Directions for Determining Buffer Zone Distances for Commodity and Structural Fumigation with Methyl Bromide (9/30/15)

Buffer zones for commodity and food handling structural applications are distributed across numerous tables. This section provides directions for determining the factors to use to identify the correct table for a given application.

The first step in determining the buffer zone is to determine the aeration method from these six broad classifications:

- Treatment
- Passive aeration
- Active aeration with attached vertical stacks
- Active aeration with open-area vertical stacks
- Active aeration with no stacks
- Active aeration with horizontal stacks

There are separate sets of tables for each of these scenarios. Definitions for the active aeration facility types are as follows:

Active aeration, or "mechanical aeration" means the use of fans or any other mechanical devices to aerate or ventilate the treatment area.

- Attached vertical stacks – Enclosures that vent gas through a stack or vent above or on the roof or affixed to the side of a building/enclosure. Vertical stack heights are measured from the base of the exterior roof of a building/enclosure to the top of the stack. Examples of attached vertical stacks includes portable stacks attached to tarped containers or tarped structures, and fixed permanent stacks, e.g., on top of a building.
- Open-area vertical stacks – Enclosures that vent gas vertically through a stack or vent in an open area that is 5 feet or more away from the side of a building/enclosure. Open-area stack heights are measured from the ground level to the top of the stack. Examples of open-area vertical stacks include stacks at least 5 feet from a building/enclosure that are portable or permanently attached to the ground.
- No stacks – Enclosures that vent gas through windows, doors and cracks instead of only through a directed stack. If gas is vented through a combination of window/doors/cracks and a directed vertical stack, the no stack category must be used if less than 90% of the gas is vented through the vertical stack. Otherwise, a vertical stack table can be used.
- Horizontal stacks – Enclosures that vent gas through a horizontal stack or vent.

Within each table, there are separate buffer zones for each combination of enclosure size (rows) and retention rate after treatment (columns). The **retention rate** after treatment is the percentage of the applied material that remains after treatment is completed and thus is the amount emitted during aeration. Directions on how to determine your retention rate are provided in Appendix 1.

One of the key factors for the active aeration buffer zones is the **air exchange rate**, which is a measure of how many air dilutions occur per hour in the enclosure during aeration. If not readily available, the air exchange rate can be calculated from the fan capacity and the enclosure size as follows:

$$AER\ (per\ hour) = \frac{Fan\ Capacity\ (CFM) \times 60\ \left(\frac{min}{hr}\right)}{Enclosure\ Size\ (ft^3)}$$

where *AER* is the air exchange rate per hour, fan capacity is in cubic feet per minute (CFM), and the enclosure size is in cubic feet. If there is more than one fan, add the results together.

Another factor is the length of treatment and the length of aeration. (Note that USDA refers to the treatment period as the "exposure" period.) This is needed to determine the correct buffer table to use. Determine if the **treatment period**, that is the length of time the commodity is exposed to methyl bromide, is 8 hours or less, or greater than 8 hours.

The next four sections explain how to determine the buffer zone for the treatment and aeration periods.

Treatment Buffers

For treatment buffer zones, the correct table can be found using the enclosure size, the application rate in lbs per 1000 cubic feet for the applicable concentration x time (CxT) schedule, and the retention rate which are summarized below. For application rates, there are separate sets of values depending on the length of time of the treatment: one set for applications lasting eight hours or less, and another for applications longer than eight hours.

Enclosure Size (ft^3)
1000
2000
5000
10,000
25,000
50,000
100,000
250,000
500,000
750,000
1,000,000
2,500,000
5,000,000
7,500,000
10,000,000

Application Rate (lbs/1000 ft^3) – Treatments 8 hours or less
1
2
3
4
5
7.5
9
15

Application Rates (lbs/1000 ft^3) – Treatments longer than 8 hours
0.5
1
3
7.5
9
15

Retention Rates (percent of applied dosing retained after treatment)
100
99
95
90
75
50
25
10
5
1

The user should identify the application rate, treatment duration, enclosure size, and retention rate that matches their enclosure and find the treatment buffer table corresponding to those factors. Within the table, the user should select the column with the retention rate after treatment that represents the application and the row corresponding to the application rate.

ROUNDING: When the specific application rate or enclosure size is not listed in the buffer zone tables, round-up to the nearest rate or size. When the retention rate is not listed in the buffer zone tables, round-down to the nearest retention rate to calculate the treatment buffer zone.

AERATION BUFFERS

Passive Aeration Buffers

Passive Aeration means the non-mechanical ventilation (i.e. opening doors, windows or removing tarpaulin cover) of the treatment area.

For passive aeration buffers, the buffer zone factors can be found under the "Treatment Buffers" section.

IMPORTANT: When the application rate, enclosure size, or retention rate are not listed in the buffer zone tables, round up to the nearest application rate, enclosure size, or retention rate to calculate the passive aeration buffer zone.

Attached Vertical Stack Buffers

To locate the appropriate table for attached vertical stacks, the user must identify five factors for the enclosure:

- The length of time anticipated for aeration (either 8 hours or less, or more than 8 hours).
- Size of enclosure.
- Height of stack.
- Air exchange rate during active aeration.
- Retention rate.

The enclosure sizes, application rates, stack heights, air exchange rates, and retention rates for which tables are available are summarized below. For vertical stacks attached to the fumigant enclosure, the **stack height** is measured from the base of the roof of the enclosure (e.g., a 10 foot stack extends 10 feet higher than the base of the roof).

Enclosure Size (ft^3)
1000
2000
4000
5000
10,000
25,000
50,000
100,000
250,000
500,000
750,000
1,000,000
2,500,000
5,000,000
7,500,000
10,000,000

Application Rate (lbs/1000 ft^3) – Aerations 8 hours or less
1
2
3
4
5
7.5
15

Application Rates (lbs/1000 ft^3) – Aerations longer than 8 hours
0.5
1
1.5
2
3
4
5
7.5
15

Stack Height (ft)
0
5
10
25
50

Air Exchange Rate (/hr) - Aerations 8 hours or less
1
5
10
20
50
70

Air Exchange Rate (/hr) - Aerations longer than 8 hours
0.5
1
3
5
10
20
50
70

Retention Rates (percent of applied dosing retained after treatment)
100
99
95
90
75
50
25

Separate sets of tables are provided depending on the length of time the commodity is aerated, either eight hours or less, or longer than eight hours. The user should identify the enclosure size, application rate, stack height, and air exchange rate for their enclosure and find the table corresponding to that combination of application rate, stack height, air exchange rate, and retention rate. If the height of the stack falls between two categories, the user must use the table with the next lower stack height. (e.g. a 15 foot stack would use the 10 foot stack table). To use the attached vertical stack buffer tables all stacks must at least be as high as the height of the roof. Any attached vertical stack that vents below the height of the roof requires the active aeration with no stack buffer tables to be used.

Within the table, the user should select the column with the retention rate and the row corresponding to the enclosure size.

ROUNDING: When the retention rate, enclosure size, or the application rate is not specifically listed in the buffer zone tables, round-up to the nearest retention rate, enclosure size, or application rate to calculate the aeration buffer zone distance.

When the air exchange rate or stack height is not specifically listed in the buffer zone tables, round-down to the nearest air exchange rate or stack height.

Open-area Vertical Stack Buffers

To locate the appropriate table for open-area vertical stacks, the user must identify five factors for their enclosure:

- The length of time anticipated for aeration (either 8 hours or less, or more than 8 hours).
- Size of enclosure.
- Height of open-area vertical stack.
- Air exchange rate during active aeration.
- Retention rate.

The available enclosure sizes, application rates, stack heights, and air exchange rates are summarized below. The open-area vertical stack heights are calculated from ground-level to the top of the stack.

Enclosure Size (ft^3)
1000
2000
5000
10,000
25,000
50,000
100,000
250,000
500,000
750,000
1,000,000
2,500,000
5,000,000
7,500,000
10,000,000

Application Rate (lbs/1000 ft^3) – Aerations 8 hours or less
1
2
3
4
5
7.5
15

Application Rates (lbs/1000 ft^3) – Aerations longer than 8 hours
0.5
1
1.5
2
3
4
5
7.5
15

Stack Height (ft)
5
10
25
50

Air Exchange Rate (/hr)
5
10
20
50
70

Retention Rates (percent of applied dosing retained after treatment)
100
99
95
90
75
50
25

The user should identify the retention rate, enclosure size, application rate, stack height, and air exchange rate and find the appropriate table. If the height of the stack falls between two categories, the user must use the table with the next lower stack height. (e.g. a 15-foot stack would use the 10-foot stack table).

Within the table, the user should select the column with the applicable retention rate after treatment that represents the application and the row corresponding to the enclosure size.

ROUNDING: When the retention rate, enclosure size, or the application rate is not listed in the buffer zone tables, round-up to the nearest retention rate, enclosure size, or application rate to calculate the aeration buffer zone distance.
When the air exchange rate or stack height is not specifically listed in the buffer zone tables, round-down to the nearest air exchange rate or stack height.

The open-area vertical stack height must be at least 5 feet, as measured from the ground level to the top of the stack, to be included in this category.

No Stack Buffers

To locate the appropriate table for the no stack category, the user must identify four factors for their enclosure:

- The length of time anticipated for aeration (either 8 hours or less, or more than 8 hours).
- Size of enclosure.
- Air exchange rate during aeration.
- Retention rate.

The available enclosure sizes, application rates, air exchange rates, and retention rates are summarized below.

Enclosure Size (ft^3)
1000
2000
5000
10,000
25,000
50,000
100,000
250,000
500,000
750,000
1,000,000
2,500,000
5,000,000
7,500,000
10,000,000

Application Rate (lbs/1000 ft^3)– Aerations 8 hours or less
1
2
3
4
5
7.5
9
15

Application Rates (lbs/1000 ft3) – Aerations longer than 8 hours
0.5
1
1.5
2
3
4
9
15

Air Exchange Rate (/hr)
0.1
0.2
0.5
1
2

Retention Rates (percent of applied dosing retained after treatment)
100
99
95
90
75
50
25
10
5
1

The user should identify the application rate and air exchange rate for their enclosure and find the table corresponding to that combination of application rate and air exchange rate. Within the table, the user should select the column with the applicable retention rate after treatment that most closely represents the application and the row corresponding to the enclosure size.

ROUNDING: When the retention rate, enclosure size, or the application rate is not listed in the buffer zone tables, round-up to the nearest retention rate, enclosure size, or application rate to calculate the aeration buffer zone distance.
When the air exchange rate is not specifically listed in the buffer zone tables, round-down to the nearest air exchange rate. The minimum air exchange rate provided is 0.1 air exchanges per hour. For air exchange rates below 0.1, use the Passive Aeration buffer zone tables.

Horizontal Stack Buffers

To locate the appropriate table for horizontal stacks, the user must identify four factors for their enclosure:

- The length of time anticipated for aeration (Note: when aerating with a horizontal stack, applicators must complete aeration in 8 hours or less).
- Size of enclosure.
- Air exchange rate during aeration.
- Retention rate.

The available enclosure sizes, application rates, air exchange rates, and retention rates are summarized below.

Enclosure Size (ft^3)
1000
2000
5000
10,000
25,000
50,000
100,000
250,000
500,000

Application Rate (lbs/1000 ft3)
1
2
3
4
5
7.5
9
15

Air Exchange Rate (/hr) - Aeration 8 hours or less
0.1
0.2
0.5
1.0
2.0
10.0

Retention Rates (percent of applied dosing retained after treatment)
100
99
95
90
75
50
25
10
5
1

The user should identify the application rate and air exchange rate for their enclosure and find the table corresponding to that combination of application rate and air exchange rate. Within the table, the user should select the column with the retention rate after treatment that most closely represents the application and the row corresponding to the enclosure size.

ROUNDING: When the retention rate, enclosure size, or the application rate is not listed in the buffer zone tables, round-up to the nearest retention rate, enclosure size, or application rate to calculate the aeration buffer zone distance.

When the air exchange rate is not specifically listed in the buffer zone tables, round-down to the nearest air exchange rate. The minimum air exchange rate provided is 0.1 air exchanges per hour. For air exchange rates below 0.1, use the Passive Aeration buffer zone tables.

Example

A user has a food handling facility that is 1.2 million cubic feet and takes approximately 24 hours to aerate. A 24,000 CFM fan is used to actively aerate the enclosure through a 12 foot vent on the roof. The retention rate after treatment was 90%. What is the appropriate aeration buffer zone for a 2 lbs/1000 **ft^3** application?

The air exchange rate is 1.2 per hour based on the fan capacity:

$$Aer\ (per\ hour) = \frac{Fan\ Capacity\ (CFM) \times 60\ \left(\frac{min}{hr}\right)}{Enclosure\ Size\ (ft^3)} = \frac{24{,}000\ CFM\ \times 60\ \left(\frac{min}{hr}\right)}{1{,}200{,}000\ ft^3} = 1.2\ per\ hour$$

For an attached vertical stack, the table corresponding to the most protective combination of application type, enclosure size, stack height, and air exchange rate needs to be located. The table is printed below and corresponds to a 10 ft stack height, air exchange rate of 1 per hour and an application rate of 2 lbs/1000 ft3.

10 ft Vertical Stack Air Exchange Rate = 1 per hour Application Rate (lbs/1000 ft3) = 2							
	Retention Rate (%)						
Size (ft3)	**100**	**99**	**95**	**90**	**75**	**50**	**25**
1000000	377	377	328	246	10	10	10
2000000	754	738	689	623	377	10	10
3000000	1214	1197	1148	1099	869	295	10
4000000	1542	1525	1476	1410	1181	656	10
5000000	1804	1788	1738	1656	1427	918	10
7500000	2362	2345	2280	2198	1902	1345	344
10000000	2821	2804	2722	2624	2280	1656	722

Since the exact enclosure size (1.2 million ft^3) is not in the table, we must round-up to the next available enclosure size (2 million ft^3). Reading down from a 90% retention rate, the buffer zone is 623 feet.

Appendix 1: What is my retention rate?

See www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml for details.

The retention rate after treatment is the percentage of the applied dosing that remains after treatment is completed which results in the amount emitted during aeration. Fumigation enclosure retention depends on the type of enclosure. Tests can be run to determine each enclosure's level of retention. In terms of retention, there are four types of enclosures:

1. Vacuum chambers,
2. PPQ-approved pressure-tested enclosures -- enclosures that pass the pressure test requirements using the procedures of the U.S. Department of Agriculture Plant Protection and Quarantine (PPQ) Manual,
3. Retention-tested enclosures, and
4. Untested enclosures.

1. Vacuum Chamber

A vacuum chamber usually is a small, metal chamber in which fumigations are conducted under reduced atmospheric pressure. The reduced pressure allows fumigations to proceed much more quickly, because methyl bromide penetrates the commodity faster during treatment and fresh air penetrates faster during aeration. Fumigation and aeration can be completed in a few hours with vacuum chambers. Document that a fumigation enclosure qualifies as a vacuum chamber and retain the record with the FMP.

Vacuum chambers are assumed to retain 99% of methyl bromide.

2. **USDA PPQ-approved pressure-tested enclosures**

A PPQ-approved pressure-tested enclosure is an enclosure that passes the USDA PPQ pressure test requirements using the procedures in the United States Department of Agriculture Plant Protection and Quarantine (PPQ) Treatment Manual. Such enclosures are completely constructed of rigid material and are well-sealed and impermeable to methyl bromide. This type of enclosure is usually made of metal, concrete, or wood coated with epoxy paint. All joints are caulked and the seals on the doors and aeration ducts are gas-tight. When fumigant is volatilized in a chamber at atmospheric pressure, a positive pressure is created, which may then be continuously reduced by leakage of the air-fumigant mixture. PPQ-approved fumigation enclosures must be sufficiently tight to retain the fumigant during the treatment (exposure) period. This type of enclosure is normally a chamber, but some silos or storage bins may also pass the test.

A fumigation enclosure passes the PPQ pressure test if the time lapse for the enclosure pressure to recede from 50 millimeters to 5 millimeters as measured by a manometer is equal to or greater than 15seconds (see PPQ pressure-test instructions in the USDA Treatment Manual). When fumigation enclosures pass the USDA PPQ pressure test, a copy of the USDA certification must be retained with the FMP. The test must be repeated annually if the retention is at least 30 seconds. The test must be repeated every 6 months if the retention is between 22 and 29 seconds. If an enclosure does not pass the USDA PPQ test, it can be retention tested or be classified as an untested enclosure.

PPQ-approved pressure-tested enclosures are assumed to retain at least 99% of methyl bromide.

3. Retention Tested

A retention tested enclosure usually is very different from vacuum chambers and PPQ-approved pressure-tested enclosures. Most chambers, silos, storage bins, sea/land containers, tarpaulin fumigations, and buildings are in this category. Many of these enclosures will retain methyl bromide very well. A retention test determines the percent of methyl bromide that leaks out of the enclosure each hour during the treatment period. See instructions for conducting a retention test and estimating the percent lost per hour for an enclosure below under the heading "Retention Testing for Fumigation Enclosures."

4. Untested

Untested enclosures are fumigation enclosures that:

- are not vacuum chambers,
- have not passed the PPQ pressure test, and
- have not been retention-tested.

Untested enclosures are assumed to retain 90% of methyl bromide.

RETENTION TESTING FOR FUMIGATION ENCLOSURES

A retention test will determine the percent of methyl bromide that is retained in a fumigation enclosure during treatment. The applicator must ensure that the retention test is conducted correctly using the procedures listed below, that the retention test results are recorded and kept with the Fumigant Management Plan and that the retention test is repeated annually.

Definition: ***Retention Rate*** is the average methyl bromide that remains in the fumigation enclosure during the treatment period. For example, if the methyl bromide retained is 98%, then an average of 2% of the applied methyl bromide leaks out during treatment. The retention rate allows fumigation operators to compute treatment and aeration buffer zones with much greater accuracy than is possible for untested fumigation enclosures.

Definition: A ***Fumiscope*** is an instrument designed specifically for measuring high concentrations of methyl bromide.

Conducting a Retention Test

Any knowledgeable person, including the enclosure operator, may conduct a retention test on a fumigation enclosure:

- Place the flexible tubing, such as Tygon™, Teflon™ into the enclosure to serve as sampling lines. There should be at least three sampling lines, depending on the volume of the enclosure. The larger the volume, the more lines are needed to get a precise reading. See the USDA/APHIS Treatment Manual for additional requirements.
- Follow the start-up instructions for the sampling instrument, which is usually a Fumiscope, although other instruments such as infrared spectrometers and photoionization detectors can be used. Note: The exhaust of the instrument must be vented away from all people or back into the enclosure.
- Following the label directions and precautions for a space fumigation, introduce methyl bromide into the enclosure in the amount that will result in the concentration within the enclosure of 1 pound per 1000 cubic feet (16 oz/1000 cu ft or 4100 ppm or 0.41%).
- Measure the concentration inside the enclosure within the first few minutes of introduction to insure that the initial concentration is correct.
- Measure the concentration inside the enclosure when the treatment period is over (e.g., 8 hours or 24 hours after the methyl bromide is introduced into the enclosure).
- Aerate the enclosure following label directions.
- Compute the **retention rate** using the average initial reading and the average final reading:

Retention Rate = 100 X (Average Final Reading / Average Initial Reading)

Example: If the average initial or starting Fumiscope reading was 16 ounces per 1000 cubic feet and the average reading 24 hours later was 15.8 ounces per 1000 cubic feet, the Retention Rate is:

100 X (15.8 / 16) = 98%

NOTE: Round the percent to a whole number.

Retention Rate: ____ percent

Multiple Methods: When fumigation enclosures are aerated using more than one aeration method, the largest of the aeration buffer zones is used for each enclosure at the work site.

Multiple Stacks: When fumigation enclosures use more than one aeration stack, each stack must meet all the requirements to qualify for a specific stack category. For example, if an enclosure used two stacks and one stack meet the requirements of a 50-foot attached vertical stack and the other stack meets the requirements of a 10-foot attached vertical stack, then the fumigation enclosure aeration qualifies as having a 10-foot attached vertical stack aeration method.

Enclosure with Capture Systems

Systems are available that capture methyl bromide from the headspace around the commodity during aeration following commodity fumigation in enclosures. Rather than releasing the methyl bromide directly into the atmosphere, the methyl bromide is captured and recycled, recovered, or broken down into nonhazardous and nonvolatile components.

Commodity fumigation systems equipped with highly efficient capture systems can reduce the size of the aeration buffer zone. Some examples of effective systems include: carbon adsorption systems, zeolite adsorption systems, and scrubbing systems. In order to reduce aeration buffer zones, the capture efficiency of the system must be obtained and be certified by the system manufacturer and the system must be monitored and maintained following the manufacturer's instructions. Once known, this value can be used to modify the retention rate and subsequently the size of the aeration buffer zone.

When enclosures with capture systems are used during aeration, the capture efficiency must be incorporated into the retention rate using the following equation.

Retention Rate with Capture System =Enclosure Retention in % x (100% – Capture Efficiency in %)

Example: If a vacuum chamber is used, the retention rate is assumed to be 99%. If a capture unit with 90% capture efficiency is used during aeration, then the retention rate including the capture system would be roughly 10%. If the retention rate calculated is not available in the buffer zone table, the next highest retention rate must be used.

Retention Rate with Capture System = 99% x (100% – 90%) = 99% x 10% = 9.9% ≈10%