LABORATORY GUIDE FOR MANAGING CHEMICAL WASTE

VANDERBILT UNIVERSITY MEDICAL CENTER

Office of Clinical and Research Safety (OCRS)
https://www.vumc.org/safety
615-322-2057

Revision 2: 2-22

TABLE OF CONTENTS

IDENTIFYING HAZARDOUS WASTES IN YOUR LABORATORY

Laboratory personnel should treat all waste chemical solids, liquids, or containerized gases as hazardous wastes unless a specific chemical waste has been confirmed to be a non-hazardous waste by OCRS. A laboratory chemical becomes a "waste" when you no longer intend to use it, regardless of whether or not it has been used or contaminated. Also, spilled chemicals and absorbent materials used to clean the spill should be disposed of as hazardous waste. Please note that the term "chemical" includes items containing chemicals such as ethidium bromide gels, paints, solvents, degreasers, glues, varnishes, and disinfectants in addition to stock chemicals and chemical solutions used in laboratory processes.

OCRS Quick Facts:

- Treat all waste chemical solids, liquids, and containerized gases as hazardous waste.
- Acute hazardous wastes are F-, K-, and P-listed hazardous wastes.

ADDITIONAL INFORMATION ON THE DEFINITION OF HAZARDOUS WASTE

To ensure consistency with the hazardous waste determination process, laboratories should treat all waste chemicals as hazardous waste and allow OCRS to make the final determination as stated above. However, a more complete description of the hazardous waste determination process is provided here for informational purposes.

Hazardous wastes are defined by the United States Environmental Protection Agency (USEPA) as waste solids, liquids, or containerized gases that meet the definition of a **characteristic** or **listed** hazardous waste. Each hazardous waste type is described in detail below.

CHARACTERISTIC HAZARDOUS WASTES

Waste solids, liquids, or containerized gases that exhibit any of the following characteristics are defined as characteristic hazardous wastes: 1) Ignitability; 2) Corrosivity; 3) Reactivity; or 4) Toxicity.

LISTED HAZARDOUS WASTES

The USEPA has already predetermined that certain wastes are hazardous and these hazardous wastes have been incorporated into published lists. The hazardous waste lists are included on the OCRS website.

K-Listed Hazardous Wastes: K-listed hazardous wastes are source-specific wastes that are generated by specific industries such as iron and steel production facilities. K-listed hazardous wastes are not likely to be found in a laboratory.

F-Listed Hazardous Wastes: F-listed hazardous wastes are non-specific source wastes that are generated by particular industrial processes that can occur in various industries. Industrial processes that generate F-listed hazardous wastes include wood preservation, electroplating and other metal finishing processes, and processes that generate waste solvents.

IDENTIFYING HAZARDOUS WASTES IN YOUR LABORATORY

P- and U-Listed Hazardous Wastes: The P- and U-listed hazardous wastes are pure and commercial grade formulations of specific unused chemicals that are considered wastes. Unused chemicals may be considered wastes because they are no longer needed, they are spilled, or they are off-specification.

Acute Hazardous Wastes

Certain listed hazardous wastes are considered to be acutely toxic to human health and the environment and are further defined as "acute hazardous wastes." Acute hazardous wastes include F-, K-, and P-listed hazardous wastes described above.

Listed Hazardous Wastes in Laboratories

F-, P-, and U-listed hazardous wastes are the most likely listed hazardous wastes to be found in laboratories. F-listed hazardous wastes may be found in laboratories where electroplating or metal finishing operations are conducted that utilize solutions containing cyanides. Other F-listed wastes that may be found in laboratories include the following solvents or mixtures containing 10 percent or more of the solvent (before use) when spent:

Tetrachloroethylene	Trichloroethylene	1,1,1-trichloroethane	1,1,2-trichloroethane	Chlorinated fluorocarbons
Ortho-dichlorobenzene	Trichlorofluoromethane	Methylene chloride	Carbon tetrachloride	Cresols
2-nitropropane	Cresylic acid	Nitrobenzene	Toluene	Methyl ethyl ketone
Carbon disulfide	Isobutanol	Pyridine	Benzene	2-ethoxyethanol
Xylene	Acetone	Ethyl acetate	Ethyl benzene	Ethyl ether
Methyl isobutyl ketone	n-Butyl alcohol	Cyclohexanone	Methanol	

There are over 300 U-listed hazardous wastes. Please see the OCRS website for the complete list. The U-listed hazardous wastes most commonly found in laboratories include the following:

Acetaldehyde	Ethanol	2-Propanone	Acetone	Acetonitrile
Acetophenone	Acrylamide	Acrylonitrile	Aniline	Benzene
1-Butanol	Chlorobenzene	Chloroform	o-Chlorophenol	Cresol
Cyclohexane	Cyclohexanone	o-Dichlorobenzene	Ethylene dichloride	1,2-Dichloroethylene
Methylene chloride	2,4-Dichlorophenol	1,4-Dioxane	Ethyl acetate	Ethyl ether
Trichloromonofluoromethane	Formaldehyde	Formic acid	Hydrazine	Isobutyl alcohol
Lead acetate	Mercury	Methanol	Methyl ethyl ketone	Methyl isobutyl ketone
Methyl ethyl ketone peroxide	Methyl methacrylate	Naphthalene	Phenol	Resorcinol
1,1,1,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	Tetrachloroethylene	Carbon tetrachloride	Tetrahydrofuran
Thallium acetate	Thiourea	Toluene	Methyl chloroform	Trichloroethylene

There are over 100 P-listed hazardous wastes. Please see the OCRS website for the complete list. The P-listed hazardous wastes most commonly found in laboratories include the following:

Acrolein	Allyl alcohol	Arsenic acid	Brucine	Carbon disulfide
Chloroacetaldehyde	Chloroaniline	Cyanides	Diisopropylfluorophosphate	2,4-Dinitrophenol
p-Nitroaniline	Phosgene	Potassium cyanide	Sodium azide	Sodium cyanide
Thallium oxide	Ammonium vanadate	Vanadium pentoxide		

STORING HAZARDOUS WASTES IN YOUR LABORATORY

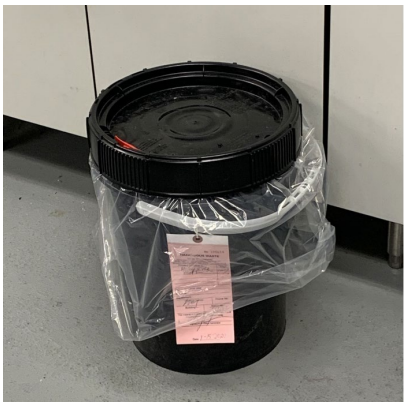
HAZARDOUS WASTE CONTAINERS

Hazardous chemical waste must be stored in containers (including lids) made of materials that are compatible with the waste. Hazardous waste containers must be in good condition and free of leaks or any residue on the outside of the container. The best container for your hazardous waste is the original chemical container. Unacceptable containers include household detergent and food service containers. Bags, liners, or receptacles specifically intended for biohazardous or radiological wastes should not be used for chemical waste unless those hazards are present in the mixed waste stream. Containers packaged in that manner will be refused by OCRS until they are packaged properly. OCRS maintains a supply of acceptable liners and containers for packaging hazardous wastes to assist the labs with compliance.

OCRS Quick Facts:

- Store hazardous waste in **sealed**, compatible containers.
- Hazardous waste containers must be kept closed at all times except to add waste.
- Label hazardous waste containers with OCRS chemical waste tags as soon as waste accumulation begins.
- Store hazardous wastes with secondary containment.
- Segregate incompatible hazardous wastes.
- Never accumulate more than 55 gallons of hazardous waste or one quart of acute hazardous waste.

Example of ***Improper*** **use of a biowaste bag**



Example of ***Proper*** **packaging for hazardous solids**

Example of *Improper* use of a **Food Grade Container** for hazardous material storage

LABELING HAZARDOUS WASTE CONTAINERS

Hazardous waste containers must be labeled with hazardous chemical waste tags provided by OCRS as soon as the container is used to collect hazardous waste, regardless of whether the container is full. These tags require the laboratory to provide specific information including name, telephone number, building, room number, and exact contents of the container. The date should be filled in on the tag when the container is full. It is important to include as much information as is known about the contents of the hazardous waste container, including percentages and water content, to facilitate disposal. If a container is being used to collect hazardous waste intermittently, the tag should be filled out immediately upon use of the container and must be edited as more waste is added. A separate tag must accompany each individual hazardous waste container. Old labels that do not accurately describe the contents of the waste container (i.e., the original label for a toluene bottle now being used to store waste xylene) must be defaced.

STORING HAZARDOUS WASTES IN YOUR LABORATORY

SEALING HAZARDOUS WASTE CONTAINERS

Hazardous waste containers must be sealed to prevent leakage or spillage. Containers should be sealed with a screw-type lid or other appropriate device. Plastic wrap, aluminum foil, and other make-shift lids are unacceptable. OCRS maintains a supply of funnels which seal the container upon closing and extra lids to assist labs with compliance.

A container holding hazardous waste must ALWAYS be closed during storage, except when it is necessary to add or remove waste. If a waste container is used to collect waste from a continuous process (i.e., drainage from a process collected with tubing inserted into a bottle), the container must still be sealed using rubber stoppers with tubing inserts or other appropriate means to prevent evaporation of volatile waste or spillage into the laboratory area.

Example of ***Improper Closure*** from a continuous process

Example of ***Proper Closure*** from a continuous process

Example of ***Improper Closure*** of funnel

Example of ***Proper Closure*** of funnel

MIXING HAZARDOUS WASTES

Hazardous wastes should be kept separate whenever possible. Mixing a hazardous waste with a non-hazardous waste can increase the volume of hazardous waste for disposal. Mixing hazardous wastes with other hazardous wastes can increase disposal costs due to differences in disposal options for certain hazardous wastes. For instance, halogenated solvents such as methylene chloride and chloroform are costlier to dispose of than non-halogenated solvents such as hexane and xylene; therefore, halogenated solvent wastes should be kept separate from non-halogenated solvent wastes.

STORING HAZARDOUS WASTES IN YOUR LABORATORY

HAZARDOUS WASTE CONTAINER STORAGE

Designate an isolated portion of your laboratory as a hazardous waste storage area. Laboratories with multiple rooms may designate one hazardous waste accumulation area for all rooms only if hazardous waste will not have to be transported in or across a public hallway or through any area that is not controlled by the lab. Hazardous wastes must be stored with secondary containment so that spills cannot reach sink, hood, or floor drains. Incompatible hazardous wastes must be segregated to prevent reaction. Segregation methods include storing in separate cabinets, storing in separate hoods, or storing in separate secondary containment containers such as 5-gallon buckets or tubs. Please refer to your laboratory's Chemical Hygiene Plan or the OCRS website for guidelines on segregating chemicals by hazard class.

Proper Hazardous Waste Storage. Hazardous waste is labeled, segregated by compatibility, stored in secondary containment, and in an isolated area.

Improper Hazardous Waste Storage. No OCRS labels, no secondary containment, no segregation, and containers are covered with residue.

Improper Hazardous Waste Storage. No secondary containment from hood drain, storage in high traffic area.

Improper Hazardous Waste Storage. No OCRS labels, no secondary containment, and container not sealed properly (open funnel).

HAZARDOUS WASTE STORAGE LIMITS

Your laboratory must NOT store more than 55 gallons of hazardous waste or one quart of acute hazardous waste at one time. You must have your hazardous waste and acute hazardous waste collected at such a frequency to prevent exceeding these limits. If these limits are ever exceeded, you must immediately submit a collection request form to OCRS, as described in the OCRS Environmental Fact Sheet, "Disposing of Hazardous Waste." Please see the OCRS Environmental Fact Sheet, "Identifying Hazardous Wastes in Your Laboratory" for the definition of acute hazardous waste.

You must also consider your storage capacity when establishing your storage area. Hazardous waste must be stored in a manner to minimize the risk of a spill, stored with secondary containment, and segregated by compatibility. You must not store hazardous waste in quantities that prevent proper storage practices. Based on your laboratory's rate of generation of hazardous waste, your storage capacity, and keeping in mind the quantity limits described above, you must determine the amount of hazardous waste you will accumulate in your storage area prior to having it collected by OCRS. Laboratories should try to minimize storage of hazardous waste

DISPOSING OF HAZARDOUS WASTE

HAZARDOUS WASTE COLLECTION PROGRAM

OCRS has implemented a Hazardous Waste Collection Program to collect hazardous waste directly from your laboratory. You must utilize the Hazardous Waste Collection Program to dispose of all hazardous waste generated by your laboratory. There is NO CHARGE for using the Hazardous Waste Collection Program. Hazardous wastes must NOT be transported to the OCRS waste storage facilities by personnel other than OCRS staff members.

OCRS Quick Facts:

- Utilize the Hazardous Waste Collection Program to dispose of all your hazardous waste, FREE of charge.
- Submit the waste collection request form to OCRS as soon as your hazardous waste is ready for pickup.
- Enter the date on the waste tags for the containers when the containers are filled.
- Never evaporate chemicals as a disposal method.
- Triple rinse empty containers that held acute hazardous waste prior to disposal as regular trash.
- Deface chemical or hazardous waste labels from empty chemical containers and remove cap prior to disposal as regular trash.
- Ensure that lab personnel are trained on proper waste handling and disposal procedures.

LABORATORY DISPOSAL OF WASTES

All hazardous wastes must be disposed of through the OCRS Hazardous Waste Collection Program. Hazardous wastes must NOT be discharged to the sewer via sink drains, hood drains, or other mechanisms.

Hazardous wastes must NOT be disposed of by evaporation – this includes evaporation in fume hoods or biosafety cabinets. Remember, hazardous waste containers must be kept closed at all times except to add or remove waste.

SUBMITTING A WASTE COLLECTION REQUEST FORM

An electronic Chemical Waste Collection Request should be submitted to have your hazardous waste collected by OCRS. This web form provides OCRS staff with a summary of the type and volume of waste to be collected so that the proper collection equipment will be utilized. Chemical hazardous wastes are collected Monday through Friday (except on observed holidays) and typically take one to three business days to be processed depending on the volume of requests received and other responsibilities. If an emergency waste collection is required, please contact OCRS directly. The Chemical Waste Collection Request Form can be found at:

https://www.vumc.org/safety/waste/chemical-waste-collection

Dating the Hazardous Waste Containers

Hazardous waste containers should be dated when they are filled and ready for pick-up. This is accomplished by filling in the date on the hazardous chemical waste tag that is attached to the container. (Please see the previous section on “Storing Hazardous Waste in Your Laboratory” for labeling requirements for hazardous waste.) Full containers should not be stored in the laboratory for excessive periods of time (i.e., have full containers collected within approximately one week).

When to Submit the Collection Request Form

Your laboratory must store hazardous waste according to the guidelines provided in the OCRS Environmental Fact Sheet, “Storing Hazardous Waste in Your Laboratory.” You must have your hazardous waste collected at such a frequency to remain in compliance with those guidelines and so that full containers of hazardous waste are note stored for excessive periods of time as described above.

DISPOSAL OF HAZARDOUS WASTE CONTAINERS

Acute Hazardous Waste Containers

An empty container that has held an acute hazardous waste must be triple rinsed using a solvent (which might be water) capable of removing the acute hazardous waste prior to disposal of the container as regular trash. Each rinsing should be performed with an amount of solvent equal to approximately 5 percent of the volume of the container. The rinseate must be collected and disposed of as hazardous waste. The containers should be defaced of any chemical or hazardous waste labels and the cap should be removed prior to disposal as regular trash. Please see the OCRS Environmental Fact Sheet, "Identifying Hazardous Waste in Your Laboratory" for a definition of acute hazardous waste.

Other Hazardous Waste Containers

A container that has held any hazardous waste, other than an acute hazardous waste, can be disposed of as regular trash once all the waste has been poured out. The waste should be emptied out leaving as little residue as possible. The containers should be defaced of any chemical or hazardous waste labels and the cap should be removed prior to disposal as regular trash.

TRAINING FOR LABORATORY PERSONNEL

Your laboratory personnel should be trained on the proper handling, storage, labeling, and disposal of hazardous wastes generated by your laboratory. Training should also include procedures for responding to spills or leaks and waste minimization practices. Training should be administered at a frequency sufficient to ensure competency in the proper management practices.

OCRS Quick Facts:

- Order only the quantity of chemicals you need.
- Utilize inventory management and control to prevent the buildup of waste chemicals.
- Substitute non-hazardous or less hazardous chemicals and/or modify your process to use smaller quantities of hazardous chemicals whenever possible.
- Utilize good housekeeping practices to minimize the risk of a spill.

PRODUCT SUBSTITUTION

Laboratories should attempt to substitute non-hazardous or less toxic materials into their processes and experiments whenever possible. One example is the substitution of biodegradable (non-hazardous) scintillation fluids for hazardous scintillation fluids.

INVENTORY MANAGEMENT AND CONTROL

Laboratories should periodically evaluate their chemical inventory and dispose of unwanted/obsolete chemicals. Purchase only the quantity of chemicals required for specific projects. Vanderbilt University has to pay for the disposal of hazardous wastes. Ordering bulk quantities of chemicals to save money may end up costing more money after disposal of the excess quantity.

PROCESS MODIFICATION

To the extent that it does not affect vital research or teaching, laboratories should modify experiments to decrease the quantity of hazardous chemicals used and generated. Microanalysis techniques can greatly reduce the amount of hazardous waste generated.

SEGREGATION AND CHARACTERIZATION

To the extent possible, do not mix wastes or waste streams. In particular, do not mix non-hazardous waste with hazardous waste. Segregation and characterization allow waste to be redistributed for reuse by another researcher. If the waste cannot be redistributed, segregation minimizes disposal costs.

NEUTRALIZATION AND RECLAMATION

Some laboratories generate a simple, pure chemical stream, such as a dilute acid or base that can be rendered non-hazardous by simple neutralization. Other laboratories may generate a dilute aqueous stream that contains a metal that can be easily precipitated, rendering the waste stream non-hazardous. Additionally, reclamation systems are available for some waste streams such as silver recovery systems for photograph fixer solutions. Strict laws apply to processes for neutralizing hazardous wastes. For these types of waste streams, labs are encouraged to contact OCRS to determine if they can process these materials to render them non-hazardous.

GOOD HOUSEKEEPING PRACTICES

Spilled chemicals and the materials used to clean up the spills must be disposed of as hazardous waste. Good housekeeping practices to minimize the likelihood of a spill can reduce the amount of hazardous waste generated.

HIGHLY HAZARDOUS CHEMICAL WASTES

Certain chemical wastes must be handled by special procedures due to their highly hazardous nature. ***These chemicals include expired isopropyl and ethyl ethers (these chemicals typically expire 6 months after the container is opened), dry picric acid, and dry 2,4-dinitrophenylhyrdazine.*** These chemicals can explode during opening or routine handling. A comprehensive list of highly hazardous chemicals can be found at the OCRS website. If you encounter these or other highly hazardous waste chemicals in your laboratory, leave them alone and notify OCRS immediately to arrange for disposal. Highly hazardous chemicals must NOT be handled by laboratory personnel.

OCRS Quick Facts:

- Highly hazardous chemical wastes must not be handled by laboratory personnel.
- Contact OCRS immediately if you encounter highly hazardous chemical wastes in your laboratory.
- Spilled chemicals and supplies used to clean spills must be disposed of as hazardous waste.
- Clean up spills when they happen or contact OCRS for assistance.

Expired ethyl ether.

Expired ether is one of the most common highly hazardous chemicals found in laboratories. Ether is extremely flammable and can form explosive peroxides after exposure to air and light. Since it is packaged in an air atmosphere, peroxides can form even in unopened containers. Therefore, it is very important to write the date received and the date opened on all ether containers. Opened containers should be disposed of through the OCRS Hazardous Waste Collection Program within 6 months. Unopened containers should be disposed of through the OCRS Hazardous Waste Collection Program within one year. Ether should be stored in the smallest container possible, away from heat and sunlight and any source of ignition, and in a flammable storage cabinet or refrigerator/freezer certified for storing flammable materials.

Your laboratory/department will be charged for the disposal of highly hazardous chemicals, since they are not included in the Hazardous Waste Collection Program budget. The charge will be the direct cost charged to OCRS by our disposal contractor. OCRS does not mark up the disposal charges for these chemicals.

HAZARDOUS WASTE SPILLS

Chemical spills must be cleaned up immediately. Spilled chemicals should be treated as hazardous waste. The materials used in the spill cleanup should also be treated as hazardous waste unless the materials can be decontaminated. Chemical spills that cannot be cleaned up by laboratory personnel should immediately be reported to OCRS after evacuating and isolating the spill area.

INTRODUCTION

Vanderbilt University Medical Center is required to comply with sewer disposal restrictions established by the Metro wastewater treatment plant and all applicable State and Federal regulations. This guide is designed to assist laboratories with the identification of waste streams that are prohibited or limited from sink/sewer disposal. Wastes must **NOT** be intentionally diluted to comply with sink/sewer disposal requirements. Please note that application of some regulatory requirements to laboratory waste streams is extremely complicated. Contact the Office of Clinical and Research Safety (OCRS) for assistance in applying these guidelines to your specific waste streams. For more information on how to collect and manage hazardous wastes, contact OCRS.

WASTES FORBIDDEN FROM SINK/SEWER DISPOSAL

The following wastes must **NEVER** be discharged to the sanitary sewer in **ANY** concentration. These wastes must be collected and managed as hazardous waste.

1. **Raw Chemical Waste.**
   Unused, pure, or concentrated chemicals.

2. **Chlorinated Hydrocarbon Waste.**
   Chlorinated hydrocarbons are compounds that contain chlorine, hydrogen, and carbon. Examples of chlorinated hydrocarbons include but are not limited to:
   a. Chloromethanes:
      Specific examples:
      Methylene chloride
      Trichloromethane (chloroform)
      Trichlorofluoromethane
   b. Chloroethanes:
      Specific examples:
      1,1-Dichloroethane
      1,1,1-Trichloroethane
      1,1,2-Trichloroethane
      Hexachloroethane
   c. Chloroethylenes:
      Specific examples:
      Vinyl chloride
      Trichloroethylene
      Tetrachloroethylene
   d. Chloropropanes, chlorobutanes, chlorobutenes:
      Specific examples:
      Dichlorobutadiene
      Hexachlorobutadiene
   e. Chlorinated paraffins;

f. Chlorinated pesticides

Specific examples:

Aldrin	Heptachlor epoxide
Chlordane	Hexachloride
DDT	Hexachlorobenzene
2,4-D	Lindane
Dieldrin	Methoxychlor
Endrin	Mirex
Heptachlor	Toxaphene

g. Nucleus-chlorinated aromatic hydrocarbons

Specific examples:

Dichlorobenzene
Dichlorotoluene
Chlorobenzene
1,2-Dichlorobenzene
1,4-Dichlorobenzene
Chlorinated biphenyls (including PCBs)
Chlorinated naphthalenes
Pentachlorophenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

h. Side-chain chlorinated aromatic hydrocarbons

Specific examples:

Chloromethyl benzene (benzyl chloride)
Dichloromethyl benzene (benzal chloride)
Trichloromethyl benzene (benzotrichloride).

3. Chlorofluorcarbon Waste.

4. Brominated Hydrocarbon Waste.

Specific examples:

Bromoform
Bromomethane

5. Cyanide Waste.

Includes cyanide, cyanate (OCN-), and thiocyanate (SCN-) compounds.

Specific examples:

Potassium cyanide
Sodium cyanide
Hydrogen cyanide
Zinc cyanide
Copper cyanide
Nickel cyanide.

6. **Heavy Metal Waste.**
Specific examples:

Antimony	Mercury
Arsenic	Nickel
Barium	Selenium
Cadmium	Silver
Chromium	Thallium
Copper	Zinc
Lead	

7. **Corrosive Waste.**
Corrosive wastes are wastes that could cause corrosive structural damage to the sink/sewer piping. All wastes with a pH lower than 6.0 Standard Units (S.U.) or higher than 9.0 S.U. are considered corrosive wastes. Laboratories must not neutralize corrosive wastes to comply with this requirement unless it is part of a written protocol for the laboratory process generating the waste and the neutralization process is carried out by trained, qualified personnel.

8. **Solvent Waste.**
Wastes containing any of the following solvents in any concentration:

Acetone	Ethyl Ether
Benzene	Isobutanol
n-Butyl Alcohol	Methanol
Carbon Disulfide	Methyl Ethyl Ketone (MEK)
Carbon Tetrachloride	Methyl Isobutyl Ketone
Cresols	Nitrobenzene
Cyclohexanone	2-Nitropropane
Cresylic Acid	Pyridine
2-Ethoxyethanol	Toluene
Ethyl Acetate	Xylene
Ethyl Benzene	

Please note that acetone used to wash glassware falls into this category.

9. **Oil and Grease Wastes.**
Waste oils and grease, including vacuum pump oil, must be collected and managed as hazardous wastes. Wastes that are contaminated with oil or grease in concentrations greater than 50 mg/L must also be collected and managed as hazardous waste.

10. Ignitable Wastes.

Ignitable wastes are: 1) Liquid wastes with a flashpoint less than 60 ^{O}C (140 ^{O}F); 2) Non-liquid wastes that can cause fire through friction, reaction with moisture, or spontaneous chemical changes; 3) Ignitable compressed gases; or 4) Oxidizers. Ignitable wastes include most waste solvents found in laboratories, ignitable compressed gases such as hydrogen, and oxidizers such as nitrates/nitrites (sodium nitrate, potassium nitrite, etc.) and chlorates and perchlorates (magnesium perchlorate, etc.). Ignitable wastes include mixtures of ignitable chemicals with other materials if the mixture still exhibits the ignitability characteristic (i.e., flashpoint less than 60 ^{O}C).

11. Unused or Out-Dated Pharmaceuticals

U.S. Environmental Protections Agency regulations require that certain discarded drug wastes must be managed as hazardous chemical wastes. Pharmaceutical drugs are considered to be wastes and must be discarded when the drugs:1) are opened but unused, 2) have been partially administered 3) or can no longer be used for the intended purpose.

12. Reactive Wastes.

Reactive wastes: 1) Are normally unstable and readily undergo violent change; 2) React violently or form explosive mixtures with water; 3) Can generate toxic gases, vapors or fumes when mixed with water or exposed to extreme pH conditions; 4) It is a forbidden explosive as defined in 49 CFR 173.54, or is a Division 1.1, 1.2 or 1.3 explosive as defined in 49 CFR 173.50 and 173.53. or 5) Are capable of detonation or explosive reaction under certain conditions. Common reactive wastes found in laboratories include certain cyanides, sulfides, and silanes or any mixtures of multiple wastes that exhibit reactivity characteristics.

13. Solid or Viscous Wastes.

Solid or viscous wastes that may coat, clog, or otherwise cause obstruction to the flow of sewer pipes must never be discharged to the sewer. Examples of prohibited solid or viscous waste include sand, animal tissues, bones, plastics, rubber, glass, wood chips, wood shavings, plaster, paint, etc. in such quantity, concentration, or form that may cause interference with proper sewer flow. Depending on the nature of the waste, it may be discharged to the normal trash or collected and managed as hazardous waste.

14. Nuisance Waste.

Wastes that may cause a discoloration or that may cause interference in the Metro wastewater treatment plant must not be discharged to the sewer. Wastes that are noxious or malodorous to the extent that a nuisance may be created at the Metro wastewater treatment plant or in other laboratories must not be discharged to the sewer.

15. Untreatable Waste.

Wastes that contain any element or compound that cannot be adequately treated or removed by the Metro wastewater treatment plant (biological activated sludge treatment) and that is known to be an environmental hazard must not be discharged to the sewer.

16. Hot Liquid or Vapor Wastes.

Liquid or vapor wastes with a temperature above 65.5 ^{O}C (150 ^{O}F) must not be discharged to the sewer.

17. Ethidium Bromide and Acrylamide Waste.

Buffer solutions and other solutions containing ethidium bromide or acrylamide in any concentration and ethidium bromide and acrylamide gels.

18. <u>Priority Pollutant Wastes.</u>

All wastes containing any of the following priority pollutant compounds in any concentration must be collected and managed as hazardous waste:

Volatiles		
Acrylonitrile	Benzene	Bromoform
Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane
Chloroethane	2-Chloroethylvinyl ether	Chloroform
Dichlorobromomethane	Dichlorodifluoromethane	1,1-Dichloroethane
1,2-Dichloroethane	1,1-Dichloroethylene	Dichloromethane
1,2-Dichloropropane	1,2-Dichloropropylene	1,3-Dichloropropylene
2,4-Dichloropropylene	Ethylbenzene	Methyl bromide
Methyl chloride	Methylene chloride	1,1,2,1-Tetrachloroethane
1,1,2,2-Tetrachloroethane	Tetrachloroethylene	Tetrachloromethane
Toluene	Trans-dichloroethylene	1,2-Trans-dichloroethylene
1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethylene
Trichlorofluoromethane	Trichloromethane	Vinyl chloride
Base/Neutral		
Acenaphthene	Acenaphthylene	Anthracene
Benzidine	Benzo(a)anthracene	Benzo(a)pyrene
3,4-Benzofluoranthene	Benzo(ghi)perylene	Benzo(b)fluoranthene
Benzo(k)fluoranthene	Bis(2-chloroethoxy)methane	Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether	Bis(2-chloromethyl)ether	Bis (2-ethylhexyl)phthalate
4-Bromophenyl phenyl ether	Butylbenzyl phthalate	2-Chloronaphthalene
4-Chlorophenyl phenyl ether	Chrysene	Dibenzo(a,h)anthracene
1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene
3,3'-Dichlorobenzidine	Di-n-ethyl phthalate	Diethyl phthalate
Di-c-methyl phthalate	Dimethyl phthalate	Di-n-butyl phthalate
2,4-Dinitrotoluene	2,6-Dinitrotoluene	Di-n-octyl phthalate
1,2-Diphenylhydrazine	Fluroranthene	Fluorene
Hexachlorobenzene	Hexachlorobutadiene	Hexachlorocyclopentadiene
Hexachloroethane	Indeno(1,2,3-cd)pyrene	Naphthalene
Nitrobenzene	N-nitrosodimethylamine	N-nitrosodi-n-propylamine
N-nitrosodiphenylamine	Phenanthrene	Pyrene
1,2,4-Trichlorobenzene		
Pesticides		
Acrolein	Aldrin	BHC, alpha
BHC, beta	BHC, delta	BHC, gamma
Chlordane	4,4'-DDT	4,4'-DDE
4,4'-DDD	Dieldrin	Endosulfan, alpha
Endosulfan, beta	Endosulfan sulfate	Endrin
Endrin aldehyde	Heptachlor	Heptachlor epoxide
Isophorone	PCB-1016	PCB-1221
PCB-1232	PCB-1242	PCB-1248
PCB-1254	PCB-1260	TCDD (Dioxin)
Toxaphene		

Inorganics, Metals, Phenols, and Cresols		
Antimony	Arsenic	Asbestos
Beryllium	Cadmium	Chromium
Copper	Lead	Mercury
Nickel	Selenium	Silver
Thallium	Zinc	Cyanide
2-Chlorophenol	Cresols	2,4-Dichlorophenol
2,4-Dimethylphenol	4,6-Dinitro-o-cresol	2,4-Dinitrophenol
2-Nitrophenol	4-Nitrophenol	P-chloro-m-cresol
Pentachlorophenol	Phenols	2,4,6-Trichlorophenol

18. **Rinseate.**
    Empty containers that are being rinsed should be triple rinsed with a minimal amount of liquid and the rinseate collected and managed as hazardous waste, if the container held any of the wastes described above in Sections 1, 2, 3, 4, 5, 6, or 8. Subsequent rinses may be discharged to the sewer. Depending on the waste, fewer rinses may be required to be collected. Contact OCRS for evaluation of specific waste containers. Rinseate from empty containers that held other types of waste may be discharged to the sewer if the rinseate does not exhibit the hazardous characteristic of the waste (for example, rinseate from a container that held ignitable waste may be sewer disposed if the rinseate is not ignitable).

WASTES WITH LIMITED SINK/SEWER DISPOSAL

1. **Radioactive Wastes.**
   A radioactive waste that is water soluble or readily dispersible in water and not prohibited from sewer disposal based on the criteria described in the previous section may be disposed via the sanitary sewer system. The disposal limit is 200 μCi per laboratory per day. Records of sewer disposal must be maintained on the Radioactive Material Usage Log.

2. **Biological Materials.**
   Biological waste must not be discharged to the sewer unless it has been properly treated. Please refer to Proper Disposal of Biological Waste in the Guide to Biosafety at Vanderbilt for biological waste disposal policies and procedures (OCRS website). Biological waste intended for sewer disposal must not be prohibited from sewer disposal based on the criteria described in the previous section.

3. **Specific Organic Chemicals in Concentrations of One Percent or Less.**
   Organic chemicals suitable for sink/sewer disposal are described below. Only those organic compounds that are reasonably soluble in water are suitable for sink/sewer disposal. A compound is considered water soluble if it dissolves to the extent of at least three percent. Chemicals listed below must be in concentrations of approximately one percent or less to be suitable for sink/sewer disposal. If the total volume of waste to be disposed is greater than four liters per day, approval by OCRS is required. Sewer discharges of these chemicals must not be prohibited in the previous

section. Any chemicals that fall into categories described below but are specifically prohibited from sink/sewer disposal in the previous section must NOT be discharged to the sewer.

a. Alkanols with 4 or fewer carbon atoms.
   Specific examples:

2-Butanol	2-Propanol	Tert-butanol
Ethanol	1-Propanol	

b. Alkanediols with 7 or fewer carbon atoms.
   Specific examples:

Butanediol and isomers	Butylene glycol
Ethylene glycol	Heptamethylene glycol
Heptanediol and isomers	Hexanediol and isomers
Hexylene glycol	Pentanediol and isomers
Pentylene glycol	Propylene glycol

c. Sugars and sugar alcohols (polyols).
   Specific examples:

Dithioerythritol	Dithiothreitol	Erythritol
Glycerol	Lactitol	Maltitol
Mannitol	Molasses	Sorbitol
Xylitol		

d. Alkoxyalkanols with 6 or fewer carbon atoms.
   Specific examples:
   - Butoxyethanol
   - Ethoxyethanol
   - Methoxyethanol

e. Aliphatic aldehydes with 4 or fewer carbon atoms.
   Specific examples:
   - Acetaldehyde
   - Butyraldehyde (butanal)
   - Formaldehyde
   - Glutaraldehyde
   - Isobutyraldehyde
   - Propionaldehyde (propanal)

f. $RCONH_2$ and RCONHR with 4 or fewer carbon atoms and $RCONR_2$ with 10 or fewer carbon atoms.
Specific examples:

Acetamide	Butanamide
Butyramide	Formamide
Isobutyramide	N,N-Diethyl formamide
N,N-Dimethyl acetamide	N,N-Dimethyl propionamide
N-Ethyl acetamide	N-Ethyl formamide
N-Methyl acetamide	N-Methyl formamide
N-Methyl propionamide	Propionamide

g. Aliphatic amines with 6 or fewer carbon atoms.
Specific examples:

Amylamine	Isobutylamine	Butylamine
Dimethylpropylamine	Ethylamine	1-Ethylpropylamine
Hexylamine	Isobutylamine	Isopropylamine
Methylamine	Methylbutylamine	N-Ethylbutylamine
N-Ethylmethylamine	N-Methylpropylamine	Trimethylamine
Iso-amylamine	Diethylamine	

h. Aliphatic diamines with 6 or fewer carbon atoms.
Specific examples:

Ethylene diamine	Hexamethylene diamine and isomers
Pentamethylenediamine and isomers	Piperazine
1,2-Propanediamine	1,3-Propanediamine
Triethylenediamine	

i. Alkanoic acids with 5 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
Specific examples:

Acetic acid	Butyric acid	Formic acid
Isobutyric acid	Isovaleric acid	Propionic acid
Valeric acid		

j. Alkanedioic acids with 5 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
Specific examples:

Fumaric acid	Glutaric acid (1,5-pentanedioic acid)
Malic acid	Malonic acid (1,3-propanedioic acid)
Oxalic acid (1,2-ethanedioic acid)	Succinic acid (1,4-butanedioic acid)
Tartaric acid	

k. Hydroxyalkanoic acids with 5 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
Specific examples:
Glycolic acid
3-Hydroxybutyric acid
2-Hydroxyisobutyric acid
Lactic acid (2-hydroxypropanoic acid)

l. Aminoalkanoic acids with 6 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
Specific examples:

3-Amino butyric acid	4-Amino butyric acid
Amino isobutyric acid	5-Amino pentanoic acid and isomers
3-Amino propanoic acid	

m. Esters with 4 or fewer carbon atoms.
Specific examples:

Ethyl formate	Isopropyl acetate	Isopropyl formate	Methyl acetate
Methyl formate	Methyl propionate	Propyl formate	

n. Nitriles.
Specific examples:
Acetonitrile
Butyronitrile
Isobutylnitrile
Propionitrile

o. Sulfonic acids and sodium and potassium salts of the acids.
Specific examples:

Methane sulfonic acid	Ethane sulfonic acid
1-Propane sulfonic acid	1-Butane sulfonic acid
1-Pentane sulfonic acid	1-Hexane sulfonic acid
1-Heptane sulfonic acid	1-Octane sulfonic acid
1-Decane sulfonic acid	1-Dodecane sulfonic acid
1-Tetradecane sulfonic acid	1-Hexadecane sulfonic acid

4. <u>Elementary Neutralization of Corrosives</u>

Some facilities on campus are equipped to have the ability of treating corrosive hazardous waste via the plumbing system in an elementary neutralization unit (ENU) which does NOT require a RCRA treatment permit [40 CFR 270.1(c)(2)(v)]. Contact your Department's Administration and OCRS if unsure of your facility's capabilities for this.

a. This process can only be used on wastes that are regulated solely because they exhibit the characteristic of corrosivity (D002) from having a pH of less than or equal to 2.0 or greater than or equal to 12.5.

i. The neutralized waste must have a pH between 6 and 9 when exiting the unit.

b. Waste acids should be less than a 50% dilution of the concentrated acid, cannot exhibit any other hazardous waste characteristics (i.e. ignitability, reactivity, toxicity), cannot contain organic solvents. Examples of acids and bases that may not be neutralized via this option include:

- Perchloric acid at any concentration
- Nitric acid, concentrated
- Sulfuric acid, fuming (concentrated)
- Hydrofluoric acid
- Acids or bases with high concentrations of metals or other contaminants
- Acids or bases that contain dyes or surfactants defined as Nuisance Wastes
- Any organic acids and bases that are still toxic after neutralization (most organic acids and bases; one exception is acetic acid with a concentration of less than 80 percent)

5. <u>Specific Inorganic Chemicals in Concentrations of One Percent or Less.</u>

Inorganic chemicals suitable for sink/sewer disposal are described below. Only those inorganic compounds that are reasonably soluble in water are suitable for sink/sewer disposal. A compound is considered water soluble if it dissolves to the extent of at least three percent. Chemicals listed below must be in concentrations of approximately one percent or less to be suitable for sink/sewer disposal. If the total volume of waste to be disposed is greater than four liters per day, approval by OCRS is required. Sewer discharges of these chemicals must not be prohibited in the previous section. Any chemicals that fall into categories described below but are specifically prohibited from sink/sewer disposal in the previous section must NOT be discharged to the sewer.

a. Inorganic salts for which both the cations and anions are listed in the following table.

Cations	Anions
Aluminum, Al^{3+}	Borate, BO_3^{3-}, $B_4O_7^{2-}$
Ammonium, NH^{4+}	Bromide, Br^-
Calcium, Ca^{2+}	Carbonate, CO_3^{2-}
Cesium, Cs^+	Chloride, Cl^-
Hydrogen, H^+	Bisulfite, HSO_3^-
Lithium, Li^+	Hydroxide, OH^-
Magnesium, Mg^{2+}	Oxide, O_2^-
Potassium, K^+	Iodide, I^-
Sodium, Na^+	Nitrate, NO_3^-
Strontium, Sr^{2+}	Phosphate, PO_4^{3-}
Tin, Sn^{2+}	Sulfate, SO_4^{2-}
Titanium, Ti^{3+}, Ti^{4+}	
Zirconium, Zr^{2+}	

REFERENCES

1. Tennessee Department of Environment and Conservation (TDEC) CHAPTER 0400-12-01, 6/2018
2. Metropolitan Government of Nashville and Davidson County Code of Laws Title 15.60.
3. Citation for 40 CFR (RCRA)
4. Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, D.C., 1981.
5. Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, D.C., 1983.
6. Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, National Academy Press, Washington, D.C., 1995.

SUMMARY OF SPECIFIC CHEMICALS FORBIDDEN FROM SEWER DISPOSAL

The following chemicals must not be discharged to the sanitary sewer in any concentration. This list contains examples of specific chemicals and does **NOT** include all chemicals that are forbidden from sewer disposal. For more information on whether a chemical not listed below can be discharged to the sewer, refer to the detailed sections in this guide or contact OCRS.

Specific Chemicals Forbidden from Sewer Disposal	
Acenaphthene	Acenaphthylene
Acetone	Acrolein
Acrylamide	Acrylonitrile
Aldrin	Anthracene
Antimony	Arsenic
Asbestos	Barium
Benzene	Benzidine
Benzo(a)anthracene	Benzo(a)pyrene
Benzo(b)fluoranthene	Benzo(ghi)perylene
3,4-Benzofluoranthene	Benzo(k)fluoranthene
Beryllium	BHC, alpha
BHC, beta	BHC, delta
BHC, gamma	Bis (2-ethylhexyl)phthalate
Bis(2-chloroethoxy)methane	Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether	Bis(2-chloromethyl)ether
Bromoform	Bromoform
Bromomethane	4-Bromophenyl phenyl ether
Butylbenzyl phthalate	Cadmium
Carbon Disulfide	Carbon Tetrachloride
Chlordane	2-Chloroethylvinyl ether
Chlorinated biphenyls (including PCBs)	Chlorinated naphthalenes
Chlorobenzene	Chlorodibromomethane
Chloroethane	Chloroform
Chloromethyl benzene (benzyl chloride)	2-Chloronaphthalene
2-Chlorophenol	4-Chlorophenyl phenyl ether
Chromium	Chrysene
Copper	Copper cyanide
Cresols	Cresylic Acid
Cyanide	Cyclohexanone
2,4-D	DDT
4,4'-DDD	4,4'-DDE
4,4'-DDT	Dibenzo(a,h)anthracene
Dichlorobenzene	1,2-Dichlorobenzene
1,3-Dichlorobenzene	1,4-Dichlorobenzene

Specific Chemicals Forbidden from Sewer Disposal	
3,3'-Dichlorobenzidine	Dichlorobromomethane
Dichlorobutadiene	Dichlorodifluoromethane
1,1-Dichloroethane	1,2-Dichloroethane
1,1-Dichloroethylene	1,2-Trans-dichloroethylene
Dichloromethane	Dichloromethyl benzene (benzal chloride)
2,4-Dichlorophenol	1,2-Dichloropropane
1,2-Dichloropropylene	1,3-Dichloropropylene
2,4-Dichloropropylene	Dichlorotoluene
Di-c-methyl phthalate	Dieldrin
Diethyl phthalate	2,4-Dimethylphenol
Dimethyl phthalate	2,4-Dinitrophenol
Di-n-butyl phthalate	Di-n-ethyl phthalate
Di-n-octyl phthalate	4,6-Dinitro-o-cresol
2,6-Dinitrotoluene	1,2-Diphenylhydrazine
Endosulfan sulfate	Endosulfan, alpha
Endosulfan, beta	Endrin
Endrin aldehyde	Ethidium Bromide
2-Ethoxyethanol	Ethyl Acetate
Ethyl Benzene	Ethyl Ether
Ethylbenzene	Fluorene
Fluroranthene	Heptachlor
Heptachlor epoxide	Hexachloride
Hexachlorobenzene	Hexachlorobutadiene
Hexachlorocyclopentadiene	Hexachloroethane
Hydrogen cyanide	Indeno(1,2,3-cd)pyrene
Isobutanol	Isophorone
Lead	Lindane
Mercury	Methanol
Methoxychlor	Methyl bromide
Methyl chloride	Methyl Ethyl Ketone (MEK)
Methyl Isobutyl Ketone	Methylene chloride
Mirex	Naphthalene
n-Butyl Alcohol	Nickel
Nickel cyanide	Nitrobenzene
2-Nitrophenol	4-Nitrophenol
2-Nitropropane	N-nitrosodimethylamine
N-nitrosodi-n-propylamine	N-nitrosodiphenylamine
PCB-1016	PCB-1221
PCB-1232	PCB-1242
PCB-1248	PCB-1254
PCB-1260	P-chloro-m-cresol

Specific Chemicals Forbidden from Sewer Disposal	
Pentachlorophenol	Phenanthrene
Phenols	Potassium cyanide
Pyrene	Pyridine
Selenium	Silver
Sodium cyanide	TCDD (Dioxin)
1,1,2,1-Tetrachloroethane	1,1,2,2-Tetrachloroethane
Tetrachloroethylene	Tetrachloromethane
Thallium	Toluene
Toxaphene	Trans-dichloroethylene
1,2,4-Trichlorobenzene	1,1,1-Trichloroethane
1,1,2-Trichloroethane	Trichloroethylene
Trichlorofluoromethane	Trichloromethane (chloroform)
Trichloromethyl benzene (benzotrichloride)	2,4,5-Trichlorophenol
2,4,6-Trichlorophenol	Vinyl chloride
Xylene	Zinc
Zinc cyanide	

SUMMARY OF SPECIFIC CHEMICALS WITH LIMITED SEWER DISPOSAL

The following chemicals may be discharged to the sewer in concentrations of approximately one percent or less. If the percentage is greater than one percent, approval by OCRS is required. If the total volume of waste to be disposed is greater than four liters per day, approval by OCRS is required. Sewer discharges of these chemicals must not be prohibited for any other reason. Specifically, solutions containing these chemicals must not also contain chemicals specifically forbidden from sewer disposal. This list contains examples of specific chemicals and does **NOT** include all chemicals with limited discharge to the sewer. For more information on whether a chemical not listed below can be discharged to the sewer, refer to the detailed sections in this guide or contact OCRS.

Specific Chemicals with Limited Sewer Disposal	
Acetaldehyde	Acetamide
Acetic acid	Acetonitrile
3-Amino butyric acid	4-Amino butyric acid
Amino isobutyric acid	5-Amino pentanoic acid and isomers
3-Amino propanoic acid	Amylamine
Butanamide	Butanediol and isomers
1-Butane sulfonic acid	2-Butanol
Butoxyethanol	Butylamine
Butylene glycol	Butyraldehyde (butanal)
Butyramide	Butyric acid
Butyronitrile	1-Decane sulfonic acid
Diethylamine	Dimethylpropylamine
Dimethyl sulfoxide (DMSO)	Dithioerythritol
Dithiothreitol	1-Dodecane sulfonic acid
Erythritol	Ethane sulfonic acid
Ethanol	Ethoxyethanol
Ethyl formate	Ethylamine
Ethylene diamine	Ethylene glycol
1-Ethylpropylamine	Formaldehyde
Formamide	Formic acid
Fumaric acid	Glutaraldehyde
Glutaric acid (1,5-pentanedioic acid)	Glycerol
Glycolic acid	Heptamethylene glycol
Heptanediol and isomers	1-Heptane sulfonic acid
1-Hexadecane sulfonic acid	Hexamethylene diamine and isomers
1-Hexane sulfonic acid	Hexanediol and isomers
Hexylamine	Hexylene glycol
3-Hydroxybutyric acid	2-Hydroxyisobutyric acid
Iso-amylamine	Isobutylamine
Isobutylamine	Isobutylnitrile
Isobutyraldehyde	Isobutyramide

Specific Chemicals with Limited Sewer Disposal	
Isobutyric acid	Isopropyl acetate
Isopropyl formate	Isopropylamine
Isovaleric acid	Lactic acid (2-hydroxypropanoic acid)
Lactitol	Malic acid
Malonic acid (1,3-propanedioic acid)	Maltitol
Mannitol	Methane sulfonic acid
Methoxyethanol	Methyl acetate
Methyl formate	Methyl propionate
Methylamine	Methylbutylamine
Molasses	N,N-Diethyl formamide
N,N-Dimethyl acetamide	N,N-Dimethyl propionamide
N-Ethyl acetamide	N-Ethyl formamide
N-Ethylbutylamine	N-Ethylmethylamine
N-Methyl acetamide	N-Methyl formamide
N-Methyl propionamide	N-Methylpropylamine
1-Octane sulfonic acid	Oxalic acid (1,2-ethanedioic acid)
Pentamethylenediamine and isomers	Pentanediol and isomers
1-Pentane sulfonic acid	Pentylene glycol
Piperazine	1,2-Propanediamine
1,3-Propanediamine	1-Propane sulfonic acid
1-Propanol	2-Propanol
Propionaldehyde (propanal)	Propionamide
Propionic acid	Propionitrile
Propyl formate	Propylene glycol
Sorbitol	Succinic acid (1,4-butanedioic acid)
Tartaric acid	Tert-butanol
1-Tetradecane sulfonic acid	Triethylenediamine
Trimethylamine	Valeric acid
Xylitol	

Inorganic salts for which both the cations and anions are listed in the following table.

Cations	Anions
Aluminum, Al^{3+}	Borate, BO_3^{3-}, $B_4O_7^{2-}$
Ammonium, NH^{4+}	Bromide, Br^-
Calcium, Ca^{2+}	Carbonate, CO_3^{2-}
Cesium, Cs^+	Chloride, Cl^-
Hydrogen, H^+	Bisulfite, HSO_3^-
Lithium, Li^+	Hydroxide, OH^-
Magnesium, Mg^{2+}	Oxide, O_2^-
Potassium, K^+	Iodide, I^-
Sodium, Na^+	Nitrate, NO_3^-
Strontium, Sr^{2+}	Phosphate, PO_4^{3-}
Tin, Sn^{2+}	Sulfate, SO_4^{2-}
Titanium, Ti^{3+}, Ti^{4+}	
Zirconium, Zr^{2+}	