RESEARCH REPORT
ANIMAL WELFARE

Title: Modification of a standard dump trailer to meet requirements as a CO2 euthanasia device for market weight or adult swine **– NPB #20-121**

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Institution: Pipestone Veterinary Services

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Industry Summary: The content should include the following: an explanation of the objectives, descriptive narrative of how research was conducted, a discussion of the research findings sufficient to give a thorough understanding of the results, and explain what these findings mean to the industry. This summary is to be written for non-technical audiences. Please include your contact information.

The current design for on-farm euthanasia of market weight or adult swine typically relies on individual handling and restraint of each animal. In a large scale depopulation event (major market disruption or foreign animal disease outbreak), the stress on personnel both physically and emotionally from individual animal handling is problematic (Stikeleather et a., 2013). The development of a method for depopulation events that meet humane euthanasia standards that do not require individual animal handling is needed. Carbon dioxide (CO2) inhalation is an American Veterinary Medical Association (AVMA) approved euthanasia method for swine. The advantages of CO2 include its non-flammable properties and easy reversal in events of accidental human exposure. The objectives of this project are to successfully modify and validate a mobile dump trailer into a portable CO2 device for the euthanasia of groups of market weight and adult swine.

An 8’ wide x 40’ long x 40” tall dump trailer was modified to handle CO2 gas input and holding time for euthanasia swine. A ceiling was built inside the trailer 3’ high to limit the area needed to fill with CO2. The ceiling also provided a means to ensure animals could not lift their heads above the CO2 gas line for proper exposure. The ceiling contained a hinged cover along the middle. This hinged cover could be opened to provide a space for people to walk upright with a sorting board to aid in loading the trailer. A swing gate hinged at the level of the ceiling was installed at halfway of the trailer to ease the loading process. This gate could be lowered into place and locked after the front half of the trailer was filled with animals to prevent them from running back off the trailer. The back half of the trailer could then be filled to reach the max animal capacity. Once the trailer was loaded and closed, the gate was unlocked. Once the euthanasia process is completed, the gate can swing open by the weight of the carcasses during the dumping process.

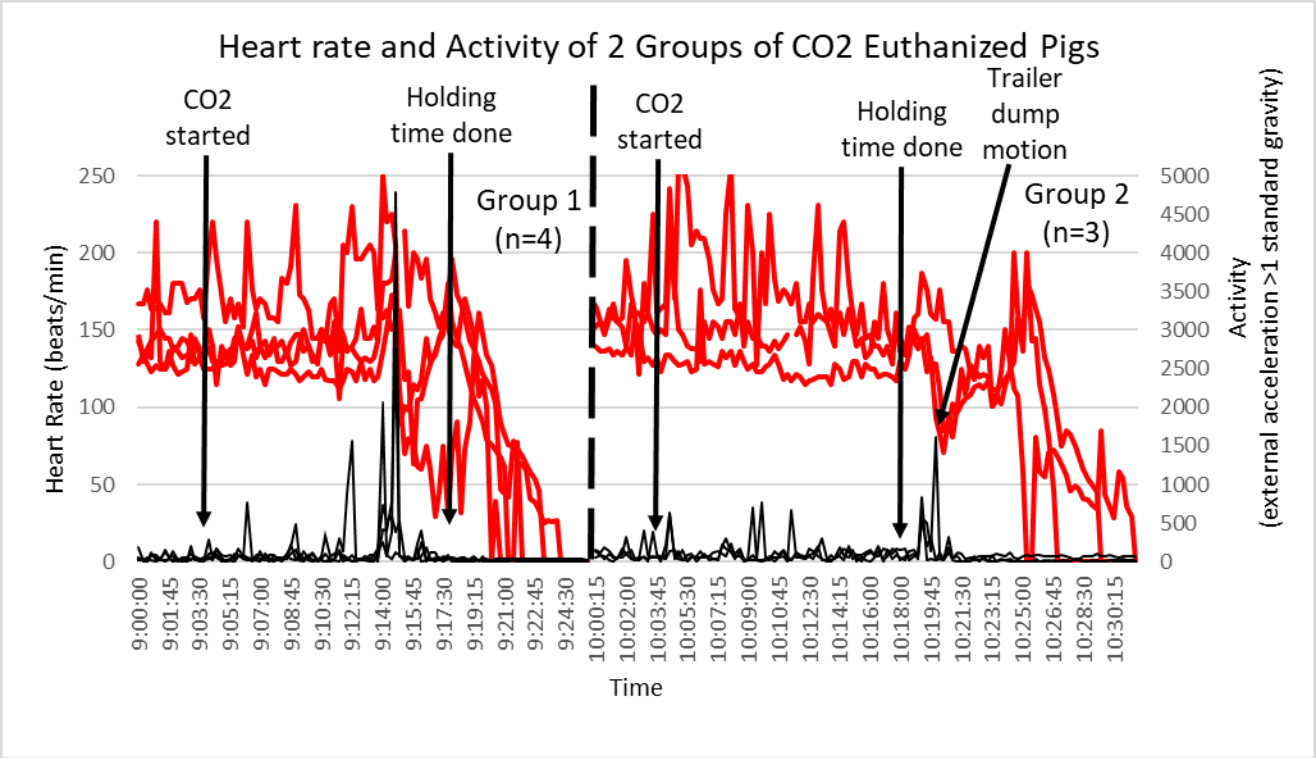
Four (4) 2” ball valve ports were built into the lower half of one side of the trailer. On the opposite side, 4 ball valve ports (2”) were installed up high on the trailer (but under the 3ft ceiling). The lower ports allowed for CO2 input while the higher ports could be open to allow air to escape as the heavier CO2 gas would fill from the bottom to displace the oxygen in the container. CO2 flowed into the trailer through the 4 CO2 ports by hoses connected to a 1000-gallon low-pressure tank (4 hoses from one tank). The 1000-gallon tanks were repurposed LP tanks redone with new fittings, gauges, and pressure relief valves for safety. Coming off the 1000-gallon tank, 1.5” couplers attached to a 1” hose that went to the couplers installed on the trailer. The 1000-gallon tank was filled enough CO2 to fill the dump trailer up to the level of the installed ceiling (120psig). At the 120psig fill a 1000-gallon tank held enough CO2 to fill the dump trailer once.

A total of 5 minutes of CO2 flow into the trailer achieved complete replacement of the volume with an average flow rate of 20% per minute. While CO2 entered, oxygenated air was allowed to escape through the higher placed ports on the opposite side of the trailer. Once CO2 reached its proper fill time and level, valves could all be closed to prevent CO2 escape and the entrance of air. After the 5-minute fill, the trailer was held sealed for 10 minutes (15 minutes total from the start of the CO2 to the end holding time). After the holding time was achieved, carcasses were dumped by the trailer’s hydraulic lift system onto the ground. During the dumping process and immediately afterward, carcasses were observed by veterinarians to ensure proper death had occurred, and no animals were revived.

The 1000-gallon tanks were filled from liquid CO2 held in 440-pound vertical gas-liquid (VGL) cylinders. A non-electric vaporizer was used for the transfer of CO2 to speed the transfer between tanks. Transfer of CO2 from VGL cylinder to the 1000-gallon tank took approximately 30min with the use of the vaporizer at 75°F ambient environmental temperature.

Eight (8) pigs were surgically implanted with monitoring devices to measure heart rate, general activity, and body temperature to confirm the success of the process for proper euthanasia. Pigs were implanted 48 hours before the euthanasia took place by sedating and surgically placing the device under the skin just above the xiphoid (bottom part of the sternum). The implant readings confirmed the loss of heart rate and activity of the animals as the holding time of the CO2 was completed (Figure 1). One of the implanted pigs died of unrelated causes before the CO2 exposure, and its implant readings were left out. In this project, 160 market animals were euthanized by this method. Forty (40) sows were then euthanized by the same method to ensure methodology was successful in adult size animals. Approximately 700 finisher animals (250-310lbs.), 40 adult sows, and 3000 wean/nursery age pigs have been successfully euthanized with this portable CO2 device design and process. One market weight animal was documented to require a secondary euthanasia method after the CO2 method.

Figure 1: Heart rate and Activity readings of pigs on the CO2 trailer through the euthanasia process



For further questions or information on this study, please contact:
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Key Findings:

- A vertical dump trailer was successfully modified into a mobile CO2 euthanasia device
- The use of the converted dump trailer provided a depopulation method meeting AVMA standards of animal welfare with repeated success
- Readings of animal heat rate and activity demonstrated successful death of swine after the applied CO2 method
- A portable CO2 trailer is a viable option for swine depopulation events

Keywords: Carbon dioxide, CO2, dump trailer, euthanasia, depopulation

Scientific Abstract/Introduction:

The current methods for on-farm euthanasia of market weight or adult swine rely on the individual handling and restraint of each animal (Meyer et al., 2005). Individual animal handling is problematic for large scale depopulation due to the stress on personnel both physically and emotionally, which leads to an increase in hazardous activities (Stikeleather et a., 2013). Carbon dioxide (CO2) inhalation is an AVMA approved euthanasia method for swine. In a depopulation event, like a foreign animal disease outbreak, an efficient method that accounts for animal and human welfare is needed. CO2 inhalation has an advantage over other inhalant gases due to its non-flammable properties and easy reversal if accidental human exposure occurs (Meyer et al., 2005). Previous studies on the modeling of dump trucks for the CO2 euthanasia of pigs show that it can be effective if specific design specifications are met (Stikeleather et al., 2013). Required specifications include an airtight seal at the bottom and sides, impermeable top cover,

a vent to allow displaced oxygen to escape, and for CO2 to be introduced at a 20% volume/minute rate (Stikeleather et al., 2013). The further advantage of the dump trailer is allowing for pigs to be euthanized outside of the barn and then carcasses easily transported to the designated location for disposal. The simple process of euthanasia occurring outside the facility in a preloaded trailer is significant for mass depopulation. The ability to reduce human interaction with the process and limited need for physical labor to move the carcasses makes this an efficient and safe method of mass depopulation. This dumping of carcasses outside prevents the need to physically drag each animal out of the building, increase worker safety, and improve caretaker wellbeing. The development of specifications and modifications that anybody in the swine industry can replicate would provide an easily constructed and readily accessible option when the need for depopulation events arise. This project provides modifications needed to convert a standard 40'x8' dump trailer into a portable CO2 euthanasia/depopulation device. This project also confirms the success of the CO2 trailer on not only market weight animals, but also adult swine.

Objectives: From your research proposal.

1) Finalize the dump trailer modifications required to produce a portable until for euthanizing groups of market weight hogs

2) Field test the dump trailer CO2 chamber model to confirm the success rate

Materials & Methods: This section should include experimental design, methods and procedures used, number of animals, etc.

An 8'x40' dump trailer was attained for modification. Airtight decking was inserted to lower the height of the trailer (decrease required space to displace oxygen and keep pig heads low). CO2 access ports were installed low on the side of the trailer. Oxygen release ports were installed higher up on the opposite side of the trailer.

CO2 will be flowed in at a rate sufficient to displace the oxygen at snout level within 5 minutes (20% volume/minute). Pigs will be held in the airtight section of the trailer for a total of 15 minutes. At the end of 15 minutes, the container will be opened to let present CO2 disperse. All pigs will be assessed to confirm insensibility and death by attending veterinarians. Any animal that was not dead at the end of the process will be euthanized via captive bolt gun immediately. When the attempt is not 100% successful, the trailer will be examined for weak points in the design and modified to increase success and exposure repeated.

The trailer will first be attempted on 3 groups of market weight hogs (50-60 per group; up to 180 total). Once comfortable with success, the attempt will be made on sows (40-60 per group; up to 120 total).

Eight pigs of market weight hogs will have an internal monitor surgically installed to monitor the heart rate via ECG measuring, animal activity, and body temperature before and during the CO2 exposure.

Animals were used under the guidelines and approval of the Pipestone Research Institutional Animal Care and Use Committee (IACUC) protocol ID# 2020-005.

Results: Report your research results by objective.

Objective 1: Finalize the dump trailer modifications required to produce a portable until for euthanizing groups of market weight hogs

An 8' wide x 40' long x 40" tall dump trailer was modified to handle CO2 gas input. A ceiling was built inside of the trailer at the height of 3' to limit the area needed to fill with CO2 and ensure animals could not lift their heads above the CO2 gas line. The ceiling was hinged with lifetable panels down the center

to provide an alleyway for people to walk upright with a sorting board to load pigs to aid in loading the trailer (Figure 2). To ease the loading process, a hinged gate that could be lowered and locked was installed at the halfway point of the trailer length (Figure 3). This gate could be locked after the front half the trailer was loaded with animals so they could run back off the trailer while the back half was filled. After the trailer was fully loaded, the hinged gate was unlocked, and the CO2 filling and trailer holding time began. Once the holding time was met, the gate was unlocked and could swing open by the weight of the carcasses during the dumping process.

Four (4) 1.25" ball valve ports were built into the lower side of one sidewall of the trailer. On the opposite side, 4 ball valve ports were installed up high on the trailer (but below the ceiling). The lower ports allowed for CO2 input, while the higher ports could be open to allow oxygenated air to escape as CO2 gas would fill from the bottom (Figure 4). Since CO2 is heavier than oxygen, the CO2 displaces the oxygenated air out of the higher release valves (Meyer et al., 2005). Plastic piping was added onto the end of the oxygen escape ports to ensure any escaped CO2 would flow towards the ground and not into an area people may walk into (Figure 4).

The 1000-gallon low pressure repurposed propane tanks were filled from 440 pound CO2 vertical gas-liquid (VGL) cylinders. The use of a non-electric vaporizer quickened the rate of gas transfer. With the vaporizer, the CO2 transfer to the 1000-gallon tanks from the VGL cylinders took approximately 30min at 75°F ambient environmental temperature. At colder temperatures, supplemental heat would be needed or a slower fill time expected. The 1000-gallon tanks were repurposed LP tanks redone with new fittings, gauges, and pressure relief valves for safety. VGL cylinders and vaporizer was transported in a separate trailer (Figure 5). Two 1000-gallon tanks were hauled on a separate open trailer (Figure 5). CO2 flowed into the trailer through the 4 CO2 ports by hoses connected to a 1000-gallon tank (4 hoses/tank). Each 1000-gallon tank was filled enough CO2 to fill the dump trailer up to the installed ceiling (120psig). A regulated valve allows a flow of at least 20-24 psi/minute for 5 minutes for both tanks feeding into the trailer (Figure 6). After the 5min fill time, all valves (oxygen and CO2) were closed, and the trailer was held sealed for another 10 minutes (15 minutes' total time from CO2 start to end of holding time). After holding time, the carcasses could then be dumped on the ground by the trailer's hydraulic lift system (Figure 7). During and immediately after the dumping process, carcasses were assessed to ensure proper death occurred and no animals revived.

Objective 2: Field test the dump trailer CO2 chamber model to confirm the success rate

Out of a total of 700 finisher pigs euthanized by this method, only 1 animal was found to revive itself afterward and required euthanasia by a captive bolt. The same methodology was applied to 40 adult sows, with a 100% success rate.

As shown in Figure 1, the implant monitors confirmed animal death by loss of detectable heart rate and cessation of animal movement (activity).

Discussion: Explain your research results and include a summary of the results that is of immediate or future benefit to pork producers.

Keeping the seams as airtight as possible is essential for repeated success. To provide extra assurance excess CO2 was not leaking during the holding process, Gorilla tape was placed over all the ceiling lab seams. The rollover tarp was available to provide extra protection from the wind but was only needed on particularly windy days.

The swing gate installed half the length of the trailer was very beneficial for loading animals as it prevents pigs from being able to run back off the trailer. It was found that having a gate that could swing open when

not locked was important. A fixed gate was difficult to remove after the euthanasia process due to the carcass weight pressed up against it.

When using the trailer on adult sows, they were tall enough to bump the hinged part of the ceiling open during the CO2 fill time. If this method were going to be used on adult sows and boars regularly, a sturdy locking latch would be recommended to prevent this.

The implant data confirmed our CO2 portable trailer provided successful euthanasia. The heart rate and activity level cease in all the monitored pigs.

The ability to modify a dump trailer (or other similar containers) into a portable CO2 euthanasia unit provides a means for timely humane depopulation. The use of CO2 meets AVMA welfare standards and provides a safe methodology for the humans involved. The model of this trailer modification may lend itself to other potential euthanasia methods, e.g., nitrogen gas.

References:

Meyer et al. (2005). Carbon dioxide for emergency on-farm euthanasia of swine. JSHAP 13(4): 210-217.

Stikeleather et al. (2013). Evaluation of CO2 application requirements for on-farm mass depopulation of swine in a disease emergency. Agriculture 3: 599-612.

Figure 2: Inside view and outside view (open and closed) of the installed ceiling

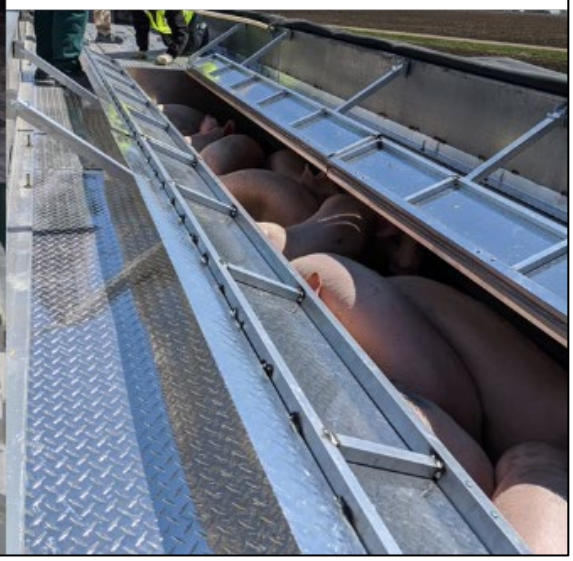
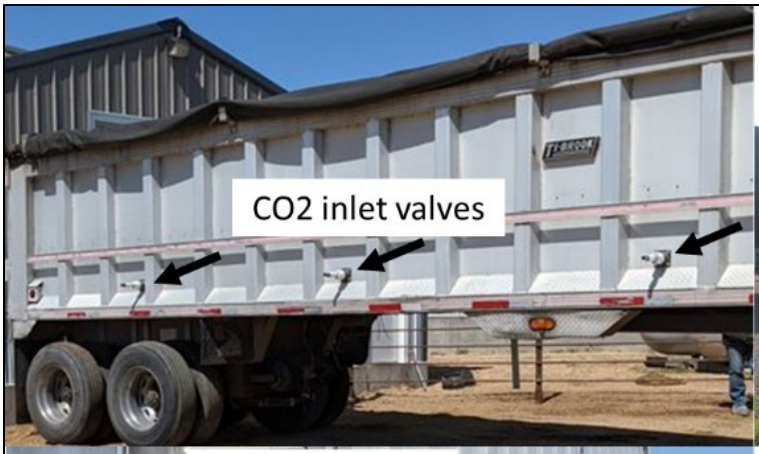


Figure 3: View of swing gate placed after trailer is filled halfway



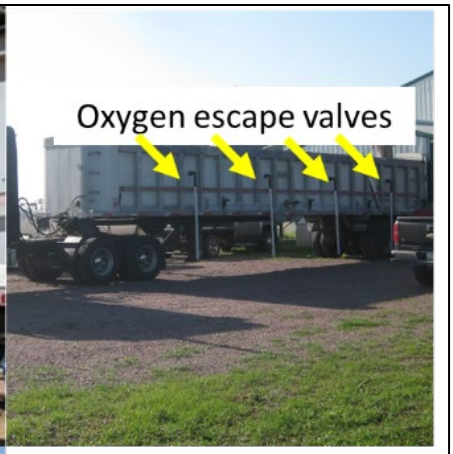


Figure 4: CO2 ball valve inlets low on trailer for CO2 to fill in and ball valve ports high on opposite side to allow oxygenated air to escape up top while CO2 filled from the bottom

Figure 5: Separate trailers used to haul the vaporizer with VGL of CO2 and the 1000-gallon low pressure tanks

Figure 6: 1000-gallon tanks hooked up to CO2 ports on dump trailer to run gas in

Figure 7: Dump trailer immediately after unloading carcasses