FOOD SAFETY AND SANITATION

Air and Water Quality

Learning Objectives

- Identify means by which air and water can introduce microbiological, physical, and chemical contaminants
- Properly screen ambient air to prevent the inclusion of physical foreign materials and filter to prevent dust, odors, chemical, or microbiological concerns
- Check airflow for negative or positive pressure
- Conduct air sampling and testing to measure the effectiveness of filtration and ventilation
- Select air drying and filtering methods to remove oil, water, and other solids from compressed air
- Use an approved water source that is tested to ensure that federal and local drinking water standards are met
- Test water from various point-of-use locations within the plant to check for microbiological contamination
- Use backflow preventers at appropriate locations to prevent backsiphonage and back pressure and establish a testing frequency for backflow preventers
- Monitor wastewater and sewage disposal routes to ensure that they do not become sources of contamination

Table of Contents

Types of Air ....................................................2
Ambient Air....................................................2
Air Sampling and Testing .......................5
Compressed Air .............................................5
Water Quality ...............................................6
Incoming Water Testing ...........................8
Point-of-Use Water Testing ............................9
Backflow ....................................................9
Wastewater Disposal .................................10
Air and Water Quality Reference Card ......11
Air Quality Workshop ...............................13
Water Quality Workshop ..........................16

© Copyright AIB International
May not be reproduced without written permission.
According to regulation, it is required that food processors maintain a sanitary environment for the safe processing of food. Two of the most important components of that sanitary environment are air and water. This chapter identifies ways air and water can contaminate food and the food processing environment and explains control measures to prevent such contamination.

**Types of Air**

There are two types or sources of air to be concerned with from a food safety standpoint.

The first is ambient air or the atmospheric air in the plant.

The second is compressed air. Compressed air is pressurized air that is often applied directly to product or product-contact surfaces.

**Ambient Air**

There are multiple considerations when addressing the quality of ambient air. First consider how air is getting into the plant and what the requirements of that air will be. Some operations will simply need to ensure ambient air is properly screened to prevent the entrance of insects, birds, and large foreign materials (e.g., leaves). For other operations, ambient air is a more critical issue and preventing the inclusion of dust, odors, or microbiological concerns is crucial. These operations typically have specific areas that must be maintained under positive pressure to ensure the air is properly filtered and so that air flow is controlled.

Proper ventilation may also be necessary to prevent overhead condensation which can lead to mold, microbiological, or odor problems that could affect the manufacturing environment. Ventilation is an exchange of unwanted air for a controlled and conditioned supply of fresh air for a specific area. Mechanical air handling equipment with proper filtration, heating, and/or cooling capabilities may be necessary.

For less sensitive operations, properly screened windows, intake fans, exhaust fans, or other openings are necessary. These screens should be 18-mesh and constructed of materials that are corrosion resistant. They should be easily removable to allow for periodic cleaning of foreign materials that may collect on the screens.
More sensitive operations will require proper filtration of the makeup air and air exchanges to maintain a healthy environment for workers and product safety. Air exchange frequency will be determined by the facility. Some environments may require a few air exchanges per hour, while others may require 30-60 exchanges per hour. These air exchanges are necessary to remove unwanted dust or moisture to prevent condensation. Dust, water, or steam evaporation may need to be removed by specific exhaust systems with collection hoods at the points where the dust, water, or steam is generated.

Intake units for air makeup systems must be provided with filters capable of removing airborne particulates of 50 microns in size (Minimum Efficiency Reporting Value [MERV] 4) or larger. More sensitive operations may require finer filtration to remove even smaller particles. Without proper filtration, microbiological and chemical contaminants can easily enter the plant and the product.

Proper maintenance and cleaning of the air makeup systems is critical. These units should be on the preventive maintenance (PM) schedule with a regular frequency of filter replacement and cleaning of the unit and associated duct work. Frequency of these activities will vary depending on the environment in which they are operating may also be affected by seasonal changes (e.g., high pollen, insect activity, dust from neighboring fields or businesses, etc.).

Cleaning of the air makeup systems and duct work must be conducted so that debris, dust, moisture, and other materials do not accumulate inside the units and lead to manufacturing environmental concerns. The units can be serviced using a vacuum to clean the interior of the units or more detailed sanitation may be necessary at specific times and require the use of chemicals or sanitizers. Detailed inspections and/or air plate monitoring may help determine a frequency of these activities.
Ventilation may also be necessary to prevent, cross-contamination from non-compatible materials. Chemicals stored on site, such as those used for maintenance, pest control, and sanitation, must be provided with adequate ventilation to ensure that the vapors from the volatile chemicals and welding fumes do not become absorbed by or contaminate raw materials and food products. This is in addition to segregated chemical storage, which is discussed in the Chemical Control Chapter.

Proper ventilation will also address dust created by the food product. Dust will eventually settle and provide a food source for microorganisms and stored product insects. The product dust may also be allergenic in nature and pose a serious health risk to consumers adversely affected by specific food allergens. Production areas should be evaluated to determine where additional ventilation or dust collection may be necessary. An example of such areas may be an ingredient addition area, mixing equipment, seasoning addition, etc. Controlling the dust from these areas will minimize the concern for contamination of other areas and reduce the overall cleaning required of surrounding areas. An effective air quality program will ensure that product dust is managed and kept to a minimum.

Restroom air is certainly a potential contaminant for food. Negative air pressure should be in place in restrooms to ensure that air flows into the restroom and is vented out of the building to control odor or microbiological issues without passing through product storage or processing areas. Restroom doors should not open directly into production, packaging, or storage areas. An easy way to check the direction of air flow at a restroom door is to hold a sheet of paper, hanging vertically from the top of the paper. The bottom of the paper will bend toward the direction of air flow. More specific checks can be conducted of these areas using air flow meters or smoke cartridges.
Air Sampling Testing

Air sampling and testing measures the effectiveness of filtering and ventilation. Air exposure plates (pre-filled Petri dishes) are the most common way to test for microorganisms. Air collection devices may be used to ensure a consistent collection, or simply leaving the plates exposed for a defined period of time (60 minutes) can be done.

The frequency of the testing is at the discretion of the plant. Typical tests include yeast and mold and Aerobic Plate Count (APC). While there are no regulatory limits for these microbiological tests, the plant should establish a limit at which it will react. High microbiological counts in the air typically indicate a sanitation failure or cleaning deficiency.

When establishing reaction levels (upper limits), the plant should establish a baseline to determine normal levels. These tests are recommended to be done immediately before and immediately after a deep cleaning of the area. This will provide a guide to best and worst case scenarios.

Compressed Air

Compressed air has many applications in a food plant. Of particular concern from a food protection standpoint is compressed air that is applied directly to food-contact surfaces or food products. Some examples of air applied directly to these surfaces include compressed air used for cleaning, inflating bags for packing, agitating or stirring product, drying product, and transporting or propelling product.
Compressed air is generated by pulling in ambient air and compressing it. Compressed air may contain water vapor, particulate matter, oil vapor or droplets, and microorganisms. Other contaminants, such as liquid oils, oil aerosols, and oil vapor, may be generated by the compressor if seals, orifices and/or O-rings become worn. Water aerosols and droplets of water will also be generated as the compression process raises the temperature of the air and then it is cooled before use. The water in the compressed air can lead to rust and corrosion in the transfer piping and create physical foreign materials.

Compressed air should be dried and filtered to remove oil, water, and other solids. Air dryers and filters are typically installed at the compressor to address any foreign materials that may be part of the ambient air being compressed and moisture generated as part of the compression process. Air traps and filters may also be installed as close as possible to the point of use to control any foreign materials picked up by the compressed air in the transfer piping.

The size of filtration used will depend on how the air will be used within the food manufacturing operation. At a minimum, the air should be filtered to remove particles of 5 microns or larger. Sterile air filter systems may require filters capable of removing particles of .01 microns. All filters should be placed on the PM program for periodic inspection and/or replacement.

A simple way to determine if there is a failure in the drier or air trap is to apply the compressed air to a white sheet of paper. If specks of moisture or particles appear on the paper, the air is not properly filtered or dried. More detailed microbiological checks can be conducted of the compressed air applied directly to product and product-contact surfaces. A sampling device can be used to collect the air and move it to the nutrient agar or plate. A baseline test of the air at each food-contact point should be done and this testing conducted periodically to monitor for any possible issues.

### Water Quality

Maintaining water quality in a food processing environment is a fundamental component of sustaining a sanitary environment. Whether water is used as an ingredient, for sanitation, or simply for hand washing, companies must ensure that the water being used is potable and does not pose a risk of contamination.
Potable water, also known as drinking water means that it is safe for human consumption. In the US, the Environmental Protection Agency (EPA) has established the regulatory standards for potable water.

Contaminants of concern may be biological or chemical in nature. Physical contaminants in water are a less significant concern for food safety and may be viewed as quality issues. An example of this may be sediment or sand in the water supply.

Giardia and Cryptosporidium are the most common disease-causing parasites found in water. However, a major foodborne illness outbreak of Cyclospora occurred in fresh produce in 2013, and water was the suspected source of the parasite. Usually, when a person is concerned with water quality and contacts a commercial laboratory, the laboratory will recommend that the water be tested for total coliform bacteria. These are different organisms than Giardia or Cryptosporidium, but the test is used as an indicator. It is important to keep in mind that if water is tested and found to be negative for total coliforms, it does not guarantee that the water is potable.

The Good Manufacturing Practices (21 CFR Part 110.37) state:
(a) The water supply shall be sufficient for the operations intended and shall be derived from an adequate source. Any water that contacts food or food-contact surfaces shall be safe and of adequate sanitary quality. Running water, at a suitable temperature and under pressure as needed, shall be provided in all areas where required for the processing of food, for the cleaning of equipment, utensils, and food packaging materials, or from employee sanitary facilities.

The CFR also states requirements for plumbing.
(b) Plumbing shall be of adequate size and design and adequately installed and maintained to:
(1) Carry sufficient quantities of water to required locations throughout the plant.
(2) Properly convey sewage and liquid disposable waste from the plant.
(3) Avoid constituting a source of contamination to food, water supplies equipment, or utensils or creating an unsanitary condition.
(4) Provide adequate floor drainage in all areas where floors are subject to flooding-type cleaning or where normal operations release or discharge water or other liquid waste on the floor.
(5) Provide that there is no backflow from, or cross-connection between, piping systems that carry water for food or food manufacturing.

**Incoming Water Testing**

Water coming into each plant must be from an approved source. In a majority of instances, water is supplied from a local municipality. Another common water source is from a private well. In either case, the water source must be tested to ensure that it meets federal and local drinking water standards, including a battery of tests including microbiological, toxic metals, pesticides, organics, and disinfection by-products. The EPA has established standards for approximately 90 contaminants in drinking water.

If water is obtained from a local municipality, these tests are done by the local agency and the results are shared with the public on at least an annual basis. The results are typically published in an Annual Water Quality report which may be mailed, posted on a website, or published in a newspaper.

If a private well is being used, then water testing is required. The tests required are outlined by the federal and local governments for drinking water status. A lengthy list of tests may be required annually with more frequent testing required for specific elements. Records of all tests must be maintained and corrective action taken if any results exceed established limits.
Point-of-Use Water Testing

Testing incoming water will demonstrate that water supplied to a facility is potable. However, once the water comes under the control of the individual facility, there is further opportunity for contamination. For this reason, it is necessary to test water from various locations within the plant. These locations are referred to as “point-of-use” locations, such as where water is added to a mixer, used to dilute a cleaning chemical, or used for hand washing. It is recommended that at least 3-5 locations be tested at least 2-4 times per year. The complete battery of tests that is completed on the incoming water is not necessary here. In these instances, indicators are tested. They typically include total coliform and total plate count. If these test results are high, further investigation is needed.

In selecting the locations for point-of-use sampling, it is suggested to sample from locations that are farthest from the incoming main water line. Aseptic sampling methods must be established to ensure that the water samples are not contaminated during sampling.

Backflow

Backflow is the unwanted reverse flow of any liquid, solid, or gas into the potable piping system. There are two forms of backflow: backsiphonage and backpressure. Backsiphonage occurs when contaminants are pulled into the potable supply. This may happen if there is a broken water main or when nearby fire hydrants are in use. The drop in water pressure can pull materials into the water line. Backpressure happens when contaminants are pushed into the potable water supply. This can happen if there is a loss of pressure in the potable water supply, similar to the scenarios described for backsiphonage, or when there is increased pressure on the non-potable supply, such as with a pump or from heat from a boiler.

Backflow preventers are used to prevent backsiphonage and backpressure.
Air and Water Quality

Chapter 10

The EPA Cross-Connection Control Manual identifies six typical types of backflow preventers:

1. Air gap
2. Barometric loop
3. Vacuum breaker
4. Double check with intermediate atmospheric vent
5. Double check valve assembly
6. Reduced pressure principle device

When selecting and installing a backflow preventer, it is imperative that local codes are complied with. Not all types of backflow preventers are approved for all types of applications.

Once the facility identifies locations where backflow can occur, it is necessary to ensure that a backflow preventer is installed. These locations, include, but are not limited to where water enters a vessel, such as a kettle, and where hoses are connected to faucets to fill mop buckets.

A list or map of the backflow preventers must be developed and kept current. It is recommended that the serial numbers of the backflow preventers also be recorded with the corresponding locations for tracking purposes. This will help to link documentation of checks with specific devices and locations.

Once installed, annual checks of each backflow preventer are required. These checks must be done by someone who is properly trained and often requires a licensed plumber. Results of all checks must be maintained and any faulty preventers must either be repaired or replaced. Most cities conduct annual checks of the backflow preventer at the main valve to ensure that there will be no backflow into the city water supply. This test does not demonstrate that backflow issues or internal devices at the facility are controlled or functioning properly. Separate tests will need to be conducted for each of these devices and documented.

Wastewater Disposal

Disposal of wastewater and sewage must be monitored to ensure that they do not become a source of contamination. Most facilities fall under local codes that have strict specifications for proximity of potable water lines and sewer lines or reclaimed water lines. These codes typically also address the storage, collection, and transportation
of waste in relation to water supplies. Facilities involved in food handling must be aware of the local requirements and have means to ensure they are in compliance.

For environmental and economic reasons, many food plants do some form of treatment of their processing wastewater prior to discharging it. This may include the removal of solids or reuse of “clean” wastewater in non-food applications. In doing so, the risk of contamination increases. Modes of product contamination from wastewater handling must be evaluated to ensure that appropriate controls are in place.

If wastewater treatment is conducted on-site, the treatment areas should be evaluated to ensure environmental factors will not impact the production facility. Segregation of these areas via partition, separation, or distance should be evaluated. It may be necessary to evaluate traffic patterns of personnel or vehicles (e.g., forklifts, tow motors, carts) in these areas. Footbaths, shoe coverings, or general GMP measures may be necessary to prevent microbiological, chemical, or physical contaminants from being brought into the facility through these traffic patterns. Control of the air from these treatment areas should also be evaluated so that the air from this area is not under positive pressure and transferred to more sensitive areas of the facility.

Chemicals are typically located in wastewater treatment areas and should be managed as part of the overall facility chemical control program. Chemicals should be inventoried and logged, secured, and managed or controlled by designated and trained individuals responsible for the operation of these treatment areas.

**Air and Water Quality Reference Card**

Use this Air and Water Quality Reference Card as you contribute to your company’s air and water quality program. When you are ready, proceed to the workshops to apply what you have learned to real-life situations.
Air and Water Quality

Use this Air and Water Quality Reference Card to help prevent contamination to your product. When you are ready, proceed to the workshops to apply what you have learned about air and water quality to real-life situations.

Ambient Air
- Air intake filtration
  - Finer filters for micro-sensitive environments
  - Preventive maintenance schedule
- Ventilation
  - Prevent cross-contamination
  - Odors, fumes, vapors, microbes
  - Dust collection
  - Condensation prevention
  - Restrooms
  - Microbiological laboratories
  - Chemical storage areas
  - Raw vs. processed foods areas

Compressed Air
- Equipment sanitation
- Product movement or mixing
- Clean or inflate packaging
- Must filter for oil, water, and solids

Air Sampling and Testing
- Micro testing
- Baseline and reaction limits

Water Uses
- Hand washing
- Ingredient
- Sanitation

Water Testing Standards
- EPA standards (90+ contaminants)
  - Disinfectant
  - Disinfectant byproduct
  - Inorganic chemical
  - Microorganism
  - Organic chemical
  - Radionuclides

Water Sampling and Testing
- Water source
  - Municipal water – Annual water quality report
  - Well water – Quarterly testing or by regulation
- Point-of-use testing
  - Multiple locations
  - Within the facility
  - Points farthest from main line
  - 2-4 times per year
  - Micro testing (coliforms & plate count)

GMP/21 CFR 110.37(a) Water Supply Requirements
- Safe and sanitary
- Suitable temperature
- Sufficient supply

GMP/21 CFR 110.37(b) Plumbing Requirements
- Sufficient quantities
- Convey sewage and waste
- Avoid contamination
- Adequate drainage
- No backflow
- No cross-connection

Backflow
- Backsiphonage – contaminants are pulled into potable supply
- Backpressure – contaminants are pushed from non-potable supply
- Backflow preventers
  - Follow local codes
  - Installed at all locations where backflow can occur
  - Mapped or logged
  - Tested or replaced annually

Wastewater Disposal
- Follow local codes
- Minimum distance from potable water lines
- Treatment of wastewater
  - Removal of solids
  - pH adjustment
  - Reclaimed water uses
Air Testing Results - Site 1

1. What would be considered an appropriate baseline (“normal”) for Site 1?
   A. 0
   B. 100
   C. 500
   D. 1000
2. What would be considered an appropriate baseline (“normal”) for Site 2?
   A. 0
   B. 50
   C. 110
   D. 200
3. What would be considered an appropriate baseline (“normal”) for Site 3?
   A. 0
   B. 50
   C. 100
   D. 200

4. If you were to establish a single “reaction level” for air samples based on sampling and results from Sites 1-3, what level would you establish and why?
   A. 0 CFUs - Because our goal is no bacteria in the air
   B. 50 CFUs - Because 75% of our results were at or below 50
   C. 100 CFUs - Because only “spikes” were above 100. Spikes indicate an abnormal occurrence or failure
   D. 500 CFUs - Because we want a limit that is hard to exceed
Read the following Water Quality Report and identify areas of concern.

<table>
<thead>
<tr>
<th>Category</th>
<th>Contaminant</th>
<th>Public Health Goal (mg/L)²</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Chemical</td>
<td>Acrylamide</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Arsenic</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Barium</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Benzene</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Beryllium</td>
<td>0.004</td>
<td>0.005</td>
</tr>
<tr>
<td>Disinfection Byproduct</td>
<td>Bromate</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Cadmium</td>
<td>0.005</td>
<td>0.01</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Carbon tetrachloride</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Disinfectant</td>
<td>Chlorine</td>
<td>MRDLG=4.0</td>
<td>4</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Chlorobenzene</td>
<td>0.1</td>
<td>0.01</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Chromium</td>
<td>0.1</td>
<td>0.01</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Copper</td>
<td>1.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Microorganism</td>
<td>Cryptosporidium</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Cyanide</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Ethylbenzene</td>
<td>0.7</td>
<td>0.33</td>
</tr>
<tr>
<td>Microorganism</td>
<td>Fecal coliform and E. coli</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Fluoride</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Microorganism</td>
<td>Giardia lamblia</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Heptachlor</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Microorganism</td>
<td>Heterotrophic plate count</td>
<td>n/a</td>
<td>12,400</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Lead</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Microorganism</td>
<td>Legionella</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Mercury</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Nitrate</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Nitrite</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Inorganic Chemical</td>
<td>Selenium</td>
<td>0.05</td>
<td>0.006</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Styrene</td>
<td>0.1</td>
<td>0.05</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Toluene</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Radionuclides</td>
<td>Uranium</td>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>Organic Chemical</td>
<td>Xylenes</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>