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Healthcare Industry Germ Warefare

A look at microorganisms and how to control them

Table of Contents

A critical part of healthcare is the control of microorganisms, especially those that can cause disease. In the sanitation industry, cleaning and germ control are important in the kitchen, patient room, operating rooms, hallways, bathrooms, on floors, on walls and in the laundry. Cleaning and sanitation products are made to help in this battle. The use of chemicals, heat, and water in germ control are as old as the concern with the spread of disease.

As far back as biblical times, there were strict rules on cleanliness, dietary rules, and handling of wastes. Aristotle instructed Alexander the Great to have his armies boil their drinking water and bury their human waste. In 1676 Anton van Leeuwenhoek, a Dutch clothing merchant who also made microscopes first discovered microorganisms which he called “little animals”. He also discovered that pepper killed them, so he is credited with first using chemicals to kill microorganisms. During the Great Plagues, the clothes of victims were burned to avoid the spread of disease.

In 1845 and 1846 hundreds of thousands of Irish died in the infamous potato blight as a potato fungus rotted the crops in the field. What is especially tragic about this is that 10 years earlier a Frenchman, Isaac-Benedict Prevost, having discovered that microorganisms caused disease, successfully used chemical disinfectants in field tests to show that he could prevent infection. By applying copper solutions to crops he kept them from becoming diseased. Unfortunately for Prevost and the Irish, people believed in “spontaneous generation” of disease where abnormalities in the plant “juices” caused disease. Had Prevost’s methods been applied in Ireland, the famine need never have happened.

In England in 1827, Alcock recommended that chlorine be used to purify drinking water for the first time. And in the United States in 1840’s, Doctor Oliver Wendell Holmes, father of the famous Supreme Court justice, concluded that disease was being carried from patient to patient by doctors and nurses on their hands and on their clothing. At this time, the vast majority of people who went to hospitals either got sicker or died. This gave rise to the saying that “A hospital is no place for a sick person”.

An English doctor named Lister discovered that wounds became infected because of microbes in the air. His techniques helped the Berlin hospital reduce their infection rate from 90% to 15%. He was knighted and much later had a mouthwash named after him. Robert Koch, in 1881, demonstrated that bacteria did indeed cause disease, which leads us to the use of chemicals as disinfectants.

Mercury was used as far back as 1140, but its poisonous nature eventually led to its rejection. Phenol and phenolic compounds were used to treat garbage smell and for a while phenol was used to treat wounds, but after killing the microorganisms, its poisonous nature kept making the patients sick, yet another instance of doctors making people sicker rather than healthier. One phenolic emulsion patented in 1877, Lysol, is still with us (although different phenolic chemicals are being used today).
Alcohols have been used in germ control, but in 1903 Harrington and Walker demonstrated that to be effective a 60 - 70% solution needed to be used and that no amount of alcohol could kill bacterial spores (dormant bacteria). Iodine was used during the US Civil War to treat wounds. During WWI, 5000 ppm solutions of sodium hypochlorite (bleach) were used to disinfect wounds.

In modern America, many people use chemical disinfectants in their homes, while health care personnel use chemical disinfectants to prevent the spread of disease in health care establishments on hard surfaces or inanimate objects. Germ control within a plant, animal or person is done through the use of antibiotics. Having showed you a little of the history of germ warfare, what follows next is a summary of some of the terms that are used in the industry and that you may come across.

GLOSSARY OF TERMS

Antiseptics/Antibiotics - An agent that frees a body from infection or disease by destroying or inhibiting the action of microorganisms. Antiseptics are used on human or animal tissue. Antiseptics are considered drugs in the USA and are regulated by the FDA.

Bacteria - Microorganisms, often composed of one cell, sometimes containing chlorophyll, in the form of straight or curved rods (bacilli), spheres (cocci) or spiral structures.

Bactericide - Capable of killing bacteria, but not necessarily bacterial spores.

Bacteriophage or Phage - A special type of virus that kills bacteria by surrounding them and absorbing the bacteria.

Disinfectant - An agent that frees an inanimate body from infection by destroying microorganisms, but doesn’t necessarily kill bacterial spores. Disinfectants kill 100.00% of certain microorganisms, but they are not used on people, only inanimate surfaces.

Fomites - Inanimate objects such as hair and dust particles that carry airborne bacteria and establish human infections by invading the lower respiratory tract leading to systematic infections.

Fungi/Fungus - Sporebearing microorganisms that have a nucleus but are devoid of chlorophyll living as parasites on plants, animals or other fungi. Fungi reproduce sexually and asexually. Yeasts, mildew and mushrooms are all fungi.

Fungicide - Capable of killing fungi. This term generally means that fungal spores will be killed as well.

Germ - This is a generic term for microorganisms, usually for pathenogenic organisms.

Germicide - An agent that destroys microorganisms, especially pathogenic microorganisms. Generally germicides kill some microorganisms, but not spores.

Nosocomial Infections - Infections that develop in the hospital that were not incubating at the time of admission or are caused by microorganisms that were acquired during a hospitalization. The baseline for bacterial nosocomial infection is 1 to 6 cases per 1000 patients in a hospital.

Pathogenic - Capable of causing disease. Generally any microorganism capable of entering another body and causing disease.

Spore - A body, usually one cell (unicellular) found in plants and protozoa. Certain bacteria form thick walled spores that are difficult to kill. They are not reproductive. Some spores can withstand boiling in water for hours.

Sporicide - An agent capable of killing spores. Since spores are much harder to kill than other microorganisms like bacteria, fungi and viruses, sporicides are generally sterilants as well.

Sterilization - The act or process, physical or chemical, that destroys or eliminates all forms of life, especially microorganisms. Being sterile is an absolute expression. An object or body cannot be partially sterile.

Virucide - An agent that destroys or inactivates viruses, especially a chemical substance. Viruses are not living entities like bacteria or fungi, so technically, we don't kill viruses. Viruses are always found in a host cell or in a body fluid.

Virus - An infectious agent composed entirely of protein and nucleic acids. Viruses can reproduce only in living cells and are so small that electron microscopes are needed to see them. They are parasites relying on living cells.

TYPES OF MICROORGANISMS

We now move to the topic of what exactly we are killing. Microorganisms, meaning small organisms usually seen only through a microscope, include the following groups: algae, fungi, viruses, protozoa and bacteria. The sanitation industry is mainly concerned with bacteria, fungi and viruses.

Bacteria

Bacteria are the first type of microorganism we will consider. They usually have a single cell structure. Bacteria are so small that 50 billion would fit inside 1 cubic inch. They are a mix of 70-90% water, 1-10% mineral, proteins, and carbohydrates. Bacteria are self-sustaining as long as they have food and water. They live in body fluids, but don't actually enter a body cell like viruses. Bacteria move molecules of food and water through their outer membrane (called a cytoplasmic membrane) by a process called osmosis. This keeps the bacteria alive. While water and food are necessary for growth, oxygen may not be required. Bacteria that require oxygen are called aerobic bacteria, while bacteria not requiring oxygen are called anaerobic. Bacteria are pH sensitive with the pH range of 4 - 9 being the best for bacterial growth.

Bacteria are further classified as gram-positive or gram-negative based on a dye stain test developed by a scientist named Gram. This is important because gram-negative bacteria have a more complex structure with a tougher outer membrane than gram-positive bacteria. This makes gram-negative bacteria more difficult to kill with chemicals. Gram-positive bacteria are easily killed by chemicals in most cases.

Bacteria do three basic things: they eat, excrete wastes and reproduce. If bacteria only ate, they would not be as much of a problem. When they excrete wastes, they excrete substances that may be toxic to humans. The toxins can be more dangerous to humans than the bacteria itself. Often these toxins have odors which aid in the identification of spoiled food.

Every cell in a uniform population of bacterial cells retains the potential for duplication. The growth of bacteria can occur at an exponential rate. This means that two bacteria become four. Four become eight. Eight become sixteen and so forth. This is known as a logarithmic series. The rate of growth is measured by the generation or doubling time. The generation time is the time needed for the population to double. If reproduction occurs every 30 minutes, the generation time is 30 minutes.

Under favorable conditions, bacteria can double as fast as every 15 minutes. In only 20 population doublings there would be over 1 million bacteria. In 30 doublings there would be over 1 billion. This means each bacteria could generate billions of others in 8 hours. At this rate, overnight any contaminated surface would become a serious health hazard. Fortunately growth quickly slows as ideal conditions are difficult to maintain. Bacteria too far from food and water stop reproducing.

Bacteria can also generate spores. A spore is a special, much more complex, dormant form of a bacterial cell. When a bacterial cell forms a spore, it grows a hard outer shell that makes it impervious to most chemical attack. Some spores can be boiled for several hours and survive. Spores stored for 50 years have been easily activated.

Fungi

Fungi make up a diverse group of microorganisms occupying a position between bacteria and protozoa. Fungi either grow as discrete cells (yeasts) or as multicell filaments (molds). Unlike bacteria, which are somewhat self-sustaining, fungi live as parasites on or in people, animals, plants or other fungi. Yeasts, mildew, rusts and mushrooms are all examples of fungi. In nature, fungi play an important role in the disposal of dead vegetation. Being parasites, they attach themselves to a body and slowly consume it until the food is gone. Fungi growth is very pH sensitive.

When a product claims to be fungicidal (kills fungi), it is generally tested against Trichophyton mentagrophytes, which causes athletes foot. Another important fungus is Aspergillus niger, which causes mildew. To be successful there must be a 100% kill of the fungus within 10 minutes from contact. Many disinfectants are effective in killing fungi.

Viruses

The last group of microorganisms are viruses. Viruses, (and the subgroups viroids and prions) are acellular, that is they lack a cell structure. Viruses have a core surrounded by a protein coat and in some cases an additional envelope as well. Viruses have 3 common characteristics: they have a core surrounded by a protective protein shell, they multiply only inside living cells and are completely dependent on the host for energy.

Viruses destroy or modify the cells in which they multiply; thus they are potential pathogens (disease causing). Virus duplication results in destruction of the host cell or in integration of the viral genetic DNA into the host cell DNA resulting in the permanent transformation of the host cell.

The virus growth cycle is 6 to 36 hours. Up to 1,000,000 viral particles are produced by small viruses per cell. There is little that can be done to interfere with the growth of viruses since they multiply within the host cell, unlike bacteria and fungi. Viruses that have a low level of viral reproduction can establish an equilibrium in the host. This tends to develop a degenerative disease, especially if the virus attacks the central nervous system. AIDS is such a disease.

Viruses can be broken into 3 groups: lipophilic (core, protein coat and envelope), partially lipophilic (just the core and protein coat), and hydrophilic (naked viruses with just the core). In these 3 groups, there are 18 families of viruses that attack people and animals. HIV is lipophilic.

Viruses do not produce mildew or odors like bacteria. Fabrics have been known to harbor viruses. In England there have been secondary cases of smallpox infection among laundry sorters due to contaminated textiles. Viruses have been passed on the outside cap of toothpaste for at least 6 hours after contamination in an experiment. Recently, 25% of people who had eye procedures performed by a doctor later developed an eye infection (keratoconjunctivitis) when that doctor's eye infection spread to his hands and then the instruments used in procedures.

DESTRUCTION OF MICROORGANISMS

When people in the sanitation industry talk about germ kills, there are different levels of microorganism control. The highest level of germ kill is sterilization. This is the complete (100%) kill of all microorganisms including: bacteria, spores, fungi and viruses. This is usually accomplished over a period of hours. In a hospital, any instrument used in surgery or that enters the body will be sterilized. This is necessary as a precaution to prevent any organism from entering the body and causing disease.

On hard nonporous surfaces in health care environments, the term used is disinfection. This kills 100% of certain organisms as claimed on the product label in a 10 minute contact time. Rarely do disinfectants claim to kill spores or other tough to kill organisms like the hepatitis B virus or the tuberculosis bacterium. Most disinfectants will claim to kill a broad cross-section of organisms as a way of showing that in general the disinfectant will kill most microorganisms present. Disinfectants are used on tables, floors, chairs, beds, toilets, sinks, showers, baths, whirlpools and walls to name a few.

Microorganism killing is governed by: the concentration of the chemical used, the type of microorganism and its cell density (if it has a cell structure), contact time, temperature and pH of the environment, and the presence of organic matter. Germ kill is very temperature dependent. When using chemical germicides, higher temperatures are more effective.

ENVIRONMENTAL FACTORS AFFECTING GROWTH

Many environmental factors influence the growth of a microbial population (bacteria, virus or fungi). Changes in moisture, temperature, oxygen, food, and pH all affect the growth rate.

Temperature. Microorganism growth slows down and eventually stops if they are exposed to reduced temperatures. Some microorganisms can still grow at temperatures approaching 32°F. Temperature is one of the most important factors controlling the survival of microorganisms. Usually, as the temperature increases toward an ideal temperature. which varies from organism to organism, growth and metabolic functions increase. Above this temperature, activity decreases. For each organism, there are minimum and maximum temperatures below and above which growth will not occur. These temperatures are typically between the freezing and boiling point for water. No single organism can grow over the whole temperature range.

pH. Each organism has a pH range and a well defined optimum pH for growth. The typical pH range is from 5 - 9, but microorganisms have been found at a pH of less than 2 and a pH greater than 10.

Oxygen. The earth's atmosphere is about 20% oxygen. Aerobic microorganisms need oxygen to grow and generally can't grow without it. Anaerobic organisms can grow without it and several of this type of organism are destroyed by contact with oxygen.

Water. All organisms require water for life. Removing all moisture (drying or heating) may not kill organisms, but it keeps them from growing. Organisms use moisture to transfer food through the cell wall and transfer wastes out of the cell. The less water that is available, the slower the growth.

Food. Without food/nutrients, microorganisms cannot grow. Food or nutrients include some form of protein, minerals and sometimes carbohydrates or vitamins. The food or nutrient requirements for microorganisms vary from organism to organism. One of the easiest ways to help control organism growth is to deprive them of food.

Concentration. The use dilution for chemical germicides should be followed exactly. The use dilutions have been set up to give specific product concentrations. Using too little product will weaken its germ killing ability and using too much product will not necessarily perform any better.

Time. Each disinfectant sold by U S Chemical has minimum contact times to be assured of microorganism kill. For disinfectants, the contact time is 10 minutes. The surface must remain wet during this time. Contact times are just as important as the germicide concentration.

CHEMICAL DESTRUCTION

There is no single chemical that is ideal for all microorganism control. All chemicals show some selectivity, meaning they work better on some types of microorganisms and poorer on others. The better the chemicals work across the spectrum of microorganisms, the more hazardous the chemicals are to use. In hard surface disinfection the main chemicals used are quaternary ammonium compounds (quats), phenolics and occasionally iodophors.

The use of chemical germicides has helped develop strains of organisms that are increasingly resistant to germicides and antibiotics. Multiple antibiotic resistant bacteria have been isolated from drinking water. Disinfection and purification of water may also be increasing the occurrence of antibiotic resistant bacteria.

IMPORTANT MICROORGANISMS AND DISEASES THEY CAUSE

Avian infectious bronchitis, (virus) causes an acute rapid spreading respiratory infection in poultry.

Aspergillus niger (fungus) causes mildew and mold. It has also been identified with causing pneumonia and eye and skin infections.

Canine distemper (virus) causes a highly contagious disease among dogs. Symptoms include a fever and respiratory problems.

Clostridium botulinum (bacteria that causes botulism) is an organism that produces a potent neurotoxin that causes weakness, double vision, slurred speech, paralysis, and often death if ingested. Found in canned foods, it is killed through heating. The pH must be above 4.6 for the bacteria to grow. High acid foods (below pH 4.6) do not need steam for processing to kill botulinum spores.

Escherichia coli (bacteria) is found in the intestines of cattle. Meat is contaminated during slaughter. The disease is spread through eating undercooked meat. The bacteria can also be found in unpasteurized milk and apple cider and in human feces. Symptoms include watery diarrhea which turns bloody within 24 hours. Severe abdominal cramps, nausea, and occasional vomiting are common. The disease can result in kidney failure. Symptoms occur 1 to 8 days after contact. The disease lasts 5 to 8 days.

Feline leukemia (virus) appears in the mouths of infected cats and can be passed from cat to cat.

Herpes simplex type I & II (viruses) type I causes fever blisters and canker sores usually caused by colds. Type II causes lesions in the genitals and buttocks.

Influenza type A (virus) causes the flu. This is an acute respiratory infection, transmitted from person to person by coughing and sneezing.

Kliebsiella pneumonia (bacteria) is the causative agent of pneumonia. It can also cause infant diarrhea and urinary tract infections.

Proteus mirabilis & vulgaris (bacteria) causes urinary tract infections, diarrhea and respiratory tract infections.

Pseudomonas aeruginosa (bacteria) is found in water and fluids, especially in hospitals. Contact with an infected wound or having open skin are common routes of infection. The bacteria causes diarrhea, infections, cystic fibrosis and several other diseases.

Rabies (virus) enters the human body through animal bites. Symptoms include partial paralysis to full paralysis, throat muscle spasms. If untreated the patient dies.

Rubella (virus) causes German Measles.

Salmonella enteritidis, choleraesuis, and typhimurium (bacteria) cause an average of 40,000 cases/yr. 2000-3000 result in death. Salmonella is the primary infectious bacteria associated with food. It is commonly found in meats, poultry, milk and eggs. It is spread on knives, cutting surfaces or by an infected person who practices poor hygiene. Salmonella causes severe diarrhea, watery stools, nausea, vomiting and fevers over 101°F. Symptoms occur 6 to 72 hours after ingestion. The disease lasts 1 to 14 days.

Salmonella typhi (bacteria) causes typhoid fever. The bacteria enters the body through contaminated food and water, invading the intestinal tract.

Staphylococcus aureus (bacteria) produces toxins very resistant to heat. It is found in the nose and throat of healthy people and is passed to food through improper hygiene. It grows on meats, prepared salads, cream sauces and cream filled pastries. When foods are temperature abused, the bacteria grow and produce toxins. Heating kills the bacteria, but not the toxins which cause severe vomiting, diarrhea, nausea, cramps, and lightheadedness 1 - 6 hours after ingestion. The disease lasts 1 to 2 days. The disease may induce toxic shock syndrome.

Trichophyton mentagrophytes (fungus) causes athletes foot.

Vaccinia (virus) is a pox virus used for vaccination of humans for immunity against small pox.

A CLOSER LOOK AT THREE DANGEROUS DISEASES

In addition to the diseases caused by microorganisms described above, AIDS, tuberculosis and hepatitis are so important that we've dedicated a special section on each.

HIV - AIDS

The first disease we will examine is Human Immunodeficiency Virus (HIV) that causes Acquired ImmunoDeficiency Syndrome (AIDS).

In the summer of 1981, the Center for Disease Control (CDC) identified the disease which has come to be known as AIDS. As of March 2015, 36.9 million people worldwide are living with AIDS. The vast majority of the infected persons are asymptomatic (not showing symptoms) and thus unaware of their infected status.

The disease is thought to have crossed the species barrier from primates in Africa. High risk behaviors include IV drug users who share needles and sexual contact with infected persons. It is estimated that 91% of known infected persons were infected in these manners. People infected with AIDS become susceptible to opportunistic infections, so often the early signs of AIDS are disguised as other diseases.

HIV has been isolated from: blood, semen, tears, saliva, breast milk, urine, spinal fluid, bone marrow and vaginal secretions. Contact with any of these fluids could potentially lead to infection with AIDS. However, the chance of infection from saliva, tears, urine, breast milk (now being pasteurized when pooled), skin grafts, bone transplants and artificial insemination are very rare. Since blood has been screened routinely since 1985, the rate of infection for hemophiliacs has gone from very high to rare. There has been no evidence that AIDS can spread by mosquitoes or other insects. There have been several cases of transmission by an infected dentist to patients.

For health care workers, the risk of HIV infection from needle sticks contaminated with HIV infected blood is estimated as 1% by the CDC. To disinfect soiled linen, the CDC recommends washing at temperatures over 160°F for 25 minutes.

Tuberculosis

Starting in 1985 the number of people infected in the USA has increased each year from the 22,768 cases in 1986. Tuberculosis (TB) peaked at 26,673 during 1992 and has declined to 9,421 cases in 2014. Tuberculosis is a severe and often fatal disease caused by a bacteria called mycobacterium tuberculosis.

Studies have shown that TB is hard to kill. Tubercule bacilli deposited in books and magazines were recoverable alive after 2 weeks to 3.5 months. TB is especially dangerous because it is spread almost exclusively by airborne transmission of droplets from coughing, sneezing, talking, laughing, etc. of infected persons. If inhaled, the small particles are capable of reaching the sensitive deep lung tissues, where they multiply and produce infection. One cough may produce 3500 droplets, while a sneeze may produce up to 1,000,000 particles.

Infants are extremely sensitive to infection. Frequent air exchanges (six per hour) are recommended to keep infectious particles to 1% of the initial level. Mycobacteria are generally more resistant to chemical disinfection than other bacteria. 50% alcohol solutions have been shown to be effective in killing TB. Phenolics work well, but are very toxic and have a strong odor. One study showed a residual effect of up to 30 days after the application of a phenolic on a hard surface. Phenolics are useful in disinfection, because they are stable and are not inactivated by soap or organic matter. Some iodine products are effective, especially when the iodine is combined with alcohol. Chlorine compounds are not recommended for disinfection of instruments and equipment. Quats are generally believed to be of little value as a tuberculocide although there are now quat products that do kill TB.

Hepatitis

A group of five viruses induce hepatitis, an infection of the liver. These viruses are mostly part of the hepadnavirus group, with the most common form being called hepatitis B (HBV).

Acute viral hepatitis is a generalized infection with emphasis on inflammation of the liver. 64% of hepatitis cases reported in hospitals were due to contact with blood, contaminated instruments, needle sticks and contact with contaminated patients. Because this disease is mostly a nosocomial infection, combating it is difficult to do. HBV has been isolated from blood, semen and saliva. So contact with any of these body fluids of an infected person may result in infection. At the peak, there were 300,000 cases of hepatitis reported in the USA in 1987. The latest data from 2013 reports an estimated 19,800 cases of HBV in USA.

Laundering procedures should include washing for 15 minutes at 185°F. The resistance of HBV is classified as more than TB, but less than bacterial spores. HBV is one of the toughest microorganisms to kill.

GOVERNMENT REGULATIONS

Having discussed microorganisms and how the environment affects killing them we now look at how government regulates the products that do this. Federal regulation of antimicrobial products began with the regulation of pesticides in the Insecticide Act of 1910. Starting in 1947, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which is the basic law used today, was passed. These early acts were designed to protect consumers from products that did not work. Based on these early laws, disinfectants and sanitizers were regulated along with crop pesticides because they all killed organisms. Starting in

1964, the government started to be able to deny registration of products. The Federal Environmental Pesticide Control Act of 1972 drastically transformed FIFRA from a labeling law, to a comprehensive regulatory statute controlling the manufacture, sale and distribution of pesticides.

Today any product that makes a claim of killing, disinfecting or sanitizing must be registered. Surface sanitizers like chlorine bleach, iodophors and quats are regulated along with crop pesticides and rat poisons.

DISINFECTANTS

The class of antimicrobials used in health care are called disinfectants. A disinfectant is an antimicrobial agent that is applied to inanimate surfaces for the purpose of killing bacteria, fungi and viruses, but not spores. The official test organisms must be 100.00% killed in 10 minutes under the defined conditions of the official test. If an antimicrobial product is applied to the body (except for handsoaps) and it kills microorganisms, it is called an antibiotic and classified as a drug by the Food and Drug Administration (FDA).

U S Chemical does not make antibiotics (chemicals to kill microorganisms within a body). We only make disinfectants for use on hard surfaces. Where sanitizers are low chemical concentration killers of bacteria that can cause foodborne illness, disinfectants are high concentration killers of a whole slew of organisms that may be more difficult to kill. As an example, quat sanitizers are used at 200 ppm, while quat disinfectants are used at 600-1000 ppm. U S Chemical makes quaternary ammonium chloride disinfectants and one phenolic disinfectant. Organic materials - blood, serum, dirt, food, feces, etc. - can reduce the effectiveness of both sanitizers and disinfectants. Hard water can reduce effectiveness as well.

The official test for hospital-grade disinfectants uses Salmonella choleraesuis, Staphylococcus aureus and Pseudomonas aeruginosa. Please see the disease section for a discussion of the diseases that they cause. Staphylococcus aureus especially plays a role in hospital nosocomial infections (infections acquired while in the hospital).

Unlike with bacteria for sanitizer testing, the EPA does not allow prototype testing, like in many European countries, for disinfectants. This means that to make a label claim for any microorganism as a disinfectant (and be in compliance with EPA law), there must be testing data to support the claim for each organism. For sanitizers of food contact surfaces one or two bacteria are tested against the sanitizer to make a general claim of being able to "sanitize" the surface so that it is safe for food. This is allowed so that a product doesn't need to test against the thousands of bacteria that could contaminate a surface. For disinfectants, no general claim can be made, so each organism is tested individually. Some disinfectants will be tested against a small number of organisms while some disinfectants may be tested against more than 100 organisms.

Based on the organisms discussed in this brochure and on general microbiological studies, a list of relative susceptibility to chemicals can be constructed as follows.

(A = Easiest to kill, G = Hardest to kill)

A - Retroviruses (AIDS), herpes, vaccinia, influenza, mumps, measles, conjunctivitis, many enveloped viruses, many bacteria and fungi.

B - Staphylococcus aureus, some fungi, yeasts, algae

C - Adenoviruses

D - Tuberculosis, rotaviruses, reoviruses and some molds

E - polio, rhinoviruses, parvoviruses, hepatitis

F - Bacterial spores including Clostridium botulism

G - Prions, slow viruses

If a disinfectant is capable of passing the EPA virucide test against poliovirus or a rhinovirus within 10 minutes, little doubt exists that it is truly a broad-spectrum disinfectant in terms of susceptibility groups A, B, C & D, but exceptions exist. The presence of alcohol or detergents can enhance germ kill for phenolics, while disinfectants using quaternary ammonium compounds tend to be less effective against enteroviruses and adenoviruses than to the bacteria in the same group when compared to chlorine or iodine.

Phenolics

Phenolics are a class of disinfectants based on the organic compound phenol. They often have chlorine attached to the phenolic to intensify the germ killing properties of the product. The para or 'p' phenolics tend to be more effective than the ortho or 'o' phenolics.

Very small amounts of phenolics result in bacteriostatic action. Gram-negative bacteria tend to be more resistant than gram-positive bacteria to phenolics. Although both organisms contain an outer wall, gram-negative bacteria contain an additional outer membrane that makes them more resistant to chemicals.

Phenolics are considered to be effective tuberculocidal agents. Tuberculosis bacteria are more difficult to kill than other bacteria. The outer membrane of a tuberculosis bacteria is made up of waxy layers. The phenolics effectiveness may be related to the ability of the phenolics to dissolve this waxy layer.

Generally, phenolics possess the following characteristics: broad spectrum antimicrobial activity against gram-positive and gram-negative bacteria, fungicidal, tuberculocidal, virucidal against most lipophilic and many hydrophilic viruses, tolerance for organic load and hard water, residual activity and biodegradability. Phenolics and quats are not sporicidal and cannot be used for sterilization. Phenolics are used between 400 and 1300 ppm.

PCMX and Triclosan are common phenolic derivatives used in antibacterial soaps. PCMX was developed in Europe and brought to the US in 1948. Since then it has dominated the nonsurgical scrub antimicrobial hand soap category. The antimicrobial hand soaps that U S Chemical makes either use a phenolic or a quat as their active ingredient. Disinfectants formulated with phenolics (low volatile ones) impart a temporary residual antibacterial potential to surfaces. Quats can impart a temporary bacteriostatic, but not bactericidal film on surfaces.

Phenolics are very high quality germicidal agents used primarily in health care. One big advantage of phenolics over quats is that they are generally tuberculocidal. Phenolics are virucidal against lipophilic and hydrophilic viruses, but the activity against lipophilic viruses is less certain.

Quats

Quats are much safer to the user than phenolics, but tend to be more selective in the organisms they kill. Quats tend to be used between 450 - 800 ppm. Currently for a quat product to make a claim of killing the AIDS virus, there must be at least 600 ppm of quat present. The safety of people who contact chemical disinfectants is a concern, because in hospitals and nursing homes the vast majority of hard surfaces that a patient comes in contact with must be disinfected and may contain residuals from the disinfectant. Disinfection of rooms and equipment is an ongoing operation and as such, the large amounts of chemical used must be safe for workers to handle for extended periods of time and for patients to be exposed to for extended periods.

In 1916 Jacobs and coworkers published 3 papers describing the antimicrobial activity of quaternary ammonium compounds. There have been seven different generations of quats developed since then. Quats are generally described as different chain lengths of molecules on the active complex. The lower chain lengths are more active against yeast and fungi, whereas the gram-negative bacteria are more susceptible to the larger chain quats. Quats are more active against gram-positive bacteria and fungi than gram-negative bacteria.

Quats work in acidic and alkaline environments, but are most active at slightly alkaline pH's. Quats applied to the skin can form a continuous residual sheet, beneath which bacteria can survive, so quats are not used as the active ingredient in many hand soap products. Quats do not kill spores, and only in special cases can kill the tuberculosis bacteria. Quats are generally effective against lipophilic viruses.

Quats are also used in laundries. Fabric treated with a 200 ppm quat solution was allowed to air dry. This fabric demonstrated residual bacteriostatic activity against several bacteria. Some tests have shown that this effect in linen can last for at least one year.

LAUNDRY

Throughout the diseases section, several references were made to laundering procedures. In healthcare, making laundry free from disease is important, but the government has provided very little direction. There are various guidelines for disinfection of linen. The Center for Disease Control (CDC) has made recommendations concerning the control of hepatitis B and HIV. To disinfect soiled linen possibly contaminated with HIV, the CDC recommends washing at temperatures over 160°F for 25 minutes. For hepatitis B, laundering procedures should include washing for 15 min. at 185°F.

Any linen definitely contaminated by hepatitis B, tuberculosis or HIV should be red bagged and handled as a biohazard. Unfortunately, the presence of these diseases isn't always clear. Since it is not possible to achieve these temperatures in all accounts, most laundries will attempt to use chlorine bleach with a minimum concentration of 50 ppm at the end of the bleach bath. This does not guarantee disinfection, but higher concentrations of chlorine needed for true disinfection (from 200 to 1000 ppm) are very destructive to the linen and thus aren't used. So laundry workers should be cautious of any linen soiled by blood or body fluids, even that coming out of the washer.

CONCLUSION

We have addressed may of the technical aspects of germ control in health care. The battle against microorganisms growth is an ongoing one as organisms mutate making their immunity to antibiotics and chemicals greater. There are all kinds of ways that people cut corners in germ warfare. Since so many of the diseases have the potential for being fatal, it is our job to ask if the cut corner is worth the risk.

The information presented herein is, to the best of our knowledge, true and accurate. It should not be assumed that the information is 100% complete, or that it will not change in the future due to conditions beyond our control. This brochure is not to supercede and Federal, state or local regulations which may be in force.