive to certain customers based on their subjective evaluation of that fragrance. Experience indicates that pleasant fragrances that are not easily identified may be best suited for professional deodorizing compounds.

D. HEAVY-DUTY DEODORANT: A direct spray application of this chemical is designed to penetrate and neutralize odors caused by heavy char, soot and other organic odor situations. It is water based and is composed of penetrants, strong pairing agents, and a masking agent that imparts a pleasant fragrance. This product will be diluted with water according to label directions based on the severity of the odor situation encountered. It is the primary product for use whenever there is a need to substantially reduce and contain odor in the initial stages of deodorization. Specifically, scorched walls, charred studs, charred cabinets and any area of heavy contamination should be sprayed or misted with a proper dilution of this product before area cleaning and deodorization begins. In addition, it may be used for wet fogging of air space in areas of heavy contamination, and for direct application to exposed interior wall components in severe structural fire situations.

E. DRY SOLVENT-BASED DEODORANT: There are several uses for the dry solvent-based deodorant: First, it may be added to drapery or upholstery dry solvent cleaning formulae (about two ounces per gallon) to impart deodorizing characteristics. Second, the popularity of the product is growing rapidly due to the rather dramatic impression it makes when used in various types of thermal-fogging equipment available on today's market. Dry solvent-based deodorants are composed of a combustible carrier (mineral spirits) from the aliphatic hydrocarbon classification of solvents, a dry solvent compatible pairing agent and a masking agent that imparts a pleasant fragrance. Due to the intense heat encountered at the point of combustion, disinfecting cannot be claimed for a product such as this.

Recently, it has been discovered that dry solvent deodorants are excellent for direct spray applications to porous (odor trapping) unfinished wood surfaces, such as the interior of kitchen cabinets or the inside of furniture drawers. The technician should use caution here since the application of these products can darken the appearance of some wood surfaces, and on natural paneling this can generate costly complaints. Also, it may be mixed with oil-based furniture polishes (mixed one part deodorant to three parts polish) to deodorize and impart a pleasant fragrance to finished wood surfaces, especially kitchen cabinets and finished paneling surfaces. As with any polish, even applications should be made cautiously to avoid oily streaks. Book covers may also be lightly polished and deodorized in this manner following cleaning.

F. DISINFECTANT: Preferably, this will be an EPA-registered product with a quaternary ammonium chloride base, and ideally a pleasant fragrance will be added. Its primary purpose is to destroy odor producing fungal and bacterial growths. It is specifically effective in bacterial odor and water damage situations such as:

1. The disinfectant is most effective in light to moderate dog and cat *urine* odor situations. As will be brought out later, the extent and age of the contamination has a direct bearing on the result achieved. Also, the area of contamination must

be specifically defined and a saturation treatment (often two or more) must be made. For extreme protein odor situations, the disinfectant may fall short of the result achieved with enzyme deodorants. However, since the disinfectant is far less expensive to use than its enzyme counterpart, it may be the only practical treatment to use when overall contamination is present.

2. Again, due to cost and coverage considerations, the disinfectant is the only practical product to use in preventing or arresting mildew growth in **water damage** restoration situations.
3. The disinfectant is used effectively for area decontamination and fabric sanitization in severe *trauma* situations such as vandalism, accidents, murders or suicides. It should be spray applied generously over the areas where workers may be exposed to germs and bacteria, as a preparatory step for their health and safety.
4. The "phenolic coefficient" of a disinfectant simply compares that products effectiveness with carbolic acid, or phenol. It does not imply that the product contains phenol.

G. SANITIZER: Using chemicals that *control odor-causing microorganisms (germs, bacteria and fungi). Sanitizers* merely clean surfaces to a healthful state for human use as judged by public health officials. They do not have the broad spectrum kill capability of a disinfectant. Fragrance may be included in sanitizers. You should always follow label directions when using these products. Examples of disinfectants and sanitizers include:

a. oxidizing bleaches (3% hydrogen peroxide, 1% sodium hypochlorite; a bactericide or *fungicide).* Chlorine bleach can be dangerous as a disinfectant (corrodes metal, removes color from fibers, and dissolves protein (wool)
b. alcohols (ethyl or isopropyl)
c. iodophors (iodine)
d. aldehydes (formaldehyde, glutaraldehyde)
e. phenolics (carbolic acid)
f. quaternary ammonium chloride or "quat" (CATIONIC!)
g. *Persistent* antimicrobial products leave a residual or bonded chemical on fabrics or surfaces to prevent the growth of fungi or bacteria. Examples include Sylgard® (a modified quat) and UltraFresh® (tributyltin maleate).

H. ENZYME DEODORANT: This product is specifically suited to severe protein odor situations, such as milk spills, fish contamination, contamination by quantities of body fluids and, of course, heavy urine odor. Many cleaners have experimented with enzyme deodorants achieving a variety of results ranging from excellent to none at all. This is primarily due to their lack of knowledge of correct use and application procedures. There are several use considerations that must be observed if enzyme deodorants are to be effective:

1. The concentrated product must be shaken or stirred before use. Some settling of components is normal, and when the concentrate is poured or drawn from the container, some of the active ingredients may be lost unless a uniform distribution of these components is achieved by stirring.
2. As you probably are aware, bacteria grow prolifically, and enzymes are most active, at warm temperatures. Therefore, mixing should produce a use-solution temperature of from 80-120°f/27-49°c.
3. Neutral pH on the fabric is essential. Alkaline cleaners should not be used to preclean, unless they are rinsed very thoroughly, since a pH of 9 or above will destroy the enzyme deodorant. The pH range should be maintained between 6 and 8 (in the cleaning industry, that's neutral).
4. Rinse heavy protein contamination before treatment, using plain water or with a mild, neutral detergent solution. The reason is that one of the byproducts of bacteria feeding on protein is ammonia. When heavy concentrations of protein are encountered, the bacterial action may generate sufficiently high pH to kill enzymes before deodorization is achieved. Rinsing excess contaminants before applying enzymes will, for the most part, prevent this.
5. Never use enzyme digesters in conjunction with disinfectants or other antimicrobials. These other disinfectants, quite simply, destroy the bacteria producing the enzyme and the product becomes useless.
6. Completely saturate the fabric with the enzyme deodorant and allow it to remain moist at least four hours (preferably 6-12, or even overnight). In humid areas of the country, this is no problem; however, in more arid climates, you may need to cover the treated area with polyethylene plastic sheeting to inhibit evaporation while the digester does its job. Be sure the fabric being treated is colorfast.
7. Enzyme deodorants are practically ineffective at temperatures below 60°f/16°c. In colder climates, therefore, make an effort must to maintain slightly elevated temperatures during the treatment period.
8. Treatment should be followed by thorough, overall cleaning of the fabric.

One final question should be addressed. What effect will protein digesters have on the protein fiber, wool? Manufacturers of drain cleaners have tried for years to produce a safe enzyme compound that would work on hair clogs, but to no avail. Wool is a very tough fiber and is affected little, if any, by enzyme deodorants. Of far greater consequence is the effect of the high pH levels caused by the ammonia generated by urine bacteria, which result in dye change and the potential for felting (weakening) of the wool fiber.

The bottom line is that, in spite of your past successes or failures, enzyme deodorants do work with remarkable effectiveness when proper use-specifications are observed. They are, therefore, an indispensable weapon in our continuing battle with those inconsiderate dogs and cats who prey on poor, innocent cleaning contractors!

I. OZONE GAS: This powerful, electrically generated deodorizing agent is effective on any organic odor the professional technician is likely to encounter. Because of its extensive use, and the conditions under which it can be used safely, an entire chapter (Chapter V) is devoted to this subject.

J. SEALING COMPOUND: This product is normally some type of alcohol based, pigmented shellac that coats surfaces to encapsulate intense odor (e.g., scorched walls). Also, it is used to seal malodorous residue onto surfaces that are inaccessible to other cleaning and deodorizing techniques. For example, sealing and deodorizing compounds may be used to seal odor into unfinished surfaces in the attic and crawl space, and on exposed internal structural components (studs, joists) - basically anywhere appearance change is not a major consideration. Additionally, this process permanently attaches loose soot residue onto surfaces where it can do no harm.

K. SMOKED WOOD RESTORER: This is a specialty product used for cleaning, deodorizing and polishing severely smoke damaged, finished wood furniture. It consists of dry solvents to emulsify baked on, dried, oily residues; a detergent to further emulsify oily residues while suspending insoluble soils (carbon); a deodorant (fragrance plus pairing agents), and finally, a polish that is designed to replace the shine on the cleaned furniture.

A summary of the most essential chemicals used in deodorizing is included on the next page and may be used by technicians as a quick reference on product use. Specific product trade names may be written in the left hand margin beside the generic product description.

DEODORIZING CHEMICAL OPTIONS

NAME	USE SITUATION	TYPE
Deodorant Blocks, Gels, Oils	**"re-ordorizes"** an area on an air conveyance system	masking time-release
Deodorant Granules	**adsorbs** odor from air, or **absorbs** fluid contaminant	masking absorbing
General-purpose Deodorant	**additive** to wall and general cleaning compounds	masking pairing
Heavy-duty Deodorant	**direct-spray** application to charred wood or scorched wall surfaces; **wet fogging**	masking pairing
Dry Solvent-based Deodorant	**direct-spray** to porous wood, finished cabinets; **polish additive** for finished surfaces book covers, etc.; **thermal fogging;** additive for dry solvent cleaners.	masking pairing
*EPA-Registered Disinfectant	**kills** microorganism odors, germs, mildew (water damage), light urine, body, etc.	masking disinfecting
Carpet Sanitizer	**controls microorganisms** in water damage, urine or general odor on stain-resist carpet	masking sanitizing
Enzyme Deodorant	**digests** severe odor-causing, protein contamination: fish, blood, milk, egg. and body discharge. severe urine, etc.	masking digesting
Ozone Gas	**oxidizes** severe odor; used on moisture sensitive fabrics and in severe chemical allergy situations	oxidizing
Smoke Sealer	Encapsulates severe odor on scorched or highly contaminants surfaces or in difficult-to-reach areas (attics, crawlspaces)	masking pairing sealing

Comprehension Quiz: IV - Professional Chemical Options

1. No single system of deodorizing is ______under all circumstances.
2. The __________ of odor, its __________, ___________ causing penetration and the __________permeated, all combine to determine the chemicals and equipment required for optimum deodorizing results.
3. Deodorant blocks are also called ___________ - __________ deodorants.
4. Solid deodorant blocks are, for the most part, classified as __________ agents or fragrances.
5. Fragrances are used to attack ______________ odor.
6. Odor absorbing granules are used to soak up (absorb) liquid contaminant, while erecting a deodorant __________ at the source.
7. Activated charcoal may be included in absorbing granules, which work on the principle of _________.
8. A general purpose deodorant is designed to be mixed with ________compounds, for direct application to walls, furnishings and fixtures.
9. A pleasant but __________ fragrance is recommended in general purpose deodorants, in order to minimize customer complaints.
10. Heavy-duty deodorants are designed primarily for _______ _________applications and for wet _________.
11. Heavy-duty deodorants are designed to ___________ or ___________ odor in the initial stages of deodorization.
12. Dry solvent-based deodorants may be used as an ___________ to _________ compounds used in drapery cleaning.
13. Dry solvent-based deodorants are __________ and are used primarily in ______ ______ fogging equipment.
14. Direct application of solvent-based deodorant can __________ wood surfaces.
15. Dry solvent-based deodorants may be mixed with oil-based _______ ________in order to deodorize wood furniture more effectively.
16. The purpose of a disinfectant is to kill or control ___________ that cause odor.
17. Disinfectants are used primarily in _________ odor contamination situations, in

___________ - _________ restoration situations and in _______ situations involving unsanitary protein materials.

18. Enzyme deodorants must be thoroughly ____________ prior to use.

19. The best temperature range for enzyme deodorants is _________ to _____ °f/°c.

20. Enzyme deodorants require _________ pH.

21. The by-product of bacteria feeding on protein is ___________.

22. Never use enzyme deodorants in conjunction with _________ or other ______ ______ compounds.

23. Enzyme deodorants require at least _____________ hours to perform.

24. Smoked wood restorers contain _____ ________ to emulsify oils, ________ to suspend particle soil, _________ to attack odor and a __________.

V - ELECTRICALLY GENERATED DEODORIZATION

Electrically generated deodorizing involves the use of some type of electrically operated machine or device, which performs the deodorizing process. Electrically generated deodorizing may be achieved in at least two specific ways:

A. ELECTRONIC AIR CLEANERS: Electronic air purification systems achieve their air cleansing and deodorizing effect by filtering air through an electrically charged grid or scrubber. When larger airborne microorganisms (pollen, some fungi) pass through the electrically charged filtration system, they are, quite literally, burned up. Smaller microorganisms and VOCs may be filtered from air by fine mesh and activated charcoal filters or sorbents. The option to purchase and install such a system is usually in the hands of the structure owner and, therefore, is not commonly a technique used by professional deodorizing contractors.

However, with some of the "high efficiency particle air" (HEPA) filtration units used in HVAC restoration work, coupled with activated charcoal filters, deodorization technicians are able to achieve basically the same or greater extent of particle (99.97% of all particles down to 0.3 microns) and odor removal. Unfortunately, this procedure concentrates on airborne odor only and does nothing to remove the odor at its source. On the other hand, it may be desirable for removing particulates in fire restoration claims that may cause respiratory hazards during cleaning and deodorization procedures.

B. OZONE GENERATION: Ozone is an unstable combination of three atoms of oxygen. It is formed by exciting *molecular* oxygen (O_2) into *atomic* oxygen (O, or single atoms) in an energized environment that allows the recombining of three oxygen atoms to form ozone (O_3). At ambient temperatures, ozone is a blue colored gas, but at the concentrations generated for deodorization purposes, color is not apparent.

Ozone is produced by nature in two ways. First, and most commonly known by the average person today, is the production of ozone in the upper atmosphere by ultraviolet rays from the sun. As sunlight enters the upper atmosphere and encounters oxygen molecules (O_2), the ultraviolet end of the light spectrum excites and disassociates them into individual atoms. Those free atoms of oxygen then recombine forming a three-part oxygen molecule - ozone! In turn, the ozone layer dissipates approximately 80% of the ultraviolet rays coming from the sun, which function prevents sunburn, skin cancer and even blindness in humans.

Is it any wonder that scientists are worried about ozone depletion caused by long-lasting, chlorofluorocarbon gases (e.g., Freon®) collecting in the upper atmosphere?

The second way in which ozone is produced in nature is by strong electrical charges passing through the atmosphere in close proximity to the earth. This electrical charge is called lightning. The same disassociation and recombination of oxygen atoms (revised 1994) occurs, which accounts for the fresh smell in the air following a thunderstorm. That's partly because the rain has "washed" the air of many particles, and partly because of the fresh fragrance of residual ozone.

The first recorded use of ozone by man was as a disinfectant for drinking water in the Netherlands in 1893. Today it is used for many purposes such as: in aquaculture for sea water purification stations, and for input water disinfection at freshwater hatcheries and fish farms; for disinfection of recycled water in large marine aquaria; for treatment of discharged water in fish disease labs; for treatment of cooling water in heating and cooling units to prevent the buildup of fungi, bacteria and algae slimes; for sterilization of ultra-pure water used in integrated circuit processing; for treatment of spent lubricants for recycling purposes; for sterilizing of high purity waters used in the pharmaceutical industry; and for preservation of meats, fruits and cut flowers during storage or shipment.

Generally, ozone is known to be a more effective bactericide, fungicide and virucide than chlorine compounds. In many European countries, ozone, rather than chlorine, is the primary agent for water purification. This applies to drinking water as well as to water used in pools and spas where human consumption or contact is anticipated.

Because of the instability of gaseous ozone, it cannot be generated and stored for later use. Consequently, ozone needs to be generated on-site for deodorization, disinfection and even sterilization purposes.

There are several types of ozone generators on the market today. Some use **ultraviolet radiation** above 2000 Angstroms in wavelength from unshielded fluorescent bulbs to produce ozone, as does the sun in the upper stratosphere. The majority use the **corona discharge** system as the means of ozone generation.

In corona discharge ozone generation, electricity, the intensity of which is controlled by a rheostat, is relayed to a transformer where a relatively low-voltage charge is transformed into a high-voltage charge. The high-voltage electricity then flows to one or more electrodes separated by an insulator. The unit produces ozone gas, O_3, by drawing molecules of dry air, O_2, through electrodes separated by a ceramic or glass plate. The electrodes, or conductors (usually screens), are charged with high voltage static electricity. The electricity's attempt to jump between wires comprising the metal screens results in "sparks" of electrical current passing over the entire surface of that grid, forming a blue "corona." When a fan draws air through the ozone generating unit, these sparks of static electricity excite the molecules of oxygen, O_2, causing them to disassociate into individual atoms of oxygen, (O). The disassociated atoms then recombine forming a three-part molecule - ozone! Production of ozone by these units is enhanced by cool temperatures, and since ozone is heavier than air, it collects at floor level.

Ozone effectively and permanently destroys odor through *oxidation.* When ozone comes in contact with an organic odor or odor-causing microorganism, the extra atom of oxygen is imparted and oxidation of the odor (chemical "burning" in layman's terms) takes place (see figure 4. 1). The result of the oxidation reaction is a little moisture (H_2O), a molecule of oxygen (O_2) and some nitrogen dioxide (NO_2), which accounts for a somewhat pungent smell that remains when ozone is used extensively on heavy organic odor situations for prolonged periods. If this pungent smell is a problem, it may be eliminated by light area fogging of a compound containing fragrance and chemical pairing agents.

oxygen molecules (air)	static electricity generated by ozone unit	oxygen molecule split into 2 atoms	oxygen atom and other oxygen molecule combine to form ozone	ozone contacts odor	odor oxidized (destroyed) by extra oxygen atom

Figure 4.1- Ozone Oxidation Illustrated

The advantage of ozone gas is that it is clear and colorless (in use concentrations), has relatively little residual odor, although concentrations above 1.0 ppm may produce a sulfur-like odor. It is quite inexpensive to use after the initial equipment investment. Limitations include the need to use ozone in minimally occupied areas, since high concentrations result in respiratory irritation. Also, its ability to oxidize latex and to combine with moisture to form a bleach (hydrogen peroxide) that might discolor some damp fabrics after prolonged exposure in high concentrations (above 1.5 ppm), must be anticipated.

Much controversy has surrounded ozone generators since they were first introduced to the deodorizing profession for widespread use in the late sixties. As you would imagine, much of the controversy came from chemical manufacturers who saw ozone deodorization as a replacement, rather than a supplement, to chemical deodorization techniques. The fact that ozone even survived its critics is a tribute to its effectiveness as a valid deodorizing technique. Those who experimented with ozone in the early days were simply amazed at its ability to remove odor quickly and efficiently, especially when delicate or moisture sensitive fabrics (clothing, draperies, etc.) and surfaces (unfinished wood, canvas paintings, paper goods, etc.) were involved.

Today the tables are turned, and many ozone equipment manufacturers would suggest that ozone generation is the only system required. Again, we must realize that, in heavy or persistent odor situations, combining chemical deodorizing techniques and systems with ozone generation is essential for fast, effective and permanent deodorization. And today, the ozone generator has become the most essential and frequently used tool of the professional deodorizing technician.

There has been much confusion surrounding the use of ozone gas, particularly with regard to ozone toxicity. The American Council of Governmental Industrial Hygienists (ACGIH) and the Environmental Protection Agency (EPA) have determined that the Threshold Limit Value - Time Weighted Average (TLV-TWA - a safe level of ozone exposure for an eight-hour day, forty hours per week) is 0.1 (one-tenth) parts per million (ppm) of air volume (0.04 ppm, Canadian). E.R. Plunkett, in his **Handbook of Industrial Toxicology,** specifies a maximum eight-hour exposure level of 0.1-0.2 ppm. Since the concentration of ozone required for deodorization and for fungus and mildew inhibition is 0.3-1.5 ppm, it is obvious that in most cases ozone deodorization procedures will exceed the EPA's TLV-TWA when prolonged exposure is anticipated. For this reason it must be used in unoccupied, controlled access areas only.

Now, before you excitedly condemn ozone gas, one of our most effective deodorizing tools, several other pertinent points should be made. First, during thermal inversions coupled with smog in many metropolitan areas of the world, peak ozone pollution has been measured at levels higher than one (1.0) ppm for several days. In Los Angeles, a city famous for its smog, studies indicate that ozone levels on days without smog frequently peak at levels between 0.05 and 0.3 ppm. On days with smog, those peaks have been recorded at levels between 0.2 to 0.65 ppm. While ozone is not contained in automotive exhaust, it arises from a reaction between smog, sunlight and oxygen - a photochemical production process.

Why even in areas of relatively pure air, such as mountain tops in the Swiss Alps, ozone peaks ranging from 0.45 to 1.09 ppm have been recorded. Of course, these readings are associated with intense UV bombardment, coupled with cool air and an already "thin" atmosphere.

In 1984, the U.S. EPA recorded ozone peak levels in major cities in the U.S. The highest one hour reading in these cities was as follows:

City

Boston, Massachusetts

Houston, Texas

Long Beach, California

Anaheim, California	**Ozone Concentration**
Newark, New Jersey	0.15 ppm
New York City, New York	0.21 ppm
Phoenix, Arizona	0.29 ppm
	0.26 ppm
	0.14 ppm
	0.17 ppm
	0.15 ppm

For the 20 cities in the complete listing, the lowest value recorded was 0.14 ppm. The total population exposed to those peaks was in excess of 40 million people. Thus you can see that a large portion of the U.S. population experiences ozone peaks well in excess of the EPA's TLV-TWA of 0.1 ppm. Now remember, these exposures are for fairly brief periods and the TLV-TWA implies exposure for 8 hours per day, 40 hours per week. The TLV-STEL (short term exposure limit) of 0.3 ppm is another matter entirely.

The only people adversely affected in the short run during periods of peak ozone readings are those with preexisting respiratory conditions (asthmatics, smokers, etc.).

In Canada, the TLV-TWA for ozone exposure is 0.04 ppm, less than half that of the U.S. In 1985, Environment Canada recorded the following mean annual ozone concentration levels for various cities:

City	**Ozone Concentration**
Vancouver, British Columbia	0.011 ppm
Edmonton, Alberta	0.015 ppm
Calgary, Alberta	0.023 ppm
Regina, Saskatchewan	0.027 ppm
Winnipeg, Manitoba	0.023 ppm
Toronto, Ontario	0.014 ppm
Ottawa, Ontario	0.019 ppm
Quebec City, Quebec	0.026 ppm

The above discussion on natural ozone concentration levels is provided to emphasize that current levels of ozone generation for preservation purposes generally fall below the TLV-TWA of 0.04 set by Canadian government agencies. Indoors, ozone levels are always less, because ozone reacts with organic compounds more rapidly in an enclosed environment. Even most continuous odor control, and warehouse mildew suppression applications are below the thresholds established for normal work week exposure. And, while levels produced for deodorization of heavy malodors exceed these TLVs, at that point professional technicians assure that ozone generation occurs only in unoccupied areas.

Also, when considering ozone toxicity, realize that ozone is heavier than air and, therefore, tends to build in concentrations at the floor level first. Without air circulation some time is required to create a toxic situation at head level in an average room. Likewise, the larger the area being deodorized, the less likely an ozone toxicity situation will be. Third, ozone is extremely reactive and, therefore, unstable. This is particularly true in hot, humid weather. For this reason, extreme-toxicity situations are unlikely to be encountered unless cool, dry conditions exist. Of course, these conditions present our best opportunity for deodorization using ozone gas.

Note that ozone dissipates rapidly. Once an ozone generator is turned off and a room is aired out, within 10-15 minutes, it is safe to occupy again.

The "bottom line" is that ozone, like many highly effective chemical products available to professionals, must be used properly if it is to be used safely. Just as you should never leave chemicals within reach of children; just as you would never think of; drinking a deodorizing chemical, or fogging in a confined area where people or animals are present; so also, ozone gas should be used with the same common-sense precautions. ***Since ozone toxicity levels are impossible for you to measure in the field, your best course of action is to use this highly effective tool in unoccupied areas only!*** In that way, the question of ozone toxicity never arises.

A chart showing the maximum allowable concentrations of ozone, as established by the American Council of Governmental Industrial Hygienists, is found on page 68 (Chart 4). Without expensive and highly technical measuring equipment, it is impossible for the deodorizing contractor to determine the exact concentration of ozone gas being generated in a given area. For this reason, Chart 4 is only of value in showing approximate relationships that exist between ozone concentrations, exposure time, and toxicity.

Now, let's summarize this discussion of ozone with a listing of its advantages and precautions.

1. Advantages of ozone gas:

a. Ozone, as already mentioned, may very well be the only deodorizing procedure useable when the structure's occupants suffer from severe chemical sensitivity brought on by allergies. Almost all chemicals used in deodorizing, masking agents included, will leave some residue in the air or on surfaces for a period of time (several hours to several days). This, in turn, can produce severe reactions from those who are highly sensitive to these chemicals. Ozone, on the other hand, dissipates completely within minutes (the crisp smell left in the air is usually attributed to the absence of normal odors) and leaves no lingering residue to upset sensitive persons.

b. Also, when customers complain about objectionably strong fragrances left by some deodorizing chemicals, ozone may be used to correct that situation within a matter of hours.

c. It's difficult for most technicians, no matter how experienced, to remember past problems with moisture sensitive surfaces and fabrics before ozone was available. Clothing, draperies, books, paintings and unfinished wood, in particular, were a continuous problem. Now, ozone has all but eliminated their deodorization difficulties. Often, a confined chamber is required for intense deodorization of these and other items. A diagram of an ozone chamber is provided at the end of Chapter XII.

d. Because ozone gas employs the principle of oxidation, once the odor is gone, that result is permanent. This is particularly important in situations involving intense fire odors and large areas. Ozone deodorization may take a little longer; however, in the hands of professional deodorization technicians, the result is worth the effort.

e. Similarly, in water damage situations involving odor generated by microorganisms growing on unfinished wood in basements, or on interior wall wood, insulation or drywall, ozone may be the only agent available that can penetrate into complex structural surfaces, seek out and destroy odor producing microorganisms at their source. In low concentrations ozone can control the germination of mold and mildew spores while drying takes place.

f. Other than the initial investment, there's very little cost involved in operating RainbowAir® ozone units, and maintenance involves only periodic cleaning of metal screens and ceramic insulators.

g. Ozone works on a molecular basis. This means that, with proper encouragement (air thrust), it can penetrate into minute cracks and crevices that may be impenetrable by chemical deodorants. For example, recent EPA recommendations have all but eliminated the use of chemical products, sealer/deodorizers, in air duct systems - particularly when HVAC systems have internal insulation/sound liners. In moderate-to-severe fire losses with intense odor in the HVAC ductwork, non-residual ozone gas may be the only agent available to deodorize and decontaminate that ductwork.

2. **Limitations:** As we have seen, ozone gas is probably one of the safest, most effective of the deodorizing alternatives the professional technician has available. However, in the hands of amateurs or uneducated operators, hazards abound! Thus, there are a few precautions (most of which have been covered) that should be emphasized in summary:

a. You should avoid using ozone in a high humidity environment when bleachsensitive fabrics or surfaces are present. As we've seen, ozone reacts with moisture to create hydrogen peroxide ($O_3 + H_2O = H_2O_2$ and O_2). Eventually, bleaching of fabrics or other materials may occur.

b. Ozone oxidizes natural rubber (latex) products. Where this possibility exists, and where practical, a light coating of a dry silicone lubricant will provide protection during deodorizing. This oxidation process takes time, but caution should be exercised with elastic in clothing, with tires in (not on) automobiles and with any other component you suspect may contain (or being made of) natural rubber. Note that very few appliances have any natural rubber in gaskets or seals anymore. Most are plastic and are unaffected by ozone exposure.

c. Ozone is an irritant. Concentrations of 1.0 ppm produce a sulfur-like odor and may cause headache, and irritation of the eyes and upper respiratory tract. These symptoms disappear shortly after leaving the exposure area. Therefore, ozone should only be used in unoccupied areas, or in areas completely sealed off from occupied portions of a structure. Effort must be made to avoid recirculating of ozone through air returns in occupied buildings where confined area deodorizing is being accomplished; i.e., seal of returns with plastic or turn off the system. Additionally, warning signs should be placed on all entrances to areas where ozone is being used. The ultimate health hazard that's created is called *pulmonary edema.* This condition is caused by exposing individuals to ozone in high concentrations for prolonged periods (hours or days). Eventually the ozone oxidizes (burns) the alveoli, or air absorbing sacs, in the lungs. Theoretically, the lungs fill with fluids and respiratory irritation, congestion, and ultimately respiratory failure could result.

To suggest that someone would voluntarily remain in an environment where this condition is a possibility is extremely unlikely. Coughing, sneezing, severe eye imitation, nose bleeding: all are precursors of irreparable ozone toxicity. In other words, these symptoms provide plenty of advanced warning. Small children, with developing respiratory systems and body organs, are particularly sensitive. Moreover, they are unable to articulate their symptoms. Obviously, extra caution is advised.

Professional technicians never should expose themselves or others to concentrations of ozone exceeding 0.04 ppm. If you can smell it in the air, you are well above that level. Ozone gas at any concentration has never been responsible for an accidental fatality in more than 80 years of industrial use. No systemic effects have been reported following industrial exposures. It is unlikely that any other commonly used industrial chemical, including water, has as excellent a safety record!

d. Along with the above, consider that plants are eventually subject to the toxic effect of ozone gas. Therefore, to be perfectly safe, you should clear the area of small, exotic or delicate plants or pets before beginning ozone deodorization. Larger plants usually experience no ill effect even when exposed to fairly high concentrations for several days. However, when in doubt remove them from the area.

C. RAINBOWAIR®, THE PRODUCT:

1. **RainbowAir® Activator 500** was designed for small environments and medium odor control applications. It's maximum ozone output (471 mg/hr), utilizing two generator plates, is approximately one half that of the RainbowAir® Activator 1000. Boardrooms, hotel/motel rooms, nursing homes, offices, and restrooms are a few typical areas for use. Depending upon the room configuration, air flow of the area, and type odor to be treated, 15,000 cubic feet is approximately the RainbowAir® Activator 500's capacity. The 0-60 minute electronic timer allows the user to set the desired time for treatment. The timer shuts itself off.
2. **RainbowAir® Activator 1000** has been successful in areas of 50,000 cubic feet. It's fan speed and ozone production capabilities (1000 mg/hr - 1 gram) is ideal for apartments, hotels/motels, rental cars, property management, school board facilities, and garbage collection areas. The RainbowAir® Activator 1000 has the same quality features as the Activator 500 except that ozone production is twice the output and is equipped with a 0-24 hour timer with optional continuous operation. The Activator 1000 is equipped with four generator plates which are washable and easy to replace.
3. **RainbowAir® Activator 2000** is user designed and is tough, whether the job is fire and smoke restoration or deodorizing clothing or furniture. In a deodorizing room, the RainbowAir® Activator 2000 is the one to get the job done. There are no "masking odors," chemicals, perfumes, or fragrances introduced into the air. Odors caused by fire and smoke damage, garbage waste, sewage gases, protein odors, and decaying organic matter are completely eliminated. In a short time, the ozone returns to its normal oxygen form. The Activator 2000 is equipped with the same quality features found on the Activator 1000, with six ozone generator plates. The Activator 2000 is equipped to treat an area of up to 60,000 cubic feet depending on the type of odor, humidity, temperature, and air flow within the area being treated.
4. **RainbowAir® Activator 4500** - Rainbow Technology designed and engineered the RainbowAir® Activator 4500 to meet the every day, heavy duty, demanding

standards of cleaning and restoration professionals. Features designed for the professionals include: 240 cfm fan for greater ozone distribution, lapse time meter for keeping a time log for each job, auxiliary power supply for plugging two air movers into the Activator 4500, service light, power applied light, 10" semi-pneumatic tires, handle assembly, and safety switch.

The Activator 4500 is capable of producing up to 4500 milligrams per hour (4.5 grams) for those large areas and tough odor problems. Treatment up to 135,000 cubic feet can be achieved depending on the odor problem, humidity, air temperature, and the use of auxiliary fans. The Activator 4500 is the ideal choice when designing or using a deodorizing room.

Comprehension Quiz: V - Electrically Generated Deodorization

1. "HEPA" stands for __________ __________ __________ __________.
2. HEPA filtration implies the removal of __________% of all particles down to ________ microns in size.
3. Ozone is a combination of _____________ atoms of oxygen.
4. Ozone is formed when ___________________ oxygen is excited in an electrified environment, causing it to divide into _________ oxygen, and then recombine into a three atom _____________.
5. Ozone is formed in nature by radiation, and during thunderstorms by _____.

6. Without the ozone layer, human beings would suffer from _________ ______ and even ________.
7. The first use of ozone was to purify __________ __________.
8. The major way that ozone is generated is by the _____ ________ system.
9. Ozone destroys odor through a process called __________.
10. The chief advantage of ozone is its ability to remove odor from __________ or ___________ __________ fabrics and surfaces.
11. TLV stands for _____ __________ __________ and is a way of expressing _ ________ levels for chemicals in the air.
12. TWA stands for __________ ________ __________ and implies inhalation of a substance ___________ per day, ___________ hours per week.
13. The TLV-TWA of ozone gas as determined by government agencies is _____ ________ ppm.
14. STEL stands for ________ ________ ________ ________ and is the amount of a material than be breathed for short durations (generally, 15 minutes).
15. The TWA-STEL of ozone is ___________ ppm.
16. When an ozone generator is turned off and a room is opened and ventilated, it is safe to occupy in __________ minutes.
17. Ozone is ________ than air and tends to collect at _________ level.
18. Unlike some chemical deodorants, ozone gas leaves no __________.
19. Ozone is particularly effective in removing smoke odor from ________ systems with internal sound/insulation liners.
20. Maintenance of ozone generators is usually confined to periodic cleaning of metal __________ or ___________, and glass or ceramic _________.
21. When ozone combines with moisture it creates _________ __________.
22. From a health standpoint, ozone primarily is a __________ __________.
23. On unoccupied water damage claims with durable colorfast materials, ozone can be used effectively and safely to control the growth of ________.
24. In time ozone can oxidize _____________, __________ often found in clothing.
25. Today, most appliance gaskets are made of __________.

VI - BASIC EQUIPMENT OPTIONS

There are many types and variations of equipment used in deodorizing. Our purpose in this section is to enumerate some of the various types along with their respective use considerations. This discussion is, by no means, exhaustive; technicians are encouraged to consult equipment manufacturers for specific use considerations, particularly as they relate to safety. Safety precautions cannot be overemphasized, since virtually all of the equipment types discussed may involve some type of toxicity, respiratory or combustion problem, if improperly used.

As equipment has developed over the years, the primary effort has always been to come up with a machine that would produce a deodorant particle capable of penetrating anywhere the malodor penetrated, combining with that malodor, and neutralizing it. Since, as we have observed, odor particles come in microscopic and even molecular sizes, the advantage has always been on the side of the malodor. If you'll take a quick look at Chart 3 at page 68, you'll have an idea of why particle size is so important; it's a matter of malodor penetration versus deodorant penetration.

Now, let's take a look at the generic categories of deodorant safety/dispersing/-generating equipment:

A. SAFETY EQUIPMENT - Several items of safety equipment should be used when using any deodorant dispersion system that creates a fog or gas.

1. Respirators are required anytime a fog or gas is dispersed into the air a technician or customer will be breathing. A quality respirator will have replaceable, activated charcoal filters that remove virtually all deodorant vapors (wet or dry), as well as malodors, from the air the technician breathes.
2. Chemical resistant gloves should be worn when applying deodorant chemicals, especially disinfectants.
3. Eye protection should be worn when dispensing chemicals, especially those that might destroy useful bacteria on the eye.
4. Protective clothing (skin protection) should be considered when appropriate. This might include situations in which solvent-based fogs are being

dispensed.

B. SYRINGE AND NEEDLE: This is an inexpensive tool used to inject relatively small quantities of deodorant into confined areas on carpet and upholstery, especially where access to the backing and cushion isn't practical. For larger spots, or for a large quantity of spots, a trigger pump canister and injection syringe speeds up application of deodorants to malodor spots. This device has a plastic canister that contains a larger quantity of deodorant than does the syringe. It facilitates treating multiple, confined spots in carpet or upholstered fabrics, where access to backing and cushion materials isn't practical. Similarly, a trigger sprayer with a standard diffuser may be used to direct-spray deodorant onto relatively confined sources of contamination.

C. HAND PUMP SPRAYER (stainless steel or molded polyethylene): This pump sprayer should allow chemicals to be dispensed at 30-50 psi, and it is used primarily to make direct-spray applications to:

1. the sources of contamination or heavy char
2. fabrics (especially carpet)
3. exposed structural components in heavy fire-loss situations where moisture damage is unlikely and discoloration is of little consequence

D. SMOKE EJECTOR (carpet dryer): This unit is a high-powered, turbine fan. It is used to eject smoke, gases or other forms of contamination from structures. Its use results in rapid reduction of odor, flammable fumes, or other airborne contaminants.

E. POWER BLOWER: This is a high-velocity, air-propulsion unit that is designed to remove powdery, malodorous residue (soot) from surfaces (particularly fabrics). Obviously, it is used primarily outside the home, since blowers used inside the structure merely redistribute contamination!

A hand-held power blower with a flexible extension hose (see Figure 3 at the end of this chapter), along with a small thermal fogger may be used to provide additional diffusion and propulsion for dry solvent based deodorants injected into wall cavities or other inaccessible areas. The booster effect provided by the power blower pressurized an entire wall to effectively deodorize odor contaminated insulation or wall studs, without tearing out Sheetrock®. Similarly, it can be used to inject deodorant under carpet, when the need arises, by inserting the hose under the carpet at a convenient corner or floor vent, and, after turning the blower on, lightly fogging a dry solvent-based deodorant into the intake of the blower.

F. DEODORANT DIFFUSER: This device consists of a metal or plastic box through which the air in a given room is circulated on a continuous basis. This circulation is accomplished using a low-volume fan. Deodorization of that air takes place through one of two basic methods, depending on the construction of the unit. First, the air may be drawn through an electrostatic grid that removes contaminants through electrostatic combustion; or an activated charcoal filter may be used to remove contaminants by adsorption. In the second phase, deodorant blocks, chemical canisters, or even specially constructed capsules may provide pairing agents, combined with pleasant fragrances. They are released in vapor form over a prolonged period as the air is circulated through the diffuser box.

The deodorant diffuser, in its more elaborate form that combines active filtration with pairing agent diffusion, works well in air space deodorizing (see Figure 4). However, it must be supplemented considerably for complete deodorization of contents or severely contaminated structural components.

The chief advantage of the deodorant diffuser lies in the fact that it continues to provide prolonged filtration and "re-odorization" of the air in a structure with minimum labor.

Disadvantages include the prolonged periods of filtration and re-odorization that may be required. In addition, ongoing cleaning and/or replacement of filters and deodorant canisters may be somewhat expensive.

G. STANDARD WET FOGGER: Various types of single- or tri-jet foggers have been available to the cleaning industry for many years (see Figure 5 at the end of this chapter). Used basically for fogging water-based compounds, the standard wet fogger produces a mass median diameter (MMD) droplet in the twenty-micron (one micron equals 1/1,000,000 of a meter) range. Since many fire generated odors and gases are of a far smaller size (four micron MMD), it eventually became apparent that our original equipment was inadequate to produce deodorant particles that were small enough to reach the far smaller malodor particles in the various surfaces they would permeate (again, refer to Chart 3, page 68).

The first of these wet foggers had an aluminum housing and three jets for deodorant diffusion (hence the name tri-jet). It incorporated a motor almost exactly like those used in small vacuum units, only in reverse cycle (it blows instead of sucking). The forced air generated by the motor of wet foggers blows across the tip of a tube, the other end of which is immersed in the deodorant solution tank. The venturi effect (slight vacuum, or negative air pressure) created on the outlet end of the tube literally sucks the deodorant out of the holding tank to the outlet end of the suction tube. There, tiny droplets are atomized by the turbulence created by the high volume air blast, and thus a heavy fog of deodorant (20 micron MMD) is produced.

Of course, single-jet wet Loggers operate in the same manner, only a single jet can be mounted on the end of a much longer "neck." This allows the operator to direct the fog produced into confined areas (attics, crawlspaces, wall cavities, ductwork) where the tri-jet's diffusion system is too large to reach.

The chief advantage of the standard wet Logger is the large volume (and droplet size) it produces. It rapidly coats surfaces, especially rough structural surfaces (studs, joists, roof decking), during the initial stages of severe fire deodorization.

On the other hand, any chemical dispensed into the air is a respiratory irritant and this is the case with wet foggers. Of course, the major advantage of the wet fogger is also the biggest drawback: that being the size of the deodorant droplet produced. As mentioned earlier, the average smoke odor particle (the only one that's been accurately measured) has an average size of 0.1-4.0 microns MMD. Obviously, that particle can penetrate into surfaces (especially with thermal expansion considered) to an extent that a 20-micron deodorant particle produced by a wet fogger cannot. Therefore, it simply takes a very long time to get results.

To make matters worse, a droplet of the size generated by standard wet foggers can often settle on furniture surfaces, become emulsified with old finish or waxes, and cause the furniture to turn completely white - an absolute heart stopper! Fortunately, with evaporation, the furniture usually returns to its normal appearance - that is, *usually . . .* Highly absorptive surfaces (paper, books, wall paper, etc.) are never that forgiving and always require extreme care.

H. ULV FOGGER (Ultra Low Volume): Because of the problems with standard wet foggers, Ultra Low Volume, or ULV, foggers (see Figure 6 at the end of this chapter) were developed that could generate deodorant particles with a MMD of approximately 8-15 microns (again, see Chart 3, page 68). These foggers are more effective in the deodorizing function, due to the smaller particle's ability to penetrate into more places where odor hides. They also tend to use less deodorant, while running less risk of moisture damage to furnishings and structural components.

Wet foggers (particularly ULV's) are still used effectively for general, air space deodorizing; for the introduction of sanitizers (Oxine®.) in some ductwork restoration work, and for rapid general application of sealers or deodorants onto multiple surfaces or large areas.

I. THERMAL FOGGER: This equipment (see Figure 7 at the end of this chapter) is designed to produce a super heated coil or flame, into which a combustible, dry solvent-based deodorant is introduced. The heat causes the dry solvent to combust, thus breaking down the emulsified deodorant into a mass median diameter (MMD) particle in the range of approximately one-half (hi) micron. The idea is to produce many billions of deodorant particles that are able to go anywhere the malodor has gone, to pair with that malodor, and ultimately to neutralize it by changing the malodor's chemical composition (check Chart 3, page 68 again).

Like any other system, this one has its advantages and disadvantages. Let's consider some; however, don't think that this discussion is all inclusive. Always read the instructions that come with your machine, and follow all recommended safety and use precautions.

1. **Advantages:**

   a. It's impressive as the dickens! Positive customer (adjuster) impression is maximized due to the appearance of the equipment and the amount of fog generated. Ghostbusters, here we come!

   b. It's fast. We're talking "mega-volumes" of deodorant fog in seconds! You'll spend far more time preparing to fog a house, than in the actual fogging procedure.

   c. Third, it's effective. Because of the small deodorant particle produced (½ micron), it can seek out most odors regardless of where they hide.

   d. Fourth, deodorization is relatively rapid (within hours), due to the quantity, size and distribution of the deodorant particles generated (refer again to Chart 3 at page 68).

   e. Because a relatively small quantity of material is used, residues are rarely encountered, unless fogging is accomplished during periods of high humidity; i.e., just after carpet cleaning or during wet weather. If an extremely dense fog is generated in a confined area, some fall-out residue is to be expected. Proper fogging generates a haze throughout the room, but not enough so that "you can't see your hand in front of your face." If a properly formulated chemical is used, any minor residues that are encountered should evaporate completely within a few hours; or they may be wiped away easily with dry, absorbent, lint-free towels.

f. Finally, since only a dry-solvent compound is used, no additional moisture or humidity is created that might reactivate malodor or adversely affect moisture-sensitive surfaces. Few, if any, surfaces are harmed by minor residues from the solvent-based product used in this procedure.

2. **Limitations:**

a. Probably the most obvious of the precautions to be observed during thermal fogging involves flammability. This is a primary consideration when storing combustible deodorants in vans having auxiliary power or heating units, which might generate temperatures exceeding the flashpoint (vapor ignition temperature) of the solvent.

Inside the structure, absolutely no open flames from pilot lights on gas water heaters, gas stoves, or any other appliances, should be exposed to thermal fog. This applies to electrical strip heaters as well. Also, remember that dry solvent deodorants are highly effective in neutralizing the odor associated with natural gas. Therefore, precautions should be taken to ensure that absolutely no gas leaks (pilots included) are allowed during thermal fogging procedures. The ultimate in safety may even involve temporarily turning off all electricity to the structure.

b. Next, certain preparatory procedures must be considered. Of course, the local fire department should be notified when heavy thermal-fogging operations are under way in an area where neighbors or other building occupants might mistake your fog for smoke, and call the fire department themselves. Even with the fire department notified, it's a good idea to make your presence known by parking your vehicle in front of the structure, maybe even spending a little time standing around out there yourself.

In this connection, household fire alarms must be deactivated during fogging for obvious reasons. When you are unable to disconnect the power to a built-in smoke detection device, you may use a plastic bag carefully tucked in all around the alarm to prevent your deodorant fog from activating it while deodorization is underway. It's always a good idea to ask how elaborate a fire/burglar alarm system is. Once it's activated, the fire trucks will roll!

c. As with any chemical fog, thermal fogging compounds are respiratory irritants. Obviously, people and animals should remain out of the structure during fogging operations and for a period of thirty minutes to an hour after aeration has taken place. Birds, in particular, must remain out of the structure until free of all airborne chemicals. The term "dead as a hammer" takes on new meaning when observing a bird subjected to any fogging procedure!

The health and safety of technicians must be considered. They must wear skin and respiratory protection when engaged in thermal (or wet) fogging. The activated charcoal in respirator filters protects delicate lung tissues, and remember, if you can smell the chemical with your mask on, the filters must be replaced.

Also, the technician must always back out of the structure into clear air. It's easy to get disoriented or lost in a dense fog bank of your own creation!

d. The question often arises as to how much fog is too much before a residue is created and secondary combustion is approached. This author knows of only one *documented* case in which secondary combustion was experienced (and yes, the technician survived to tell about it!). However, if this possibility exists (even if only remotely), that concentration of fog must be avoided at all costs. Here again, manufacturer use recommendations must be followed carefully. A far greater problem involves the dry solvent deodorant residues mentioned previously.

e. Overfogging by inexperienced technicians has created disastrous problems with oily residue. How much is too much? Again, if a room is fogged to the extent that ". . . you can't see your hand in front of your face!" you've probably exceeded safe concentrations in terms of theoretical combustion and residue. Therefore, a good rule of thumb is to cease fogging when the other side of the room becomes slightly obscured. Otherwise, the second cleaning of the entire house and contents becomes your responsibility!

As discussed previously, oily residue is a possibility in two circum stances: first, when the technician grossly overfogs the structure, residue can appear. Second, when the air is saturated with humidity (75-100% RH), it becomes extremely difficult to keep thermal fogging compound suspended. Therefore, only light fogging should be accomplished during periods of extremely high humidity.

f. Although this is probably the most impressive system we employ, you also should be aware that the lingering effect of the solvent vapor could create problems with homeowners who are extremely allergic to a variety of chemical compounds. If, in your initial discussions, the homeowner refers to an extreme sensitivity in this area, it may be wise to rely on ozone gas as a primary means of achieving deodorization.

g. Although thermal fog can be produced rapidly and in quantity, there may be a need for repeated tops for refogging when heavy matador residues are present. We don't have a miracle here; just a good, relatively fast, effective, deodorizing technique. For the most part, however, the problem of repeated trips can be overcome by careful planning and coordination with cleaning crews.

J. MINI-THERMAL FOGGER: This is a smaller version of the larger, motorized thermal fogger discussed above. It may be electrically operated or propane fired. It's used in confined-area or touch-up deodorizing (closets, single rooms, odor pockets) where speed of dispersion isn't critical (see Figure 8 at the end of this Chapter).

1. **The advantages of the mini-thermal fogger are:**
   - a. The unit is inexpensive in terms of initial cost.
   - b. It is easily transported to the job in any vehicle.
   - c. It's quite cost effective to operate - requires only pennies!

d. The mini-thermal fogger is extremely practical for small area or touch-up deodorizing, or for fogging a truck load of clothing or furnishings just prior to delivery.

e. Like its big brother, it won't damage moisture-sensitive fabrics or surfaces.

2. **There are, however a few disadvantages that should be noted:**

a. Basically, precautions for using the mini-thermal fogger are the same as those that apply to the larger thermal fogger, but with less probability of combustion or oily residue fall-out.

b. The mini-thermal fogger is not practical for commercial or large-area deodorizing.

K. OZONE GENERATOR: Since the advantages and limitations of ozone have been discussed extensively in Chapter V, page 48, the summary here will be abbreviated.

1. **Advantages of ozone gas:**

a. Ozone may very well be the only deodorizing procedure useable when the home's occupants suffer from severe chemical sensitivity brought on by allergies. Ozone, on the other hand, dissipates completely within minutes and leaves no lingering residue to upset sensitive persons.

b. When homeowners complain about objectionably strong fragrances left by some deodorizing chemicals, ozone may be used to correct that situation within a matter of minutes or hours.

c. Ozone eliminates the difficulties associated with deodorizing moisture sensitive surfaces and fabrics, such as clothing, draperies, books, paintings and unfinished wood.

d. Because ozone gas employs the principle of oxidation, once the odor is gone, that result is permanent.

e. Similarly, in water damage situations involving odor generated by microorganisms growing on unfinished wood in basements, or on interior wall wood, insulation or drywall, ozone may be the only agent available that can penetrate into complex structural surfaces, seek out and destroy odor producing microorganisms at their source.

f. Other than the initial investment, there's very little cost involved in operating RainbowAir® ozone units, and maintenance involves only periodic cleaning of metal screens and ceramic insulators.

g. Ozone works on a molecular basis. This means that, with proper encouragement (air thrust), it can penetrate into minute cracks and crevices that may be impenetrable by chemical deodorants.

2. **Limitations:** As we have seen, ozone gas is probably one of the safest, most effective of the deodorizing alternatives the professional technician has available. However, in the hands of amateurs or uneducated operators, hazards abound! Thus, there are a few precautions (most of which have been covered) that should be emphasized in summary:

a. Avoid using ozone in a high humidity environment when bleach-sensitive fabrics or surfaces are present.

b. Ozone oxidizes natural rubber (latex) products. Where this possibility exists, dry silicone lubricant will provide protection during deodorizing.

c. Ozone is a respiratory irritant. Therefore, it should only be used in unoccupied areas, or in areas completely sealed off from occupied portions of a structure. Additionally, warning signs should be placed on all entrances to areas where ozone is being used.

d. Along with the above, consider that plants are eventually subject to the toxic effect of ozone gas.

Chart 2, summarizing the basic equipment types available to professional deodorizing technicians, is found on the next page.

DEODORIZING EQUIPMENT SUMMARY

ITEM	Thermal	**USE**	deodorizi
Safety	Fogger	Respirator, gloves, protective	ng, dry-
Equipment		clothes, goggles, boots,	solvent
		hard hat, MSDS	deodoran
			t
Pump	Thermal	Direct-spray application	Fabric
Sprayer	Fogger		deodorizi
			ng
Smoker		Evacuation of smoke,	Hard
Ejector	RainbowAir	gas, contaminants	furniture
	Ozone		
Power	Unit	Blowing off contaminants;	Large
Blower		Deodorant injection	area
		into interior walls,	deodorizi
		confined airspaces	ng
			Fabric
Deodorant		Particle filtration	deodorizi
Diffuser		Odor adsorption	ng
			Hard
Wet		Airspace fogging,	furniture
Foggers		water-based deodorant	
			Large
			area
			deodorizi
ULV		Airspace fogging	ng
Fogger		of water-based deodorant	Fabric
			deodorizi
			ng
Mini-		Small airspace	Hard

furniture	MISUSE PRECAUTIONS		MMD
Allergy to chemicals	Failure to use is misuse!		
	Overwetting	Combustion Oily residue Respiratory irritant	
		Respiratory irritant Bleaching w/moisture Latex rubber oxidation	
	Redistribution of contaminants within structure		
	Water-sensitive surfaces, (wood, fabrics) Respiratory irritant Dripping of excess		20
	Water-sensitive surfaces, (wood, fabrics) Respiratory irritant		8-15
	Combustion Oily residue Respiratory irritants		2

MMD	0.5 4	20	20±	8	½	molecule atom
	Smoke Odor	Wet Fogger	Power Blower	ULV Fogger	Thermal Gas	Ozone

Chart 3 - DEODORANT PARTICLES AND PENETRATION (x 1000)

Exposure time in Minutes

Chart 4 - OZONE TOXICITY

The Threshold Limit Value (TLV) of ozone, as established by the American Council of Governmental Industrial Hygienists for He U.S. is 0.1 parts per million by vole (ppm/v: 0.04 ppm in Canada) for continuous occupational exposure (8-hour day, 40-hour week; 0.04 ppm Canadian). Higher concentrations are intolerable only for a limited time. Source: **Prolonged Ozone Inhalation and Its Effects On Visual Parameters; J.M. Langewerf, Aerospace Medicine**, June, 1963.

Figure 3 - Power Blower

Figure 4 - Deodorant Diffuser

Figure 5 - Wet Fogger

Figure 6 - ULV Foggers

Figure 7 - Thermal Fogger

Figure 8 - Mini-thermal Fogger

Figure 9 - Ozone Generator

Comprehension Quiz: VI - Basic Equipment Options

1. All types of equipment used in deodorizing may create _______, __________, or _______ problems if used improperly.
2. A primary consideration in equipment development has been to produce a deodorant _______ capable of penetrating into all areas where odor hides.
3. Standard (tri-jet) wet foggers reduce deodorants to approximately ____________ microns in droplet size.
4. Fire generated odors average ___________ to __________ microns MMD.
5. Moisture that settles on furniture finishes can form an ______________ that is ______________ in color.
6. ______________ products may be ruined by excessive wet fogging.
7. Wet foggers that produce an 8-15 micron droplet are known as ____________ ___________ __________ foggers.
8. The _______ ________ is a device used to force deodorant into interior walls.
9. Thermal foggers create a super-heated coil or _______________ into which a _________ __________ deodorant is injected.
10. Thermal Loggers produce a deodorant particle as small as ______ - ______ microns in size.
11. Thermal fogging compounds may be hazardous because they are _____________.

12. In houses with gas appliances, __________ __________ should be turned off before thermal fogging.

13. It's a good idea to notify the __________ _______ and to deactivate _____ _____ ______ before thermal fogging.

14. ___________ protection is essential during any fogging operation.

15. Theoretically, overfogging with dry solvent compounds could result in secondary ____________.

16. Overfogging may also result in __________ ________ that may require recleaning the entire structure and contents.

17. Prior to fogging, technicians should determine if occupants of a structure are extremely _________ sensitive.

18. Deodorant diffusers incorporate __________ to cleanse the air, while ____ _____ provide masking agents to "re-odorize."

19. Ozone gas is produced naturally by ________ or by ________ radiation from the sun.

20. Most ozone units employ a __________ screen or grid to produce ozone gas.

21. The maximum allowable concentration of ozone gas for continuous breathing is ____ _____ - ________ ppm.

22. Use ozone gas in __________ areas only.

23. Ozone combines with moisture to form ___________ __________.

24. Ozone will _________ __________ oxidize rapidly.

25. Live _________ eventually will succumb to the toxic effect of ozone gas.

STRUCTURAL

DEODORIZATION

VII - ANIMAL URINE

In this and following chapters, step-by-step procedural recommendations will be made for several types of deodorization situations. Of course, no book of this type can completely cover every situation that technicians might encounter; nor should this information be considered a valid substitute for good common sense and judgement. The intended use of the information is to serve as a guide, with modifications, additions or deletions being made as each situation dictates.

Perseverance is the key to achieving effective deodorization with the procedures that are to follow. Be confident in your chemicals, equipment and, above all, yourself. Stick with the job until you are sure all the odor has been completely eliminated.

A. ANIMAL URINE - THE BASICS! Animal urine probably makes more money for professional cleaning technicians than any other household problem. We're devoting an entire chapter to the subject because it is one of the most difficult problems to resolve, if technicians don't carefully analyze all its varied components.

Another reason a separate chapter is devoted to the subject is that most damage caused by domestic pets is not covered by insurance. Damage by wild animals probably is covered, however, only an insurance agent or adjuster is in position to make that determination. At any rate, most of the situations explained in later chapters are covered by insurance. The difference is that, while animal urine deodorizing situations will be handled by cleaning technicians, most other deodorizing will come through insurance companies and will be directed to restoration technicians.

Some basic facts regarding animal urine should be understood before launching in to detailed procedures:

1. **Urine Components** - First, what are the basic components? Animal urine consists primarily of water, yellow pigment, urea, uric acid, cholesterol, enzymes, and traces of other chemicals. The time these components have remained in the fabric greatly affects their persistence, due to a buildup of non-volatile protein contaminants. Although urine leaves the animal as an acid compound, eventually, due to rapid bacterial action, the acid nature of the urine is changed to a highly alkaline compound (ammonia off-gassing as part of the bacteria's life cycle).

Ammonia can cause loss of color in fabrics, a condition that is often mistakenly associated with the presence of the urine itself (the yellow pigment). This is the basis of the claim on the part of certain chemical formulators that their chemical is "guaranteed to remove urine stains." As far as actual staining by the urine is concerned (the addition of the urine's yellow color), that's probably a true statement. However, the loss of dyes caused by prolonged exposure to ammonia is another story entirely - the one the chemical salesperson gives you when you report that the guaranteed product didn't perform as advertised! Removing urine's yellowish stain is accomplished with almost any cool, mildly alkaline solution. *Correcting* colorless caused by alkaline urine deposits is a different story entirely! That just doesn't happen. *Adding* color is the only solution to that problem.

2. **Territorial Nature of Animals -** The second basic fact that should be understood concerns the territorial nature of animals. If animals are present, urine is present; i.e., they will mark and remark (even after deodorization) their territory! It's simply part of their psychological makeup. If the animal smells his peculiar scent, he's comfortable; otherwise, he's not.

    And since seventy percent of the homes in the U.S. have at least one animal, that means a lot of animals will be marking a lot of territory! More on this later.

3. **Odor Amplification** - Next, you should be aware of those factors involved in odor amplification: First, urine forms alkaline salts that are hygroscopic (moisture absorptive). In fact, they attract quantities of moisture or humidity. As we have discussed in previous chapters, humidity amplifies (dissolves and evaporates into the air) odor.

    "What's that got to do with me?" you ask. Simply this: Cleaners introduce humidity into home environments through the cleaning process itself. Immediately, that humidity is attracted to latent urine deposits residing usually in the carpet's backing materials. When odor is amplified, it becomes noticeable to everyone, especially homeowners working in other parts of their houses. At about this time, the lady of the house rushes in and inquires about that, ". . . terrible smelling chemical you're using!" Of course you instantly respond, "Lady that's not my chemical; somebody's been peeing' on your carpet!"

    Well, after you pick yourself off the floor, you suddenly realize how dangerous some forms of odor can be! As usual, the cleaner get's the credit (or is it the blame!). So remember, humidity amplifies urine odor.

4. **Oversimplification** - The next problem to which cleaners often fall victim is the problem of oversimplification. What's that mean? Simply this: you read all the

ads about products providing "guaranteed odor removal **in all situations"** (and you even believe some of them!). You buy the product and you give it a try; but the odor's still there after five trips to the house. So what happened?

You just became a victim of oversimplification. You failed to determine just how extensive and how old the urine contamination was. If you're talking about relatively fresh urine in one or two confined spots, sure you can guarantee results. That's because fresh urine is composed of water-soluble compounds that can be rinsed and treated (deodorized) with excellent results.

In overall contamination situations, however, we must be asking insistently, "Exactly where is the contamination?"

In the process of oversimplifying, we fail to realize that shortly after the urine left the animal's body it contaminated the carpet's face yarns and primary backing. Almost immediately following that (especially if the animal was fairly large), the latex adhesive, secondary backing, and probably even the cushion became saturated. Not long thereafter (particularly with repeated applications in the same spot) the sub floor and even the tackless strip became contaminated. And if the offending animal has selected the normal spot near the baseboard or door facing, soon the shoe molding, baseboard, wall plate, Sheetrock~ and wall studs have considerable odor problems. From there, fumes from the urine become airborne, contaminating HVAC filters, and even the interior walls of the HVAC's duct system.

Upon exiting the HVAC system, urine contaminated air blows through draperies and lamp shades, and settles on upholstery, walls, fixtures, etc.

And there you are in a back corner of the master bedroom, dripping three drops on what you believe to be the source of the odor! Oversimplification!

There are also a few things you should know about carpet protection and urine damage. First, fluorochernical soil/stain repellents used as carpet protectors provide some increased reaction time for the pet owner; but eventually, urine penetrates protectors (especially the discoloring chemicals that inevitably develop) and will stain carpet.

Stain resistors (acid dye blockers) are the second type of "protector" that enable the carpet to resist the effect of animal urine. These carpet manufacturer-applied compounds may prevent staining (assuming a reasonable amount, for a reasonable time); however they do nothing to prevent the development of odor. Eventually, stain-resist carpet will both lose stain resistance and color as well. Further, traditional cationic corrective treatments cannot be used on stain-resistant carpet without voiding the warranty. Sorry 'bout that . . .

5. **Locating the Source -** The fifth fact of which you should be aware regarding urine contamination pertains to locating the source of the odor. Several

considerations apply here:

a. First, use **logic.** Corners, baseboards, door frames, furniture legs are the favorite places for animals to "do their thing." Also, be aware that animals rarely urinate in close proximity to their sleeping and eating quarters. Sometimes even the whole room may escape their territory-marking attention. Therefore, in isolating the damage, start where the animal spends most of his time and work outward from there.

   That's not to imply, however, that there won't be odor present in sleeping quarters. Far from it! Odor on the animals "home turf" can come from one of two sources. The most common is the odor produced when animal hair and body oils decompose. Oils, in particular, produce a rancid odor in the area where the animal spends most of his time. Second, if the animal gets sick, there may be body discharge (diarrhea, vomit, or other appetizing substances) that causes considerable odor. (Ready for lunch now?!)

b. Note, too, that **discolorations** from animal urine show up readily under the scrutiny provided by technicians' high-intensity inspection lights. These discolorations arise from loss of carpet dyes, from soil being attracted to gummy residues, or from browning where cellulose backings are degrading.

c. Black (ultraviolet) lights also may be used quite effectively. Ultraviolet light causes urine salts to become "fluorescent" and emit a blue-white glow. Black lights are not used exclusively by our industry in this context. Exterminators have used them to track rats to their nests (they urinate while they run), and janitorial contractors have used them to inspect bathrooms for cleanliness for years,. Their major drawback is that the room you're inspecting must be fairly dark. Further, if the customer has been using household spotting compounds extensively, the optical brightener residues they leave behind may be mistaken for extensive animal urine damage.

d. If the urine is fresh (still wet), or if gummy residues have built up over a period of years, you may consider using your **moisture detector** to locate the source of the urine. The only problem here is that there must be sufficient moisture or other contaminant present to conduct the electricity that activates the detector.

e. Of course, there's always the old **"squat 'n sniff'** test. Get close enough to the source, especially in humid weather, and you'll have no trouble determining its approximate location.

f. If all else fails, or if the customer simply refuses to admit that Fido has "accidents" ("Who says it's an accident, m'am? Maybe your dog just doesn't like you!"), you can always disengage the installation and observe for evidence of urine discolorations on carpet backings or along the tackless strip (rusted pins, mildewed wood).

6. **Aging Factors** - The amount and age of the contamination has a great deal of bearing on the severity of the odor problem. For example, if the urine is relatively fresh, odor is created by the urine itself plus rapidly forming, odor causing bacteria. This situation simply requires sanitizing and cleaning for rapid, effective, long lasting (and yes, even guaranteed!) deodorizing.

However, if there is a quantity of urine that has been allowed to build up over a period of years - say, from the homeowner's 23 pet cats! - you may expect a corresponding buildup of cholesterol and protein. Eventually, this creates a gummy residue that serves as a source of substantial bacterial growth, while it decomposes (putrefies). Now we're talking about a requirement for removing the excess and neutralizing the progressive buildup of alkalinity, followed by elaborate digesting and cleaning procedures - procedures involving the carpet, cushion and sub floor materials.

Prolonged buildups of excess urine are not only difficult to clean from arpet, but eventually, they also penetrate plastics (fibers, backings; even latex), creating a **permanent** putrid odor that's all but impossible to eliminate. Procedures here might call for removal of the carpet, cushion and perhaps even some structural components; decontamination of what's left; cleaning and sealing (painting) contaminated walls; replacing filters; cleaning and deodorizing HVAC systems - followed by replacement of contaminated carpet and cushion!

In other words, we're down to a complete structural restoration job - with appropriate charges, I might add. And unless you caused the problem, that's nothing to apologize for . . . Right?!

7. **Application Options** - Next, application equipment. Here we have several options ranging from the simple and inexpensive to the more elaborate. Got just a confined spot? Try simply a syringe or trigger sprayer with an injection needle to saturate all layers of the carpet and cushion with the appropriate solution.

Is the contamination more general? Use a device that puts down a greater quantity fast and efficiently; devices such as a hand-pump or electric sprayer will be useful here.

8. **Chemical Options** - Let's consider the *EPA-registered disinfectant* (quaternary ammonium chloride) for light odor or for light, general contamination. For heavier, older buildups, you may need to use an *enzyme deodorant* with all the

use considerations discussed in the previous chapter. And don't forget to consider the final, topical application of a residual (bonded) antimicrobial product for long- range odor control.

Note, however, that if carpet is stain-resistant, overall application of any ammonium chlorides, or residual or bonded Antimicrobials will void the carpet owner's warranty with the fiber producer. Moreover, use of cationic cleaners or additives will immediately neutralize the stain-resistant treatment. Fortunately, alcohol-based, *stain-resist Sanitizers,* designed specifically for animal urine odor removal, perform equally well in this situation.

9. **Guarantees** - OK. Bottom line: what about guarantees? Is it, in fact. even practical to offer any guarantee, considering all that we've discussed?

The answer to that question depends entirely on the level of contamination experienced and the time the contamination has been present (buildup). To offer a universal guarantee covering all situations is patently ridiculous - you know it and I know it. Above all, **NEVER GUARANTEE URINE ODOR REMOVAL IF THE ANIMAL IS STILL PRESENT!**

However, if I can pinpoint (confine) the spot; if the buildup isn't grotesque (feet sticking to the carpet!); if I can access all areas of contamination for treatment (carpet, cushion, sub floor); if the time factor hasn't allowed the urine to actually permeate the fiber polymer - sure, I'll guarantee my deodorization process! But remember, there simply are no miraculous chemicals or potions to completely eliminate pet urine or odor under all circumstances. Period . . . End of paragraph . . . End of discussion!

In following sections, we'll be discussing step-by-step procedures for urine odor elimination in the two most common types of situations professional cleaners are likely to encounter. We'll start out with a relatively easy, confined-spot procedure; then we'll progress to gross contamination and look at the procedures to be considered in severe contamination situations.

B. ANIMAL URINE - CONFINED SPOTS: This situation anticipates infrequent urine contamination at a corner or along an edge of a carpeted room, but enough to cause a noticeable odor problem for the homeowner. Although this situation allows access to both the front and rear of the carpet, bear in mind that there will be times when these areas are not accessible. Therefore, the following procedures, while seemingly elaborate, include points that must be *considered* if thorough odor elimination is to be accomplished.

Prior to cleaning, as you will recall, urine spots show up under ultraviolet light (black light). Of course, darkened conditions in the room must exist before most ultraviolet lights may be effective in this spot-isolating technique. For this reason, the use of black lights is only partially effective. But recall also that urine spots may be detected using a moisture detector when the spot is fresh or when there is a gummy residue that will conduct the electricity required to activate the detector's buzzer. Usually, the easiest and most practical identification method involves looking for surface discolorations (often associated with wool or nylon fibers) or backing discolorations. The alkalinity that develops in urine causes jute backings to brown or yellow, and will leave a yellowish discoloration on synthetic backings as well. Then, when all else fails, use your nose to "sniff out" the location of spots - don't worry, urine may even start to smell like money after a while!

Again, the following steps are to be considered and not necessarily accomplished on every light urine decontamination job:

1. Carefully **isolate** the spot(s) to be treated.
2. **Extraction clean spots on the carpet's surface to remove excess contaminants** (caution: water temperature should not exceed 150°f/66°c on the carpet, since excessive heat may set protein matter). A neutral or slightly alkaline detergent solution (<9) should be used, so as to leave the carpet in a neutral pH condition. A thorough, salvage cleaning technique (literally flood and flush) should be followed by dry vacuum stroking to ensure the removal of all excess moisture.
3. **Disengage the carpet,** if near the wall, and flush the secondary backing with cleaning solution to remove excess contaminants there. Be sure to identify the general location of the spot in order to concentrate later treatments thereon, since its location may become less apparent when the entire area becomes damp. This is particularly important when all-synthetic backing materials are present.
4. **Cut out the contaminated cushion** and arrange for replacement with cushion of a comparable size and quality. Cushion is inexpensive and absorbs such a quantity of malodorous contaminants that deodorization is usually impractical, unless no replacement cushion is readily available. If salvage attempts are made, thoroughly saturate the cushion with a disinfectant or enzyme deodorant (never use the two in combination!), wring out or extract the excess after an appropriate time lapse, and allow drying. In all probability, at least two saturations will be required for complete odor elimination.
5. **Clean the sub floor,** as required, to remove contamination, and treat all areas surrounding the spot with an EPA-registered disinfectant or stain-resist approved sanitizer. Be sure sanitizing and cleaning includes tackless strip, baseboard and wall areas that may have been exposed to urine.

6. Having systematically cleaned the carpet, cushion and sub floor in a downward progression, we're now ready to reverse the process and finalize each level as we work back up (sub floor, cushion, carpet). Where repeated saturations of urine have occurred over a prolonged period, it may be necessary to **seal the sub floor** with a non-porous paint, lacquer or finish. This is usually an outside possibility, but it should be considered. This is particularly important on porous wood subflooring materials that will allow leaching and upward wicking of contaminants into cushion and eventually into carpet over time. When sealing is impractical, as a minimum a piece of heavy gauge plastic should be placed over the spot on the sub floor where urine was absorbed, to serve as a moisture barrier. Then, new cushion may be installed on top of the plastic without fear of wicking.
7. **Replace the cushion that was removed** with new cushion of comparable thickness and density, and seam it securely in place with duct tape. When spots are out of traffic areas, a perfect match isn't necessary, but it should be as close as possible.
8. **Saturate the contaminated carpet backing** with a quality disinfectant or sanitizer solution (allow at least ten minutes of dwell time), or with an enzyme deodorant if preferred. The original spot literally should be flooded with the deodorant solution, and your treatment should be "feathered out" into surrounding areas that may have experienced bacterial growth due to tracking. Light treatment should always extend several inches out from the perimeter of the spot if at all possible.
9. **Extract the carpet nap** to pull the excess deodorant solution through the secondary backing, latex adhesive, primary backing and face yarns. If an enzyme deodorant is used on light urine contamination, following extraction, the product should be reapplied lightly and allowed to dry slowly over a period of hours. In this manner, all areas subjected to urine will be decontaminated.
10. **Reinstall** all portions of the carpet that were disengaged according to CRI 105 standards.
11. **Clean** the entire room with hot water extraction to remove contamination that may have been tracked outward from the original spot.
12. **Dry the carpet completely.** Remember, any humidity that remains will greatly magnify even slight residual odors. Therefore, it is difficult to determine exactly what we have accomplished until the area is completely dry. Upon drying, inspect the area carefully, and repeat steps 8 (saturation application) and 9 (extraction) if residual odor remains. Anticipate at least two treatments if the urine saturation has been repetitious or has been present for a relatively long

period (months). Otherwise, one treatment with a quality product should be all that's necessary.

13. By the time all carpeted areas are cleaned and equipment is reloaded, treated spots should be almost dry. Technicians should **inspect treated areas** to see if they can detect residual urine odor. If any remains a light topical **re-treatment** with the deodorant product, followed by blotting, should be all that's necessary to assure complete elimination. If the carpet is too damp to make a final check, it's always a good idea to call the customer the next day and inquire about residual odor. Assurance of customer satisfaction is of paramount importance.

Should disengaging the carpet be impractical, treatment still may be accomplished by using a syringe or trigger sprayer employing an injection needle; or simply by pouring a quantity of deodorant solution on top of the spot and working it in. A saturation quantity of disinfectant or enzyme deodorant should be made to both cushion and carpet backing materials. Application should be made around the perimeter of the spot to ensure overall saturation of the entire spot, as well as adjacent areas to which the bacterial growth may have extended. Surface extraction of the excess will expedite drying when disinfectants or sanitizers are used, and repetitious applications may be required should residual odor persist; The procedure is concluded with overall area cleaning.

It should be obvious to anyone with discernment that this is more complicated than the old procedure involving injection of a sanitizer, coupled with a strong residual masking agent, crossing your fingers and hoping. Again, it must be emphasized that our objective is to achieve technically accurate and permanent odor neutralization - at a price that justifies our considerable extra efforts

Obviously, *all of these steps will not be required in every situation.* Thank goodness! However, *all of them should be considered* in light of what your inspection reveals. The actual procedures employed will be based on the components present and the degree of contamination.

See summary outline at page 164

C. ANIMAL URINE - SEVERE CONTAMINATION: At the outset it's necessary to face the very real fact that **complete** deodorization in this situation may be impractical, if not impossible. The carpet itself may have deteriorated to the point that the cost of deodorization exceeds the value of the carpet being treated. Perhaps more important to the deodorization technician, whose reputation is based upon results, complete deodorization may be impossible for two very important reasons.

First, as previously discussed, the urine, over a period of time, may eventually combine with the fiber polymer or cell structure (natural fiber) to produce a relatively permanent malodor. This is the reason many objective industry experts, who have been able to treat heavily contaminated area rugs by immersion in strong disinfectant solutions for several days, still are unable to achieve total odor removal.

Second, underestimating the true extent of the contamination is a common mistake made by many technicians. We simply fail to realize that the bacterial growth, which began at the carpet nap, given proper growth conditions and sufficient time (months or years), will rapidly spread to the primary backing, latex adhesive, secondary backing, cushion, sub floor, tackless strip, shoe molding, baseboard, wall plate, drywall, wall studs, etc. Eventually, the odor becomes airborne and contaminates HVAC filters and the entire ductwork system. Ultimately, airborne odor permeates the upholstery, lamp shades, draperies, and many other types of porous fabrics and surfaces. And the poor, uninformed technician is still trying to rid the home of odor with an hypodermic and a few ounces of deodorant injected into a six-inch spot!

Remember that your best advice to the customer may involve partial or total carpet replacement. Remember, also, that this is the customer's problem: you are there to assist and advise in solving that problem. You can only guarantee technically accurate workmanship at a price that justifies your considerable effort - not perfect results. Keep in mind that, even if the carpet and cushion are replaced, there is still going to be a requirement for your services in deodorizing the sub floor, lower walls and interior air space of the home, etc. Otherwise, the remaining bacteria that caused the original problem may contaminate the new cushion and carpet.

Fortunately, customer requests for overall deodorizing procedures usually come when the home is being sold and is empty of contents. This renders both the front and back of the carpet easily accessible for treatment. When furnishings are present, procedures are substantially more complicated.

You should consider this type work as major restoration and should plan accordingly. Portions of two or three days may be required for the sequence listed. Several return trips to determine the progress of the treatment should be anticipated, and charges for your services should reflect the complications involved. Ideally, treatment this extensive should be undertaken only when the structure is unoccupied and can be placed in your complete control for the duration of treatment.

With all this in mind, we are prepared to discuss severe urine decontamination procedures.

1. With severe urine contamination, there may be fleas or other pests present that will considerably hamper your work effort, and possibility create health hazards. Therefore, it may be necessary to have the homeowner **hire an exterminator to treat the home** before you are exposed to the discomfort and health hazard

associated with these insects.

2. Thoroughly **clean carpet face yarns** using normal extraction cleaning procedures and neutral detergents. Careful flushing of the carpet yarns with warm (not hot) water will remove much of the gummy residue that's characteristic of severe urine contamination. Remember, however, that extremely hot water (over 150°f/64°c) may set protein, making its removal considerably more difficult. Never confuse the yellowish residue (urine salts) with actual discoloration of the fibers that often accompanies these spots, particularly on nylon or wool.
3. Carefully **disengage the installation** (with shrinkage considerations in mind) and remove contaminated portions or all of the cushion. When in doubt, cushion removal, with plans for future replacement, is usually the safest course of action.
4. Using a disinfectant cleaner, **clean (scrub and mop) the sub floor,** and ensure rapid drying by using a carpet dryer. Where a quantity of furniture remains in the room, careful planning enables you to work on half of the floor at a time. Spray the sub floor lightly overall with a quality disinfectant solution. Concentrate this application under baseboards and along the tackless strip that is salvageable.
5. **Replace severely contaminated tackless strip** that shows considerable evidence, of rusting or rotting. On concrete subfloors, disinfecting and double stripping may be the best alternative.
6. Subfloors that are severely saturated with urine, especially if they are composed of a highly porous material, may require **sealing with an appropriate coating material.** In extreme cases where there is severe contamination of particle board, plywood or even hardwood, replacement of sub floor sections may be required Obviously, this procedure is accomplished only in the most drastic situations imaginable! If the possibility of urine wicking from subfloors exists, cover them with heavy-gauge polyethylene plastic before installing new cushion.
7. **Clean and flush the most obvious areas of the carpet backing with** a warm (not hot), neutral detergent solution to remove excess urine. Extract all the excess moisture possible with dry vacuum strokes. This is necessary since your normal topical cleaning procedures are designed to clean to, but not through, the primary backing. The urine, on the other hand, has completely saturated both primary and secondary backings, and, with repeated urination, considerable quantities of gummy residue will be present on both the face and backing of the carpet.
8. **Treat all exposed backing areas with an EPA-registered disinfectant or sanitizer or enzyme solution** (remember, never use both products in combination). You should literally flood the areas of heaviest contamination. If a disinfectant or sanitizer is used, after complete penetration has been achieved

followed by at least 10 minutes of dwell time, lightly extract the excess. If an enzyme deodorant is used, do not extract, but rather leave the area wet in order to prolong digestive action for four to six hours, or more. During periods of extremely low humidity, it may even be necessary to cover the carpet with polyethylene plastic to prolong drying and enzyme activity. Under these circumstances, you would be wise to anticipate the need for two or more treatments to achieve satisfactory reduction of the odor.

9. **Re-engage the installation,** being sure not to overstretch damp (therefore weakened) jute backing materials if present. Undertake aggressive power stretching only when the jute backing is completely dry. If the carpet is not secured during drying, shrinkage of backing yarns may make reinstallation much more difficult later on.
10. Spray the carpet surface overall with the EPA-registered disinfectant or enzyme solution.
11. **Provide for drying** according to the product used. If an enzyme deodorant is used, ensure that drying takes place in no less than four, and no more than 12 hours (overnight). Remember, prolonged drying with enzyme digesters is actually desirable. When a disinfectant or sanitizer is used, the carpet will be considerably damp at this point. Therefore, drying procedures that are standard in water restoration situations, including thorough extraction and installation of carpet dryers between the carpet and sub floor will be required to return the carpet to normal use as rapidly as possible.
12. At this point consider **cleaning and deodorizing structural surfaces (walls,** woodwork, fixtures) and contents items (upholstery, draperies) throughout the contaminated area. Add a general purpose deodorant to all cleaning agents.
13. Also consider **replacing filters in the home's HVAC system, along with cleaning and deodorizing the ductwork.** Over time, the filters will collect considerable vapor-borne odor and may, for this reason, be a primary source of odor throughout the structure. Ozone is highly effective in deodorizing inaccessible surfaces inside ductwork.
14. Next, consider odor existing in the home's airspace. **Airspace deodorizing is accomplished using ozone gas** during periods when the structure is unoccupied. Ozone has the advantage of penetrating effectively into surfaces that absorb odor over time, while it serves as an effective antimicrobial agent as well.
15. Once the sub floor is dry or renovated and the carpet has been treated and dried, **install new cushion of comparable size, quality and type.** Bear in mind that cushion with a polyethylene vapor barrier may restrict the migration of residual odor that might come from the sub floor. Therefore, it may be the most desirable

type to use in the replacement process. Regardless, "like kind and quality" is the for replacement.

16. If the carpet is salvaged, it will be necessary to **final clean it** after the above procedures are completed. Tracked soil, or soil that wicks from backings, may create a scum on yarn tips during drying. When you suspect this may be the case, a light surface cleaning is in order.
17. **Consider carefully treating the carpet's nap with a quality, residual antimicrobial.** Although this step isn't essential, it certainly "tops off" a thoroughly professional job, while it helps ensure against future odor development in the carpet's nap.

    Even after all these admittedly elaborate procedures, individually retreating confined areas for residual odor may be required. Additional injection or topical spray application, using an EPA-registered disinfectant or enzyme solution, may be required.
18. Then, **place a solid deodorant block in the intake portion of the HVAC system.** This provides intermittent re-odorization of the structure over several days or weeks. Of course, this is strictly a masking operation that deals with the psycho logical aspect of the odor problem. A pleasant atmosphere is created for the time required for humidity levels in the structure to normalize.

In closing this section on animal urine deodorization, I reemphasize that I am repeatedly approached by contractors and chemical retailers who claim to have "discovered" a chemical that positively eliminates *all* urine odors under *all* conditions with only one application. These overly generalized statements simply add credibility to the old saying, "ignorance is bliss"! You must exercise common sense in evaluating these products. Permanently neutralizing malodor by changing its chemical properties, and covering it up with heavy, long-lasting perfumes are two entirely different things. In this industry there's no such thing as aerosol decontamination of all surfaces and fabrics within a home. Direct contact is required to kill microorganisms and remove contaminants causing an odor.

As previously noted, masking agents do serve a very important function in attacking psychological odor and covering over slight residual odors while nature takes its course in eliminating them. Professional deodorizing technicians must be diligent in using of all appropriate systems available and, from an ethical standpoint, in carefully outlining alternatives to customers. Consider making comments like, "The odor will be reduced to the point at which it will not be a problem," rather than, "The odor will be completely eliminated."

Remember too, the procedures listed above are for your consideration. I don't mean to imply that all must be implemented on every urine decontamination job. Obviously, there is a cost associated with elaborate procedures of this nature, but usually when consumers call you for the tough jobs, they've already tried everyone else and have learned a few expensive lessons. Either that or they need to try a few of the "miracle workers" before hiring someone with technically accurate procedures.

After all, the next alternative is carpet and cushion replacement, **along with sub floor and structural deodorization.** And don't shy away from that alternative either. Even when the carpet and cushion are too damaged to be restored, someone must be hired to remove both components, before engaging in sub floor and structure cleaning and deodorizing. There's still a lot of work for you to do!

Finally, one often overlooked, though common sense observation should be made. Regardless of how well trained homeowners may think their pets are, recontamination of a deodorized carpet eventually will occur if the pet is allowed access to that carpet. This could result in return trips to deodorize areas which, according to the homeowner, "you failed to treat thoroughly." Obviously, this could become a never ending battle. With this in mind, no guarantees of effectiveness can be made or even implied as long as the animal remains in the home.

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Comprehension Quiz: VII - Animal Urine

1. _____________ is the key to effective deodorization when severe contamination from animals is involved.

2. ___________ ___________ is the most common household odor problem.
3. Initially, animal urine is _________ in pH.
4. Without treatment urine becomes _________, due to _________ action.
5. An alkaline chemical called _________ is what eventually causes color loss in carpet subjected to urine.
6. Loss of _________ is often mistaken as urine __________.
7. Animals are ________ by nature: this is part of their __________ makeup.
8. Urine deposits form __________ ___________ that are highly _________.
9. Humidity amplifies __________ urine odor.
10. Technicians who deal with urine odor, often fall victim to the problem of ___ ________.
11. Urine vapors can become airborne and contaminate _____________ and walls in _____________systems.
12. "Favorite" spots used by animals include: ________, _______, _______frames and _______ legs.
13. Animals seldom urinate near their own ________ quarters or _________ areas.
14. Inspection lights reveal urine spots due to ______________ and soil attracted to _____________ _____________.
15. "Black" lights produce _____________ radiation.
16. Fresh urine or excess protein residue can be located with ______ ________.
17. As a last resort, you can always ________ the carpet and _____________ for evidence of urine.
18. Urine contamination shows up on tackless as ___________ pins and _____wood
19. The __________ and __________ of contamination has a great deal to do with the severity of urine odor.
20. Prolonged buildup of excess urine can eventually penetrate __________.
21. A _________ or ___________ sprayer, with injection _______, can be used to treat urine in a confined spot.
22. For large area contamination, a _________ - _________ or __________ operated sprayer may be used for deodorant application.
23. Chemicals used on urine may include cationic __________ or a (an) ________

sanitizer.

24. Never guarantee urine odor removal if the __________ is still __________.

25. The temperature of solutions used on urine deposits should not exceed ______ ______ °f.

26. A _________ detergent solution should be used to flush excess contamination from urine spots.

27. Three level treatment of urine spots includes attention to the _________ _____ ______ and _________.

28. Total deodorization of overall urine contamination situations may be _______.

29. The process of urine protein being broken down by bacteria into highly odorous amino acids is called _________.

30. Totally deodorizing gross urine saturation situations may call for ________ carpet and cushion and _______ all interior wall and ceiling surfaces.

VIII - DECOMPOSED PROTEIN

By way of preface, the protein you are likely to encounter in deodorizing usually comes from contamination by food substances (milk, meat juices, fish slime, eggs) or by body discharge (urine, feces, blood and other body fluids). Protein is comprised of complex combinations of amino acids that are synthesized by the living cells of plants or animals (or are obtained in the diet of animals). For those interested in the details, protein is comprised of the elements carbon, hydrogen, nitrogen, oxygen, usually sulfur and occasionally other elements (phosphorus or iron).

Odor associated with protein is generated through a process of decay called *putrefaction.* This process, simply stated, involves bacteria that produce enzymes, which break down complex protein molecules into smaller groups of amino acids and amines (largely responsible for the smell of ammonia that is usually present with decaying protein). These smaller groups of amino acids create that foul, obnoxious, putrid (hydrogen sulfide), persistent, gosh-awful odor!

Note that I emphasized that this odor is extremely persistent. As we saw with animal urine, protein is not highly water soluble; therefore, deodorizing isn't merely a matter of cleaning surfaces to eliminate the foul odor. It's a much more involved matter of getting to all surfaces into which that odor *or its vapors* have penetrated.

To compound the problem, protein odor usually has a profound psychological effect on the owners of the contaminated structure or property. The aura of decaying flesh or body fluids is simply so distasteful that many clients refuse to listen to your assurances about the agents and techniques at your disposal for correcting the problem. Unfortunately, the better the insurance coverage, the louder and more persistent the complaint, often resulting in replacement rather than restoration.

Therefore, deodorizing technicians must carefully gauge the attitudes of all parties involved before making heroic (and expensive!) attempts to salvage the situation.

In the next two chapters, we'll examine protein odor caused by freezers, small animals, and even skunk musk - a material closely related to protein in terms of foul odor and persistence. Because of the awareness of health hazards associated with blood and body fluids, a separate chapter will follow, which begins with a discussion of Occupational Safety and Health Act (OSHA) rules for avoiding exposure to blood borne pathogens, before continuing into a discussion of death scene decontamination and deodorization.

A. FREEZER POWER FAILURE (Decomposed Food): This situation results from prolonged interruption in power to a home or commercial freezer, which causes thawing and eventual decomposition of foods contained within the freezer. Upon thawing, meat and vegetable fluids pool in the bottom of refrigeration units and eventually, in the case of upright models, flow out the door to contaminate other surfaces. Often the mechanical components of the unit, as well as structural components, will be affected. Of course, by this time bacteria and fungus proliferates, and flies may lay eggs so that recognizable living organisms (maggots) appear in abundance. Even the insulation surrounding the lower portions of the cooler box may be significantly contaminated by odor. Be sure to look carefully for small holes in the freezer box's plastic housing that may have allowed protein juices to contaminate insulation.

While this certainly is not a very appetizing scene, restoration technicians must approach the problem with a calm mind and logical restoration procedure that avoids emotional displays or suggestive comments. It is, in other words, absolutely essential to maintain a positive, professional attitude that instills confidence in your expertise, so that customers don't develop insurmountable psychological barriers.

As a professional you are also expected to consider the *replacement* cost of the refrigeration unit compared to the *restoration* cost. If the unit is old or in poor condition, replacement may be the most practical option. Obviously, the final decision is left to the owner and/or insurance representative. Still there is a need for you to **perform structural and contents deodorizing services** even if the unit is replaced.

As is the case with animal urine, the persistence of refrigeration unit malodor can be traced to the breakdown of amino acids that are the basic building block of protein. These amino acids are highly malodorous and, after prolonged periods, they penetrate plastic surfaces that are commonly used in the unit's construction. Although these plastic components may appear to be hard, non-porous surfaces, recognize that they are far more porous than you would expect, and malodor penetration is highly probable. You should conclude that the sooner treatment is initiated, the better. This is no time to suggest that you will be able to accomplish deodorization quickly. Customers must make temporary arrangements for alternate food storage, while deodorization is being completed over the course of several days, or even a week or so.

1. Begin with a direct, **saturation application of a quality disinfecting or sanitizing solution (EPA-registered)** containing a pleasant fragrance. Not only does this agent reduce the severe odor, but it also decontaminates or creates a more sanitary environment in which technicians may work. Nevertheless, technicians must wear chemical-resistant gloves when handling contaminants. And since the odor usually is substantial (that's an understatement!), technicians should also wear a vapor respirator to eliminate the assault of decaying protein on their olfactory senses.
2. After protecting your skin, eyes and respiratory system (gloves, splash goggles, respirator), cautiously **remove all spoiled food stuffs and place them in leak-proof, heavy-duty plastic garbage bags** (perhaps in a bag within a bag). Avoid contaminating floors during this procedure. Then cautiously transport that spoiled food out of the structure to an appropriate disposal site.
3. Next, if size and security arrangements permit, **move the contaminated unit**

from the structure to an exterior carport, patio or warehouse for further processing. The objective is twofold:

a. We want to remove the source of major contamination so that structural deodorization can begin. This allows the structure to be reoccupied as quickly as possible and saves the additional cost of living expense.

b. It's best to place the refrigeration unit where aggressive (salvage) cleaning (thorough rinsing of all surfaces) may be performed. Indeed, pressure washing of all surfaces is desirable.

4. Using a warm (80-120°f/27-49°c), alkaline (pH 9-10) detergent solution, **clean all interior and exterior surfaces thoroughly.** *Pressure wash metal racks and glass shelving, interior surfaces, gasket areas and the entire exterior, when practical.* After removing racks and shelves, create a padded work surface and tilt the freezer over on its side. Then, carefully clean all insulation and equipment in the mechanical components compartment at the rear or bottom of the unit, where odor may have circulated for some time. Exercise care in protecting electrical connections while removing dusty, oily residues that accumulate over the years. While cleaning this greasy, dusty area probably doesn't seem like it should be your responsibility, remember that it can become contaminated with odor (especially if the freezer is an upright). Therefore, if contaminants aren't removed, odor will remain and become quite apparent when the unit is reinstalled and turned on.

   With extremely severe contamination, clean direct-contact surfaces with a one percent household bleach (one part chlorine to four parts water). Be absolutely sure that no chlorine remains in or on the unit when it is transported back inside Me structure!

5. Normally, upright refrigeration units will experience pooling of contaminated fluids in the lower portion of the freezer box. Since the seams of the plastic panels comprising the freezer box are not water tight, anticipate that fluidic contaminants will penetrate into insulation behind these panels. Usually contamination extends only a few inches up the insulation, since it runs out the freezer's door after a few gallons of thawed fluid collects inside. **Residues on insulation must be removed with cleaning, followed by compete decontamination;** otherwise, odor will persist for years. The freezer box must be disassembled and Fiberglass' insulation must be flushed free of contaminants. Then, it must be disinfected thoroughly, followed by exposure to concentrated ozone deodorization for 94-48 hours. Only then can the freezer box be reassembled. Cleaning and decontamination of insulation is all that is necessary. Replacement is a somewhat difficult and expensive job, since it may be held in

place with adhesives.

6. Once all surfaces are clean and free from contaminants, a thorough **application of EPA-registered disinfectant solution should be made.** The disinfectant should remain in contact with these surfaces without rinsing. Light brushing around and beneath gaskets will achieve complete penetration into these critical areas. Final rinsing followed by drying completes the disinfecting process.
7. Next, **isolate the refrigeration unit in a small room, or completely enclose it in a tent of polyethylene plastic.** This material may be purchased in twelve-footwide rolls from the local hardware store. The tent need not be completely air tight, since some exchange of fresh air is desirable. If the freezer is in a small room, no tent is required, since the room itself serves as an ozone chamber.
8. Place a RainbowAir® ozone generator **outside** the plastic tent and **pipe ozone gas into the tent** through the RainbowAir® optional hose kit. The hose directs ozone into the freezer box where the worst contamination occurred. Allow ozone injection to continue for 36-48 hours without interruption. This is probably the most important step in the entire procedure. If the freezer is being deodorized with ozone inside the structure, occupants must not be present. Don't be concerned about ozone escaping from the plastic "tent," since this only aids in complete structural deodorization. Obviously, if contamination and odor is light, deodorization time is reduced accordingly.

   In frost-free freezers, malodorous vapors may penetrate the air recirculation chamber used for dehumidification. Therefore, it may be necessary to circulate ozone through the small holes in the cooler compartment or door by cycling the unit on and off several times, while concentrated ozone is being piped in.
9. Since, in most cases, the refrigeration unit is deodorized outside the structure, technicians must turn attention to **deodorizing the inside of the structure.** This begins by completely cleaning the kitchen or the area where the unit was located, and it is followed by wet or dry fogging. Ultimately, liberal use of ozone is the best way to completely eliminate structural malodor.
10. Once sufficient time for freezer deodorization has elapsed, return to the job site and remove the tent used to confine the ozone gas. Allow the freezer to air out for 15-30 minutes. Then **carefully check for residual odor by "sniffing out" all areas that might retain pockets of odor.** Carefully check gaskets, irregular surfaces, seams in plastic housings, and within the air recirculation compartment that creates the frost-free effect. If residual odor remain, repeat steps 4, 6, 7 and 8 (clean questionable areas, disinfect, tent and ozone for 36-48 hours), until all odor is gone. Decayed protein odor is extremely persistent when heavy

contamination is involved; therefore, treatment may take a week or even more. Attention to details, **patience** and confidence are the requirements for success!

11. Once no odor is detected within the refrigeration unit, **place a solid deodorant block in the cooler box.** Plug the unit in and allow the unit to operate. Open and close the door several times at two minute intervals to allow "re-odorized" air to circulate through compartments providing the frost-free capability. Then operate the unit normally overnight.
12. Return and remove the deodorant block and thoroughly check for complete odor removal before returning the refrigeration unit to normal use. Once the unit is returned to its position within the home or business, **place a deodorant block in the mechanical components compartment beneath the unit where air is circulated whenever the compressor runs.** This provides a pleasant fragrance over a prolonged period and reduce potential "psychological" odor.
13. If the malodor has entered the HVAC system, ozone should be injected into the air return ductwork using the optional five foot hose assembly. HVAC filters should be change out to prevent odor from recontaminating the structure overall.

Remember, protein odors require aggressive cleaning, and they take time and persistence to resolve. The longer the exposure period and the greater the heat generated, the worse the situation becomes and the more patience is required. Inform customers accordingly and apply procedures meticulously. Ultimately, ozone gas is your most effective weapon in dealing with this intense odor problem. In time you will get results at far less cost than the other alternative - replacement!

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B. DECOMPOSED ANIMAL IN A CRAWLSPACE: In this situation, a small animal (dog, cat, rodent, skunk, raccoon, possum, armadillo, etc.) has entered the crawl space beneath a structure and has expired (as in dead!). Given proper conditions involving time, temperature and humidity, decomposition begins, along with a rather severe protein odor. Finding the exact location of the dead animal and reaching that location may be quite a challenge requiring great creativity on the part of the deodorizing technician. Of course, the odor problem is compounded by the fact that the area may be infested with fleas and ticks. Never hesitate to *call an exterminator to spray the area to eliminate any infestation* before you enter to search for the carcass. Even then, protective clothing and a vapor respirator are required for technician comfort and safety during the initial stages of this procedure. Obviously, chemical resistant gloves are required when handling anything on or near the carcass and to prevent direct contact with pathogenic microorganisms or flea bites.

After these initial steps, deodorization procedures are accomplished as follows:

1. Upon locating the animal (use a long drop cord or strong flashlight for illumination), **use a spade to shovel the carcass, along with contaminated soil in the immediate area, into a heavy-gauge plastic garbage bag.** Remove and properly dispose of (bury) these remains at a point well removed from the structure.
2. If, for some reason, you are unable to dispose of all the contaminated soil, or if the carcass is lying on a structural member, it may be necessary to **decontaminate the area and components with a 1-2% chlorine bleach solution** (mix household bleach 1:4 or 1:2). Chlorine is a strong oxidizer that will rapidly decompose any remaining contaminant, while sanitizing the area. Remember that chlorine bleach can be used only in areas where surfaces are durable and colorfast.
3. Thoroughly **saturate the spot and surrounding areas with an EPA-registered disinfectant.** Also, make a ground saturating spray application of heavy-duty deodorant to the underside of the structure's subflooring components. Normally a quart trigger sprayer will be adequate for this tasks. This step is critical to overall deodorization and must be accomplished with care.
4. After taking measures to seal off crawlspace air vents, and with appropriate safety precautions in mind, liberally **wet or dry (thermal) fog the entire crawl space area.** This is easily accomplished by placing a carpet dryer at the entrance to the crawlspace and fogging directly in front of the air flow created by the dryer.
5. Once again, *after taking appropriate safety precautions,* carefully fog the interior of the structure.
6. Should any residual odor remain, repeat steps 3, 4 and 5. In very severe situations of this type, **place one or more RainbowAir® ozone generators on or near the spot of heaviest contamination.** Since the crawlspace has been somewhat sealed and since ozone gas is heavier than air, it tends to collect in the crawl space area. Ozone penetration into the structure's interior should be minimum if any at all, unless fresh air exchange vents are located underneath the structure. Take appropriate precautions to confine concentrations of ozone to the crawlspace only, unless the structure is unoccupied. For this reason, this technique can be used in a commercial structures at night, or in a residence during the day when occupants are not present. The owner can easily unplug an extension cord providing power to the ozone generator(s) at all other times, if appropriate reminders (i.e., warning signs) are posted.

7. **Spread approximately one gallon of odor-absorbent granules over the spot from which the animal was removed; or make a second saturation application of heavy-duty deodorant to that area.** As a minimum, place one or more solid deodorant block in this area to create a pleasant fragrance, since it will remain suspect in the customer's mind for a period of days or even weeks.
8. Next, consider infiltration of odor within the structure itself. This condition may be resolved often with simple **thermal fogging procedures.** Heavier odor inside the structure may require the use of **ozone gas** for 24-36 hours.
9. When you are certain that total odor removal has been accomplished, **place a solid deodorant block in the structure's HVAC system** so that psychological odor problems are contained, while occupants adjust to their deodorized structure.

If a small animal dies within a wall cavity inside a home or business, locating the carcass becomes a challenge. However, once the approximate location has been determined, and especially if the carcass is inaccessible, you may be able to inject lime (a caustic powder) into the wall cavity where the carcass is located. When the lime contacts protein matter, it causes rapid decomposition within days. This prevents having to tear out the entire wall area. Using dry solvent deodorant injected into the wall cavity through a power blower, or ozone gas injected over a period of hours (24-48), the odor should disappear.

It is always best, however, to open the wall cavity and physically remove the carcass, if at all possible. This allows direct contact when cleaning and applying deodorizing and decontaminating agents. These procedures can be followed with wall repair and painting.

See summary outline at page 165

C. SKUNK ODOR: While skunk odor isn't exactly a decomposed protein situation, you may easily arrive at the conclusion that it isn't much worse than protein odor! At any rate, this problem is handled similarly to the decomposing protein situation.

Skunk odor is produced by any of ten different species of short-legged, bushy-tailed mammals with characteristic black and white markings, which belong to the classification mustelidae. The skunk is equipped with a gland located under its tail, that produces and excretes an extremely malodorous material called musk. This fluid can be propelled to a distance of fifteen feet along a relatively straight line with extreme accuracy. Spraying, as this defensive activity is called, is preceded by stamping of the front paws and a low growling noise. All affected areas become severely contaminated upon contact with the musk. In new buildings where interior wall components were sprayed, the odor has been known to remain severely obnoxious for over two years.

The exact composition of this oily, yellowish musk has not been fully determined. It is comprised of mercaptans that resemble alcohol except that sulfur is substituted for oxygen in the chemical compound, and the sulfur is chiefly responsible for the foul residual odor. Butylmercaptan has been found in almost every musk producing species of the mustelidae family. Again, basically, the foul smell is that of sulfur.

The odor of skunk musk resembles that produced by a combination of garlic, carbon disulfide (an odorless chemical that dissolves sulfur but that usually contains impurities causing it to smell like rotten eggs), burned cork, rubber and hair or feathers. Some actually find the odor pleasant (can you believe it!), while others become so upset from exposure that nausea, vomiting, headaches and general weakness results for hours after exposure to concentrated musk odor. The liquid is harmless to the skin and can be washed off easily. With direct contact, it irritates the eyes, causing extreme pain. It may even result in temporary vision loss.

Procedures for skunk odor removal include the following:

1. Carefully **clean all areas directly contacted by skunk musk** with a warm detergent/deodorant solution that is mildly alkaline (pH 9). This step is critical to rapid and effective odor removal. In cases where a quantity of musk has contacted durable, colorfast surfaces, a direct spray 20 Volume (6%) hydrogen peroxide may be used to oxidize remaining malodorous residues following cleaning. In extreme instances, a 2.5% solution of sodium hypochlorite may be used on skunk musk. Household bleach from the grocery store is a 5.25% solution of sodium hypochlorite and, therefore, should be diluted with an equal part of water in order to form the 2.5% use solution (i.e., mix 1:1). You should be aware, however, that color loss, oxidation of metals, and fabric deterioration are likely. And that's not to mention long-term residual odor and toxic fumes produced by chlorine bleach, unless procedures for neutralization (application of sodium bisulfite or hydrosulfite antichlors) are used.
2. **Make a direct-spray application of heavy-duty deodorant** (smoke odor counteractant) to all surfaces within the area of immediate contamination. On highly absorbent surfaces, two or three applications are recommended. If you fail to accomplish these first two steps, and proceed with fogging only, the odor may *never* be permanently neutralized! Once surfaces are dry, strongly consider the application of a quality sealer as appropriate.
3. Now **consider cleaning other surfaces within and surrounding the point of direct contamination.** Add a general purpose agent to all cleaners. Meticulous

cleaning is basic to professional deodorization.

4. **Wet or dry fog the entire area,** concentrating on areas of heaviest contamination. Allow the deodorant fog to remain until almost completely dissipated (perhaps an hour or longer). In those instances where structures experience only infiltrated skunk odor (odor brought in through windows or doors on the windward side of the structure), fogging may be the only procedure required for total odor elimination.
5. **Place a RainbowAir® ozone generator in the area of immediate contamination and allow it to operate at maximum power for 48 hours *minimum*.** Since skunk musk is an organic compound, the oxidizing capability of ozone gas is ideally suited to this type of odor problem. Do not, however, underestimate the persistence of the musk odor! Extended treatment may be required.
6. Return and aerate the structure for 20 to 30 minutes to remove all traces of ozone gas. **If slight odor remains, repeat steps 4 and 5 until complete removal is accomplished.** Anticipate the need for at least two thorough treatments and charge accordingly.
7. Wet or dry fog the structure one last time and **place a solid deodorant block in the structure's HVAC system** to arrest psychological odor problems.

If only one room was sprayed and the structure must remain occupied, open a window an inch or so to allow ventilation and depressurization. Then place an ozone generator inside that room, and completely seal off all entrances and vents (especially cold air returns) with polyethylene plastic. This allows continuous use of concentrated ozone gas, even when the structure is occupied.

Even after all odor is apparently gone, plan to return after several days to check for "last traces." If none exist you may proceed to brag about your abilities as a deodorizing expert!

See summary outline at page 165

Comprehension Quiz: VIII - Decomposed Protein

1. Protein deodorization situations usually arise from decaying ______ or _____ _____ __________.
2. Protein is comprised of complex combinations of _________ __________.
3. Odor associated with protein is caused by a decaying process called ________.
4. Since protein contaminants are not highly __________ __________, odor tends to be extremely ________.

5. Protein odor tends to have a profound ___________ effect on the owners of contaminated property.
6. When flies lay eggs in decaying protein contaminant, _________ appear.
7. Professionals are expected to consider the ___________ cost of the refrigeration unit, compared to the cost of ___________.
8. Even if a freezer is replaced, there still will be a need for ___________ and __ ________ cleaning services.
9. Since ___________ components are more porous than you would expect, malodor _________ is highly probable.
10. The first step in refrigeration unit restoration is _________ with a _______ solution.
11. Spoiled foods should be removed in a _______ - __________, plastic ____.
12. The freezer should be cleaned ____________ the structure, if at all possible, using _________ ___________ procedures.
13. After cleaning the freezer's interior and exterior, consider cleaning the ______ _____ ________ .
14. With severe contamination, consider cleaning durable, colorfast surfaces with 1% ___________ __________.
15. Ultimately, freezers should be placed in a confined area or in a _________made of plastic, and subjected to high concentrations of _________ ________.
16. The final step in completing a freezer deodorizing job is to place a solid _____ ________ ________ in the mechanical components compartment.

17. Due to the possibility of fleas and extreme odor, when removing animal carcasses from beneath a structure, always wear protective __________ and a ___________.
18. When located, both the _______ and saturated _______ should be removed from the contaminated area.
19. Saturation of the carcass's location with an __________ disinfectant, followed by general spray application of ___________ - ___________ deodorant is recommended.

20. Once the crawlspace or exterior of a structure has been treated, technicians should turn their attention to deodorizing the structure's _____________.
21. Decomposition of the carcass of small animals within wall cavities may be expedited with ___________.
22. Skunks produce an oily, highly malodorous material called _____________ that is extremely _____________.
23. The odor produced by skunks is basically that of _____________.
24. Since skunk musk is extremely penetrating and persistent, directly contaminated surfaces may require treatment with __________ __________.
25. Infiltrated skunk odor usually can be eliminated simply with wet or dry _____ ___________.

IX - DEATH SCENE

Before discussing physical procedures for handling death scene odor situations, it's first to have a thorough understanding of OSHA regulations governing companies involved in such work. On December 6, 1991, the Occupational Safety and Health Administration (OSHA) issued its final ruling on *"Occupational Exposures to Bloodborne Pathogens."* Although the regulation was aimed primarily at employees exposed to ***significant quantities of blood or discharge from patients in healthcare facilities,*** it actually covers all employees who could come in contact with human blood or potentially infectious materials in the course of ***routine*** work. This regulation is **incident** specific; not **industry** specific. After being published in the Federal Register, the 178-page document became a legal standard that must be applied to the workers of a particular company.

Bloodborne pathogens are harmful microorganisms present in blood, or other potentially infectious materials, that could cause disease or even death in humans. Included among these microorganisms are *hepatitis B virus* (HBV) and *human immunodeficiency virus* (HIV).

Of primary concern in our industry is not necessarily the typical technician who may encounter casual contact with discharge from residential customers (minor bleeding from cuts or scrapes; vomit, etc.); rather it is those *janitorial or disaster restoration* workers who may encounter such exposures on a more or less *regular* basis. This obviously includes janitorial personnel who maintain healthcare facilities; but it also may apply to technicians engaged in *restoring homes and businesses subjected to trauma losses* (accident, murder, suicide), or conceivably even *water damage involving sewage bacig1ows* within structures. **Regardless of the exposure level anticipated, all professional cleaning and restoration workers must be informed on the subject of bloodborne pathogens and take steps to ensure protection.** AIDS is incurable and, regardless of liability, the person exposed can take little solace in having someone to blame.

Although my effort here is to create general understanding, *the assistance of legal council, experienced in occupational safety and health compliance is necessary to determine whether or not a particular technician falls under the jurisdiction of the regulation.*

EFFECTIVE DATES AND REGULATION SUMMARY

A. UNIVERSAL PRECAUTIONS: On March 6, 1992, ***"universal precautions"*** must have been implemented by employers falling under the regulation's jurisdiction. "Universal precautions," those developed by public health officials in 1985 to reduce infectious exposures, include adopting procedures mandating that employees treat all blood or other body fluids as potentially infectious materials. In particular, *all patients in healthcare facilities are assumed to be infectious for HBV, HIV and other bloodborne pathogens.*

B. EXPOSURE CONTROL PLAN: By May 5, 1992, an ***Exposure Control Plan*** must have been implemented by employers and made available to all employees and to OSHA inspectors. This plan must include a determination of occupational exposure to blood or potentially infectious materials to include:

1. A list of **job classifications** with potential exposure to bloodborne pathogens. Deodorizing technicians working on death scene restoration may fall into one of these job classifications.
2. A **description of work-related tasks and functions in which** exposures might occur.
3. A schedule for **implementation** of the elements of the plan.
4. A procedure for **evaluation of incidents** when employees are exposed to bloodborne pathogens or other potentially infectious materials.

C. RECORD KEEPING AND TRAINING: By July 4, 1992, ***record keeping and training programs*** on bloodborne pathogens must be implemented.

1. **Record keeping** by the employer on each employee with occupational exposure to blood or potentially infectious materials must include:
    a. A file with the employee's name, social security number, medical records, evaluations, and documents generated in the course of a post-exposure evaluation and follow-up.
    b. Records relating to individual employees must be kept confidential and not disclosed without the employee's written consent.
    c. Records relating to individual employees must be retained for the duration of the employee's employment plus an additional 30 years.
    d. Employers must preserve records showing the dates of training, the name and qualifications of the trainer, and the name and job titles of the attenders.
    e. Records relating to training must be retained for three years.
2. **Training** must be provided *to all employees* ***with occupational exposure potential*** *within 90 days of the effective date of the regulation, or at the time of initial assignment to the work situation, with at least an annual employee update.* Company training programs must be reviewed and updated annually. Training must be conducted by a qualified person and must be appropriate to the employee's education level, literacy and language. Training should include the following:
    a. Distribution of a copy of the regulation and explanation of its contents.
    b. Explanation, epidemiology and symptoms of bloodborne pathogens.
    c. Modes of transmission of bloodborne diseases.
    d. Explanation of the company's *"Exposure Control Plan"*
    e. Recognition of tasks, such as death scene restoration, that may involve exposure to blood or other potentially infectious materials.
    f. Methods for preventing and reducing exposure.

g. The types, selection, use, handling and disposal of personal protective equipment (PPE).
h. The benefits and administration of the hepatitis B vaccine series (at company expense).
I. Emergency response procedure in the event of an exposure incident.
j. Understanding of signs and labels.
k. Opportunity for questions and answers.

D. ENGINEERING AND WORK PRACTICE CONTROLS: By July 6, 1992, ***engineering and work practice controls*** must have been implemented by employers. These include:

1. Procedures for ensuring **proper packaging** of bodily specimens, disposal of body wastes, decontamination of equipment used in such efforts, etc.
2. Accessible **hand washing** facilities and antiseptic cleansers for employees exposed to blood or potentially infectious materials (antiseptic towelettes for situations where washing facilities are not available). Employees are required to wash hands as soon after contact as possible.
3. Rules prohibiting the bending, recapping or breaking of **sharps (e.g.,** needles, scalpels, dental wire, etc.). Reusable sharps must be stored or transported in containers that are puncture-proof, leak-proof on the sides and bottoms, and properly labeled at all times.
4. Prohibiting eating, drinking, smoking, applying cosmetics, or touching contact lenses, in situations where blood or potentially infectious materials may be present.
5. All potentially contaminated **equipment must be decontaminated immediately** or as soon after use as possible. This includes buckets, brushes, ladders, hand tools, vacuum and solution hoses, and extraction equipment.
6. **Personal protective equipment (PPE),** including chemical resistant gloves, gowns, lab coats, face shields, masks, respirators, splash goggles, etc., which will not allow blood or potentially infectious materials to pass through it, must be provided by the employer free of charge to employees.
    a. PPE must be at **reasonably accessible locations** in the work place or job site.
    b. Employers must ensure that PPE is **used as directed and repaired or replaced** as necessary.
    c. Serviceable gloves must be required whenever employees may have hand contact with bloodborne pathogens. Employees with **open cuts or sores** are not allowed to handle blood or potentially infectious materials.

7. **Housekeeping -** Employers must implement an appropriate **written schedule** for cleaning and decontaminating the work place, including all equipment, storage areas, bins, pails, containers, receptacles, etc.
   a. **Decontamination** is required immediately after the above items are in contact with blood or potentially infectious materials.
   b. Otherwise, decontamination must be scheduled at the **end of each shift or workday.**
   c. Employers must prohibit employees from directly **handling or "hand cleaning"** broken glassware or sharp objects (tackless) that may have been exposed to bloodborne pathogens or potentially infectious materials.
8. **Immunizations -** Employers must identify or designate employees who may be exposed to work situations involving bloodborne pathogens or potentially infectious materials and provide appropriate immunizations. Only those employees will be allowed to work on death scenes.
   a. **The hepatitis B vaccination series** (initial shot, 30-day booster, 6-month booster) must be made available free of charge to all employees who may be exposed to bloodborne pathogens or infectious materials within ten days of assignment to such work.
   b. Employees who refuse the vaccination must be required to sign a **waiver form** as prescribed in the regulation.
9. **Exposure incidents -** When an employee is involved in what the regulation calls an *"exposure incident,"* in which blood or potentially infectious materials come in contact with an employee's skin, eyes, mucous membrane, or in some way contacts the employee's own blood as a result of a needle stick, cut, abrasion, or piercing of the skin, the regulation requires that the employer respond as follows:
   a. The employer must immediately make available to the employee, at no expense, a **medical examination** and any necessary follow up.
   b. The employer must attempt to document the route and circumstances of **exposure.**
   c. The employer must **identify and document the individual who was the source of the potential infectious material** and obtain, as soon as possible, a test of that individual's blood, if feasible. The result of the source's blood test must be provided to the employee, together with information concerning the obligation to keep such medical information confidential. If unable to obtain a blood test, the employer must document its inability to obtain consent.
   d. The employee's blood should be **tested for HBV and HIV** as soon as possible. If the employee consents to a blood test but not to HIV testing,

the blood sample must be retained for 90 days in case the employee changes his or her mind; in which case the test must be promptly accomplished.

e. The employee must be provided with appropriate **counseling,** any appropriate methods to **preserve his or her health and prevent the spread of possible diseases,** and an **evaluation of any illness** that may be reported.

f. The employer must provide the physician or other healthcare professional who evaluates an employee with a copy of OSHA's *"Occupational Exposure to Bloodborne Pathogen "* **regulation,** a description of the **employee's duties relating to exposure,** the result **of the source individual's blood test,** if available, and any **pertinent medical records** of the employee.

g. A report by the physician should be **provided to the employer** to confirm that the employee has been informed of the result of the medical evaluation and advised of the medical conditions that may result from the exposure, which may require additional evaluation and treatment. All other findings and diagnoses are confidential and should not be included in the report to the employer.

10. **Labeling responsibility** - Containers of blood or other potentially infectious materials (fabrics, etc.), as well as work areas and storage areas where blood or other potentially infectious material is present must be **labeled** with a color-coded **"BIOHAZARD"** warning sign prescribed by the regulation (fluorescent orange or orange-red with contrasting lettering or symbols specifying "Biohazard"). Red bags or containers may be used instead of labels.

E. DECONTAMINATION PROCEDURES: The general method for decontamination of surfaces in healthcare facilities calls for the application of a 1/2% solution of sodium hypochlorite (a 5.25% solution of household chlorine bleach mixed 1:9). This is recommended because chlorine bleach is readily available and familiar to the general population. A saturation application to the area of immediate contamination is required, followed by liberal application around the perimeter of the direct contamination.

Trained professionals in the cleaning and restoration service industries recognize immediately that this procedure would result in destroying the color, if not the carpet or fabric, in a typical residential or commercial spotting situation. According to public health officials, EPA-registered quaternary ammonium chloride disinfectants (0.04-1.6%), or 6090% alcohol-based contact germicides, used in strict accordance with label directions will also provide broad spectrum *sanitization* without subsequent damage to carpet or upholstery fabrics. In any case when in doubt, don't hesitate to contact public health officials in your community or state for decontamination and disposal options.

F. CONTAMINATED WASTE DISPOSAL PROCEDURES: While *decontaminated materials* removed from structures need not be considered a problem, any *contaminated* materials removed, for example, from the scene of a trauma claim, should be handled as a biomedical waste and disposed of accordingly. This procedure may involve calling a hazardous waste management team (HAZMAT) for proper identification, packaging, labeling and disposal (incineration). Again, contact local or state public health officials for direction when this situation arises.

SUMMARY

Whether a cleaning or restoration contractor falls under OSHA's new regulation for "Occupational Exposure to Bloodborne Pathogens" is a matter that each individual employer must decide. Ignorance of the law (or any aspect thereof) is no excuse. As a simple matter of common sense, however, no one should be exposed to these deadly pathogens: the consequences simply are too great. Even if you don't believe that you or your company's employees are being placed in exposure situations covered by the regulation, a few common sense precautions are still in order.

BASIC RULES FOR AVOIDING BLOODBORNE PATHOGENS

1. Educate - Employers must keep abreast of current federal and state OSHA, EPA, CDC regulations relating to worker safety. They should provide general training for all employees on the hazards of bloodborne pathogens in accordance with OSHA regulations.
2. **Designate** - Specify which employees will be placed in situations where questions about potential exposure might arise.
3. **Vaccinate** - Ensure that proper immunizations are obtained and kept current.
4. **Protect** - Make available and use personal protective equipment (PPE): gloves, goggles, respirator, etc.
5. **Decontaminate** - Use chlorine bleach (1/2%); contact disinfectant (60-90% alcohol, 0.04-S9b o-phenylphenol); 0.4-1.6~o quaternary ammonium chloride; 2% glutaralde hyde-based products, under proper label directions and use conditions.
6. **Dispose** - Do not attempt to salvage questionable materials.
7. **Clean** - Use extraction equipment, as appropriate; always decontaminate equipment and tools.
8. **Disinfect** - Thoroughly disinfect salvageable surfaces at least one last time!

As those in the cleaning and restoration service area can see, this regulation was designed primarily for healthcare personal, since many of the situations presented are never, or only rarely encountered in our industry. But always remember, this regulation is **task** specific, not **industry** specific. Nevertheless, because of the dire consequences of exposure, managers must be familiar with the regulation and prepared to implement it with regard to any employee who may have potential exposure to blood or potentially infectious materials.

See summary outline at page 166

G. DEATH SCENE RESTORATION PROCEDURES: This deodorizing situation involves circumstances in which someone dies in a home or business and remains undiscovered for a time period long enough, and at a temperature warm enough, for heavy decomposition to occur. Generally, it is not uncommon for all body muscles to completely relax, resulting in the immediate discharge of body fluids or wastes. Over time, of course, the problem is compounded by a buildup of fluids and gases that cause the body to bloat. Eventually this pressure and fluid must be released. Often this release of pressure occurs with considerable force, extending the area of direct contamination to many surfaces all over the room.

Obviously, this isn't a job you would care to look in on just after a big lunch!

The major problem that must be overcome is purely psychological. By all means, ensure that the mortician has come and gone before you arrive to begin work. Hopefully, by this time, relatives, friends, the press and law enforcement officials have departed also, or they have regained control of their emotions to the extent that you may begin coordination.

In your coordination procedures, never to ask questions regarding anything that doesn't relate directly to your job. It may be quite embarrassing for a close relative to try to explain how the death occurred. Also, there is no need to go into a lot of detail about processing procedures, and you should avoid references to the deceased in any but the most tactful terms.

One other point should be considered. When personnel are placed on the job site for the restoration procedure, at the outset they may be expected to be rather quiet while performing such morbid work. After a period of time, however, they usually become more relaxed, sometimes to the extent that they crack jokes about the situation, that could be overheard by grieving relatives. This results in extremely poor customer relations. Carefully brief all personnel about keeping comments to themselves and concentrating only on their work.

As the inspector, you should take two precautions when you proceed to the job location. First, you should take along a quality disinfectant solution to spray directly on the body's former location. This may aid somewhat in reducing the high level of malodor, but its primary purpose is to *sanitize* the area to make it somewhat safer for you to work in. Do not anticipate that this will completely remove all unsanitary safety hazards. Second, protective gloves, splash goggles, protective clothing and respirators must be worn by anyone evaluating or handling heavily contaminated contents or structural components. The respirator enables inspectors to make a careful examination of the situation, even in the presence of extremely intense odor.

Strongly recommend that relatives or homeowners leave the job in your hands under these circumstances. Specifically, they should move in with relatives for a few days. This is no place for amateurs or those prone to emotional extremes. Encourage them to stay away until processing is completed, if at all possible.

With all the precautions relating to *OSHA rules on bloodborne pathogens* in mind, the steps taken to decontaminate and deodorize the above situation are as follows:

1. **Use only those technicians who have been trained in procedures for situation involving potential contact with bloodborne pathogens.** Records of that training must be kept on file at the company headquarters.
2. All technicians working on death scenes must be provided all the necessary personal protective equipment (PPE), in compliance with OSHA Regulations for Bloodborne Pathogens. As a minimum PPE must include, chemical resistant gloves, splash goggles, protective clothing and respiratory protection.
3. Be sure to note how old the death scene situation is. Even though most bloodborne pathogens are unable to survive outside the host cells for long, it is important to thoroughly **sanitize the area as possible before beginning work.** This may be accomplished by a direct spray application of appropriate disinfectants to all areas of heavy contamination, walls and ceilings included. The direct spray may be followed immediately by heavy fogging of sanitizer in the entire room in which the major contamination occurred. Anyone who must enter this area during fogging, or shortly thereafter, must wear a vapor respirator, since quaternary ammonium chloride disinfectants are not normally recommended for air space fogging due to the respiratory irritation they cause.
4. Wearing proper protective clothing, **remove all heavily contaminated fabrics and dispose of them.** These fabrics may include mattresses, box springs, carpet and cushion, upholstered furniture, etc. Generally, it is not economically feasible to clean and deodorize these fabrics, and, even if restoration were possible, there still might remain a tremendous psychological problem associated with future

contact by other family members.

With applicable OSHA Regulations in mind, decontaminate all disposable materials prior to removal from the structure; or call a HAZMAT team to remove, label and properly dispose of items you are unable to decontaminate.

5. **Next, examine the structure carefully to determine the path of fluid saturation.** Occasionally, body fluids will penetrate carpet and cushion, and wet out plywood or particle board subflooring. When this is the case, remove and replace contaminated sections with new materials. Severe fluidic contamination of relatively durable surfaces, such as concrete, hardwood or linoleum, necessitate decontamination followed by resealing or refinishing all or part of these materials.
6. After determining which components can be saved, **begin comprehensive structure and contents cleaning using appropriate deodorants added to all detergents.** Start at the ceiling and, depending on its surface composition, clean with an appropriate solution. Here is one instance in which the disinfecting properties of ceiling cleaning compounds (hydrogen peroxide) may actually help deodorizing contractors. Follow ceiling cleaning with thorough wet cleaning of walls and fixtures (doors, windows, lights, cabinets, etc.) using solutions containing a general purpose deodorant additive. Clean downward from the ceiling and walls to the contents and flooring as well.

   With moderate contamination, only the room of immediate exposure may require overall cleaning. However, when the odor problem is extremely severe, all structural surfaces and contents throughout the structure may require processing. Experience, good judgement and common sense will dictate the extent to which cleaning must be performed.

   Again, prior to disposing of mattresses, upholstery, carpet or other material that may contain bloodborne pathogens due to direct contact with remains, saturate contaminated materials with a one percent solution of chlorine bleach (household bleach mixed 1:4). Decontaminated materials may be disposed of; otherwise you must call a HAZMAT Disposal Team to remove, label and properly dispose of materials that have not been thoroughly decontaminated.
7. After cleaning any salvageable surfaces, **consider another direct spray application of a heavy-duty deodorant** throughout the area of immediate contamination.
8. Although **thermal fogging** has little neutralizing effect on the heavy protein odor, do it anyway in order to penetrate into all areas of the structure for whatever benefit may be derived.
9. With all safety and general use considerations observed, **install an appropriate**

number of RainbowAir® ozone generators. Operate them continuously for 36-48 hours at maximum setting during all periods when the structure is unoccupied. Don't attempt to deodorize too much area at once, based on room sizes and the intensity of odor, and be sure to place a fan in the area to ensure maximum circulation and penetration of the ozone into all areas of contamination. Attack this type of organic odor with a safe, powerful, oxidizing agent, such as ozone.

10. Next, **all salvageable surfaces that were in direct contact with or even in proximity to the victim (following decontamination, cleaning and disinfecting) should be sealed and painted as required.** Sealing heavily contaminated surfaces becomes a critical step in rapid, permanent odor removal.
11. After operating RainbowAir® ozone generators for several days, and after all cleaning and sealing procedures have been accomplished, if residual odor remains, **continue to use steps 7, 8 and 9 until achieving complete odor elimination.** Never hesitate to inject ozone into ductwork for complete deodorization, and filter replacement is always recommended.
12. Now, you must **aerate the structure to return it to normal odor levels.** Then, place a solid deodorant block into the intake of the HVAC unit to produce a continuous fresh fragrance over the next few weeks.

One final point should be made before leaving this subject. Often it is the owner of the structure who has died, and now the structure must be sold by a realtor. Idle talk about how grotesque the situation was by you or other employees may lead to embarrassment and grief for surviving relatives, as well as great difficulty for the realtor who must sell the property. This is one occasion when busy mouths should remain shut!

See summary outline at page 166

Comprehension Quiz - IX, Death Scene

1. OSHA regulations regarding bloodborne pathogens is designed primarily for workers in __________ facilities.
2. Bloodborne pathogens are harmful microorganisms present in blood, or other potentially infectious materials that could cause ________ ________ or in humans.
3. Bloodborne pathogen rules are ______ specific, not ________ specific.
4. ________ ________ require that employees treat all blood or body fluids as infectious materials.
5. A company's procedures developed to ensure that no employee contacts bloodborne pathogens in the course of work is called an __________ ________ ________.
6. Employees working on jobs that may involve potential exposure to bloodborne pathogens must have a series of vaccinations against ___________ within 10 days of assignment to such work.
7. Containers of blood or potentially infectious materials must be properly

packaged and labeled " ____________ ."

8. General decontamination of surfaces with bloodborne pathogens may be made with a __________ % solution of _________ __________.
9. The major problem that must be overcome in the death scene situation is purely __________.
10. Gloves, splash goggles, respirators and protective clothing are generally referred to as _________ __________ __________ or PPE.
11. Heavily contaminated fabrics and contents should be _________ from the death scene situation and __________ __________ as quickly as possible.
12. Severe fluidic contamination of durable structural components requires _____ ________ with new materials or __________ or __________ as a minimum.
13. Cleaning procedures should incorporate appropriate __________ added to all cleaning compounds.
14. Ultimately, the primary deodorant used to eliminate residual death scene odor is __________ __________.

X - GAS, FUEL AND CHEMICAL ODORS

In this section we'll examine the affect of gases (tear gas), fuels (gasoline, fuel oil) or chemicals (drugs, nicotine). Throughout the chapter emphasis will be placed on safety for the technician providing decontamination and deodorization.

A TEAR GAS: Tear gas is a riot control chemical compound that affects the eyes, nose, throat and lungs. It causes blinding tears and often violent coughing. Once the victim reaches fresh air, however, most of the effects of the tear gas disappear within minutes. There are two types of tear gas, CS and CN, and both involve organic chemistry; i.e., both are treated the same way.

Tear gas is infrequently used by most police departments, and many times canisters are fired into buildings that are uninsured - often by virtue of the illegal activities of the occupant(s). When it is used in an insured home or business that must be reoccupied immediately, standard procedure is to contact the fire department. The fire department, if available, then brings in smoke ejection equipment and, perhaps, a mop and pail to clean up the heaviest residue surrounding the expended tear gas canister. After that, the structure's owner is told that fresh air and time are the solutions to the problem.

Sure enough, within a few days and with a little general cleaning on the part of the structure's owner, the odor and the effect of tear gas disappears . . . they hope!

On even rarer occasions, the police department gets carried away and fires multiple canisters into an insured residence or business to flush out a suspect who does not own the structure. There is insurance coverage for restoration work, and the effect of the tear gas is quite severe, to the point that the structure cannot be reoccupied for weeks or even months. And since the tear gas is discharged from its canister using pyrotechnics (burning), there may even be fire or smoke damage associated with the tear gas contamination.

From this, you might conclude that there is little chance of your ever being called in to decontaminate a structure subjected to tear gas. Although it is not a frequent occurrence, some commercial buildings (banks, department stores, homes with large families, etc.) and some insurance companies attempting to provide responsive service to large policyholders insist on immediate decontamination procedures. In some severe situations your efforts at decontamination may be quite prolonged and more involved than you would ever dream possible!

Be sure to confirm insurance coverage before jumping into a situation of this type. Remember, if a crime is involved, there may be no coverage and you may be left holding the bill as your client is dragged off to jail.

Because of the variation in severity, several of the steps listed in the procedures that follow are only to be *considered.* All of them would be implemented in only the worst possible scenarios. Don't think that just because they are listed they must be performed. Your judgement and common sense must prevail.

When tear gas contamination arises, the following procedures should be undertaken:

1. Begin by **ensuring protection for technicians** by providing respirators, goggles, gloves and protective clothing. When tear gas contacts the skin, particularly moist skin, it is highly irritating. Although numerous studies indicate that there is no residual effect from contact with tear gas, there are still the possibilities of psychological reactions or simply the nuisance of itching skin and irritated mucous membranes. With this in mind, protection is the first order of business.
2. Like the fire department mentioned in the introduction, we too should **provide copious aeration** if at all practical. In the absence of smoke ejectors (turbine fans), your carpet dryers (squirrel cage fans) will perform well in evacuating excess tear gas residue. Be sure, however, to place them approximately ten feet inside the door and point them outward, in order to prevent the development of a vortex (repeated circulation) of fresh air from the outside. Likewise use any exhaust fans that may be present within the structure. Look for these in kitchens and bath areas. Replacement of contaminated interior air with exterior air is the

objective here.

3. **Remove any tear gas canisters that are present and clean up glass and debris from flooring surfaces.** Repair damaged windows and doors as soon as possible so that later, you will be able to confine any deodorizing fogs or gases that will be required.
4. ***Consider* the effect of the tear gas on insulation** that might have received direct exposure to heavy concentrations. Rather than attempting to decontaminate, it may be best to remove highly contaminated insulation and replace it. Insulation inside walls or within ceilings separating floors of a multiple-story structure is seldom a problem. This is a consideration when many canisters are used or when canisters are fired directly into an attic or crawlspace.
5. ***Consider* the need to seal unfinished, highly porous structural members** in attics, basements or crawlspaces (before replacing insulation). Apply a clear smoke sealer to floor or ceiling joists, to rafters, and to the underside of roof or floor decking materials. As with point 4 above, this will be necessary only in severe contamination situations.
6. **Remove and replace the filter(s) on HVAC systems.** They will be highly contaminated and will continue to release irritating materials. *Consideration* should be given to cleaning and deodorizing the HVAC system ductwork. Remember that some HVAC trunk lines have internal sound/insulation liners that may collect a quantity of the tear gas in severe situation. Ozone gas is highly effective in deodorizing ductwork contaminated by tear gas.
7. Next, the airspace within **the structure should be wet fogged with an appropriate solution of heavy-duty pairing agent.** Our purpose here is twofold: First, we want to produce a fresh fragrance that provides a diversion from the psychological impact of the tear gas. Second, the wet-fog mist literally washes the air, causing the tear gas chemical to precipitate out of the air and onto horizontal surfaces, such as the floor.
8. The fogging procedure should be followed immediately by a light, **general cleaning of all major *horizontal* surfaces.** Quickly wipe down the tops of counters and furniture with appropriate cleaning solutions. Then turn attention to the major horizontal surface, the floor.

   Immediately damp mop hard surface flooring, such as hardwood, sheet vinyl, linoleum or concrete. Sweeping prior to damp mopping is not normally advised but may be substituted with the a dust mopping procedure, using a *treated* mop head.

   Clean carpet using the hot water extraction method. Again, any vacuum process that might redistribute the tear gas into the air should be avoided.

Truckmounted cleaning plants are ideally suited to this operation, since contaminants are flushed from the carpet to a recovery tank located outside the structure. Moreover, any dry vacuuming performed with a truckrnount has the advantage of exhausting contaminants outside the structure where they are dissipated harmlessly into the outdoor air.

9. Once again, **aerate the structure** while floors are drying. Then, "sniff out" the structure to determine the degree of success you've achieved.
10. ***Consider* cleaning other structural surfaces and materials.** Give particular attention to fabrics on lamp shades, upholstery, draperies, etc., but walls, ceilings, fixtures and the like may have residues as well.
11. When any necessary cleaning and drying is complete, wet fog the airspace a second time, using the same heavy-duty deodorant compound to neutralize any tear gas that may remain. Follow this fogging process, like the first, with thorough aeration of the entire structure.
12. With all safety and general-use considerations observed, **install an appropriate number of RainbowAir®. ozone generators.** They should be operated continuously at maximum settings during all periods when the structure is unoccupied. Be sure to place a fan in the area to ensure maximum circulation and penetration of the ozone into all areas that may be contaminated. The primary deodorant used in severe tear gas contamination should be a safe, powerful, highly effective oxidization agent such as ozone.

    RainbowAir® units should be operated for a minimum of 24-48 hours. Since tear gas is an organic compound, the oxidizing capability of ozone is ideally suited for this type of odor problem. Do not, however, underestimate the persistence of tear gas! Extended treatment may be required. And don't forget to treat the HVAC system with ozone as well, along with filter replacement. Of course, appropriate warning signs must be posted at all entrances to the structure.
13. In light tear gas situations, **repeat the wet fogging and aeration sequence** as the situation dictates. Within 12 hours or less, the effects of the tear gas should be completely gone. In heavier contamination situations, follow wet fogging and aeration with ozone generation and aeration, and within several days the situation should be satisfactorily resolved.

When extreme contamination is encountered, don't make excuses to clients or insurance companies. State the facts surrounding the problem and proceed with steps that will ensure complete satisfaction from all parties. Total restoration simply takes time.

See summary outline at 167

B. FUEL OIL: Fuel oil contamination that requires the service of a professional deodorization contractor usually comes from one of several sources. The fuel may leak from the combustion chamber of a malfunctioning heater if incomplete or no combustion takes place. It may occur as the result of a spill within the structure, or it may even seep in from a spill external to the structure, perhaps from a leaking fuel storage tank. In any event, the result is contamination of portions of the structure that are close to the source of the leaking fuel problem.

Gasoline, though more volatile than fuel oil, creates approximately the same sort of situation wherever surfaces are contaminated. A concentration of vapors creates a potentially hazardous (explosive) situation, while gas fumes result in quite a substantial odor *and toxicity* problem. Safety, therefore, becomes one of our first priorities when dealing with any contamination involving highly flammable fluids.

The light fuel oils found in homes or businesses are primarily a refined, organic combination of hydrogen and carbon (hydrocarbons). Most of these fuels contain small amounts of nitrogen, oxygen, sulphur and ash, which accounts for the residual odor even when burned. The more highly refined a fuel oil is, the less the potential for odor, additives not being a factor. However, highly refined fuels generally are also more volatile and, therefore, more flammable and toxic.

The procedures for the elimination of fuel oil contamination and odors involve the following:

1. **The area should be ventilated by opening as many doors and windows as possible.** Remember that a quantity of vapor from any combustible liquid creates a potentially hazardous situation. Tell the owner to immediately begin aerating the structure, even before you arrive. If a quantity of a highly flammable fluid is involved, it may be wise first to **have the local fire department conduct an in spection with a fume detection device, to determine if the area is safe for occupancy.** As little as 5 ppm of gasoline vapor in the air inside a structure is hazardous from a flammability standpoint, and the structure may have to remain opened and unoccupied until the fire department declares it "on limits" again. Certainly the operation of any equipment producing a flame or electrical arc (i.e., thermal foggers, ozone machines) would be out of the question until this safety inspection is made. Therefore, aeration may be the only procedure we can use initially with some types of fuel spills or leaks.

   Later, when workers are providing extensive restoration procedures, an additional safety hazard may arise from breathing too many fumes. This is especially possible in basements where fumes that are heavier than air may collect, creating a toxic environment. Therefore, effort must be made to dust contaminated air from basements using drying equipment and flexible dusting. **All technicians must wear solvent vapor respirators with fresh cartridges** during initial work efforts.

2. Once safety hazards are overcome, **inspect the source of contamination carefully,** preferably with a qualified contractor.
    a. determine the **cause (source), duration and approximate quantity** of fuel discharge
    b. inspect the **immediate area** of contamination
    c. consider **inaccessible areas** where fuel may "pool," under concrete slabs (consider core samples), perimeter floor joints, between joists, in sump drains, etc.
3. **Notify your State Emergency Response Commission** (EPA) if fuel oil contacts soil outside the structure (exiting through drains, sewers, doorways, seams in concrete, etc.), or is allowed to enter a municipal sewer system (treated or untreated). Then:
    a. contract to remove contaminated soil and plan to replace it
    b. convey contaminated soil to a licensed hazardous waste hauler
    c. have contaminated sewer systems inspected and decontaminated by municipal authorities
4. Once safety hazards are overcome, our next step is to **absorb or mop up the excess fluid that may be present.** Again, use no mechanical components in this operation due to electrical arcing and potential flammability problems. A mop head and wringer bucket may be used, and make plans to dispose of the mop head and to thoroughly clean the wringer bucket with strong detergents before using it again. A second absorption procedure involves the use of oil absorbing compounds that may be purchased from automotive, janitorial or industrial chemical supply houses. Simply sprinkle these compounds over the entire area of fluid contamination and then provide appropriate dwell time for them to absorb the excess completely (30 minutes). After absorption, sweep or shovel the compound into a bucket for transport to the outside and for proper disposal. If a dirt floor (beneath a structure) is the primary area contaminated, remove saturated soil and replace it with uncontaminated soil, as required.
5. **Remove items that have suffered damage as a result of direct contact with the fuel oil.** Consider the **nature** of all components contacted by fuel oil. If porous components are saturated, don't hesitate to **shore up, tear out and replace.** Cleaning and sealing structural components is a false economy,

especially with prolonged exposure and absorption of fuel in quantity. If thorough decontamination isn't accomplished correctly, nuisance odor and ongoing health hazards may haunt you for years to come. **DO IT RIGHT THE FIRST TIME!**

It is very doubtful that efforts to salvage carpet, for instance, could ever be justified, since a hydrocarbon begins immediately to dissolve the latex used as a construction adhesive. The same is true of linoleum or sheet vinyl that has been adhered to a sub floor. Therefore, removal and eventual replacement would be in order. Sorry, no miracles here!

The same thing is true of fuel oil saturated structural members. If the fuel leak occurred over a prolonged period, joists, decking, baseboards, wall studs, drywall or paneling may be saturated to the extent that salvage attempts are impractical. In this case, qualified contractors must remove these components and replace after accomplishing initial decontamination procedures (soaking up excess). Obviously, structural component replacement alone may cause this deodorizing procedure to be one of the most costly you undertake. Therefore, the insurance company must be carefully briefed about the need for, and cost of, restoration. Do not attempt to cut corners!

Even surfaces that are considered extremely durable may require replace meet. It is next to impossible to drill holes in concrete slabs or block and inject degreasers and sealers to decontaminate subsurfaces or internal surfaces.

Fuel oil deodorization is difficult at best, and short cuts only produce complications!

6. If the fuel oil contamination has been caught quickly and structural components have absorbed only a small amounts, **decontamination and cleaning of all durable, colorfast surfaces may be accomplished with strong alkaline "degreasers"** (pH 10.5-12.5 approximately). These highly alkaline cleaners, which often contain blended dry solvents from the propylene glycol classification, always should be accompanied by positive ventilation and the use of a solvent vapor respirator and chemical resistant gloves. If a concrete floor is the primary component involved, use a caustic concrete cleaner containing sodium hydroxide. This effectively emulsifies and suspends the fuel oil, until rinsing for complete removal may be accomplished.

   During the cleaning process, be sure to consider the probability of fuel oil being tracked to other areas of the structure. In most cases at least some, if not all the carpet throughout the structure must be cleaned before the odor problem can be completely eliminated.

7. After cleaning remaining structural components that were contaminated, **spray them with dry solvent-based or heavy-duty deodorant.**

8. If the odor remains, ***consider*** **carefully whether or not concrete surfaces that were directly exposed to the fuel oil should be sealed.** Following decreasing, treat concrete or masonry products with an **acid** to "etch" surfaces. Sealed concrete may require stripping, acid etching and resealing. Seal clean surfaces with quality products that prevent migration of contaminant, no matter how slight, from the concrete sub floor.

   Seal salvageable wooden structural members, such as joists or framing studs, with a durable, alcohol-based sealer. As a rule of thumb, when in doubt seal it! Be sure to let paint retailers know what you are trying to accomplish, so they can assist you in selecting the proper sealer. In marginal situations, you may want to resort to a spray application of clear, acrylic polymer based, smoke sealer for this step. Be sure to make a test application of the compound to be sure it will adhere to the surface being treated. If adhesion problems arise, replacement or further cleaning and degreasing of residues may be required.

9. By now the source of the odor should have been eliminated, for the most part, and **we must begin deodorizing for vapor contamination.** With the general procedures common to all deodorizing situations, we must chase out the solvent-based odor vapor with our own solvent-based deodorant vapor; i.e., thermal fogging. Safety considerations having been observed, carefully thermal fog the source of contamination, followed by light fogging of all other areas of the structure. Allow the fog to penetrate all areas of the structure for at least 20 minutes before aeration. Bear in mind that some solvent-based deodorants may leave a very slight odor of their own (similar to kerosene) in spite of manufacturer claims to the contrary. If this compound is used exclusively, it may be very difficult to ever satisfy the structure owner, who now has a heightened awareness of fuel oil odor. Therefore, supplemental deodorizing concepts and equipment may be required, e.g., wet fogging a heavy-duty smoke odor counteractant through a ULV fogger.

10. If residual odor remains in the airspace, **use ozone gas for its elimination** over a longer period (several nights or days, depending on occupancy). Supplement this procedure with periodic wet fogging of heavy-duty deodorants. Continue alternating these two procedures until complete odor removal is achieved.

    With all safety and general precautions observed, install an appropriate number of RainbowAir® ozone generators. They should be placed in an elevated position and operated continuously at maximum settings during all periods when the structure is unoccupied. Be sure to place a fan in the area to ensure maximum circulation and penetration of ozone into all areas of contamination. The primary agent used to combat this type of odor is a safe, powerful oxidizing agent such as ozone.

Of course, don't forget to inject ozone into the HVAC air duct system and replace the system's filter. Appropriate warning signs must be posted at all entrances of the structure during ozone deodorization.

11. Before departure from the job site, place a solid deodorant block in the HVAC system to provide periodic re-odorization of the structure with a pleasant fragrance. In closing, let me re-emphasize the need for careful attention to safety precautions.

Never hesitate to replace oil saturated structural components. Heroic efforts to salvage surfaces are misguided, and they usually result in greatly prolonging an already difficult and tremendously inconvenient situation for the structure's owner. Finally, remember that *fuel oil decontamination is one of the most complicated, expensive, sometimes frustrating jobs an adjuster or restoration contractor will face.*

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C. DRUG LABS: A phenomena of today's permissive society, the term drug lab or "crack house" implies a structure in which a variety of drugs have been formulated and sold. The chemicals and preparation processes emit gases that permeate structural materials throughout. In fact, this situation is really a "catch-all" that includes a variety of malodor problems that arise from chemical contamination within a home or business. In particular it covers **nicotine** odor in structures where heavy smoking has occurred over prolonged periods.

The calls for deodorizing drug labs are few, simply because they usually involve older commercial or residential structures that have little value and even less insurance. When a deodorizing contractor is called, it is usually to a motel room or apartment complex where the manufacture of drugs took place for a few days or weeks before suspicion was aroused and the dealers either moved on or were arrested.

In any event, most of the obnoxious odor comes from organic chemicals used in compounding the drugs. They respond well to deodorizing if procedures are not short-cut.

Consider the following steps:

1. Foremost, you must **establish ownership of the property and ensure payment from a responsible party.** While you're at it, ensure that the police department has gathered all its evidence and has released the crime scene for restoration.
2. **Consider fogging or making a direct spray application of heavy-duty deodorant** to the room in which the actual manufacturing took place. This begins to reduce odor and make the structure less objectionable for work crews.
3. Clean all structure and contents with residue contamination. There may be no visible residue and you may be tempted to skip this step, especially when

property owners want a "quick fix." Don't let that happen! Chemical odors of this type are quite difficult to remove without some physical cleaning of residues - visible or not. Use a general purpose cleaner with a general purpose deodorant additive. Provide as much ventilation as possible during cleaning operations.

4. **Carefully clean all fabrics with hot water extraction procedures.** Add a general purpose deodorant additive to all cleaning compounds.
5. **Remove and replace the filter on the HVAC system.**
6. **Use an appropriate number of RainbowAir® ozone generators on maximum settings,** in the unoccupied structure for 24-48 hours. Begin in source area and progressively move ozone generators to surrounding areas as odor intensity decreases. Consider piping ozone into ductwork systems to neutralize odor there.
7. Aerate the structure, allow it to re-acclimate and determine if all odor is gone. If any remains, continue ozone deodorization for another 24-48 hours.
8. **Thermal fog the structure,** allow 30 minutes for complete penetration and then open it up for ventilation.
9. **Repeat ozone generation and fogging procedures if odor remains,** until satisfactory results are obtained.
10. In extreme odor situations, **the entire structure may require sealing and painting** in order to return it to normal. This may be a very practical step in commercial properties (motel, apartment, business rental) when income is being lost.
11. **Place a solid deodorant block in the HVAC system** for prolonged re-odorization of the structure.

With intense **nicotine** odor, similar procedures apply. Don't make the mistake of thinking that nicotine odor is only in the air. Nicotine penetrates all fabrics and coats all surfaces with a thin, yellow film that can be difficult to dissolve, particularly on delicate surfaces. That film is intensely malodorous.

Normally, you will be called to deodorize for nicotine odor when smokers move from a home and non-smokers are purchasing it. Everyone will be interested in a "quick fix" - you know, a few drops of Super X, all-purpose deodorant in each room. It won't happen! Warn clients that meticulous cleaning of all fabrics and surfaces (with glycol solvent added to cleaning compounds), followed by fogging and ozone generation, is the only way to guarantee results.

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D. STINK BOMBS: This final situation involves deliberate vandalism involving foul smelling compounds. One odor problem that we hear about with increasing frequency involves businesses, especially abortion clinics, into which "stink bombs" are thrown. In the past stink bombs were made of feces, rotten eggs or other disagreeable substances, which could be cleaned up and deodorized with relative ease. Today, vandals have gone "high-tech." Newer stink bombs usually are composed of **butyric acid** ($C_4H_8O_2$), a corrosive material, that smells like highly concentrated vomit. In fact, the odor is so pungent that it is virtually impossible for anyone to work in the affected area without respiratory protection - including deodorizing technicians! It can be dissolved in water or alcohol and is more soluble in cool solutions than hot.

Usually, the stink bomb is thrown into the structure in a glass bottle and, upon impact, the bottle breaks and the butyric acid directly contacts materials at the point of impact. From there acid fumes begin to penetrate many seemingly non-porous surfaces, while fumes are carried on air currents to other parts of the structure. *This odor is extremely persistent!*

Initially, seal off the room(s) in which direct contamination took from the rest of the structure, to prevent cross contamination. Also, turn off the HVAC system, if practical, to avoid circulation of fumes into other areas of the structure. This should be accomplished by structure users even before restoration crews arrive.

To resolve this intense odor problem, *consider* the following steps:

1. Ensure that the police department has gathered all its evidence and has released the vandalism scene for restoration. **Protect all technicians who will be working this situation.** Initially, respiratory protection will be essential. Further, acid resistant gloves and splash goggles must be worn.
2. **Ventilate the structure with copious air movement.** This dilutes the odor and makes the work area more manageable. If possible, seal off the source area and exhaust air from that room directly outside the structure. This minimizes ongoing cross contamination.
3. **Remove the debris and neutralize the residue.** Pick up the glass and then spray the acid residue with an alkaline cleaner (high pH or ammoniated) that is appropriate for the surface being cleaned. This neutralized the acid and cleans the surface simultaneously.
    a. Carpet should be preconditioned with an alkaline Reconditioner, followed by deep rinsing with a hot water extraction unit (flood and flush several times).
    b. Vinyl composition tiles (VCT), linoleum or sheet vinyl should be treated with an alkaline floor stripper or cleaner, followed by rinsing, to neutralize and remove the majority of the acid contaminant.
4. **Remove and dispose of floorcoverings.** It is doubtful that **floorcoverings will**

be worth saving. The acid usually discolors VCT or sheet vinyl almost immediately and may do the same to nylon carpet. Even if discoloration doesn't appear, the acid and odor penetrates surfaces easily and is extremely difficult to remove completely. Be sure to clean the remaining sub floor or decking with an appropriate alkaline cleaner.

5. **Fog or make a spray application of heavy-duty deodorant** within the room in which direct contact took place. This begins to reduce odor and make the structure less objectionable for work crews.
6. *Consider* the need to **clean structure and contents within the area of direct contamination.** It is particularly important to clean walls, fixtures or furnishings that were contacted directly by the acid, using an alkaline cleaner with general purpose deodorant additive. If results are to be effective, each step in this procedure must be accomplished meticulously. Continue to ventilate as possible during cleaning operations.
7. ***Consider* careful cleaning of all interior decor fabrics with hot water extraction.** Add a general purpose deodorant additive to all cleaning compounds.
8. **Remove and replace the filter on the HVAC system.** Heaven forbid that the acid is injected into the HVAC system! If so, the entire contaminated portion of the duct system probably will have to be replaced, especially if an internal sound/insulation liner is present, and intense ozone deodorization of the remainder of the system will be required.
9. **Use an appropriate number of RainbowAir~ ozone generators on maximum settings,** in the unoccupied structure for 36-48 hours. Begin in source area and progressively move ozone generators to surrounding areas as odor intensity decreases. Consider piping ozone into ductwork systems.
10. Aerate the structure and determine if all odor is gone. If any **remains, continue ozone deodorization for another 24-48 hours.**
11. Thermal fog the structure, allow 30 minutes for complete penetration and then open it up for ventilation.
12. In extreme odor situations, **the area of direct contact may require sealing and painting** to return it to normal. In commercial structures, this may be the best alternative in spite of increased cost.
13. **Place a solid deodorant block in the HVAC system** for prolonged re-odorization of the structure.

In almost any chemical odor situation, deodorizing should take place before painting. Unfortunately, too many customers believe that a coat of paint will resolve almost any problem. It won't. If results are achieved, they come from following procedures, step by step.

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Comprehension Quiz: X - Gases, Fuels and Chemical Odors

1. Tear gas is a ___________ control agent that affects the ___________, _______, throat and lungs.
2. Once the person exposed to tear gas reaches fresh air, its effect wears off in ________.
3. Most light tear gas situations are self correcting within a few _________.
4. The first step in tear gas decontamination is to provide ________, __________ and _______ protection for technicians.
5. The second step in tear gas decontamination is usually to provide copious _.
6. Airborne tear gas can be "washed" from the air with __________ - _________ procedures using a general purpose, __________ agent.
7. General cleaning of all ___________ surfaces exposed to tear gas is essential.
8. All flooring surfaces in the tear gas situation should be ________ - _________or, if carpeted, _________ cleaned.
9. Severe tear gas situations may require removal and replacement of highly ___ ________ materials, such as _________.
10. Severe tear gas situations may also require prolonged use of ____________ deodorization.
11. Vapor concentrations in fuel contamination situations create a potentially ___ ___________ environment.
12. Highly refined, volatile fuels create a potential problem with _________.
13. Later, when workers are present, volatile fuels create a potentially _______

environment.

14. Before workers occupy a structure subjected to fuel oil contamination, it should be checked by the fire department with a _________ ________device.
15. Before the fire department declares the fuel contaminated structure "on limits," never use equipment that produces a __________ or electrical ___________.
16. Excess fuel oil may be removed using ______ procedures or by using _______ ________ compound.

17. A critical step in resolving fuel oil contamination involves removing oil-saturated, ___________ components.
18. Fuel oil contaminated surfaces may be cleaned using highly ______ ________ ________.
19. Always keep in mind the possibility of fuel oil being __________ into other areas of the structure.
20. In order to control airborne fuel oil vapors, _____________ ____________ may be used.

XI - FIRE AND SMOKE ODOR

Smoke odor removal is an integral part of the fire damage restoration process, and is required generally for all fire damaged structures and contents. Since we've examined procedures used on contents in separate sections of this book, we'll confine our remarks here to structural components.

Two general concepts that apply to all deodorizing situations should be kept clearly in mind: First, always *initiate deodorizing procedures as rapidly as possible.* This immediately reduces the psychological worry or indecision as to whether or not deodorizing should be attempted. It also avoids the possibility of insureds assuming that odor is not a problem during periods of decreased humidity, or while the odor is covered up by a stronger odor, such as paint. Eliminating odors that later "come out of the woodwork" is substantially more complicated following construction, than it is when smoke odors are attacked while all "pockets" of odor are exposed and structural components can be treated in proper sequence.

Second, a professional restoration technician should realize that the *procedures required for small homes are identical to those required for large commercial structures.* Only the scope of the project increases, requiring that deodorization procedures be appliedin one section of the building at a time. Don't be overwhelmed by the magnitude of the job!

Before proceeding, technicians are reminded of the ***four basic principles of deodorization,*** since they will be incorporated in the procedures that follow. First, effort must be made to **remove the source of the odor,** or unsalvageable debris that contributessignificantly to odor generation, along with corresponding recontamination of cleaned and deodorized areas. Second, **cleaning** is basic to deodorization. Physical removal of malodorous residue through cleaning is essential if odor is to be reduced rapidly and permanently. Third, technicians should **recreate the conditions of odor penetration** with n appropriate odor counteractant. This is accomplished with direct application of deodorants, or by generating a deodorizing fog or gas that seeks out and combines with the malodor, thereby neutralizing it. Finally, salvageable surfaces that are inaccessible, scorched, discolored or slightly charted must be **sealed,** not only for aesthetic purposes, but primarily to encapsulate odor and prevent progressive recontamination.

For the remainder of this section, we'll be dividing smoke odor elimination into two primary categories: smaller, *confined area deodorization* (kitchen fire), and *overall smoke odor contamination* (structure with gutted room or rooms). This is necessary not only because of the of the extent of the damage sustained, but also due to the sequence of events required to accomplish complete deodorization.

A. SMOKE ODOR - *CONFINED AREA:* This section deals with deodorizing smoke odor from a confined source - for example, a typical grease fire on a stove, resulting in superficial exterior burning of the cabinets immediately over the stove or vent hood area. Soot damage in this situation will be heavy at the immediate source (usually the stove), but only moderate throughout the remainder of the kitchen. Light soot damage and odor usually is sustained in all areas throughout the remainder of the structure.

Although considerably less complicated procedures actually may be required, *consider* the following procedures for complete odor removal:

1. **Safety -** First and foremost, check for safety hazards. Water and electricity create rather obvious safety hazards. Therefore, unplug appliances before cleaning, or the turn off the circuit breaker controlling the flow of electricity to the unit (stove, vent hood). Likewise, check to ensure that there are no live wires exposed in the vent hood system that might create an electrical shock hazard. Consider health and safety hazards relating to wet or thermal fogging, or ozone deodorization as well.
2. **Source Elimination -** Remove the odor source (pot or sauce pan), along with the charred remains of whatever else fueled the fire. Collect other loose contaminants, as practical, and remove this debris to the exterior of the structure. Don't dispose of the debris, charred remains or damaged cooking utensils, until you're sure the insurance representative has viewed and documented them, and has determined whether or not the situation is covered by the provisions of the policy.
3. **Odor Containment -** Next, make a spray application of heavy-duty smoke odor counteractant to the source and immediate vicinity of heaviest contamination. This application serves two purposes. First, the deodorant's active ingredients are allowed to penetrate and react with malodor residue and begin a very real reduction of the odor problem. Second, the pleasant fragrance incorporated into the deodorant assures insureds (psychologically) that steps are under way to

eliminate the problem permanently. In addition, this makes your deodorizing effort immediately apparent to everyone, and consideration about whether or not to deodorize becomes a foregone conclusion.

4. **HVAC Restoration** - Prior to reactivating the HVAC system, with the possibility of circulating soot particles into respirable airspaces, the HVAC system must be evaluated for cleaning and appropriate restoration. Following these restoration efforts the system should be deodorized with by injecting ozone gas within all main and branch runs for 24-48 hours, depending on the severity of odor. Plans must be made to clean or replace the HVAC system filter as well.

5. **Cleaning** - At this point, bring in crews for thorough cleaning of all surfaces within the kitchen area as a minimum. Wherever practical, use wet cleaning procedures incorporating a general-purpose deodorant mixed into cleaning solutions. Disassemble and clean the burner eyes on the top of the stove, as well as wiring compartments. and it may be necessary to disengage and slide out built-in stoves to clean the sides and rear. Train cleaning crews to look for odor pockets, such as the vent hood filter and exhaust stack, or the mechanical component compartment of the refrigerator where a quantity of smoke and odor may have circulated and collected while that appliance was operating during the fire.

    Because of their location relative to the source of the fire (over the stove), and because they are often used to evacuate smoke from the structure, stoves and vent hoods (with their filters) usually collect a concentration of malodorous substances (rancid grease). Therefore, they demand particular attention. In addition to the disassembly and careful cleaning of the stove, fully disassemble the vent hood and give all components careful attention. Soak permanent filters (usually metal) in heavy-duty degreasers, followed by hot water rinsing, and clean them twice. Make an effort to physically remove contaminants from the exhaust pipe as possible. Even the fan's electrical motor may require degreasing procedures. Consider *lightly* spraying a heavy-duty deodorant mist through the exhaust system while the fan is running.

    Of course, if any of the vent hood or stove's electrical components were subjected to extreme heat during the fire, checked them for operational safety by calling a qualified service technician, before they are placed in operation again.

6. **Direct Spray -** *Mist* a second application of heavy-duty smoke odor counter-actant onto heavily contaminated surfaces following cleaning. Concentrate on areas in the immediate vicinity of the fire. On porous wood surfaces, such as the interior surfaces of drawers or cabinets, a direct spray application of dry solvent-based deodorant is specifically recommended and may be used without fear of swelling or other problems associated with water-based deodorants. Remember,

however, that this chemical can cause porous wood surfaces to turn darker and, if they are visible, complaints may arise later. Therefore, only make direct application if the surface is not readily visible (underside and rear of drawers, for example). Deodorize finished wood kitchen cabinets by mixing four parts of oil based furniture polish with one part dry solvent deodorant (4:1) and polish cabinet surfaces carefully.

7. **Fogging Procedures** - Once appropriate safety precautions have been taken, proceed with wet- or dry-fogging procedures using an ultra low volume fogger ULV) and heavy-duty deodorant; or use a thermal fogger and a dry solvent-based deodorant. Allow the fogging compound to remain confined in the structure for 20-30 minutes. Do not use the central air handling system to circulate the deodorant fog, since this results in rapid dissipation of the concentrated deodorant. Most homes are not air-tight, and commercial structures are required to have a fresh air exchange provision that ensures complete exchange of air within the structure every few hours. The idea is to have the fog penetrate all surfaces before aeration.
8. **Aerating the Structure** - Return and aerate the structure thoroughly before checking for residual odor. Should *light* odor remain, repeat steps 5 and 6. However, deodorizing with ozone gas while the structure is unoccupied during the day is another recommended course of action.
9. **Ozone Deodorization** - Ozone deodorizing is specifically recommended if the structure is to remain unoccupied overnight or if the malodor is unusually persistent. Protect (pad) counter surfaces and place a RainbowAir®. ozone unit in an elevated position close to the odor's source; allow it to operate for at least 24 hours. Appropriate warning signs must be posted on all entrances to the structure.
10. **Follow Up -** Once all odor has been removed, place a solid deodorant block in the mechanical components compartment of the refrigerator. This provides an intermittent flow of fresh fragrance close to the source of the odor problem each time the refrigerator's compressor cooling fan is activated. Another alternative for placement of the deodorant block is, of course, the structure's HVAC system; however, the refrigerator is usually a better alternative. since it is located in the primary odor source area.

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B. ***OVERALL* SMOKE ODOR CONTAMINATION:** The situation involves a structure with a major portion severely burned (room gutted). An example of might be a serious kitchen fire in which a large portion of the cabinetry has been burned completely, or a bedroom in which most of the furnishings have burned, along with severe burning or scorching of walls and other fixtures (doors, window frames, etc.) throughout the structure. Usually, the structure must be vacated for a period of several days, if not weeks, during cleaning, reconstruction, painting and deodorizing.

1. **Safety Considerations -** First and foremost, check the damaged structure for safety hazards. Most apparent are falling structural components, and hard hats must be worn by all technicians entering the structure. Next, eliminate electrical shock hazards throughout severely damaged portions of the structure, especially if water was used to put out the fire. Similarly, identify and remove tripping and slipping hazards to protect technicians.

   In severely smoke damaged structures, another unseen hazard involves breathing quantities of soot. During initial processing and, especially, during demolition (tear out) procedures, considerable quantities of particle soot become airborne. Without the use of a dust mask or respirator, considerable irritation of the respiratory system may occur.

2. **Debris Removal -** Encourage reconstruction or remodeling crews to remove the burned debris as rapidly as possible. It may be necessary for deodorizing technicians to initiate procedures along this line by removing some of the burned components themselves. Even though the time element may not seem crucial (since the reconstruction process may require weeks to complete), remember that debris removal must occur before effective deodorization can begin. This procedure not only eliminates a great deal of the odor problem, it also serves to prevent recontamination of structural areas in which odor removal has been completed.

   It is often wise to remove contents that have sustained heavy damage, in terms of both smoke and odor, after they have been declared a total loss by the insurance adjuster. Removal of odor saturated items, such as carpet, upholstery, draperies, clothing and bedding, which are destined for disposal, will result in rapid reduction of odor.

3. **Odor Containment** - Make a saturation spray application of heavy-duty deodorant to all areas containing scorched or partially charred structural components. This application should be made to walls, ceilings, fixtures and flooring materials that were burned to the extent that replacement or heavy sealing, as a minimum, is a probable alternative. Avoid spraying areas that have only a heavy, loose soot residue until rough cleaning with a dry cleaning sponge has been accomplished. Remember, water-based solutions will set loose residues that could, and should, be removed by cleaning. Once again, our primary purpose is to contain the odor, if only slightly, while assuring insureds that procedures for

complete odor elimination are underway.

4. **Ductwork Restoration -** Prior to extensive cleaning of the structure and before sealing and painting wall surfaces is begun, HVAC restoration procedures should be accomplished. The procedures for ductwork cleaning and deodorizing are explained in detail in *"After the Smoke Clears,"* LJB, 1993.

5. **Cleaning -** All surfaces and furnishings within the structure should be cleaned with appropriate compounds mixed with a general purpose deodorant. The more furnishings (upholstery, draperies, wood furniture, etc.) you are able to remove to your plant for processing, the easier becomes the job of structural deodorization. The structure should be cleaned from top to bottom, i.e., ceilings, walls, fixtures and floors, and from the area of heaviest residue to the lightest. The logic in top-to-bottom cleaning is that, if the lower surfaces are cleaned first, then when upper surfaces are cleaned, soot fallout from them will recontaminate the previously cleaned lower areas. In the areas of heavy soot contamination, scorched walls should be cleaned of excess loose soot (neutralizing the residue) and then sprayed liberally with a heavy-duty smoke odor counteractant in order to "set" any minor amounts of loose soot which may remain, while simultaneously neutralizing heavy odor.

   In the confined area situation covered at Section A, cleaning normally begins ***at the source*** of the damage and progresses ***outward*** from there. However, in more severe fire situations, cleaning usually begins ***in structure extremities*** of the structure and progresses ***back to the source.*** The reason is obvious: destroyed structural components in the source area have been removed by now and there's little left to clean! Furthermore, removal of ceilings, walls doors or windows doesn't allow a deodorant fog or gas to remain in that area long enough to accomplish the job.

   Clean restorable carpet at the outset of the job for more rapid and effective deodorizing, while neutralizing acid soot residues that might result in permanent staining of fibers. Of course, a second carpet cleaning will be required once reconstruction has been completed, but this is a far better (less expensive) alternative than carpet replacement. The insured or insurance representative should be given a choice with the stipulation that you will begin cleaning in areas of heaviest contamination. If the response is unsatisfactory, then they may coordinate the replacement alternative without the full expense of the entire cleaning job. This approach is fair to all involved.

   Once natural wood surfaces, such as cabinets, doors or paneling have been cleaned initially, wipe them down with a cloth saturated with a dry solvent-based polish/deodorant (mixed 4:1). This procedure has an additional advantage in that the addition of dry solvent-based deodorant to the cleaner/polish will not cause wood surfaces to swell or warp, as can water-based deodorants. Be sure to test your solution before extensive use to determine if oily residues will remain due to the quantity being applied. Again, recall that direct application of solvent-based deodorant on *painted* or *porous* surfaces will result in darkening those surfaces, often permanently!

6. **Initial Ozone Deodorization** - As quickly as practical, put two or more RainbowAir® ozone units in operation, beginning in areas of *least* odor contamination. Operate them nightly, as a minimum, and even during the day if the ozone gas can be confined to one specific room. Insureds appreciate deodorizing efforts that are visible and continuous.

   Again, we emphasize beginning in areas of least contamination for one simple reason: The removal of structural components in fire gutted rooms (source areas) makes it impossible to confine deodorizing gases or fogs for the time required for deodorizing to take place, especially when door and window units have been removed! Therefore, we begin in rooms we can confine with least contamination, progressively moving units toward source areas as those areas are "dried in" by reconstruction crews.

7. **Direct Spray Application** - As soon as major construction components (paneling, drywall) have been removed from the destroyed area, make a direct spray application of heavy-duty deodorant to salvageable structural components, such as the wall studs, ceiling and/or floor joists, etc. Make two or more liberal spray applications to the newly exposed interior wall components. Throughout reconstruction, monitor the structure constantly and, as structural components are exposed, make appropriate deodorizing efforts.

   This process, accomplished in the close coordination with reconstruction crews, is absolutely critical if "odor pockets" are to be avoided. Once odor on interior wall components is sealed in by new drywall, it becomes much more difficult to access and therefore, to remove. Maintaining the proper sequence is extremely important in total, permanent deodorization.

8. **Thermal Fogging** - When openings that provide for excess air ventilation (burned out windows, doors, roofs) have been repaired, begin intermediate dry solvent deodorant fogging. Because of its ability to generate and maintain a large quantity of penetrating fog, a thermal fogger is specifically recommended for this application. Wearing specified safety gear and having taken other appropriate safety precautions, begin fogging operations at the rear of the structure and work out to a convenient exit. Open all closet, cabinet and fixture doors for complete penetration into these areas. Accomplish fogging at a time when the structure can

remain completely closed for 20-30 minutes.

If you or insureds suspect that odor may exist on interior wall components behind salvageable drywall, that odor may be attacked without tearing out the drywall. Simply turn off electricity in the room, remove an electrical cover and wedge the tapered nozzle of a power blower between the drywall and the electrical outlet junction box. When the power blower is turned on. it will pressurize the entire wall cavity and force air throughout all areas where the smoke may have gone. Then, using a mini-thermal fogger (propane or electric), inject a very light fog into the intake of the power blower. The fog will be rapidly dispersed throughout interior cavities.

9. **Further Ozone Deodorization -** After intermediate fogging operations have been accomplished, set up RainbowAir® ozone generators in the area of the heaviest contamination, where they can operate for at least 72 hours. This allows the ozone gas to attack odor on interior wall components before those areas are enclosed with new insulation and drywall. Be sure to provide circulation of the ozone gas with circulation fans.

10. **Finalization Procedures -** Once overall reconstruction, sealing and painting has been accomplished, begin final deodorizing procedures. Remove your RainbowAir® ozone equipment, air out the entire structure, and carefully checked for residual odor pockets. If any are found, provide localized deodorization, using chemical (water-based or dry solvent-based) deodorants. In some cases, an entire room may require isolation and retreatment with both fogging and an appropriate deodorant, and with ozone gas.

    Normally, by this time, no odor will be present. The finalizing procedure, using wet- or dry-solvent compounds, should be classified primarily as "overkill."

11. **Deodorant Block -** Finally, place one or more solid deodorant blocks in the HVAC system to pleasantly "re-odorize" the entire structure each time the system is turned on over the next few days or weeks.

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Comprehension Quiz: XI - FIRE AND SMOKE ODOR

1. Initiating deodorizing procedures as __________ as possible reduces _______ worry and _______ for insureds.
2. This also avoids assuming that odor isn't a problem during periods of decreased ________or when odor is ________ by a stronger odor such as __________.
3. Eliminating odor at the end of a fire job is more complicated than when _____ ________ of odor are exposed and then can be treated in proper ___________.
4. Procedures for use in _________ are the same as those required for _________ ______ structures, only ___________ the of the job changes.
5. In confined area situations, soot and odor damage is usually ______ at the immediate source, ______ in the remainder of the source room, and ________ ___ throughout the remainder of the structure.
6. The first step in the confined smoke odor situation is to check for __________ ___________.
7. In particular, check for live electrical wires exposed in the ________ ________ area.
8. The second standard step is almost always to remove the _________ of contamination.
9. An application of _________ - _________ deodorant at the source of heaviest contamination will begin ________ odor immediately, while making your efforts ___________ to everyone involved.
10. The third standard step in confined smoke odor procedures involved _______ ________ all surfaces exposed to significant residue.
11. In grease fire situations, stoves and vent hoods should be _________ for complete cleaning.
12. Two areas of particular concern in grease fire situations are the vent hood ___ _______ and ___________ ___________.
13. Check electrical components subjected to extreme heat for _________ ______

__________ by a qualified technician.

14. Initial steps for air space deodorizing involve ________ or ________ - ______.

15. For ultimate air space deodorizing, you may have to install an _____________ ______________ at the ___________ of the odor.

16. Finally, install a ____________ ___________ ___________ in the ____________ compartment of the ___________.

17. In overall contamination situations involving smoke, encourage removal of charred __________ ___________ as soon as possible.

18. In addition, remove and dispose of all ______ that have been declared a "total loss."

19. Initially, make an application of ________ - ______ deodorant to remaining areas that are _______ or partially ________.

20. Before extensive cleaning is accomplished in this situation, perform ________ ___________ to prevent recontamination of clean surfaces.

21. With extremely heavy smoke damage, removing ________ for processing outside the structure aids considerably in reducing odor.

22. To avoid recontamination, clean surfaces within the structure progressing from ___________ __________ to ________.

23. Begin cleaning associated with total odor removal in the ______________ of the structure and progress back to the __________ in heavy fire damage situations.

24. In order to save carpet and achieve rapid odor reduction, cleaning may be required at the _________ of the job as well as the _________.

25. As soon as practical, install two or more __________ ___________ in salvageable areas of __________ contamination.

26. As soon as ____________ wall components are exposed, make an application of ___________ - _________ deodorant to all structural members to prevent residual odor __________.

27. As soon as the source area has been "dried in" so that deodorants can be contained, begin intermediate ___________ ________ procedures in those areas.

28. Open all _________, __________ and __________ doors during final deodorizing procedures.

29. Once deodorizing is complete, allow the structure to air out, and make a final check for residual ____________ ___________.

30. As a final step, place one or more __________ ________ ________ in the intake of

the structure's _______ system.

CONTENTS

DEODORIZATION

XII - CONTENTS DEODORIZATION (SMOKE ODOR)

The following will be a discussion of deodorization considerations regarding various types of contents items within a structure. Generally, this section covers situations in which moderate-to-heavy odor is encountered. Common sense dictates that all the rather extensive procedures suggested would not be used under all circumstances. The judgement as to how many of the steps outlined will be necessary to ensure complete deodorization will be left to the discretion of individual technicians.

Never forget the principle of "over kill" in deodorization procedures and always consider eliminating psychological odor problems after the real odor problem has been addressed.

A. CARPET is almost always installed on a horizontal plane, and due to this fact, everything that precipitates from the air eventually settles there. In indoor air quality discussions, we call this the "sink effect." In addition, a great deal of contamination that has settled on other surfaces - especially sheet vinyl or other hard surfaced furniture or fixtures - will likely be tracked or dusted onto the carpet. Dampness and hot, rapidly expanding air contributes to deep penetration of malodor contaminants.

Since everyone walks on the carpet and since it is far removed from the nose, little thought is given to its deodorization until after other components in the structure have been processed. Then, as the family returns to normal activities, especially during periods of high humidity, their use of the carpet other than for walking (i.e., lounging while watching T.V., playing games, etc.), may cause them to detect residual smoke odor in their carpet.

These are the reasons why, in moderate or heavy smoke odor situations, carpet must be deodorized on an individual basis rather than as a part of structural deodorization.

Much has already been said about carpet deodorizing in the chapter covering deodorizing procedures for animal urine, and many of the general principles apply to smoke odor as well. Therefore, this discussion serves primarily as a summary of procedures that you already should clearly understand.

1. Often restoration technicians encounter situations in which there is substantial smoke residue on carpet. If the carpet is to be saved, this acid residue must be neutralized and removed before permanent yellowing takes place. Also, this heavy residue is normally associated with heavy odor. Technicians should, at the outset of work processing, turn their attention to carpet deodorization and

restoration. Dry vacuum the carpet and consider **hot water extraction cleaning at the outset of the job.** This is followed by a **direct spray application of heavy-duty, smoke odor counteractant.**

When carpet is unsalvageable, substantial odor reduction in the structure is achieved by removing it as soon as possible. With light-to-moderate residues, however, only the following steps need be taken.

2. As ceilings, walls and other furnishings are cleaned of discoloring soot residues in the initial stages of processing, **make plans to provide minimal protection for the carpet as well.** Protective procedures include dry vacuuming carpet initially before traffic grinds in soot and odor. As initial cleaning of other surfaces above the carpet is completed, final vacuuming is required as well. This prevents tracking soot residue deeply into the carpet's pile and backings, and helps minimize both cleaning and deodorizing problems later on. Drop cloths may also be used to protect carpet from fallout of soot and odor from lighter surfaces as they are processed.
3. **Never expect odor to completely dissipate before thorough final cleaning is accomplished.** The flushing action of hot water extraction cleaning is specifically recommended. Note that when moisture is introduced during any comprehensive cleaning procedure, odor may be greatly magnified. This is no cause for alarm but simply confirms some of the basic principles you learned at the beginning of this book regarding odor and humidity. Adding general purpose deodorant to extraction solutions helps considerably.
4. **Make a direct spray application of heavy-duty, smoke odor counteractant (pairing agent) to the carpet immediately after cleaning.** Carefully distribute the deodorant throughout the pile with a finishing brush, comb or groomer. Deodorizing moist carpet with high concentrations of ozone gas may produce discoloration and, therefore, is not recommended at this point. Also, there are questions regarding the ability of ozone to penetrate a multi-layered fabric, such as carpet. This is especially true when the expansion of superheated air in severe fires, coupled with traffic, may have caused deep contamination. Consider, too, that if ozone gas is forced to penetrate both primary and secondary backings, latex degradation or oxidation is likely. This is why spray application of water-based deodorant is necessary on carpet.

As mentioned earlier, avoid thermal fogging immediately after carpet cleaning, since the humidified air in the structure may refuse to allow the solvent-based deodorant fog to remain suspended as it should. The result is that the solvent may precipitate from the air and coat furnishings with a slightly oily film that may necessitate recleaning those surfaces.

5. Should smoke odor in carpet persist, **a repeat application of a non-residual, smoke-odor counteractant (pairing agent) may be made,** followed by careful finishing with a brush, comb or groomer.

Another technique that is highly effective in achieving total penetration of carpet construction components is thermal fogging. This procedure may be required when insureds are concerned about odor penetration under the carpet into cushion or onto subfloors. It is accomplished, preferably on dry carpet, by installing a carpet dryer in a closet or corner of the room with the snout positioned between the carpet backing and cushion. With the carpet dryer "floating" the carpet, *lightly* fog a solvent-based deodorant into the intake of the dryer, or at intermittent intervals into a four-inch PVC pipe inserted beside the snout of the dryer. The entire carpet surface will begin to smoke as if it were on fire, which demonstrates how thoroughly all pores are being permeated by the deodorant fog. The residual fragrance will be quite pleasant and long lasting, and since no moisture has been used, very little, if any, smoke odor will be amplified.

Now, while the alarmists are dashing about looking for a red flag to wave, note that safety is of paramount importance in this procedure. First, observe all safety precautions regarding thermal fogging, including the use of solvent vapor respirators. In addition, note that only *light* fogging is recommended and at *intermittent intervals,* which gives the fog a chance to dissipate rapidly due to the quantity of air movement produced by the dryer. Finally, observe that effort is expended in deodorizing the carpet only, and, therefore, we can open the structure's windows and doors to allow copious ventilation and fresh airflow.

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B. UPHOLSTERED FURNITURE: Much like carpet, the horizontal portions of furniture are subject to heavy soot and odor contamination. Fortunately, the construction characteristics of upholstered furniture, for the most part, do *not* allow for extensive penetration of odor. The weaves usually are tight, they have latex back-coatings, and they often are underlaid with batting and stuffer materials that form an airflow inhibiting barrier. Of course, outside arm, outside back and bottom dust covers may represent exceptions to this statement. Thus we may conclude that the majority of the smoke odor on upholstered furniture will be at, or within, the surface or face materials.

Due to the ongoing damage created by acid soot residues, upholstery must be removed and processed at your facility, or processed on-location, as rapidly as possible. The need for a meticulous inspection prior to processing when non-colorfast or problem fabrics are encountered cannot be overemphasized. This brings us to the question of how odor may be eliminated.

1. **Remove as much loose soot as possible** either by removing the furniture to the exterior of the structure and blowing it off with a hand-held power blower, or with careful dry vacuuming. In some cases both systems in combination may be used - even, on occasions, being followed with light cleaning, using a dry cleaning sponge.
2. Since cleaning is basic to comprehensive deodorization, our next step is a thorough **wet or dry cleaning** procedure, depending on the fabric's construction and dye stability. Add a water or dry solvent-based deodorant depending on the cleaning medium selected.
3. After cleaning and drying the piece, check for residual odor. If odor remains, **thermal fog the piece with a solvent-based deodorant to penetrate** the fabric, as did the smoke with its accompanying odor. Avoid over application of thermal fogging compounds to avoid oily residues.
4. With severe odor, place the clean, dry upholstered furniture in an ozone room (ref. page 145), or polyethylene plastic tenting as a minimum, and **subject it to concentrated ozone gas for 24 to 72 hours.**
5. Should odor remain at this point, repeat steps 3 and 4 until it is completely eliminated.
6. Prior to returning the furniture to the home, **lightly thermal fog each piece,** paying careful attention to highly porous dust covers that might have allowed deep odor penetration. To accomplish this, lay the furniture on its back and thermal fog directly through the dust cover into internal construction components.

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C. DRAPERIES: Because draperies are exposed readily to air currents bearing quantities of smoke and odor, they often represent one of the most obvious odor contamination challenges within the structure. Keeping in mind the ongoing damage caused by acid soot residues, remove draperies and have them processed by a dry cleaning subcontractor, or process them on-location as rapidly as possible. Draperies are easily affected by age or atmosphere pollutants, and the need for a meticulously thorough inspection prior to cleaning cannot be overemphasized.

1. **Dry vacuum the draperies cautiously** to remove some of the residue and odor, whether they are being cleaned on-location or in-plant. This vacuuming process may also help eliminate a grayish cast around the drapery headers caused by air

currents.

2. **Add a dry solvent-based deodorant to all dry solvent cleaners** (rinse solutions). This is particularly important when an in-home or non-immersion cleaning system is used.
3. As with upholstered furniture, **thermal fog draperies with a dry solvent-based deodorant following cleaning.** The sub-micron droplets of deodorant fog easily penetrate all areas of the fabric, while its dry solvent composition eliminates the possibility of moisture circles or shrinkage.
4. **In severe odor situations, use ozone gas.** Hang draperies within a confined area, such as an ozone chamber (ref. page 145), and provide continuous air circulation throughout both face and lining materials. A small fan or blower may be used to force ozone to penetrate the fabric. Exposure time of 24-48 hours is required.
5. Should residual odor **remain, repeat steps 3 and 4 until all** odor is eliminated.

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D. NON-FABRIC (WOOD) FURNISHINGS: This discussion is primarily intended to address the deodorizing challenges brought about by finished wood furniture subject to intense smoke. Because of its construction characteristics, finished wood furniture overlaps many other components in homes and businesses, such as paneled walls, bookcases, decorative wood fixtures, kitchen cabinets and bath vanities.

All wood surfaces remain somewhat cooler than fabrics or even painted walls, and for this reason, they create quite an initial attraction for hot smoke and odor residue during a moderate-to-severe fire. The result, of course, is a rapid buildup of substantial smoke and odor.

Additionally, many furniture components are quite porous. This includes unfinished bottoms, back coverings (particularly when fiberboard is used), and interior surfaces, such as drawers. Porous surfaces are highly absorbent. Therefore, the use of water-based compounds must be limited to prevent swelling and possibly splitting them, along with the need for extensive repairs before the piece is useable again.

Porous surfaces also swell in the presence of the intense heat and humidity that is generated by a fire. This allows smoke, and particularly odor, to migrate deep within expanded surfaces and to be trapped there once the surface cools and contracts again. This accounts for our difficulty in removing the lingering traces of smoke odor.

Of course, there is always the problem of nicks and scratches that pre-existed the fire; but a careful inspection enables you to discover most of these and protect yourself from "unearned" liability.

Perhaps a more insidious pre-existing problem relates to old, oxidized or dissolved finishes. Over time, contact with hand and body oils, airborne cooking oils and even furniture waxes, causes an oily buildup on certain areas of any finished piece. Over many years, this oily residue softens and eventually dissolves the finish. When technicians begin to apply cleaning and deodorizing techniques, the inevitable result is partial, or even total removal of finish in these seemingly serviceable areas.

Clues as to which pieces or areas will manifest this problem may be obtained by asking about the age of the piece, observing its location within the structure, and its use by the occupants. Common sense questions you can ask are: "How old is this piece of furniture?" and, "Has it ever been refinished?"

Location within the home is important for two reasons. First, furniture located near the kitchen will be exposed to greater quantities of animal and vegetable oils that build up on and ultimately soften furniture finish. Second, the manner and frequency of use will affect the condition of the finish. Those areas that experience frequent contact with hands, arms or other body parts contain substantial body oil residue that eventually eats into the finish. Areas surrounding the hardware on kitchen cabinets are a classic example of this problems. These areas are exposed daily to body oils, cooking oils, heat, sunlight and the abrasive action of fingernails as well. Naturally, when a deodorizing technician performs precleaning as part of total deodorization, many of these areas simply clean down to the unfinished wood surface or, as a minimum, they become very gummy or tacky.

Also, plastic furnishings must be carefully evaluated. In a severe fire loss, plastic furnishings become heavily contaminated with smoke residue and odor. Often the extent of the odor problem is never fully realized because the residue discolors the piece to the extent that it must be replaced. If, however, the furnishing is not replaced, odor removal from the plastic may become a rather difficult job. The problem is compounded when smoke residues from burned plastics or synthetic foam materials, are involved. In other words, the chemical residues from these materials settle on, and combine with, other plastic surfaces within the home. Then odor removal becomes not only difficult but often, depending on the replacement cost of the item involved, impractical. It is with this in mind that professional deodorizing technicians occasionally recommend replacement of plastic shower curtains, handbags, wallpaper and inexpensive furniture items, rather than employing extensive and time consuming deodorization procedures.

The point of this entire discussion is simply to emphasize the importance of a thorough inspection, followed by a careful insured or insurance representative briefing on problems over which you have no control.

Only then are you ready to proceed with hard surface furniture deodorizing tech piques.

1. The first step in our procedure for deodorizing wood furniture is, as you might expect, to **thoroughly clean all finished and unfinished surfaces.** In light-to--moderate residue situations, cleaning with a mild detergent and a general-purpose deodorant may be all that is required. In heavy contamination situations, cream restorers, incorporating powerful pairing agents, are extremely helpful both in the cleaning and deodorizing function. Cream restorers consist of a gel emulsion that contains dry solvents, emulsified detergents and polishes, along with the deodorants previously mentioned. The gel allows us to apply the cream restorer evenly to vertical, as well as horizontal surfaces.

   The cleaning process itself substantially aids in the process of deodorization in several ways: First, the detergents in the compound suspend excess soot residue for easy removal later on. Second, the dry-solvent agents soften the uppermost of several layers of finish found on most fine furniture. After this softening process takes place, the soot staining (yellowing) is polished out of the finish with 0000 (polishing grade) steel wool. Simultaneously, most of the malodor that has become a part of the soot stained finish is removed.

   Third, highly porous wood surfaces (drawer interiors, backs, etc.) may be cleaned with water-based solutions containing general purpose or heavy-duty deodorants. Bear in mind that excess moisture may easily damage porous surfaces; therefore, cleaning technicians must use only a slightly **moist** cloth or sponge, and they must rely on agitation to remove much of the smoke stain on these surfaces. Follow the cleaning process with light sanding of residual smoke stains, until uniform appearance is achieved on all porous wood surfaces.
2. Next, **apply a dry solvent-based deodorant directly to all non-visible, highly porous surfaces.** This may be accomplished with a dry solvent deodorant saturated cloth or with a small sprayer capable of dispensing dry solvents. Spread the solvent evenly over all surfaces with heavy odor. Although dry solvents do not cause problems in terms of swelling and splitting the wood, be cautious about oily residues due to over application of the deodorant.
3. Once the furniture has been cleaned and porous surfaces have been treated with a dry-solvent deodorant, **follow with ozone deodorization.** Again, confine the airspace either in a relatively airtight room or specially constructed ozone chamber (ref. page 145), or use plastic tenting. Elevate the RainbowAir® ozone generator, and provide an auxiliary fan for effective dispersion of the gas. Open all drawers slightly for interior, as well as exterior, deodorizing. A 24 to 48-hour minimum exposure time is recommended.
4. While the furniture is still in a confined area, thermal fog to penetrate every area with dry-solvent deodorant. Expose the furniture to the fog for at least 20

minutes before thorough aeration is begun.

5. Once the furniture has aired out completely, **critically evaluate it for residual odor.** If any exists, repeat steps 3 and 4 until all odor is completely eliminated. Remember, in many cases, this furniture will be used to store intimate clothing articles. Remaining odor not only will be noticed by consumers, but it may also result in cross contamination of garments.
6. If the furniture remains in storage for a period of time, deodorization may be extended throughout the period by placing a deodorant block inside. Be sure to place the block on a sheet of aluminum foil to avoid staining porous wood surfaces by the essential oils contained in the block.
7. Immediately prior to delivery, thermal fog each furniture item one last time. Finally, follow up by dusting and polishing carefully. Almost invariably, customers will open a drawer on each piece and "sniff out" the interior. They must be greeted with an overwhelmingly pleasant fragrance to prevent the possibility of psychological odor problems that may hamper the successful conclusion of the job.

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E. CLOTHING: Homeowners have several misconceptions relating to odor in clothing and other household fabrics. First, they believe that closed closet doors or closed drawers provide protection against smoke residue and odor in a moderate to heavy smoke-damage situation. That's simply not true. Second, they believe that polyethylene plastic coverings provide minimum protection from soot-residue contamination, while they actually decrease the probability of severe odor in the garment. The fact is that rapidly expanding air in the fire situation easily penetrates into clothing even when plastic covers are present. Later, as the air cools and fresh air circulates throughout the home, including the closets, garments covered by plastic with odor inside are not subject to the normal airing-out process. Therefore, the malodor has an opportunity to thoroughly penetrate the garment. To compound the problem, the plastic itself actually attracts and retains odor to a considerable degree and, for this reason, it must be removed and disposed of as soon as practical.

Clothing is a highly personalized item that is worn in close proximity to the body It is, therefore, subject to considerable scrutiny by its owner. Additionally, as the person wearing the garment warms up and "humidifies" the garment with perspiration, residual smoke odor may become readily apparent.

For these reasons, deodorization efforts on clothing must be carefully applied and thoroughly effective.

1. One of the best ways to get the insureds occupied and to take their mind off the disaster they have suffered is to get them busy **separating garments into four categories.**

a. *Disposables* - Ask insureds to separate and dispose of all worn out or outgrown clothing that probably should have been thrown away years ago. This saves the insurance company money, which may be appreciated by the insurance representative, while it minimizes deodorizing problems by reducing the quantity of clothing being processed.

b. *Immediate Needs* - The second category includes a few garments for each family member's immediate needs. Expedite processing of these garments in order to reduce expenditures for immediate clothing needs.

c. *High-value Items* - The third category includes all high-value items; i.e., items you need to identify, list and hand carry to the dry cleaner so that there's no possibility of their getting lost in the shuffle. Examples are furs, leathers, formal wear, etc. This prevents financial liability for your company.

d. *Routine Cleaning* - The fourth category includes all other garments insureds wish to have cleaned, using normal procedures.

2. **Clean all clothing as quickly as practical.** Again, cleaning is basic to thorough deodorization and will actually result in saving more clothing, due to rapid neutralization of acid soot residue.

Many restoration schools in the past have taught that all clothing must be deodorized prior to being dry cleaned with chlorinated solvents (perchloro-ethylene), **while** the decision is optional when petroleum (Stoddard) solvents are used. The impression conveyed is that somehow chlorinated solvents actually set the odor in clothing. Since most dry cleaners use chlorinated solvent and since deodorization prior to cleaning is a more prolonged and expensive process, the question is, "Just how valid is this information?"

Extensive testing by cleaning firms having access to both chlorinated and petroleum systems indicates that there is no appreciable difference in odor retention when deodorizing occurs after cleaning, other than a significant reduction in the time required for complete deodorization to occur. Also, dry cleaners have solvent-based deodorizing compounds that can be added to either type of cleaning solution.

Moreover, if technicians leave acid soot residues on clothing for the time necessary for odor removal to take place first, then that residue may discolor the garment to the extent that salvaging it is not possible. Also, remember that clothing with the majority of the malodorous residue removed is much easier and faster to deodorize. Thus, the clothing required for the family's immediate use can be returned sooner.

A wise deodorizing technician anticipates somewhat higher charges from the dry cleaner for cleaning garments with high levels of NVR (non-volatile residues) (moderate-to-heavy soot damaged clothing). Elevated levels of NVR require more frequent solvent filtration or distillation, which is a rather expensive procedure. Failure to monitor and clean NVR from the solvent bath results in contamination of future loads of clothing run in the unfiltered solvent.

3. After cleaning, place clothing in a confined airspace area, such as an ozone room (ref. page 145), and **subjected to ozone gas for** 24-48 **hours. Continuous** forced air circulation is a must, since ozone gas is heavier than air and tends to build from the floor level upward. Locate the RainbowAir® ozone generator outside the chamber or well above the floor in order that fresh air may be obtained. Be sure that none of the clothing is damp during this process, since ozone gas combined with moisture produces a bleaching effect (hydrogen peroxide) that may in turn result in color loss.
4. A follow-up, or even an alternative to ozone deodorization in light odor situations, **is thermal fogging with solvent-based deodorants.** Thermal fogging procedure produces more rapid results, depending on malodor composition, and has the secondary advantage of leaving a light, pleasant residual fragrance in the garments being deodorized. Like ozone gas, the thermal fogging techniques require a confined airspace for application. Allow the fog to remain in continuous contact with the clothing for 20-30 minutes prior to complete and thorough aeration. Caution: if insureds express concern about severe chemical sensitivities, stick to ozone only for deodorizing anything as intimate as clothing.
5. Should residual odor remain, **repeat step 3 for a period of 24-48 hours** with plenty of ozone circulation throughout clothing fabrics.
6. A very light, non-confined thermal fogging of clothing, upholstery, draperies and other fabrics just prior to delivery creates a very positive impression on the odor sensitive customer with whom you are dealing.

See summary outline at page 170

F. HOW TO BUILD AN OZONE ROOM:

1. **Construction Specifications:**
    a. Construct room approximately 12' wide by 12' long by 8-10' high. Frame the room carefully and caulk the base plate (sill plate) with silicone caulk

to prevent ozone from escaping later on. In facilities with extended ceiling height (over 12'), consider using 2x6" ceiling joists. This provides extra storage space and supports heavy objects on top of the ozone chamber for miscellaneous storage. This may be critical as your business grows!

b. The room can be constructed from Sheetrock~ (drywall), plywood or plastic sheets. Once the room is framed and enclosed with drywall or plywood, consider installing batt insulation to further confine the airspace within the chamber. Then wrap the room in heavy-gauge plastic sheeting, stapling the plastic to the exposed interior wall studs. Finally, finish the interior with drywall, plywood or paneling.

c. Door opening must be constructed with sufficient height and width (double doors) to accommodate the in-and-out movement of large furniture items. A moveable threshold is a good idea to allow furniture to be rolled in and out of the chamber on carts or dollies. Be sure the doors seal tightly against frames when closed, so that minimum ozone escape into other areas of the facility, even with slight negative air pressure inside.

d. Depending on where the RainbowAir® ozone unit is placed, an optional exhaust system may be needed to evacuate ozone gas to the outside when entrance to the chamber is required (refer to drawing on the following page). **Ozone will revert back to oxygen in approximately one to two hours.**

2. RainbowAir® Ozone Generator Use:

a. For deodorization purposes RainbowAir® Activators should be set at maximum output.

b. Remember that ozone gas is heavier than air and tends to settle to the floor of the ozone chamber. Therefore, a circulating fan or airmover should be used to move ozone around room to achieve maximum efficiency in penetrating into all areas where odor may be trapped.

c. When deodorizing clothing, hang garments on a pole that is installed so that the bottom of long garments are at least 18" off the floor, if possible. Separate the garments (two fingers between each hanger) and, with heavier garments such as winter coats, unbutton or unzip them.

d. When deodorizing fabric furniture in an ozone chamber, remove cushions and place them on rack or furniture platform in "tee-pee" configurations.

CAUTION: *Exposed* natural rubber must be coated with a silicone spray to prevent cracking. This does not apply to urethane foam cushion materials.

Comprehension Quiz: XII - CONTENTS DEODORIZATION

1. Contamination of carpet by odor and debris is aggravated by the fact that it is installed on a __________ plane.
2. Carpet must be deodorized on an __________ basis, rather than as part of ____ ___________ deodorizing.
3. As a basic part of carpet deodorization ____________ __________residues must be and ___________.
4. During structural restoration carpet must be protected from ________ _______ ________ from surface cleaning.
5. A _________ - _________ application of _________ - __________ deodorant is required for carpet deodorization.
6. Should insureds be concerned about penetration of smoke odor into cushion of sub floor areas, a _______ application of _______ ________ deodorant may be made using a ________ ________.
7. Airborne odor penetration into upholstered fabrics is limited by ______ _ of fabrics.
8. A quantity of odor causing residue may be removed rapidly from upholstery using a _________ ___________.
9. All upholstery cleaning agents, either wet- or dry-side, should incorporate an appropriate _________ during __________.
10. Follow cleaning of upholstery with ___________ ___________.
11. If odor in upholstery fabric persists, confined ________________ deodorization is specifically recommended.
12. Prior to its return to the home, lightly _________ ___________ all furniture.
13. To ___________ ___________ avoid caused by smoke residue, process draperies immediately.
14. Add a ___________ ___________ deodorant to all drapery cleaning solvents.
15. ________ fogging is highly effective where draperies contaminated with smoke odor are concerned.
16. In severe contamination situations, _______ ________ may be required to remove

persistent odor from draperies.

17. Porous wood surfaces _______ in the presence of intense __________ and __ ________.
18. Always inspect finished wood surfaces carefully for _______ _______ prior to using cream restorers in the cleaning and deodorizing process.
19. People humidify garments with ________ that amplifies odor.
20. Deodorize moisture sensitive clothing with _________ __________ or _____ _____ _______ only.

AUTOMOBILE

DEODORIZATION

Automobiles contaminated by various "disaster" situations represent an area of challenge to professional deodorizing technicians that should not be overlooked In this chapter we'll examine three of the most common automotive deodorizing situations you're likely to encounter. The procedures used on these three, with modifications as circumstances dictate, enables you to formulate a plan for resolving almost any other automotive deodorizing situation you're likely to encounter.

A. GENERAL PROTEIN ODOR (Fish, Milk, Egg, Blood): This deodorizing problem involves persons who transport protein foods in their automobiles in containers (polystyrene cooler, grocery bag) that are cracked or, in some other way, allow leakage inside the car. This is fairly common, particularly with fish contamination, and, therefore, warrants separate coverage. Of course, fish slime carried by water from melted ice saturates carpet and cushion throughout the area of immediate contact and, depending on the amount of moisture, will migrate to surrounding carpeted areas. In severe cases, penetration may extend through the metal flooring and even into insulation material comprising the fire wall that separates the catalytic converter from the underside of the vehicle.

The malodor problem is generated by bacterial growth related to, and decomposing protein in the fish slime. Steps to consider in resolving this situation are:

1. Technicians must **wear appropriate personal protective equipment during** all procedures of this type. **Decontaminate** all surfaces for operator health and safety.
2. **Remove interior components (seats, etc.), as required,** that hamper your ability to have ready access to all the carpet and cushion. Protein in liquids almost always creates more extensive contamination than is apparent. Almost invariably auto owners will initiate procedures in their attempts to correct the problem. Therefore, it is very easy to underestimate the extent of damage.
3. **Extract all excess protein fluids** that remain with a wet pickup vacuum.
4. **Clean all areas of severe contamination.** Make this a "flood and flush" operation with a cool-to-warm, neutral (pH 6-8) sanitizing (ammonium chloride) solution. Extremely hot solutions (in excess of 150°f/66°c) may set protein. Remove and aggressively "flood and flush" floor mats as well. Final rinse with clear water.
5. Upon drying, completely ***saturate*** **the clean carpet and cushion with a properly diluted, quality, enzyme deodorant solution.** Your primary effort is to digest the protein fish slime causing the malodor. Remember that enzyme digesters work best in a warm (80-120°f/27-49°c), moist, neutral environment.

Also, saturation of the matador area for a prolonged period (4-8 hours) is required, and, therefore, you should not extract the excess enzyme solution.

6. While the carpet and cushion is soaking in the enzyme deodorant solution, thoroughly **clean all interior components that were subjected to odor vapors.**
   a. Clean upholstery with normal solutions containing a quality, general purpose or heavy-duty odor counteractant. Be sure to concentrate on surfaces that may be in direct contact with the contaminated carpet (subject to wicking). Of course, if the upholstery was also saturated with fish slime, apply the same enzyme deodorant used on the carpet. Anticipate that odor removal from foam rubber cushion materials may be extremely difficult, due to the degree of penetration and the density of the foam.
   b. Clean hard surfaces within the vehicle with solutions containing a general purpose deodorant.
   c. Dry clean fabric headliners with solvent-based deodorant added to cleaning solutions.
   d. Clean and wipe down dashboards and vinyl components with solutions containing silicone lubricants (Armor Alla) mixed 4:1 with dry solvent deodorant.
   e. Clean trunk liners with wet- or dry-cleaning techniques (with appropriate deodorant additives), depending on the degree of contamination.
7. After sufficient dwell time has elapsed (4-8 hours), **extract the excess enzyme solution and establish positive drying procedures.** Accomplish this using a carpet dryer and volumes of airflow directed at or under the carpet, or by enclosing a dehumidifier within the vehicle. Positive ventilation is always an important part of rapid deodorization.
8. If odor persists, thoroughly **thermal fog the vehicle interior** and allow the fog to remain inside for at least 20 minutes before aeration. Then repeat steps 4 and 6. Eventually, the enzyme deodorant will break down and neutralize the protein odor problem. Make plans to retain the vehicle for a 2-4 day processing period, depending on the severity of contamination. For this reason, begin work as soon as the vehicle is received.

   In severe protein situations, as much as two weeks has been required for total deodorization!
9. After using the enzyme deodorant treatment two or there times, if odor still persists, **saturate areas of direct contact** with an EPA-registered disinfectant to attack residual bacterial odor. Never use disinfectants with enzymes, nor should they precede the use of enzymes.

Of course, disinfectants work within 10-15 minutes; therefore, after a saturation application has been made, extract the treated carpet and cushion carefully. Then, implement drying procedures. Note that ozone generators are of limited use in *carpet deodorization,* primarily because they are unable to penetrate the carpet and cushion where the concentrated odor resides. However, ozone may be quite useful in deodorizing other components subjected to odor vapors. Be sure that all components that may contain natural rubber are protected with dry silicone lubricant, and do not use ozone gas when vehicle fabrics are moist, since this could result in color loss over time.

10. Once the odor is completely removed, **lightly extract (final clean) the carpet and final clean all other interior surfaces** as well.
11. **Reinstall all interior components** (seats, etc.), if removed, and mount a solid deodorant block underneath the front seat where air circulation will produce a pleasant fragrance over a prolonged period.
12. Thoroughly **clean the vehicle exterior** in order to create a positive psychological impression. Carefully clean interior and exterior glass surfaces in this step.
13. **Lightly thermal fog the vehicle interior a few hours prior to delivery** (then, air it out) in order to produce an overall pleasant fragrance.

The most common mistake made in protein odor situations involving automobiles is that technicians grossly underestimate the "staying power" of this odor. Success in this situation requires meticulous and repeated application of these procedures over a period of time. If the vehicle's owner can't survive without it for several days, you simply will not have sufficient time to complete all procedures in sequence.

Depending on the degree of contamination, carpet and cushion replacement may be an ultimate option.

****See summary outline at page 171****

B. DEATH SCENE - Automobile: This situation involves a vehicle in which an individual has died, whether by murder, suicide, or from natural causes. Naturally, some time at a mild-to-warm temperature, must have elapsed in order for decomposition and subsequent contamination to occur to the extent requiring the comprehensive deodorization procedures.

If you or one of your employees must drive the car from its present location to your plant, be sure to take at least four precautions: First, be sure that you have liability insurance that covers you while driving someone else's car, since most standard business policies do not cover this. Second, make plans for an immediate application of an EPA-registered disinfectant to sanitize the area of severe contamination. Third, a vapor respirator will be essential to the driver's survival during transport! Finally, take along some plastic sheeting to cover the area of most severe contamination and, thereby, to confine the odor at its source, at least to some extent.

And did I mention that you should pick it up *before* lunch?!

Let the owner know at the outset that one to two weeks may be required for processing. Make arrangements to accomplish initial deodorization outside your facility, since the severity of this odor problem - both real and psychological - will easily cross-contaminate other articles, not to mention its adverse effect on the minds and olfactory senses of employees who must remain in the facility.

Now, consider the procedures that follow:

1. Assuming that surfaces were sprayed with disinfectant prior to transporting the **vehicle, remove and dispose of all replaceable, heavily contaminated fabrics** (carpet, padding, upholstery, foam cushions - perhaps more!). Often seats and carpet are severely contaminated with decaying organic fluids; therefore replacement is, by far, the most reasonable alternative. If these components are to be salvaged, remove them anyway for separate processing outside the vehicle. Then, salvage cleaning and deodorizing procedures may be undertaken, to include:
    a. flood and flush directly contaminated surfaces with a warm, neutral detergent solution.
    b. repeatedly flood and soak (4-6 hours) directly contaminated surfaces (especially fabrics) with enzyme deodorants or with strong disinfectants, as discussed in the preceding section on protein odor. Never mix the two.
2. **Thoroughly clean all surfaces within the automobile** (both hard and soft surfaces) with a medium-duty detergent solution (pH 8-9.5) containing a general purpose deodorant. This must be a very meticulous cleaning process that includes virtually every crack and crevice that can be cleaned. If *any* protein remains, odor will return!
3. **Make a direct application of disinfectant/deodorant to all durable surfaces within the automobile.** Obviously, avoid moisture sensitive surfaces and components.
4. Next, with carpet and seats removed, **coat all gaskets and natural rubber components within the automobile with a dry silicone compound** (Armor-All®, Amway). Remove the spare tire and park the vehicle in a well ventilated place. The dry silicone spray prevents decomposition of natural rubber components during subsequent deodorizing procedures using ozone gas.

5. **Place a RainbowAir® ozone generator within the passenger compartment** (or trunk) where the most severe contamination occurred, and allow it to operate for a minimum of 24 hours on a maximum output setting. In this manner, the air within the vehicle is circulated while a high concentration of ozone gas is maintained.
6. Next, remove the RainbowAir® generator and aerate the vehicle for at least 30 minutes. Then **place the RainbowAir® ozone unit outside the vehicle and, using the optional RainbowAir® hose kit, pipe fresh ozone from the outside into the vehicle.** This procedure creates slight positive pressure inside the automobile and forces ozone into every crack or crevice that may have been contaminated by malodor. Allow this application to continue for 48-72 hours, at least.
7. At this point **aerate the vehicle and carefully determine the amount of odor reduction.** If the odor remains fairly substantial, continue employing steps 3, 4, 5 and 6 until satisfactory removal is achieved. Total odor removal in any severe protein contamination situation is a frustrating and prolonged procedure. However, if you persist with aggressive procedures, positive results eventually will be realized.
8. Final clean all interior and exterior surfaces.
    a. Clean cloth headliners with standard dry solvent formulations mixed with approximately two ounces of solvent-based deodorant to each gallon of solvent.
    b. Final clean all salvageable carpet and upholstery with water-based cleaning solutions containing a general purpose deodorant.
    c. Final clean all hard surfaces with a detergent/deodorant solution. Be sure to pay careful attention to interior glass surfaces to assure a positive impression.
    d. Carefully clean exterior surfaces also for that all-important, first impression.
    e. Wipe down dashboards and vinyl components liberally with solutions containing silicone lubricants (Armor All.) mixed 4:1 with dry solvent deodorant.
    f. Clean trunk liners with wet or dry cleaning techniques (with appropriate deodorant additives), depending on the surface and degree of contamination.
9. **Thermal fog the vehicle interior.** Allow the dry-solvent deodorant fog to remain in the vehicle for at least one-half hour prior to final aeration.
10. **Place a solid deodorant block in an inconspicuous area under the driver's**

seat. Lodge this block within the seat springs in order to enable it to continuously "re-odorize" the automobile for a period of weeks after delivery.

11. **Air out the vehicle** with forced, fresh air for several hours before delivery in order to return it to as normal a condition as possible.

Anticipate having to spend between 12 and 18 hours in actual work processing, depending on your experience, in a situation of this type. This time requirement, along with chemical and equipment usage, should be the basis of at least half of your actual charge for the procedure. The other half should be for the knowledge you use to tackle an extremely difficult deodorizing situation, which results in changing a relatively worthless vehicle into something that again has value.

Plainly stated, be sure the owner or insurance company knows that *several* hundred dollars will be involved in the restoration procedure before tying up this much of your time effort, *and experience* (knowledge).

This is a tough one! Don't sugar coat your explanation of the problems - rather challenges - involved.

See summary outline at page 171*

C. SMOKE ODOR: This situation involves a vehicle that has experienced minor-to-moderate smoke damage associated with the engine compartment or electrical system. Due to the nature of the synthetic materials that are burned, deodorization may be more difficult than you might think on your first appraisal of the situation, Odor removal is complicated by burning synthetics (plastics), as opposed to organic components, since most of the chemicals and equipment we use are oriented toward the removal of organic odors. These gaseous residues are quite acid and cause rapid oxidation of metal components and discoloration of other plastic surfaces. Moreover, gaseous residues may penetrate and combine with the actual chemical structure of other plastic components in the vehicle, thereby, creating a tenacious (long lasting) malodor situation.

Your first step is a very careful inspection, in coordination with the insurance company's representative, to determine the extent of the damage and the cost of restoration, versus replacement with a vehicle of comparable value. This evaluation must consider the cost of cleaning and deodorizing, as well as the cost of components that must be replaced.

Once the determination to proceed has been made, consider the following steps:

1. **Remove all components that are damaged beyond repair** as a result of contact

with the fire or excessive heat. This may include unusable wiring harnesses, dashboard components, carpet, upholstery, etc. Have a certified mechanic remove these components, so that he or she can see how the components are related in their overall installation, and parts for replacement can be ordered to expedite overall restoration. Remove all major vehicle components that are easily detached (upholstered seats, etc.) for processing outside the vehicle, in order to expose more interior surfaces.

2. Next, **expose all surfaces to a direct spray application of heavy-duty, smoke odor counteractant.** Use common sense here and do not introduce excess moisture on sensitive items, such as electronic components or fabric headliners that should be dry cleaned.
3. Shortly after the initial deodorant application, **clean the entire interior** using appropriate cleaning agents with a deodorant additive on each different surface encountered. Clean and deodorize carpet and upholstery materials in the manner described in the previous chapter on contents deodorization. Process the headliner with on-site, dry solvent cleaning procedures similar to those used on draperies, unless it is heavily smoked (requires replacement) or composed of plastic fabrics that can be wet cleaned.
4. After cleaning and drying interior components, **thermal fog the vehicle.** Allow the automobile to remain closed for 30 minutes for complete penetration of the deodorant fog into all areas.
5. Next, carefully **coat all gaskets and other natural rubber components within the automobile with a dry silicone compound** (Armor-All®, Amway). Remove the spare tire and park the vehicle in a well ventilated place. The dry silicone spray prevents decomposition of natural rubber components by subsequent deodorizing procedures using ozone gas.

   Place an RainbowAir®. ozone machine in operation outside the vehicle, and, using the optional hose kit, pipe fresh ozone from the outside into the vehicle. This creates slight positive pressure inside the automobile and forces ozone gas into every crack or crevice that may have been contaminated by malodor. Allow this procedure to continue for 48-72 hours.
6. Should smoke odor remain, sniff out odor pockets, concentrating your attention on plastic components. If these components are the major source of residual odor, a **direct application of dry solvent deodorant may be made** by saturating a cloth with the undiluted deodorant and applying it directly to the plastic surfaces. Be sure to *test carefully* in an inconspicuous spot before using this procedure. If color transfer, surface dulling or other damage is noticed after

the surface dries, *do not use this procedure.*

7. At this point, carefully determine the amount of odor reduction. If the odor remains fairly substantial, **repeat steps 2, 4 and 6 until satisfactory** removal is achieved.
8. Once the smoke odor has been completely removed, **final clean the interior** *and* **exterior surfaces of the vehicle.** Accomplish detail cleaning on glass and chrome in order to achieve a positive psychological advantage when the vehicle is first viewed by the owner.
9. Lightly **thermal fog the interior one final time and place a solid deodorant block in an inconspicuous area under the driver's seat.** Lodge this block within the seat springs in order for it to continuously "re-odorize" the automobile for a period of weeks after delivery.
10. Finally, **return the vehicle to the mechanic who will be installing replacement components for those that had to be removed.** This renders the vehicle ready for use by the owner.

Note that if a vehicle contains leather upholstery, the dry solvent deodorant will be most persistent, to some clients, even objectionable. This situation can usually be corrected with an overnight application of ozone gas.

***See summary recline at page 171 ***

D. TOBACCO SMOKE (NICOTINE ODOR): This section addresses situations in which tobacco products have been used in automobiles for some time, usually to the point where nicotine odor quite offensive to a prospective buyer. Tobacco products used in an automobiles can produce two phases of odor and staining problems: Gas phase and particle phase.

The gas phase can produce a number of chemical compounds such as carbon dioxide, carbon monoxide, ammonia and acetone. The particle phase also will produce its own group of chemicals including tar, nicotine, toluene and phenols. In all, tobacco smoke contains more than 3,600 different chemicals including formaldehyde and nitrogen dioxide.

The gaseous and particulate residues are quite acidic and very rapidly will cause oxidation of metal components and discoloration of leather, fabric and plastic surfaces. Moreover, these gaseous residues may penetrate and combine with the actual chemical structure of plastic components in the vehicle, and thereby create a very tenacious (long lasting) malodor situation.

The first step then is a careful inspection to determine what will be replaced due to damage caused by burning tobacco products (i.e., floor mats, seat covers, etc.). Consider the cost of cleaning and deodorizing, as well as the cost of components which must be replaced. Once the determination to proceed has been made, the following steps should be undertaken:

1. Expose all surfaces to a direct spray application of heavy-duty, smoke odor counteractant. Use common sense and do not introduce excess moisture on sensitive items such as electronic components or fabric headliners which should be dry cleaned.
2. Shortly after the initial deodorant application, the entire interior must be meticulously cleaned, using appropriate cleaning agents with deodorant additives on each different surface encountered. Clean and deodorize carpet and upholstery materials in the manner described in the previous chapter on contents deodorization. Process headliners with on-site, dry solvent cleaning procedures similar to those used on draperies, unless they are heavily smoked stained (requires replacement) or composed of plastic fabrics not affected by wet cleaning.
3. **All gaskets and other natural rubber components within the automobile should be carefully sprayed with silicone lubricant (Armor All.). Remove the spare tire and park the vehicle in a well ventilated area. The silicone spray prevents decomposition of natural rubber components by subsequent deodorizing procedures using ozone.**

   Place the RainbowAir® machine in operation outside the vehicle and, using the optional 5' hose kit, pipe fresh ozone from the outside into the vehicle. This procedure creates slight, positive pressure inside the automobile and forces ozone gas into every crack or crevice which may have been contaminated by malodor. Allow this procedure to continue for 12-24 hours. When using ozone within the automobile, periodically operate the heating or AC system to circulate ozone throughout the system so that all odors are completely removed. Failure to do so will result in odors being tapped within the system and later, being reintroduced throughout the automobile when the system eventually is turned on.
4. Should tobacco odor remain, sniff out odor pockets concentrating attention on plastic components. If these components are the major source of residual odor, a direct application of dry solvent-based deodorant may be made by saturating a cloth with the undiluted deodorant and applying it directly to plastic surfaces. Be sure to *test* carefully in an inconspicuous spot before using this procedure. If color transfer, surface dulling, or other damage is noticed after the surface dries, do not use this procedure.

5. At this point, carefully determine the amount of odor reduction. If the odor remains fairly substantial, continue to employ steps 2, 4 and 5 until satisfactory removal is achieved.
6. Once the smoke odor has been completely removed, final clean the interior and exterior surfaces of the vehicle. Detail cleaning should be accomplished on glass and chrome in order to achieve a positive psychological advantage when the vehicle is first viewed by the owner. Finally, the vehicle should be turned over to the mechanic who will be installing replacement components for these which were removed. This renders the vehicle ready for use by the owner.

NOTE: If a vehicle contains leather upholstery, the dry solvent deodorant will be most persistent - to some clients even objectionable. This situation can usually be corrected with an overnight application of ozone.

Comprehension Quiz: XIII - AUTOMOTIVE DEODORIZING

1. Protein contamination in automobiles usually includes substances such as ___ ______, ________, ________ and _______.
2. The technician's biggest problem in automotive deodorizing involving protein is ___________ the extent of ________.
3. To gain access to all carpeted areas to thoroughly process automobiles, it is usually necessary to remove _________ as a minimum.
4. Basic to protein decontamination is thorough ___________ using ___________ detergent solutions.
5. The first chemical normally considered in neutralizing protein odor is an ____ _______ deodorant.
6. Anticipate that protein odor removal from ________ ________ cushion materials may be difficult due to the degree of _______.
7. Clean fabric _________ in cars with _________ ___________.
8. Treat dashboards and vinyl materials with a _______________lubricant mixed 4:1 with _________ - _________ deodorant.
9. Positive _________ is always an important part of total odor removal.
10. In severe protein odor situations, as much as ______ ________ time has been required for total deodorization.
11. After using enzyme deodorant, if protein odor persists, ___________- _______ ___________ may be used to attack bacterial odor.
12. Light odor on interior surfaces not directly contaminated with protein may respond well to _________ ___________.
13. Clean the vehicle exterior for positive _________ ___________.
14. Before transporting a car from a death scene to your facility, be sure your company has adequate ___________ ___________.
15. Whenever technicians drive severely malodorous vehicles, they should wear ________ ___________.

16. Vehicles with death scene odor may require one to two ________________ for processing.
17. Severely contaminated __________ may require replacement in death scene situations.
18. While ________ or ________ disinfectants may be used to attack odor in vehicle fabrics, _______ ________ is usually the best deodorant for use on airspace and other components within vehicles.
19. Thoroughly _________ a vehicle before final inspection for odor pockets is mandatory.
20. Final cleaning applies to both __________ and _________ surfaces.
21. In coordinating the restoration of a smoke damaged vehicle, evaluate _______ versus __________ costs.
22. To expedite restoration, remove all ________ ________ within the vehicle that are easily ______.
23. Spray all salvageable surfaces within a smoke damaged vehicle with _______ ___________ - _________ deodorant.
24. Dry clean vehicle headliners with _________ _________ deodorant added to cleaning solutions.
25. Apply __________ deodorization for _________ hours.

XIV - ORGANIC ODORS AND POLLUTANTS CONTROLLED BY OZONE AND CHEMICAL REACTIONS

Acetaldehyde
Acetic Acid
Acetic Anhydride
Acetone
Acetylene
Acrolein
Acryaldehyde
Acrylic Acid
Acrylonitrile
Adhesives
Aged Manuscripts
Air Wick
Alcohol
Alcoholic Beverages
Amines
Amyl Acetate
Amyl Alcohol
Amyl Ether
Animal Odors
Anesthetics
Aniline
Asphalt Fumes
Automobile Exhaust
Bacteria
Bathroom Smells
Benzene
Body Odors
Burned Flesh
Burning Food
Burning Fat
Butadiene
Butane
Butanone
Butyl Acetate
Butyl Alcohol
Butyl Cellosolve
Butyl Choloride
Butyl Ether
Butylene
Butyne
Butyraldehyde
Iodoform
Irritants
Isophorone
Isoprene
Isopropyl Acetate
Isopropyl Alcohol
Isopropyl Ether
Kerosene
Kitchen Odors
Lactic Acid
Lingering Odors
Liquid Fuels
Liquor Odors
Lubricating Oils and Greases
Lysol
Masking Agents
Medicinal Odors
Melons
Menthol
Mesityl Oxide
Methane
Methyl Acetate
Methyl Acrylate
Methyl Alcohol
Methyl Bromide
Methyl Butyl Ketone
Methyl Cellosolve
Methyl Cellosolve Acetate
Methyl Chloride
Methyl Chloroform
Methyl Ether
Methyl Ethyl Ketone
Methyl Formate
Methyl Isobutyl Ketone
Methyl Mercaptan
Methylal
Methylcyclohexane
Methylcyclohexanol
Methylcyclohexanone
Methylene Chloride
Mildew

Butyric Acid
Camphor
Cancer Odor
Caprylic Acid
Carbolic Acid
Carbon Dioxide
Carbon Monoxide
Carbon Tetrachloride
Cellosolve
Cellosolve Acetate
Charred Materials
Cheese
Chlorine
Chlorobenzene
Chlorobutadiene
Chloro Nitropropane
Chloropicrin
Cigarette Smoke
Citrus and Other Fruits
Coal Smoke
Combustion Odors
Cooking Odors
Creosote
Cresol
Crotonaldehyde
Cyclohexane
Cyclohexanol
Cyclohexene
Dead Animals
Decane
Decaying Substances
Decompostion Odors
Deodorants
Dibromethane
Dichlorobenzene
Dichlorodifluoromethane
Dichloroethane
Dichloroethylene
Dichloroethyl Ether
Dichloromonofluormethane
Dichloro-Nitroethane
Dichloropropane
Dichlorotetrafluorethane
Diesel Fumes
Diethyl Amine
Diethyl Ketone
Dimethylaniline

Mixed Odors
Mold
Monochlorobenzene
Monofluorotrichloromethane
Moth Balls
Naphtha (Coal Tar)
Naphtha (Petroleum)
Naphthalene
Nicotine
Nitro Benzene
Nitroethane
Nitroglycerine
Nitromethane
Nitropropane
Nitrotoluene
Nonane
Noxious Gases
Octylene
Octane
Odors
Odorants
Onions
Organic Chemicals
Packing House Odors
Paint & Redecorating Odors
Palmitic Acid
Paper Deteriorations
Paradichlorobenzene
Paste & Glue
Pentane
Pentanone
Pentylene
Perchloroethylene
Perfumes, Cosmetics
Perspiration
Persistent Odors
Pet Odors
Phenol
Pitch
Plastics
Popcorn & Candy
Poultry Odors
Propane
Propionaldehyde
Propionic Acid
Propyl Acetate

Propyl Alcohol
Dipropyl Ketone
Embalming Odors
Ethane
Ether
Ethyl Acetate
Ethyl Acrylate
Ethyl Alcohol
Ethyl Amine
Ethyl Benzene
Ethyl Bromide
Ethyl Chloride
Ethyl Ether
Ethyl Formate
Ethyl Mercaptan
Ethyl Silicate
Ethylene
Ethylene Chlorhydrin
Ethylene Dichloride
Ethylene Oxide
Essential Oils
Eucalyptole
Exhaust Fumes
Fabric Finishes
Fecal Odors
Female Odors
Fertilizer
Film Processing Odors
Fish Odors
Floral Scents
Fluorotrichloromethane
Food Acromas
Formaldehyde
Formic Acid
Freon
Fuel Gases
Fumes
Gangrene
Garlic
Gasoline
Heptane
Heptylene
Hexane
Hexylene
Hexyne
Hospital Odors
Household Smells

Dioxane
Propyl Chloride
Propyl Ether
Propyl Mercaptan
Propylene
Propyne
Putrefying Substances
Putrescine
Pyridine
Rancid Oils
Resins
Reodorants
Ripening Fruits
Rubber
Sauerkraut
Sewer Odors
Skatole
Slaughtering Odors
Smoke
Solvents
Sour Milk
Spilled Beverages
Spoiled Food Stuffs
Stale Odors
Stoddard Solvent
Stuffiness
Styrene Monomer
Tar
Tarnishing Gases
Tetrachloroethane
Tetrachloroethylene
Tetrahydrofuran
Theatrical Makeup Odors
Tobacco Smoke
Toilet Odors
Toluene
Toluidine
Trichloroethylene
Turpentine
Valeric Acid
Valeric Aldehyde
Vapors
Varnish Fumes
Vinegar
Vinyl Chloride
Viruses
Volatile Materials
Waste Products

Incense
Indole
Incomplete Combustion
Industrial Wastes
Waterproofing Compounds
Wood Alcohol
Xylene

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CHEMICAL REACTIONS OF OZONE

The chemical reactions of ozone are related to its molecular structure. One of the oxygen atoms can be detached relatively easily, yielding thereby nascent oxygen and this makes ozone practically the strongest oxidizing agent. In other reactions, the whole of the ozone molecule can add to a reagent.

Ozone takes part in inorganic reactions as an exceptionally powerful oxidizing agent. This behavior follows also from its high redox potential, exceeded only by that of fluorine. It oxidizes metals (with the exception of gold, platinum and iridium) to oxidates of the metals in their highest oxidation states, oxides to oxides of higher oxidation number or to peroxides, sulfides to sulfates, carbon to carbon dioxide (even at normal temperatures), and ammonia in either the dry gaseous or liquid states, or dissolved in carbon tetrachloride, to ammonium nitrate. Ozone does not react with ammonium salts. In the majority of oxidation reactions, it is reduced to molecular oxygen releasing only one oxygen atom.

Ozone can react in three different ways with organic compounds, vis. (I) a common oxidation reaction takes place, (II) peroxide compounds are formed or (III) addition to double or triple bonds is brought about with the formation of ozonides, in many cases only as intermediates.

Oxidation, particularly at high ozone concentrations, can go as far as to the formation of CO_2 and H_2O. Usual concentrations, however, cause the formation of substances containing more oxygen or less hydrogen from the original molecule.

INTERACTION BETWEEN OZONE AND VARIOUS SUBSTANCES

For materials in contact with ozone, two considerations apply. The first relates to the extent to which ozone attacks the material in question, the second being associated with the magnitude of the effect exerted by the material on ozone itself to promote or catalyze its decomposition. Groups of materials encountered in practice will be investigated below according to the two viewpoints referred to above. As has been shown earlier, most metals are strongly oxidized by ozone. Corrosive action can be generally noted over 2 to 3 ppm, particularly in the presence of moisture. Lacquering or other surface treatments applied for corrosion protection can be beneficial to a certain extent. Metals promote in most cases the decomposition of ozone, some of the reactions being catalytic. Good catalysts are, for example, iron, particularly if rusted, zinc, mercury, platinum, and silver. According to Yemelyanova et al, noble metals are the most active catalysts at low temperatures.

Kastanov et al, found that of all the metals, pure aluminum has the smallest catalyzing effect at low ozone concentrations and 373 K. Schumacher found aluminum acceptable at low temperatures even for the stability of liquid oxygen-ozone mixtures, whereas, according to Lamneck decomposition is slower under such conditions, for example in the presence of copper than in contact with aluminum. Mahieux's investigations showed that a room temperature and an ozone concentration of 7 per cent, decomposition of O_3 is not assisted by pure lead, copper, or tin, in addition to aluminum. Stainless steel, besides anodized aluminum, is suggested as a metallic material of construction, particularly for applications involving low temperatures and high ozone concentrations. In terms of chemical resistance and stability of ozone, glass would be an ideal material for vessels and piping. Owing to its low strength and lack of elasticity, however, the use of glass is severely limited. For higher mechanical loads (due to pressure, for example) and increased ozone concentrations, therefore, the use of glass-lined steel is proposed. It is noteworthy that Waller and McTurk found bottles made of stainless steel with the inside surface phosphated to be as satisfactory as glass. Minimum wall effect and maximum half-life for the thermal decomposition of ozone were experienced with such bottles.

Due to their large specific surfaces, all absorbents such as activated carbon, molecular sieves, silica gel, activated alumina, etc., act as strong catalysts to assist the decomposition of ozone at room temperature. In the case of activated carbon, oxidation also takes place, whereas the pure adsorption effect prevails in molecular sieves because the catalytic effect ceases on saturation. The catalytic effect of molecular sieves for preventing the decomposition of ozone can be well utilized in practice, e.g. for the deozonization of tail gases containing ozone. Judging from the investigations of Szabo, a properly sized stainless steel reactor packed with 13X type molecular sieves is suitable for continuous deozonization at room temperature, yielding an ozone-free outlet stream even with ozone concentrations of the inlet stream in the percent range. Due to the exothermic decomposition, the part of the catalyst bed, the state of which is dependent on ozone concentration and flow velocity, will be heated to a temperature above ambient. Melted pure x-Al_2O_3 containing relatively large pores has practically no catalytic effect on decomposition, the presence of a small amount of metallic oxide inclusions, however, can initiate explosive decomposition. Oxides of iron, cobalt, nickel, silver and manganese are particularly active catalysts. Pure CuO, in turn, has practically no effect on ozone. Activity of catalysts is strongly dependent on their crystalline structure, the presence and distribution of moisture, and other factors.

A good catalyst for cracking ozone is soda lime, which is also used in practice together with metallic oxides and the absorbents referred to above for the removal of ozone from tail gases discharged into the atmosphere.

Rubber, which is used in practice as material for seals, pipes and other components, like organic materials in general, reacts actively with ozone.

Synthetic rubbers have a superior resistance to ozone over natural grades. From among plastics, fluorinated polymers can be used with advantage as material for seals, pipes, and even as general construction materials, due to their resistance to the action of ozone and to their lack of catalytic action to promote decomposition. For high ozone concentrations, use of PTFE and polydichlorodifluorethylene is recommended. These plastics can be utilized for coatings, e.g. for lining steel bottles used in the storage of concentrated ozone. PVC and PE can also be used, mainly for lower concentrations of ozone.

XV - APPLICATIONS IN OTHER INDUSTRIES

BACTERICIDAL, STERILIZING AND OTHER EFFECTS IN LOWER ORGANISMS

The use of ozone for decades in water purification was mainly due to its toxic effects on microorganisms found in water, effects which exceed those of any other disinfectant. Experience has demonstrated that it destroys with extreme efficiency the spores of molds, amoebae, viruses, and bacteria as well as various pathogenic and saprophytic germs. These microorganisms represent a wide variety of species, genera, and families. Therefore, organisms were to be selected for further investigations which would best represent typical pathogenic effects on humans and animals. It was similarly the long and successful use of ozone that created interest for its utilization as a general germicide and sterilizing agent and for highlighting its advantages over other germicides generally used for water purification, primarily chlorine. Special importance can be attached to investigations relating to the specific destructive power of ozone on selected bacteria, including quantitative data and the mechanism of sterilizing and germicidal effects.

As is known, bacteria are microscopically small, single-cell creatures having a primitive structure, and they take up foodstuffs from, and release metabolic products to, the exterior and multiply by division. The bacteria body is sealed off towards the exterior by a relatively solid-cell membrane. Their vital processes are controlled by a complex enzymatic system to which macro-molecular organic compounds, frequently containing sulphur or phosphorus, contribute.

Viruses are extremely small, independent particles, built up by crystals and macromolecules. Unlike bacteria they multiply only within the host cell. They transform the protein of the host cell, to a certain extent autocatalytically, in proteins of their own. Germicides and sterilizing agents interfere with the metabolism of bacterium-cells, most likely through inhibiting and blocking the operation of the enzymatic control system. A sufficient amount of oxidizing agent breaks through the cell membrane and this leads to the destruction of the bacteria or virus. The free electrical charge of the cell membrane constitutes in most cases a strong obstacle for the effective operation of the disinfectant. Chlorine is known to enter into reaction with water and the reaction products generated will have a distribution depending on the pH of the water. Free chlorine and disassociated HOCI can penetrate relatively easily into the bacterium cell; penetration, however, is not so easy for the negative OCI (hypochlorite) ion.

Therefore, it is more difficult for chlorine to kill germs in an alkaline solution (pH>7) where dissociated OCI ions are in preponderance. The destruction rate of germs depends in general on the concentration, the number of bacteria in unit volume, and on the pH of the medium.

The process of necrosis of bacterium cells and the contribution of the penetration of germicides through the cell membrane and the part played by the various reactions taking place in metabolism have not been fully explored as of yet so an all-embracing theory cannot be propounded.

On the basis of the considerations referred to above, and bearing in mind that ozone does not react with water, it can be assumed that the free electric charge of the cells does not reduce the effect. Holluta and Unger showed that the destruction rate of germs has no measurable dependence on pH. This fact constitutes one of the major advantages of ozone over other disinfectants.

For comparison, the germicidal effect of ozone and chlorine on the basis of experiments conducted by independent investigators is shown in Table 21. For the experiments, the bacterium Escherichia cold was selected as a characteristic indicator of contaminants stemming from faeces found in natural water. Despite the different circumstances, the better germicidal effect of ozone can be inferred from the comparison. Kizhinov and Kozhinov report the bactericidal action of ozone on the basis of measurements carried out at one of the municipal waterworks in Moscow.

Measurements carried out by Fetner and ingots indicated the need for higher ozone concentrations and longer exposure times under approximately identical conditions. Deviations can probably be attributed to changes in the technique used for the analysis and to differences between the experimental conditions.

The curve for chlorine is logarithmic, however the effect of ozone below a certain critical concentration value is small, or zero, but practically all germs above this level are destroyed. This effect is called all-or-none response and the critical concentration is referred to as "flash point." The critical concentration lies just at the level generally between 0.4 and 0.5 mg dm^{-3} that produce a small amount of residual ozone in water. The threshold value of 0.4 to 0.5 mg dm^{-3} was observed by several research workers in case of the viruses of influenza and polio, certain coliform bacteria, and the spores of Clostridium botulinum.

For water purification it is the residual concentration which is the critical factor in controlling the destruction of microorganisms. At the beginning of the 1960's it was unanimously established that ozone solutions, particularly in the presence of free ozone, have a more rapid effect on viruses than is attained by the action of chlorine. Thus, viruses prove to be resistant to chlorine under certain circumstances, but as has been proved by a number of experiments, it is increasingly difficult to destroy them even by exposure to ozone. In general, the venous genera of the polio virus was used for the experiments. Katzenelson et al put greater emphasis on the effect exerted on viruses during their investigations since they are known to be more resistant to disinfectants than bacteria. A noteworthy phenomenon of their investigation was the two-step process of inactivation. Period one lasts less than 10 seconds during which time a kill rate of about 99 percent is achieved. Period two runs for several minutes to complete destruction. Ozone was applied at seven intermediate levels between 0.07 and 2.5 mg dm-3, but the phenomenon was independent of the changes in the concentration.

According to Berg et al the higher resistance of viruses is caused by the formation of clumps. To establish the theory, a preparation of polio virus was subjected to ultrasound of 100 W for two minutes at 20 MHZ. Ultrasound caused the breakdown of such virus clumps which then became extremely susceptible to ozone.

The other interesting observation was that the susceptibility of the virus to ozone exposure persisted for a long time, even after protracted storage of the culture of 203 K. The virus relocated to a storage temperature of 258 K, however became resistant. To account for this phenomenon the most acceptable explanation appears to be that a significant percentage of the viruses form clumps.

Sommerville and Rempel published data (referring to results obtained in 1943 by Kessel et al according to which the virus was inactivated within one and a half to three hours at a residual concentration of 1 mg dm-3 At the same time, Naumann stated in 1954 that a residual ozone content of 0.45 mg dm-3 inactivated the polio vines within two minutes.

As virus transmission can take place in water, possibilities of inactivation had to be more precisely determined to prevent infection by viruses. In France, Coin et al investigated the inactivation of the poliomyelitis virus by ozone. They attained a kill of 99.99 percent with a residual ozone content of 0.3 to 0.4 mg dm-3 in water within three or four minutes. Gevaudan et al studied, under somewhat different conditions and by various methods, the destruction of viruses from the Sabin species of the poliomyelitis III genus. They found that inorganic and organic substances in water reduce the effects of ozone. In other respects, their findings were identical to those published by Coin etal in 1964.

American investigators studied a variety of typical microorganisms to determine the specific killing effect of ozone. These included Bacillus anthraces (which causes generally anthrax in sheep, cattle, and pigs, but is also a human pathogen), Clostridium botulinum (its toxin paralyzes the central nerve system, being a poison multiplying in food and meals), influenza virus, Bacillus subtilis (hay bacillus, it decomposes organic matter in the soil and water, but not pathogens).

For the experiments, an average ozone concentration between 100 and 200 ppm was used. Miller et al achieved a full sterilization of the spores of Bacillus subtilis by exposing them to 100 ppm of ozone for 45 minutes. Mice were inoculated with type A toxin of the bacterium causing botulism and cultures of egg with influenza virus. The culture contained a maximum of 10 bacilli causing botulism which represents exactly the lethal dose for mice. An exposure of the culture for 30 minutes to ozone was generally sufficient for inoculated animals to survive. In the case of the influenza virus, the egg cultures remained negative during the check examination.

It was shown also for other microorganisms that they could be destroyed by the application of 1.5 to 2 mg dm-3 ozone. Included in this class were the Klebs-Loffler bacillus, the pathogen of diphtheria, the Eberth bacillus or typhus abdominalis, that spreads typically by aqueous infection and causes typhoid. This group also contains the typical staphylococci causing general inflammation as well as the spores of Aspergillus niger known under the name of black mount.

At present, treatment at a suitable temperature is used for sterilization, but sterilization by chemical means was also suggested. Results obtained from a large number of experiments carried out with water show that most probably ozone is the only substance which can be used as a chemical sterilizing agent to substitute for the effects of temperature.

Ozone excites intense light emission of Armillaria mellea, a luminescent basidiomycete, over the concentration range of 75 to 500 ppm investigated. Exposures running for three hours were not fatal for all of its species (269). This property favoring ozone is caused by a pigment of melanine type because another species of luminescent basidiomycetes having no such pigment was destroyed after an exposure to 100 ppm of ozone for 10 minutes.

For the progeny of Vicia faba, ozone causes chromosome aberration and its effect is twice that observed by the action of X-rays.

APPLICATIONS IN FOOD INDUSTRY AND AGRICULTURE; OTHER USES

Reference will be made here to the possibility for quick and efficient destruction in an ozone atmosphere of various non-pathogenic microorganisms including molds, spores, and other primitive single-cell creatures. The manifold possibilities for using ozone in the food industry and agriculture as well as in other fields, are created similarly by its bactericidal and germ-killing power. Not only does it act as a germicide, but as a spore-killing agent as well. Fruits, foodstuffs, etc., exposed to its effect undergo a more or less pronounced change as a consequence of its action on the vital process of cells, the process of their metabolism particularly, through the inactivation of their metabolic products. At the same time it reacts with other materials present that can be oxidized and thereby it destroys fragrances and odors.

Use of these properties makes ozone eminently suitable for increasing the storage life of perishable foods in refrigerated premises. At the same time its use is economic as the investment and operational costs of the equipment are on an acceptable level in relation to the size of refrigerated rooms. Its application eliminates the risk of leaving the unpleasant odor or other traces of antiseptics used for preservation of foodstuffs. Utilization of ozone for increasing the storage life of food, particularly if held at low temperatures, is believed to have started in 1909 when in the cold-storage plant of Cologne, the reduction in the germ count on the surface of meat stored there was observed after an ozone generator had been installed in the duct of fresh air used to ventilate the storage room. Much more extensive examinations and experiments were required on the storage of fruits in cold-storage plants in order to decide whether treatment by ozone could be deemed favorable or unfavorable because of the different requirements imposed on the storage of various fruits.

Although few publications or research reports have as yet become part of the public domain, the use of ozone is increasing in several major cold-storage plants in Europe. Van Laer and Troquet described, as early as 1928, the utilization of ozone in breweries. R.I. Tenney focused attention again in 1972 on the possibilities for its use in the brewing industry. The technical shortcomings of the ozone generators in the 1940's were responsible for the setbacks encountered at the time.

PRESERVATION AND STORAGE

Practical operations for preservation start with the sterilization of air in such a way that air entering the storage room contains a sufficient amount of ozone to destroy microorganisms. At the same time, however, ozone decomposition to a significant extent is to be expected due to the high moisture content required, the walls of the storage room, the packaging materials, the adsorption effect of the stored goods, and also to the oxidation reactions taking place. These two requirements demand the most perfect distribution of ozonized air in the storage room and make it imperative that the capacity of the ozone generator ensures the maintenance of the appropriate ozone concentration throughout the whole mass of air. Otherwise ozone may not reach the storage space properly, let alone the surface of the goods stored. The required effect can be attained by a strong air movement; the storage space, in turn, need not be hermetically sealed as, for example, in the cast of storage under static CO_2 gas atmosphere. A state of equilibrium can set in, even in these relatively closed premises, between the amount of ozone consumed by the environment, the packaging materials, and the walls, etc., through adsorption and utilized by the stored goods (for the destruction of surface germs, the oxidation of metabolic products, etc.) on the one hand, and the amount of ozone introduced on the other. After stopping feed, decomposition continues for which ozone is supplied up to a certain time by de-absorption from the environment; even so, the total depletion of the ozone content sets in rapidly.

During storage, ozone exerts a threefold effect by destroying the microorganisms,

oxidizing the odors, and affecting the processes of metabolism.
Germicidal effect of ozone has already been covered in general terms. For applications in the food industry, a greater emphasis should understandably be put on the changes in quality taking place following the ozone treatment, along with specific effects exerted on individual products.

The germicidal power of ozone is generally specific in respect of individual species. Its primary action on molds is to suppress their growth and this effect can set in rapidly, particularly in the initial stage on a mold-free surface. Afterwards, this process leads to the destruction of the cultures already formed. Ozone immediately attacks the easily accessible cells on the surface since ozone exerts a surface effect in the first place and has only a slight depth of penetration.

Kolodyazoaya and Suponina investigated the microflora causing the deterioration of a potato. Pure mold cultures of Fusarium solani, Rhizoctonia solani, and Phytophtora solani were exposed to the action of ozone. From these species, Fusarium solani proved to be resistant to ozone. Ozonization applied for the storage of refrigerated meat destroys surface microorganisms, particularly the family of Pseudomonas responsible for spoilage. Increasing the moisture content of the environment favorably influences the germicidal effect. This is brought by the swelling of microbes making them more susceptible to destruction. Experi-ments conducted with beef showed that ozone is most efficient if the surface has a definite moisture content of around 60 percent.

Effect on odors - Ozone itself has a characteristic odor, yet the result of its application does not mask odors. Atomic oxygen formed by the decomposition of ozone immediately oxidizes the different smelling materials.

The characteristic putrid odor, however, remains and is difficult to eliminate even with the use of ozone. In general, the lower the temperature and the larger the molecules taking part in the reaction, the weaker is this oxidizing effect. The moisture content in the air has no effect on the process. At a very slight concentration, say between 0.01 and 0.04 ppm ozone, the air of the room or storage space is felt to be fresh and pleasant and no stuffy odor is sensed. It is an established fact that the odor of aromatic fruits such as strawberries is enhanced in the presence of ozone. It is possible that the formation of fragrances and odors giving the fruit its characteristic flavor is assisted by the action of ozone. The sterilization of the air in fruit stores by ozone prevents the odors of packaging materials from being transferred to the goods stored, a phenomenon which frequently takes place otherwise, particularly when wooden crates are used in refrigerated stores at relative humidities of 85 to 90 percent.

EFFECT ON METABOLISM

The effect on metabolism is also a consequence of the strong oxi-dizing power of ozone. No deterioration of fruit was observed. The reason being that ozone only affects the surface of the fruit which contains compounds difficult to oxidize in most cases. During storage the process of respiration of fruit is accelerated and so is ripening. In the case of a more rapid ripening than would be desirable, ethylene is produced which affects the other fruit and so initiates even more intensive ripening. The external signs of this process are the turning brown of the skin, the softening of the flesh of the fruit and, finally, decay. This process is controlled by the presence of ozone because it oxidizes the metabolic products created initially, reducing thereby the possibility of back action on other fruits. Moreover, it promotes the healing of wounds and enhances resistance to further infection.

MEAT

For the storage of meat, it was found that a satisfactory effect can be brought about by one or two periods daily of ozone application, lasting two hours each time if the ozone content was held at 6 mg (0_3) m-^{3} (air). Application of ozone proved to be particularly beneficial to the process of tenderizing meats. During tenderizing, fresh beef sides are kept for 42 to 44 hours in a closed space at a temperature of 293 K and a relative humidity of 85 percent. The process of tenderizing consists, in actual fact, of the digestive action caused by enzymes naturally present to soften and slacken muscles and connective tissue. The same process can take as much as 20 days at a temperature of 279 K. The accelerating effect of temperature increase on tenderization promotes the formation of fertile soil suitable for the multiplication of infectious bacteria and spores of deleterious nature. The aim to be achieved with ozone treatment is the destruction of these injurious surface organisms. in such a tenderizing room, a concentration of 0.1 ppm and a relative humidity of 60 to 90 percent should be maintained according to Ewell. According to others ozone is efficient even if present in a concentration of 0.04 ppm and, although it fails to bring about full sterilization, it still retards growth of bacteria. The germicidal action of ozone is restricted only to the surface in the case of meat also, and has small depth of penetration. Molds present in the form of spores can be destroyed only if attacked by a high concentration of ozone.

The storage life of beef in a refrigerated state can be increased by 30 to 40 percent if the beef is kept in an atmosphere of 10 to 20 mg(0_3) m-^{3} (air) and the microbial saturation of its surface is not greater than 103 bacteria cm. Billon conducted a detailed investigation of the storage life of beef, veal, lamb, pork, chicken, and rabbit in ozonized atmospheres. In the case of the varieties of meat stored in a normal atmosphere, it was found that a significant microbial contamination sets in after seven days; contaminations of the same level were reached with meats exposed to the action of ozone only after 14 days under identical conditions. It can be stated in general that in a refrigerated atmosphere and in the presence of ozone the growth of the surface microflora (pseudomonas families, spores, almonellae, staphylococci) is slowed down. Nevertheless, no effect is exerted by ozone on the surface microflora if the extent of contamination is very large already. Thus, although ozone fails to produce an express antiseptic effect on stored meats, it still makes the atmosphere of refrigerated stores rather fresh and healthy. Fresh fish can also be stored longer if washed in water containing ozone and preserved by ice produced from ozone.

CHEESE

Experiments for the use of ozone during the process of ripening and storage of cheese were successfully conducted. Spores created on the surface of cheese during the ripening period were destroyed and storage life was increased to 11 weeks by the application of a small ozone concentration (0.02 ppm) at 288 K and a relative humidity of 80 to 85 percent. Experiments were conducted with cheddar cheese which indicate that odors otherwise present in storage rooms were also eliminated by the oxidizing action of ozone.

EGGS

Ozone has been successfully used for the storage of eggs. By the end of the 1930s, more than 80 percent of refrigerated egg stores in the United States were equipped with ozone-generating equipment to increase storage life.

BEVERAGES

Ozone treatment speeds up the aging of wine, avoids turbidity, and refines its bouquet, which is retained for a longer time. The storage life of milk, bottled juices, and soft drinks is also improved by ozone through suppressing sour spoilage. Independent of municipal water supply, large quantities of bottled water disinfected with ozone are retailed in the United States. The sterilization of water required for the production of beverages is a significant subject due to the increased demand for water of good quality by production plants. For the industrial scale production of soft drinks, so-called humic waters can be used which are perfect in meeting biological requirements (taste, odor), but their brownish color is undesirable. This color taken from the soil can be eliminated by means of ozone. The main requirement to be met is the retaining of the sterile state in the four to eight week period lapsing between filling and consumption. Ozone treatment has proved the most efficient for sterilization surpassing conventional processes used previously such as U.V. irradiation, chlorination, silver treatment, and sterilization filtering; moreover, it has cost advantages as well. One of the most widely consumed soft drinks is bottled mineral water. Many grades, how-ever, contain manganese and iron. If the usual methods are applied for the removal of manganese and iron, the naturally dissolved carbon dioxide content is largely depleted. Use of ozone in this respect is of particular advantage as both iron and manganese can be fully oxidized by ozone with the simultaneous retention of the high concentration of the dissolved carbon dioxide.

Ozone is also used in the milk industry to suppress souring. Such a sterilization step greatly increases storage life. In the brewing industry, ozone is advantageous for the disinfection of pipelines, filters, bottles, etc. If phenolic wastes are present, chlorine oxidizes them to chlorophenols which have tastes and odors intolerable to brewers. Ozone creates points of special interest to brewers and users of other similar processes because it represents a biocide with non-persistent and non-toxic residues.

DISINFECTION AND REMOVAL OF ODORS

Storage sites, warehouses, and refrigerated stores can be disinfected in most cases by the use of ozonized air which is independent of the direct action exerted with food, fruits, beverages, etc. stored there. Such a process, apart from disinfection, removes the frequently unpleasant odor of packaging materials so that the various produces retain their original flavor. It happens frequently that the stored products are accommodated in separate premises yet the odors are transmitted from one room to the other or between products, due to insufficient air locking, imperfect separation, or facilities for communication. The oxidiation of compounds creating odors in such premises has an advantage in that it creates an atmosphere resembling pleasant, fresh air. For such a purpose, a very low ozone concentration of 0.01 to 0.04 ppm is sufficient..

In refrigerated tunnels, meat tenderizing halls, and meat warehouses ozone is generated by special sterilizing lamps which are designed to have a portion of their radiation band in the range below 200 nm so they have an active photochemical ozone generation effect. Initially, when "by-product" ozone generation was discovered in the application of U.V. lamp systems, efforts were made to restrict the formation of traces of ozone associated with the use of these lamps. Later, it was found that the presence of ozone at concentrations of up to 0.1 ppm by volume protects meat against decay. The increase in storage life (see preceding section) had the secondary benefit of reducing odors.

The effect of ozone in a domestic refrigerator was also investigated. Here too, sterilizing lamps were used for ozone generation. It was necessary to find a balance between the amount of ozone potentially available and ozone demand so that mold and bacteria on the food and the refrigerator walls would be destroyed and the level of food odor and their transfer to other foods would be greatly reduced. Ozone, if present at a concentration of 0.1 ppm, is capable of destroying microorganisms and removing odors after an exposure lasting for about 48 hours. A longer exposure time (at lower concentrations) is equivalent in terms of bactericidal effect it fails, however, to eliminate the odors.

STORAGE BENEFITS OF OZONE WITH FRUITS AND VEGETABLES

PRESERVATION AND STORAGE - Practical operations for preservation start with the sterilization of air in such a way that air entering the storage room contains a sufficient amount of ozone to destroy microorganisms. At the same time, however, ozone decomposition to a significant extent is to be expected due to the high moisture content required, the walls of the storage room, the packaging materials, the absorption effect of the stored goods, and also the oxidation reactions taking place. These two requirements demand the most perfect distribution of ozonized air in the storage room and make it imperative that the capacity of the ozone generator ensures the maintenance of the appropriate ozone concentration throughout the whole mass of air. Otherwise it many happen that ozone may not reach the storage space properly let alone the surface of the goods stored. The required effect can be attained by a strong air movement; the storage space in turn need not be hermetically sealed.

Using a very slight concentration of between 0.01 and 0.04 ppm ozone, air in a room or storage space is felt to be fresh and pleasant and no stuffy odor is sensed anymore. *It is an established fact that the rider of aromatic fruits such as strawberries is enhanced in the presence of ozone.* It is possible that the formation of fragrance and odors giving the fruit its characteristic flavour is assisted by the action of ozone. The sterilization of the air in fruit stores by ozone prevents the odors of packaging materials from being transferred to the goods stored, a phenomenon which frequently takes place otherwise, particularly when wood crates are used in refrigerated stores at relative humidities of 85 to 90 percent.

EFFECT ON METABOLISM - The effect on metabolism is also a consequence of the strong oxidizing power of ozone. No deterioration of fruit was observed. The reason being that ozone only affects the surface of fruit, which contains compounds difficult to oxidize in most cases. During storage the respiration process of fruit is accelerated along with the ripening process. In the case of a more rapid ripening than would be desirable, ethylene is produced which affects other fruit and so initiates even more intensive ripening. The external signs of this process are the browning of the skin, the softening of the flesh of the fruit, and decay. This process is controlled by the presence of ozone because it oxidizes the metabolic products created initially, reducing the possibility of back action on other fruits. Moreover, it promotes the healing of wounds and enhances resistance to further infection.

FRUITS, FOODSTUFFS, BEVERAGES - In storing fruit, special care should be exercised so that each piece is sufficiently clear of the other or is not packed in closed containers. This ensures only the best possible effect by offering the least resistance to forced air flow. At the same time, *ozone prevents the formation of various mold colonies on the walls of the storage room, packaging materials, and wooden crates. These molds, even if doing no harm to the produce, readily impart a study odor to the fruit. In the environment of refrigerated stores, the so-called blue mold rot multiplies readily and its growth is not retarded even by temperatures as low as 273 K*

Due to the rapid decomposition of ozone, humans are allowed to enter storerooms shortly after stopping the ozone feed without injury to their health. This feature, together with the rapid disinfection effect after restarting ozone generation, are of great importance particularly in the exchange of stored goods.

BANANAS - Bananas exhibit intensified metabolism in the presence of ozone only if the concentration is high. Physiological injury can be induced however, by small concentrations, 1.5 ppm for example. After eight days, black spots appear on the skin if the ozone concentration is maintained between 25 and 30 ppm. If it is kept between 30 and 90 ppm, the respiration process is accelerated, yet the process of ripening remains unaffected. This phenomenon can be attributed to the destruction, immediately on their formation, of substances (produced by the more ripened fruits) which speed up the process of ripening.

Finally, concentrations of between 1.5 and 7 ppm and a storage temperature of 285 K proved to be the best conditions for the ozonized storage of bananas where neither the rate of ripening nor the intensity of respiration change significantly. In recent times, good results were attained in increasing the storage life during transport.

ORANGES - Oranges are insensitive even to relatively high ozone concentrations (40 ppm)in the storage space. Their ripening is also slowed down by the oxidation of ethylene and other metabolic products.

BERRY FRUITS - *Strawberries, raspberries, and grapes are particularly likely to develop mold colonies during storage. This tendency can easily be eliminated by' means of ozone present in 2 to 3 ppm, without the quality or the flavor of the fruit being affected. In this manner, the storage life can he doubled.* The method of packaging must not interfere with the contact between ozone and the fruit.

APPLES - Depending on the species, an effect showing biological disturbances can be detected during the storage only about the range 2 to 11 ppm of ozone. *Experiments conducted in the United States showed that the majority of species suffered no deterioration, even after cold storage for five months under an ozone concentration of 2 ppm.* If the concentration was slightly raised, a stickiness and a weakness of flavor were observed with certain species. The removal of generated ethylene has a significant effect on the increase in storage life. The inactivation of evanescent products of metabolism also reduced browning of the skin.

PEARS - For a specific species investigated, no deterioration could be observed after storage for a period of 17 days at 3 ppm ozone concentration and a temperature of 278 K. Under these conditions, no increase was detected in the respiration rate.

APPLICATION TO AGRICULTURE

Ozone is eminently suitable for the processing of various by-products and secondary products originating in the agriculture and food industries. It has proved to be suitable for the bleaching of beeswax, starch, flour, straw products, bones, feathers, lard, and among others. The majority of these products become whiter after treatment and their smell is improved.

If cotton and wool are treated with ozone, the grease and wax-like materials on the surface of fibers are decomposed. The removal of these substances increases significantly the storage life of cotton fibre and improves the dyeability of wool with a simultaneous bleaching action. The ozonization of flax speeds up the process of ripening and facilitates further processing. For the removal of odors from large stalls, ozone has long been used in the Soviet Union, the United States, and Canada in conjunction with a process described previously.

OTHER APPLICATIONS

Finally, fields of application not referred to previously will be summarized. At the same time, the processes and methods described previously will serve as examples for a variety of further applications where each of them uses the high reactivity of ozone in some form.

The textile industry uses ozone to bleach various basic materials, yarns, and textiles.

Health protection or, in an indirect way, medical science examined long ago the strong disinfecting and bactericidal action of ozone in the interest of its use on a wide basis. In this framework, successful experiments were conducted for the bleaching of hospital linen by ozone generated via sterilizing lamps. Orlowski reports on the disinfection of bandage and surgical devices where the action of ozone was used instead of the conventional temperature effect. Chemical industry and metallurgy utilize the process described previously for the neutralization of vent gases from sewage works to remove industrial odors which are frequently harmful to health.

For deodorization or refreshing of air in rooms accommodating large masses of people such as theatres, assembly halls, etc. and for improving air in offices, ozonized air is widely used in conjunction with air conditioning systems. In this way, demand for make-up air is reduced as the recycle system furnishes air of sufficient purity. For premises such as theatres, assembly halls, etc., stringent code requirements limit the allowable concentration of ozone in the air. The allowable concentration must not exceed several pphm. At the same time it has been proved that the effect of various unpleasant smells, i.e. body odor, cigarette smoke, etc., can be eliminated by treatment with a small amount of ozone.

SWIMMING POOLS

In the field of the classical water and waste water treatment, further new applications have been found for ozone processes. According to official regulations, only hygienically and aesthetically perfect water is allowed in baths and swimming pools due to infection hazard. Ozone, as a dominating disinfectant, is not only efficient in reconditioning bathing water due to the destruction of spores and viruses and the decomposition of human urine, but its use brings economies owing to a reduction in the demand for make-up water. Equipment normally used to purify drinking water complemented by special units required for the particular application is suitable also for the reconditioning for bathing water. (Reconditioning means an appropriate recirculation method to ensure proper filtering and dispersion of the disinfectant.) In Switzerland, hundreds of indoor and outdoor swimming pools are equipped with these ozone treatment devices. The development of the "Sauter-Var ozone process" is due to the Swiss firm, A.G., which also supplies the ozone generator. No injury to health has been experienced so far in baths operated with ozone reconditioning. An essential part of the "Complex ozone-permutite-mixed-bed filter" process is formed by the filter, inoculated with ions of heavy metals and metal oxides. The name of the "Indirect Quantozone" process implies the use of ozone mixed indirectly into water. It is used particularly for the purification of water in salt-thermal baths. The "Combined Ospa Chlorine-Oxygen" process is based on the production of chlorine by electrolysis. The electrolytic method allows a concentrated oxygen content in the bathing water with the consequent presence of traces of ozone. The number of processes clearly shows the headway ozone has made in this special field. Apart from the use of ozone, an essential feature of all these processes is the incorporation of water purification steps into the process. A more detailed discussion of this subject, however, would go beyond the parameters of this work.

The sometimes sketchy description of the multitude of applications shows the increasing utilization of ozone in a great variety of technical fields. From this review it can be inferred that the use of ozone in certain areas is not yet fully competitive with other long established conventional methods. Thus, ozone represents no "cure all", but it has definite advantages in many cases making worthwhile a search for its economic use. In addition to the applications described here, a great number of possibilities will develop in the future of which only laboratory experiments have so far been carried out.

XVI- CLOSING REMARKS

Many of the deodorizing procedures outlined in this book will be unusually comprehensive to the point at which some may even seem unnecessary. Many details have been brought out that cannot even be recognized, much less appreciated, without several years of hard won experience. It is with this in mind that you should re-read the information a second time. Also, carefully study sections relating to a specific deodorizing problems before beginning the procedures relating to that problem. This is the essence of professionalism. Of course, the reason behind the often lengthy and possibly repetitious explanations is to enable the inexperienced technician to come up with enough alternative treatments to tackle any situation, no matter how severe.

Common sense in when to begin and end the procedures recommended is essential. In other words, once results are achieved it is time to move on to procedures for concluding the job.

A summary of each procedure follows this chapter. These outline summaries may be copied and given to technicians as an on-the job reminder of procedural sequences to **be used - but only after reading the longer explanation of procedures contained in Chapters VII-XV!**

Pricing for deodorizing services varies widely throughout the North America. Some advocate time and materials pricing (so much per hour, per machine, per gallon of chemical used); however, this tends to ignore the cost of obtaining the knowledge required to effectively process the deodorizing job. More realistic contractors, who have invested considerable money in education, chemicals and equipment, and who understand the value of their service in light of replacement costs saved, have moved increasingly toward unit pricing. In other words, structural deodorization procedures are priced by the cubic foot (length times width times height), and contents pricing is calculated as a percentage of the cost of cleaning (20-50% of cleaning charges based on the severity of odor).

Another point must be made regarding the various manufacturers and retailers of chemicals and equipment. They are in a position, by virtue of the number of customers they serve, as well as the variety of situations on which they are questioned, to provide some excellent answers to your questions as well. Don't hesitate to ask questions about their products as they relate to the situations and use considerations outlined in this book.

Make every effort to use and support manufacturers and formulators who *specialize* in deodorizing chemicals and equipment. Even then, be wary of those who categorically dismiss the precautions and attention to details that have been so carefully covered in this book. Above all, be cautious of those who suggest that, "two squirts of our product will solve all your problems in all situations."

Remember, we, as professionals, are responsible and accountable for results - not the formulator who makes, but often never uses, a particular product.

Even with all the elaborate procedures you can muster, there still will be those rare situations that defy all common sense, technical expertise and logic. In these situations simply persist in your efforts and continue to apply alternative procedures until you are successful.

Good luck - if there is such a thing - and good deodorizing!

Rainbow Technology

PROCEDURE SUMMARIES

CHAPTER VII - STRUCTURAL PROCEDURES - ANIMAL URINE

ANIMAL URINE, CONFINED SPOTS (page 79)

1. **Isolate** major contamination.
2. Spot **clean** excess contaminate from face yarns.
3. **Disengage** installation and flush backing, if practical.
4. **Remove** contaminated cushion, if practical.
5. **Clean** and disinfect sub floor, as required.
6. **Seal** sub floor as required (primarily wood).
7. **Replace** cushion with comparable type.
8. **Saturate** backing with EPA-registered disinfectant or stain-resist approved sanitizer.
9. **Re-engage** carpet and extract face to remove excess deodorant.
10. **Reinstall and clean** entire room to remove tracked contamination.
11. Let **dry and inspect;** repeat 8 (topical saturation) and 9 as required.

ANIMAL URINE, OVERALL CONTAMINATION (page 82)

1. Spot **clean** face yarns where major contamination exists.
2. **Disengage** installation and remove cushion as required (as it usually is!)
3. Clean and **disinfect** sub floor as required.
4. **Replace** severely contaminated tack strip as required.
5. **Seal sub floor** as required.
6. Spot **clean carpet backing** in areas of major contamination to remove excess.
7. **Saturate backing** with enzyme deodorant (disinfectant; stain-resist approved sanitizer, if desired).
8. **Re-engage installation** lightly.
9. **Treat nap with enzyme deodorant** (or EPA-registered disinfectant). Note that an increased odor of arurnonia may be noticed when enzymes are used.
10. Provide for **drying** according to the type product used.
    a. if disinfectant - dry immediately
    b. if enzyme deodorant - leave wet 6-12 hours before instituting drying procedures.
    c. never allow the two to be mixed!
11. Consider cleaning other **structure surfaces and contents** items exposed to airborne contamination.
12. **Replace filter** and restore the air conveyance system as required.
13. **Deodorize airspace.**
14. Install new cushion of comparable type.
15. Final clean carpet.

CHAPTER VIII - PROTEIN ODOR

FREEZER POWER FAILURE (page 90)

1. **Saturate** contamination with disinfectant to sanitize for safety.
2. **Remove spoiled food** and dispose.
3. **Remove freezer** to exterior of structure, if practical.
4. **Clean** interior and exterior thoroughly.
5. Consider contamination on **insulation:** disassemble and clean or replace.
6. Apply **disinfectant** to all surfaces for final sanitizing.
7. **Tent** freezer.
8. Inject **ozone** gas for 36-48 hours.
9. **Check for odor reduction** and repeat steps 5, 6 and 7 as required. Complete deodorization may take several days!

DECOMPOSED ANIMAL, CRAWL SPACE (page 94)

1. **Shovel remains** and contaminated soil into garbage bag and disposed of properly.
2. **Saturate spot** with 2% chlorine bleach solution (consider surfaces involved).
3. **Saturate spot** with residual deodorant (water or dry solvent-based)

4. **Fog** crawl space.
5. **Fog** structure's interior.
6. **Repeat** 2, 3 and 4 as required (add ozone at source).
7. Spread odor **granules** over the ground.
8. Place **solid deodorant block** in HVAC system.

SKUNK ODOR (page 96)

1. **Clean** areas of direct spray with detergent/deodorant solution (consider chlorine bleach, depending on materials encountered; i.e., are they durable and colorfast?).
2. **Direct spray heavy-duty deodorant** (water based) on all surfaces in immediate area of contamination.
3. **Clean other surfaces** (ceilings, walls, carpet, fabrics) in the area of contamination as required
4. **Fog** the entire area with heavy-duty deodorant (water based).
5. Operate **ozone** unit at source of odor for 24-48 hours.
6. **Return and check for odor -** repeat 2, 3 and 4 as required.
7. **Final fog** and place **deodorant block** in air-handling system.

Chapter IX - DEATH SCENE

BASIC RULES FOR AVOIDING BLOODBORNE PATHOGENS (page 101)

1. Educate - Employers must keep abreast of current federal and state OSHA, EPA, CDC regulations relating to worker safety. They should provide general training for all employees on the hazards of blood borne pathogens in accordance with OSHA regulations.
2. **Designate -** Specify which employees will be placed in situations where questions about potential exposure might arise.
3. **Vaccinate -** Ensure that proper immunizations are obtained and kept current.
4. **Protect -** Make available and use personal protective equipment (PPE): gloves, goggles, respirator, etc.
5. **Decontaminate -** Use chlorine bleach (l/2%); contact disinfectant (60-90% alcohol, 0.04-5% o-phenyl phenol); 0.4-1.6% quaternary ammonium chloride; 2% glutaraldehyde-based products, under proper label directions and use conditions for the surface encountered.
6. **Dispose -** Do not attempt to salvage questionable materials.
7. **Clean -** Use extraction equipment, as appropriate; always decontaminate equipment and tools.
8. **Disinfect -** Thoroughly disinfect salvageable surfaces at least one last time!

DEATH SCENE (page 107)

1. Provide **protective and safety gear** and mental preparation for all workers.
2. **Sanitize** (decontaminate) work area to generally remove biocontaminants **for technician safety.**
3. **Remove and dispose of directly contaminated fabrics** even if salvageable, due to psychological impact.
4. **Remove and replace saturated structural components** as required.
5. **Clean all structural and contact surfaces** within the room (consider use of 1% chlorine bleach, depending on surface durability).
6. **Direct spray heavy-duty deodorant** to non-moisture sensitive surfaces in the area of immediate contamination.
7. **Wet fog structure** with heavy duty-deodorant (water based).
8. **Install ozone generators** (2) for 72 hours (primary system).
9. **Seal and paint** as required.
10. If residual odor remains, **repeat 5, 6 and 7.**
11. Place solid **deodorant block** in air conveyance system (ACS).

CHAPTER X - GAS, FUEL AND CHEMICALS

TEAR GAS (page 112)

1. **Provide protective equipment** for technician.
2. **Aerate** structure.
3. Remove expended canisters and **clean up debris.**
4. Consider the effect of concentrated tear gas on **insulation materials.**
5. Consider the need to seal porous structural materials.
6. Remove and **replace HVAC filter(s).**
7. **Wet fog** the structure with heavy-duty deodorant.
8. Lightly **clean** all major horizontal surfaces.
9. Aerate again.
10. Consider cleaning of **other structure and contents** items.
11. **Final wet-fog** structure.
12. Deodorize with **ozone gas** as necessary.
13. Repeat 3 and 5 as required.

FUEL OIL (page 115)

1. **Ventilate** structure for safety.
2. **Inspect the source** carefully. Notify EPA if external contamination exists.
3. **Absorb and remove excess** oil.
4. **Remove saturated structural components.**
5. **Clean** surfaces with alkaline detergents.
6. **Direct spray source** with dry solvent-based or heavy-duty deodorant.
7. **Seal and/or paint structural surfaces** as required.
8. **Fog structure** with dry solvent or heavy-duty deodorant.
9. **Operate ozone unit** at the odor's source for 48 hours.
10. Place a solid deodorant block in HVAC system.

DRUG LABS (page 120)

1. **Establish ownership** of the property and **ensure payment** from a responsible party.
2. **Fog or make a direct spray application** of heavy-duty deodorant to the room in which the actual manufacturing took place.
3. **Clean structure and contents** with residue contamination.
4. Carefully **clean all fabrics** with hot water extraction procedures. Add a general purpose deodorant additive to all cleaning compounds.
5. Remove and **replace the filter** on the HVAC system.
6. **Use ozone generators** on maximum settings, in the unoccupied structure for 24-48 hours. Consider piping ozone into ductwork systems.
7. Aerate the structure and determine if all odor is gone. If any remains, continue ozone deodorization for another 24-48 hours.
8. **Thermal fog the structure,** allow 30 minutes for complete penetration and then open it up for ventilation.
9. In extreme odor situations, the entire structure may require **sealing and painting** in order to return it to normal.
10. Place a **solid deodorant block** in the HVAC system for prolonged re-odorization of the structure.

STINK BOMBS (page 121)

1. **Protect all technicians** who will be working this situation with acid resistant gloves, splash goggles and respirators.
2. **Ventilate** the structure with copious air movement.
3. **Remove the debris** and neutralize the residue.
4. **Remove and dispose of floor coverings.**
5. **Fog or make a direct spray application** of heavy-duty deodorant to the room in which direct contact took place.
6. *Consider* the need to **clean structure and contents** within the area of direct contamination.
7. *Consider* careful **cleaning of all interior decor fabrics** with hot water extraction. Add a general purpose deodorant additive to all cleaning compounds.
8. Remove and **replace the filter** on the HVAC system.
9. **Use ozone generators** on maximum settings, in the unoccupied structure for 24-48 hours. Consider **piping ozone into ductwork.**
10. **Aerate the structure and determine** if all odor is gone. If any remains, continue ozone deodorization for another 24-48 hours.
11. **Thermal fog the structure,** allow 30 minutes for complete penetration and then open it up for ventilation.
12. The area of direct contact may require **sealing and painting** to return it to normal.
13. Place a **solid deodorant block** in the HVAC system.

CHAPTER XI FIRE AND SMOKE

SMOKE ODOR, *CONFINED AREA* (page 126)

1. Check for and **eliminate safety hazards.**
2. **Remove the source.**
3. Immediately make a direct spray application of heavy-duty deodorant on and around the source.
4. **Restore and deodorize ductwork** by injecting ozone gas; replace HVAC Alter.
5. **Clean** the entire area(s) of heavy contamination using general purpose cleaner combined with general purpose deodorant.
6. **Direct spray** heavy-duty deodorant again, as required.
7. Wet or dry fog the structure using a ULV fogger and heavy-duty deodorant, or a thermal fogger and dry solvent deodorant.
8. Aerate the structure and evaluate residual odor, if any.
9. If odor persists, **repeat steps 5 and 6,** and/or operate an **ozone unit at** the source for 24 hours minimum.
10. Place a **solid deodorant block** in the refrigerator's mechanical components compartment.

SMOKE ODOR, *OVERALL CONTAMINATION* (page 128)

1. Check for and eliminate safety hazards.
2. **Remove charred debris,** as possible.
3. Immediately make a **direct spray** application of heavy-duty deodorant on scorched or charred surfaces and within source areas as practical, or fog lightly using a dry solvent deodorant followed by aeration.
4. **Restore ductwork**
5. Remove furnishings as possible, and clean salvageable surfaces as practical, using general purpose cleaner combined with general purpose deodorant.
6. Install two or more **ozone units** in salvageable rooms as soon as possible and engage in continuing deodorizing efforts as additional rooms are "dried in" by reconstruction crews.
7. **Direct spray** interior wall components before insulation and drywall replacement with heavy-duty deodorant.
8. Wet or dry **fog the structure** using a ULV fogger and heavy-duty deodorant, or a thermal fogger and dry solvent deodorant, as areas are dried in.
9. If odor persists, **repeat steps 5 (ozone) and 7 (fogging)** until eliminated.
10. Isolate **pockets of odor** and thermal fog as required.
11. Place a **solid deodorant block** in the refrigerator's mechanical components compartment.

CHAPTER XII - CONTENTS DEODORIZATION

CARPET (page 136)

1. With heavy residue, **consider vacuuming and cleaning immediately.**
2. Make a **direct-spray application of heavy-duty smoke odor counteractant.**
3. After cleaning structural and contents components (ceilings, walls and furnishings), **thoroughly dry vacuum fallout debris from carpet.** Remember, cleaning is the first basic step in physical odor removal!
4. Upon completion of reconstruction, clean carpet thoroughly.
5. Follow cleaning with **direct-spray of heavy-duty smoke odor counteractant.** If carpet is stain-resistant, apply stain-resist sanitizer only. Also, wet or dry fogging the airspace over the carpet is recommended option here.
6. If odor remains after structural deodorizing is completed, consider **sub-surface thermal fogging.**

UPHOLSTERY (page 138)

1. **Vacuum or blow off** loose soot.
2. **Clean** with appropriate deodorant additive.
3. **Thermal fog** upholstery.
4. Deodorize with ozone gas for 24-48 hours.
5. **Repeat steps 3 and 4** as required.
6. Final **thermal fog** prior to delivery.

DRAPERIES (page 139)

1. **Dry vacuum** thoroughly.
2. Dry or wet **clean** with dry-solvent deodorant added to cleaning solvents or heavy-duty odor counteractants added to water-based detergent solutions.
3. **Thermal fog** draperies lightly.
4. Deodorize with **ozone** gas as required for 24-48 hours.
5. **Repeat steps 3 and 4** until odor is completely eliminated.

HARD FURNISHINGS (page 140)

1. **Clean** with appropriate medium (water based detergent with deodorant additive or smoked wood cleaner/restorer/deodorizer).
2. **Apply dry solvent deodorant** to non-visible porous surfaces.
3. Deodorize with **ozone** gas for 36-48 hours.
4. **Thermal fog** furniture.
5. **Repeat steps 3 and 4** until all odor is removed. If odor persists, sealing surfaces as appropriate with a clear lacquer or varnish may be required.
6. During storage, **periodically spray non-visible, wood surfaces with dry solvent-based deodorant.**
7. **Final polish and fog prior to delivery.**

CLOTHING (page 143)

1. Have customer **separate into four categories.**
2. **Clean** as required.
3. Deodorize with **ozone gas** for 24-48 hours.
4. **Thermal fog.**
5. **Repeat** steps 3 and 4 as required.
6. Lightly **thermal fog** prior to delivery.

CHAPTER XIII - AUTOMOTIVE DEODORIZATION

GENERAL PROTEIN ODOR (page 150)

1. **Remove interior components** as required.
2. **Extract excess contaminant.**
3. Clean with warm, neutral detergent. Never exceed 150°f (66°c) in any protein cleaning situation.
4. **Saturate (wet out) fabrics with** enzyme **deodorant.**
5. **Clean interior components** (seats, head liner, hard surfaces) with appropriate deodorant additives.
6. After 4-6 hours, **extract enzyme and dry.**
7. If odor persists, use ozone gas for 24-48 hours; air out and evaluate.
8. **Final clean** all surfaces.
9. **Reinstall components** if removed.
10. **Clean vehicle exterior.**
11. Lightly **thermal fog** and air out prior to delivery.

DEATH SCENE (page 152)

1. Remove **and dispose of replaceable, heavily contaminated fabrics.**
2. Thoroughly clean throughout with disinfectant solution.
3. **Direct-spray all durable surfaces** with heavy-duty deodorant solution.
4. **Seal accessible metal components** with appropriate sealers.
5. **Protect natural latex components,** if any, and operate ozone unit inside contaminated vehicle for 24 hours.
6. Operate **ozone unit** placed outside vehicle for 48-72 hours. Anticipate that protein odor may be extremely persistent and require weeks to remove.
7. **Air out vehicle and repeat steps 3 and 6** as required.
8. **Final clean** inside and out.
9. **Thermal fog interior.**
10. Install **solid deodorant block.**
11. Air-out prior to delivery.

SMOKE ODOR (page 155)

1. **Remove destroyed components** and order replacements.
2. **Direct-spray durable surfaces** with smoke odor counteractant.
3. Carefully **clean all interior components.**
4. **Thermal-fog interior.**
5. **Protect natural latex rubber** components with dry silicone lubricant.
6. **Operate ozone unit** for 48 hours.
7. **Repeat steps 2, 4 and 6** as required.
8. **Final clean** interior and exterior.
9. Final **thermal-fog interior** lightly.
10. **Replace destroyed components.**

ANSWER KEY:

CHAPTER I - General Discussion (page 14)
1. nose 2. olfactory 3. water 4. mucous membranes 5. olfactory nerve (epithelium) 6. olfactory lobe 7. Real, olfactory 8. psychological 9. humidity (moisture), temperature (heat) 10. Latent 11. sulphur 12. non-humid (dry) 13. fungi, bacteria 14. microscopic, submicroscopic (molecular) 15. penetrate (permeate) 16. micron 17. 0.1, 4.0 18. porous (permeable); temperature (heat) 19. heavy, dwell (exposure) time 20. doubles 21. velocity 22. porous 23. contract, trapping (holding) 24. patience, persistence, meticulous 25. pathogenic

CHAPTER II - Basic Deodorizing Principles and Procedures (page 20)
1. Oversimplification 2. rapid (quick), effective, permanent (long lasting) 3. four 4. source, contaminants (debris) 5. clean 6. vapor, gas 7. penetration (permeation) 8. fog (vapor), gas 9. sealing 10. time (productivity), money

CHAPTER III - Classes of Deodorants (page 38)
1. time-release 2. perfume, fragrance 3. psychological (imagined) 4. Sorbents 5. absorbent, fragrance (perfume) 6. adsorption 7. heat, steam (pressure) 8. humidity (moisture), heavier 9. chemical 10. microorganisms 11. sunlight, fresh air 12. temperature, relative humidity 13. control (limit, regulate), kill 14. oxidation 15. color, dissolve, corrode (rust, tarnish) 16. carbolic acid 17. toxic, harsh 18. phenolic coefficient 19. quaternary ammonium chloride 20. Environmental Protection Agency 21. consistent quality (effectiveness) 22. eye, skin, respiratory 23. cationic 24. protein 25. digestion 26. long lasting (prolonged) 27. preventive, corrective 28. allergy, medical (healthcare), animal (pet)

CHAPTER IV - -Professional Chemical Options (page 46)
1. ideal (perfect) 2. type, source, heat (temperature), surfaces (materials) 3. time-release 4. masking 5. imagined (psychological) 6. barrier 7. adsorption 8. cleaning 9. non-specific (undefinable) 10. direct spray, fogging 11. contain, trap 12. additive, dry cleaning 13. combustible (flammable), thermal 14. darken (discolor) 15. furniture polish 16. microorganisms 17. urine, water damage, trauma 18. mixed (shaken) 19. 80-120°f/27-49°c 20. neutral 21. ammonia 22. disinfectants, antimicrobial (sanitizing) 23. four 24. dry solvent, detergents, deodorants, polish

CHAPTER V - Electrically Generated Deodorization (page 57)
1. high efficiency particle air 2. 99.97%; 0.03 3. three 4. molecular, atomic, molecule 5. ultraviolet, lightening 6. sunburn, skin cancer, blindness 7. drinking water 8. corona discharge 9. oxidation 10. air, moisture sensitive 11. Threshold Limit Value, toxicity 12. Time Weighted Average, eight, 40 13. 0.1 14. Short Term Exposure Limit 15. 0.3 16. 10-15 17. heavier, floor 18. residue 19. HVAC (ACS, duct, air handling) 20. grids, screens 21. hydrogen peroxide 22.

respiratory irritant

CHAPTER VI - Basic Equipment Options (page 71)

1. toxicity, respiratory, combustion 2. droplet (particle) 3. 20 4. 0.1 to 4 5. emulsion, white 6. paper (porous wood, cellulose 7. ultra low volume 8. power blower 9. flame, solvent based (dry solvent) 10. one-half 11. flammable (combustible) 12. pilot lights 13. fire department, smoke detectors 14. respiratory (lung) 15. combustion 16. oily residue 17. chemical (allergy) 18. filters, chemicals (fragrances, perfumes) 19. lightening, ultraviolet 20. metal (electrically charged) 21. one-tenth 22. unoccupied 23. hydrogen peroxide 24. natural latex (rubber) 25. plants

CHAPTER VII - Animal Urine (page 88)

1. Perseverance (persistence) 2. animal urine 3. acid 4. alkaline, bacterial 5. ammonia 6. color, deposits (pigment, staining) 7. territorial, psychological 8. alkaline salts, hydroscopic (absorbent) 9.1atent 10. oversimplification l l. filters, HVAC (air-handling, ACS) 12. corners, baseboards, door, furniture 13. sleeping, eating 14. discolorations, gummy residue 15. ultraviolet 16. moisture (aqua) sensor (detector, probe) 17. disengage, observe 18. rusted, rotted (mildewed, discolored) 19. amount (quantity), age 20. plastics 21. trigger, pump, syringe (hypodermic) 22. hand-pump, electrically 23. disinfectant (quat), stain-resist 24. animal, present 25. 150 26. neutral 27. carpet, cushion, sub floor 28. impractical (impossible) 29. putrefaction 30. replacement (removing), painting (sealing)

CHAPTER VIII - Decomposed Protein (page 99)

1. food, death scenes 2. amino acids 3. putrefaction 4. water-soluble, persistent 5. psychological 6. maggots 7. replacement, restoration 8. structural, contents 9. plastic, penetration 10. decontamination, disinfectant 11. heavy-duty, garbage bag 12. outside, pressure washing 13. mechanical components 14. chlorine bleach (sodium hypochlorite) 15. tent, ozone gas 16. deodorant block 17. clothing, vapor respirator 18. carcass, soil (dirt) 19. EPA-registered, heavy-duty 20. interior 21. lime 22. musk, persistent 23. sulfur 24. oxidizing bleach (sodium hypochlorite) 25. fogging

CHAPTER IX - Death Scene (page 111)

1. healthcare (medical) 2. disease (sickness), death 3. incident, industry 4. Universal precautions 5. exposure control plan 6. HBV 7. Biohazard 8. 1/2, sodium hypochlorite 9. psychological 10. personal protective equipment 11. removed, disposal of 12. replacement, sealed, refinished 13. deodorants 14. ozone gas

CHAPTER X - Gases and Fuels (page 124)

1. riot, eyes, nose 2. minutes 3. days 4. skin, eye, respiratory 5. ventilation (aeration) 6. wet fogging, paring 7. horizontal 8. damp mopped, extraction 9. absorbent, insulation 10. ozone 11. hazardous (flammable, explosive) 12. flammability 13. toxic 14. fume detection 15. flame,

arc (spark) 16. mopping, oil absorbing 17. structural 18. solvent, alkaline detergent 19. tracked 20. ozone gas

CHAPTER XI - Fire and Smoke (page 133)

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