Chapter 12

Chamber Maintenance

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Introduction

The success of research accomplished in a growth chamber is directly related to the quality of chamber maintenance. Poor maintenance usually indicates poor reliability and poor control of the environment, whereas good maintenance greatly enhances reliability and improves the accuracy of the environmental control. A growth chamber is a highly specialized piece of equipment in constant need of care. It may operate constantly, 24 hours a day, 365 days a year. The lighting system adds heat, which must be removed by refrigeration. Cooling coils condense water from the air, so a humidification system is necessary to replace moisture in the atmosphere. Temperatures are commonly programmed to change in regular cycles each day. The heating, cooling, and humidification equipment is always operating, which in turn requires frequent adjustment, repair, cleaning and calibration. Poor maintenance may result in extra strain on one part of the system, which in turn may cause quicker wear and poorer control.

Maintenance is a budget item to be considered when purchasing a growth chamber. In the early 1980s the maintenance and energy costs of the growth chambers at Cornell University were analyzed (Langhans and Redder, 1981). Maintenance costs of $30 per sq ft of chamber space were reported, about 40% of their electrical costs ($77 per sq ft). These costs were similar to those from a worldwide survey made by de Bildering of France (de Bildering, 1980). Experience with large-unit installations such as the Biotron at the University of Wisconsin, the Phytotrons at North Carolina, and the multiunit installation at Cornell indicates that specially trained maintenance personnel are essential. Records from these installations show very few unscheduled down times and indicate that the chambers were able to repeat the desired environmental conditions time after time. Much credit for the reliability of these chambers belongs to the maintenance personnel.

For most growth chambers, however, maintenance responsibilities fall on the shoulders of the persons purchasing the equipment. To help organize an effective maintenance program, we have divided this chapter into three parts: installation, operation, and shutdown.

INSTALLATION

Five major items must be considered when installing the growth chamber: space, electric supply, water drainage, heat removal, and calibration.

SPACE

Situate the growth chamber to allow easy access for maintenance and to facilitate heat removal. It is important to leave at least a meter of space around the chamber to facilitate such functions as changing the refrigeration equipment, lamps, ballasts, transformers, etc. Locate the chamber area where the unit can be delivered from the manufacturer with a minimum of handling problems. Some parts of the chamber are large and heavy, therefore, measure the doors, stairs, etc., leading to the designated location before delivery of the unit.

ELECTRIC SUPPLY

All growth chambers use a great deal of electric power, commonly from a 208 or 220 volt service. An insufficient capacity of electric service will cause problems. An average walk-in chamber requires 30,000 watts, and an average reach-in chamber requires 6,000 watts.

WATER DRAINAGE

It is difficult to avoid having water released within a chamber. Water can come from excessive applications to the plants or condensation from the cooling coils. Therefore, it is necessary to have some means of draining the chamber. Since the water may contain chemicals (i.e., fertilizers), the drainage must go into the sanitary and not the storm sewer system.

HEAT REMOVAL

Growth chambers produce large quantities of heat. Essentially all the electric power utilized in the chamber can be considered heat and must be removed. The major proportion of the heat in the chamber is removed by the refrigeration system, and in most chambers this heat is removed through water-cooled condensers. This requires a supply of cooled or cold water provided either through an exterior heat exchanger (cooling tower) or through cold tap water. The latter cooling method is the simplest solution but necessitates the use of a large quantity of water that flows through the condenser and is then immediately released into the storm sewer. Many municipalities have (or may develop) rules governing this type of water use. Make certain an adequate supply of cooled water is available for the removal of this heat from the refrigeration coils. With some chambers, particularly small chambers, the refrigeration is air-cooled and then the heat is released into the growth chamber area. This can pose a serious problem if not recognized before installation of the chambers. Other sources of heat not handled by the refrigeration system are light caps, walls of the chamber, and the ballasts for the lights. The amount of heat added to the room can be significant and must be removed. Sometimes it is possible to remove the heat with an outside air ventilation system;

i.e., outside air replaces the room air. Room air conditioners also may be used to remove the heat.

Calibration

If the environmental conditions in the chamber are unknown, the experimental results are not very useful. It is critical to calibrate all sensors so they reflect actual conditions. The more accurate the sensors, the more accurate the data from the chamber. The specific chapters on environmental conditions (radiation, temperature, relative humidity, and CO_2) discuss in detail the various sensors and their installation and calibration. It is critical to follow carefully the calibration and maintenance procedures for the various sensor systems.

Operation

A good preventive maintenance program is the only way to insure reliability of the chamber. The first step is to acquire operating and service instructions from the manufacturer, including diagrams and parts lists. This information should be reviewed and a maintenance procedure designed that includes general cleaning, refrigeration and electronics inspections. identify the proper maintenance personnel and involve them in this planning. Careful records and logs of all inspections and maintenance should be kept and analyzed periodically to detect any particular problem or trends. When trouble shooting, it is most critical to review the records.

Inspections should occur daily, twice a day if possible. The inspector should be alert to changes in sounds and signs that may indicate a pending problem. Check the records of temperature, lighting, and relative humidity to be sure the chamber is performing as it should. The inspector should use all of his or her senses: Look for leaks, smell for hot equipment, and listen for noisy bearings or loose belts. Most developing problems give ample signs and time to be discovered before the final catastrophic failure.

Lighting System

Lamps are usually the first equipment to fail. Incandescent lamps may fail in as few as 200 hours. Fluorescent lamps have a normal life of 7,000 to 10,000 hours, but as discussed in the chapter on radiation, their output decreases rapidly. The lamps should be changed when the irradiance in the chamber has decreased below an acceptable level, not after they fail. Some operators know from experience the decay rate of the fluorescent lamps in their chambers and will program a regular change schedule; for example, they may change one-third of the lamps every 1500 hours. With this change procedure, each lamp is in use for 4500 hours, which generally ensures that no lamps fail and intensity only changes moderately. HID lamps do not decay as rapidly as the fluorescent lamps, and their life is much longer, up to 20,000 hours. These lamps should be changed before they fail. Records of the chamber operating time or, more specifically, the lamp operating time are important in determining the time to change the lamps. As a general rule, replacing HID lamps every 15,000 hours should ensure good irradiance levels and prevent lamp failures.

Failing ballasts can usually be identified by a burning smell; they should be replaced immediately. Ballasts may last many years, but excessive heat in the ballast areas is usually the cause of failure. However, ballasts also degrade over time, and the output from the lamps is decreased. This will be particularly noticeable for ballasts after 10 to 15 years of use.

The light barrier must be kept clean to avoid significant irradiance loss. Depending on the chamber and the location (clean or dirty) the light barrier probably should be cleaned every time the lamps are changed. The reflective walls are critical in maintaining good irradiance levels in the chamber. Avoid splashing walls with water and chemicals, and keep them clean of dust and dirt. The air filters on the chamber and the room should be inspected for dust and dirt and cleaned when needed. This maintenance can be critical in keeping the whole area clean.

Temperature

Many types of temperature controls are used, so a specific discussion is difficult. The inspector should be familiar with the system and its operation. The sensors should be checked at regular intervals to be sure they are clean and have not been displaced or covered. A review of the temperature recordings of the previous 24 hours will give a reasonable check on the effectiveness of the sensor. If the system is not working properly, one of the first items to check is the sensor.

Inspect all the circulation fans in the chamber. If they are visible, check to see if they are turning. If they are not visible, put your hand in the airstreams to see if they are working. Many fan motors require lubrication; check the manufacturer's recommendations.

If erratic temperature indications have been recorded, a more extensive inspection should be made. Electronic breakdowns are unusual with today's solid-state equipment, especially if the equipment has been running well for a period of time. Studying the pattern of oscillations in temperature can be useful in determining the problem. Give this information to the refrigeration or electronics repair person.

Most packaged growth chambers have sealed refrigeration units, and maintenance on this equipment is minimal. It is important to keep the cooling coils clean of dust and dirt. This is critical for air-cooled units. Most manufactures recommend replacement of the compressor unit after a specific operating time. A record of this time should be kept to ensure that units are changed as the manufacturer suggests. An alternative is to have a replacement unit ready so that when the unit begins to act up (noisy bearings, running hot), it can be replaced quickly. A planned time change is the most reliable program, however.

Some chambers do not have sealed refrigeration units (usually the larger chambers), and this equipment requires regular maintenance inspections. Belts, oil levels, refrigerant, etc., must be checked on a regular basis. The manufacturer of the equipment will recommend an inspection program.

Water-cooled refrigeration units contain additional items needing inspection. The water cooling system, whether a cooling tower or a once-thru water system, must operate efficiently and reliably or the whole refrigeration system will fail. If a cooling tower is used, the pumps and motors must be maintained regularly, and the water must be treated for hardness, salts, algae, and other microbial growth. The cooling tower is a hard-working piece of equipment and prone to failure, so an alternative back-up system should be installed.

Humidification

Adding steam or fine sprays of water into the airstream are common ways of increasing the humidity of the air. Usually the steam or water spray is visible in the airstream when the system is operating. A visual check should be part of the daily inspection. Steam systems usually have problems with a solenoid valve sticking in either the on or off position. Water spray systems may develop clogged or worn nozzles. Control sensors are prone to shifting calibration and need to be checked at least twice a week or duplicate sensors may be installed and checked against each other. If relative humidity is an important variable in the experiment, extra care is needed to insure that the humidification system and its controls are operating properly. This is discussed in the chapter on relative humidity.

Spare Parts

The growth chamber manufacturer should be able to suggest a list of spare parts and supply those most commonly needed. This service is especially critical for difficult-to-find parts: fan motors, pumps, compressors, electronic boards, sensors, etc. Most lamps, ballasts, transformers, and relays can be purchased at a local electrical store.

Shutdown

If the chamber will not be used for a period of 2 weeks or less, it is best to keep the temperature control system and fans operating. Turn off the lighting system and adjust the temperature close to room temperature (20 to 25°C). This will reduce the heat load but keep the equipment running.

If the shutdown will be for longer than 2 weeks, the unit should be shut off. The manufacturer will specify a shutdown procedure that should be followed carefully to avoid future problems (drying of gaskets, loss of fluids and gases, condensation of water, etc.). The manufacturer's procedures should be followed when starting the chamber after a shutdown period.

Literature Cited

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