

QUALITY ASSURANCE PROCEDURES FOR ENVIRON-MENTAL CONTROL AND MONITORING IN PLANT GROWTH FACILITIES

North Central Regional 101 Committee On Growth Chamber Use

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This information has been compiled to provide procedures for ensuring that the environment of controlled growth facilities is known and can be documented with accuracy. It has been developed to provide guidelines to biologists to emphasize the level of control and monitoring that they should strive to achieve in chambers and rooms that they supervise and the level that they should request when using centralized facilities that rent chambers or rooms for their use. The biologists should find these procedures particularly valuable when planning purchases of either monitoring instruments or controlled environment chambers and rooms. In addition, these procedures should provide information needed by engineers in the design and construction of effective and cost-efficient controlled environment facilities.

These quality assurance procedures cover control, acquisition and calibration. It is recommended that separate systems be utilized for each of these different types of measurement. If control and acquisition are undertaken with the same system, a separate redundant acquisition system should be maintained to indicate sensor drift or failure. The on-line reference sensors should not be operated and recorded through the same electronic system that operates the control and acquisition system. All on-line reference records should be retained on a permanent basis.

The scope of these procedures includes monitoring both prior to and during experiments. However, these procedures are developed to document only the level of the conditions in the room and not necessarily the conditions around the plant experiments. Monitoring and recording of the particular conditions around the plants should be undertaken as detailed in the previously published guidelines for reporting research investigations (*1982 Agricultural Engineers Yearbook*, pp. 406-409, ASAE, St. Joseph, MI; *J. Environ. Qual.* **11** (4): 719-720, 1982; *Physiol. Plant.* **56**: 231-235, 1982).

The following general recommendations for sensor types and measurement procedures have been developed for the separate parameters. Forward suggestions and comments on these procedures to the address below.

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Radiation

	Control	Acquisition	Calibration	
			On-line reference	Primary calibrator
Type	NA	No requirement	Cosine corrected photon meter	Cosine corrected photon meter for 400–700 nm
Accuracy	NA	<±10% of reading	<±5% of reading	<±5% of reading
Resolution	NA	<±1% of reading	<±1% of reading	<±1% of reading
Response time	NA	<30 s	<30 s	<30 s
Sampling location	NA	Anywhere in room	Center of room above maximum height of plants	In room under lamps used in experiments
Monitoring frequency	Start and end of photoperiod	Middle of each photoperiod	Weekly	Every six months
Data to file	Daily on and off times	Daily level	Original and corrected level	Deviation of auditor from calibrator
<i>Alarms</i>				
Range	NA	> ±10% of reading	NA	NA
Time delay	NA	10 min	NA	NA
<i>Calibration</i>				
Instrument or standard	NA	On-line reference	Primary calibrator	Instrument traceable to National Bureau of Standards
Location	NA	In growth room	In growth room	In growth room
Frequency	NA	Every 6 months	Every 6 months	Every 24 months
Check points	NA	5 levels over range attainable	5 levels over range attainable	5 levels over range attainable

Temperature

	Control	Acquisition	Calibration	
			On-line reference	Primary calibrator
Type	Shielded sensor	Shielded sensor	Shielded and aspirated sensor	Mercury thermometer traceable to or calibrated by the National Bureau of Standards
Accuracy	±0.5°C	±0.5°C	±0.2°C	±0.05°C
Resolution	±0.1°C	±0.1°C	±0.1°C	±0.02°C
Response time	<1 min	<1 min	≤30 s	<1 h
Sampling location	In air stream	Plant height center of room	Plant height center of room	Constant temp. bath
Monitoring frequency	<3 min	≤Every 30 min	Weekly	≤Every 6 months
Data to file	None	30 min values or averages	Original and corrected values	Deviation of auditor from calibrated thermometer
<i>Alarms</i>				
Range	±5°C	±5°C	NA	NA
Time delay	15 min	15 min	NA	NA

Calibration

Instrument or standard	On-line reference	On-line reference	Primary calibrator	Additional mercury thermometer, platinum resistor or precision thermistor traceable to the National Bureau of Standards
Location	Growing room	Growing room	In temperature control bath	National Bureau of Standards
Frequency	Every 6 months	Every 6 months	Every 6 months	Annually
Check points	3 temperatures over range of experiment	3 temperatures over range of experiment	0, 10, 20, 30 and 40°C	0, 10, 20, 30, and 40°C

Humidity

	Control	Acquisition	Calibration	
			On-line reference	Primary calibrator
Type	Aspirated and shielded sensor	Aspirated and shielded sensor	Psychrometer, dew point or infrared	Constant humidity chamber
Accuracy*	≤ ±5% RH	≤ ±5% RH	≤ ±5% RH	≤ ±2% RH
Resolution	≤ ±5% RH	≤ ±5% RH	≤ ±5% RH	≤ ±2% RH
Response time	<2 min	<2 min	<2 min	<15 min
Sampling location	In air stream	In air stream	Near plants	Convenient location
Monitoring frequency	<2 min	<30 min	Weekly	Monthly
Data to file	None	Every 30 min	Original and corrected levels	Original and corrected levels
<i>Alarms</i>				
Range	> ±5% RH	> ±5% RH	NA	NA
Time delay	15 min	15 min	NA	NA
<i>Calibration</i>				
Instrument or standard	On-line reference	On-line reference	Primary calibrator	None
Location	In room	In room	Convenient location	NA
Frequency	Every 6 months	Every 6 months	Every year	NA
Check points	30, 60 and 90% RH	30, 60 and 90% RH	30, 60 and 90% RH	NA

* At 20°C.

Carbon dioxide

	Control	Acquisition	Calibration	
			On-line reference	Primary calibrator
Type	Infrared analyser	Infrared analyser	Cylinders of span concentration of CO ₂ in air and N ₂	Gas mixing-pumps with cylinders of CO ₂ and N ₂ gas
Accuracy	< ±3% of reading	< ±3% of reading	2% of reading	1% of reading

Resolution	1% of reading	1% of reading	1% of reading	1% of reading
Response time	<1 min	<1 min	<1 min	<1 min
Sampling location	In air stream	In air stream	NA	NA
Monitoring frequency	<2 min	Every 30 min	Weekly	Annually
Date to file	None	Every 30 min	Original and corrected conc.	Original and corrected conc.
<i>Alarms</i>				
Range	> ±10% of set point	> ±10% of set point	NA	NA
Time delay	5 min	5 min	NA	NA
<i>Calibration</i>				
Instrument or standards	On-line reference	On-line reference	Primary calibrator	Analysed cylinders of CO ₂ in air from National Bureau of Standards, or cylinders directly traceable to these standards
Location	Growing room	Growing room	Convenient location	Convenient location
Frequency	≤Daily	≤Daily	Annually	≤5 years
Check point	0 and span daily every 6 months	0 and span daily every 6 months	Cylinders in use	NA

Air movement

	Control	Acquisition	Calibration	
			On-line reference	Primary calibrator
Type	NA	NA	Directional hot wire anemometer	NA
Accuracy	NA	NA	≤ ±5% of reading	NA
Precision	NA	NA	≤ ±3% of reading	NA
Stability	NA	NA	≤ 1% of reading/annum	NA
Response time	NA	NA	≤ 3 s	NA
Sampling location	NA	NA	Above plant growth level	NA
Monitoring frequency	NA	NA	Start and end of experiment	NA
Data to file	NA	NA	Velocity at start and end of experiment	NA
<i>Alarms</i>				
Range	NA	NA	NA	NA
Time delay	NA	NA	NA	NA
<i>Calibration</i>				
Instrument or standard	NA	NA	Calibrated wind tunnel	NA
Location	NA	NA	Convenient location	NA
Frequency	NA	NA	≤ Annually	NA
Check points	NA	NA	4 velocities over the range of velocities in chamber	NA