

Title: Validation of a Mobile Electrocutation System for Humane Mass Depopulation of Swine – NPB #20-123

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Industry Summary: During the Spring of 2020, the US Pork industry experienced unprecedented supply chain interruption because of packing plant closures and slowdowns. While the industry quickly adapted feed rations to slow pigs' growth rate, some producers ran out of time and space and were forced to euthanize pigs. This crisis revealed the fact that other than sending pigs to harvest, the US was unprepared for humane mass depopulation of pigs on farm. Therefore, humane and approved methods are needed that can operate on-farm with high throughput capacity, that would allow for sites to be depopulated quickly. To this end, we proposed to adapt electrical stunning techniques once utilized in harvest plants into an automated, single step electrical euthanasia system that is fully mobile. The objectives of the project were: 1) To validate an AVMA-approved method of humane euthanasia for on-farm application, to ensure the same standard of welfare is met during mass depopulation events that is provided under federally regulated conditions in slaughter plants. 2) To provide real-time industry assistance with mass depopulation while gathering data that will be used to develop SOPs and infrastructure for future crises. 3) To develop a unit that can be replicated for national preparedness and response to catastrophic events on farm that may be considered for addition to the USDA stockpile. The investigators used an expired patent for an auto-stunner that had been designed for slaughter plant use as the starting point for the project. Under slaughter conditions, electrical stunning is accepted as a humane method of rendering swine immediately unconscious, but a second step is required to prevent return to sensibility and ensure death. The aim of this project was to validate automated electrocutation as a humane, single step method for on-farm euthanasia on a large scale.

A brief description of the mobile unit is as follows. A v-belt restrainer was mounted onto a 30' flatbed gooseneck trailer. At the rear of the trailer is a lead up chute that is chute/dock height. The electric components and the electric drive unit for the hydraulic are mounted to the front of the trailer and powered by connecting to a 3 phase 220-volt power source with 30

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amps. A negative contact was positioned to make contact with the left legs of the pigs as the restrainer moved them through the unit. An insulated paddle is lined on one side with a steel contact plate for the hot positive contact point. The pigs enter the unit via the lead up chute, transition into the restrainer which carries them forward to make contact with the negative contact bar followed by the hot paddle. When the pigs are in contact with both the negative contact bar and the hot paddle, head to heart electrical euthanasia occurs with a single step. By introducing the current across the head, instantaneous unconsciousness occurs, and the body contact achieves fibrillation (cardiac arrest). Pigs maintain the contacts for a minimum of 3 seconds. The restrainer carries the pigs to the end of the restrainer where they transition onto the exit slide and are discharged from the trailer.

The unit was not completed in time to assist with depopulation, which was objective #2. Sixty pigs ranging in weight from 125 pounds to ~600 pounds were processed through the unit for validation. 56 of the 60 pigs were euthanized with the single step automated electrocution as designed. The four pigs that required the use of a secondary method to ensure death pointed to size limitations (lower limit) or the need for a lower hold down apparatus, not a design issue with the use of automated single step electrical euthanasia. The investigators were extremely pleased with the ability of the electrical contacts to apply and maintain good electrical contact as the pigs were transported on the restrainer, even on mature Duroc boars with thick coarse hair. The above leads investigators to be extremely pleased with progress towards objectives 1 and 3. Farm staff that observed the use of the mobile unit all preferred its use vs their standard farm protocols of euthanasia.

The most important contribution this project has to pork producers is the validation of hands-free single step electrical euthanasia in a mobile unit on pigs ranging from 125 pound to ~600 pounds. While pork producers now have access to one operation unit, the process that has been undertaken on this project ensures the unit can be copied by other companies/government agencies to make their own unit(s). The fact that it does not require a human to apply the euthanasia holds great promise for worker mental health. Additionally, as it is extremely quick and bloodless, the visual aspects are also of importance for worker mental health. The unit also is designed in such a way to minimize the number of workers needed on site and greatly reduces the need for workers to move animals. All told, this is a safe, highly effective mobile unit that can perform hands free single step electrical euthanasia with minimal staff needed and to perform a necessary task in the most humane and mentally acceptable manner possible.

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Key Findings:

- Single-step electrocution may be considered for humane euthanasia
- The emotional impact of euthanasia on animal caretakers may be reduced in this system
- Anecdotal feedback from personnel trained to perform captive-bolt euthanasia suggests their preference for this method over HHCB

Keywords: auto-stunner, electrocution, euthanasia, depopulation, swine

Scientific Abstract:

During the Spring of 2020, the US Pork industry experienced an unprecedented supply chain interruption because of packing plant closures and slowdowns. This crisis revealed the fact that other than sending pigs to harvest, the US was unprepared for humane mass depopulation of pigs on farm. If the US were to experience a foreign animal disease outbreak such as ASF or FMD, livestock would not be allowed to be transported off the farm for euthanasia. The challenges encountered by the industry pointed to the need for more work developing humane methods of depopulation specifically for on-farm use, that can accommodate large numbers of animals. Therefore, humane and approved methods are needed that can occur on-farm with high throughput capacity, to allow for sites to be depopulated quickly. To this end, we proposed to adapt electrical stunning techniques once utilized in harvest plants into an automated, single step electrical euthanasia system that is fully mobile.

The investigators used an expired patent for an auto-stunner that had been designed for slaughter plant use as the starting point for the project. A brief description of the mobile unit is as follows. A v-belt restrainer was mounted onto a 30' flatbed gooseneck trailer. At the rear of the trailer is a lead up chute that is chute/dock height. The electric components and the electric drive unit for the hydraulic is mounted to the front of the trailer and is powered by connecting to a 3 phase 220-volt power source with 30 amps. A negative contact was positioned to make contact with the left legs of the pigs as the restrainer moved them through the unit. An insulated paddle is lined on one side with a steel contact plate for the hot positive contact point. The pigs enter the unit via the lead up chute, transition into the restrainer which transports them forward to make contact with the negative contact bar followed by the hot paddle. When the pigs are in contact with both the negative contact bar and the hot paddle, head to heart electrical euthanasia occurs with a single step. Pigs maintain the contacts for a minimum of 3 seconds. The restrainer continues to transport the carcasses to the end of the restrainer where they transition onto the exit slide to be discharged from the trailer.

Sixty pigs ranging in weight from 56 kg to ~272 kg was processed through the unit for validation. 56 of the 60 pigs were euthanized with the single step automated electrocution as designed. Four pigs required the use of a secondary method to ensure death. The four pigs that required the use of a secondary method to ensure death pointed to size limitations (lower limit) or the need for a lower hold down apparatus. The electrical contacts applied

and maintained sufficient electrical contact as the pigs were transported on the restrainer, even on mature Duroc boars with thick coarse hair. Though not a measurable outcome, farm staff that observed the use of the mobile unit all preferred its use versus their standard farm protocols of euthanasia. The mobile unit was found to be effective in performing hands free single step electrical euthanasia with minimal staff needed and to perform a necessary task in the most humane and mentally acceptable manner possible.

Introduction:

Lambooy and van Voorst (1986) conducted electrocution experiments under laboratory conditions, where a chain curtain served as electrodes, and a metal floor was the negative contact. One limitation identified was that pigs could turn around, and if the chains initiated contact with the hindquarters of the pig rather than the head, insensibility was not immediately achieved, and pigs were left recumbent but not euthanized. Preliminary work in the US (Probst-Miller, 2010) provided the framework for on-farm electrocution as a humane method of depopulation of neonate pigs. Shortly after this, Douma, et al. (2012) described testing of a mobile unit for electrocution of market-weight hogs. This study cited gaps in ensuring consistent delivery of electrical current to pigs entering the system, including the introduction of electrical current to locations other than the head initially, resulting in a failure of this system to reliably render pigs immediately unconscious. A recent systematic review of existing methods of swine depopulation refers to depopulation by electrocution when approximately 700,000 pigs were eradicated in the Netherlands during a CSF outbreak. While the articles included in the review (Arruda, et al., 2020) do not include a description of the euthanasia device, it was described as an automated system mounted on a truck, consistent with the features of the original Lambooy and van Voorst system. Despite this successful testing and use, electrocution as an option for humane depopulation has not been adopted for wide on-farm use in the United States.

During the Spring of 2020, the US Pork industry experienced an unprecedented supply chain interruption because of packing plant closures and slowdowns. Hundreds of thousands of pigs were market weight and ready to harvest, but the plants were not able to take them. While the industry quickly adapted feed rations to slow pigs' growth rate, some producers ran out of time and space and were forced to euthanize pigs. This crisis revealed the fact that other than sending pigs to harvest, the US was unprepared for humane mass depopulation of pigs on farm. Not only were producers unprepared, but the USDA stockpile resources for producer support only included hand-held captive bolt guns, which is not a practical solution for FAD response. During the 2020 crisis, documented depopulation methods used by the industry include ventilation shutdown plus, captive bolt, and gunshot, though many additional methods were explored. In some instances, pigs were transported offsite for euthanasia in plants that operated only for emergency euthanasia and did not harvest pigs euthanized under those circumstances. If the US were to experience a foreign animal disease outbreak such as ASF or FMD, livestock would not be allowed to be transported off the farm for euthanasia. The challenges encountered by the industry pointed to the need for more work developing humane methods of depopulation specifically for on-farm use, that can accommodate large numbers of animals. Therefore, humane and approved methods are needed that can operate on-farm with high throughput capacity, that would allow for sites to be depopulated quickly. To this end, we proposed to adapt electrical stunning techniques

once utilized in harvest plants into an automated, single step electrical euthanasia system that is fully mobile.

Objectives:

The objectives of the project were:

- To validate an AVMA-approved method of humane euthanasia for on-farm application, to ensure the same standard of welfare is met during mass depopulation events that occurs under federally regulated conditions in slaughter plants
- To provide real-time industry assistance with mass depopulation while gathering data that will be used to develop SOPs and infrastructure for future crises.
- To develop a unit that can be replicated for national preparedness and response to catastrophic events on farm that may be considered for addition to the USDA stockpile.

Materials and Methods:

The investigators used an expired patent for an auto-stunner that had been designed for slaughter plant use as the starting point for the project. Under slaughter conditions, electrical stunning is accepted as a humane method of rendering swine immediately unconscious, but a second step is required to prevent return to sensibility and ensure death. The aim of this project was to validate automated electrocution as a humane, single step method for on-farm euthanasia on a large scale. To accomplish this, the unit needed to be mobile and versatile. The investigators decided to build the unit on a new 30-foot tandem axle (15,680 GVW) classic flatbed trailer, which can be pulled by a $\frac{3}{4}$ ton or 1 ton pickup, making it easily deployable should the need arise for its use. This allows for onsite euthanasia in the event of a foreign animal disease outbreak or it can be set up at a regional site. A reconditioned v-belt restrainer was mounted on the flatbed trailer, and an 8-foot single-file lead up chute was constructed on the back of the trailer. The chute entrance is 48 inches from the ground to accommodate most loading docks. The positive contact of the auto stunner is a stainless-steel plated, insulated swinging paddle suspended at head-height over the v-belt restrainer. The negative contact is stainless steel pipe, 1.5 inches in diameter and 36 inches long that is fixed an inch below the bottom of the belt on the stationary side of the restrainer and protrudes $\frac{3}{4}$ inch into the center of the restrainer. Having the negative contact a set length where full contact occurs allows for the restrainer speed to be adjusted up or down to allow the operator to precisely control the amount of time that pigs maintain contact with the complete circuit.

The unit can be operated by wiring into a three-phase, 220-volt power on site, or a 20kw generator capable of producing 30 amps can be rented. It is critical to ensure when using on-site power, that 220 volts are delivered since it is not guaranteed to produce 220 volts. Additionally, pigs must be wet down prior to entry into the restrainer to ensure maximum electrical conductivity, so having access to water is mandatory.

Trailer setup: The trailer should be backed into place (loading chute, facility dock, or site for semis to back up to). The electrical contacts for the “hot paddle” and the negative bar should be checked to ensure they are tight. The metal plate on the hot paddle and the negative leg bar should be cleaned with wire brush to ensure they are clean and rust free to maximize electrical conductivity. The trailer should be disconnected from the pickup so that the trailer can be stabilized with the dual 12,000-pound jacks up front. Jacks are also in the storage compartment under the lead up chute to be placed at the rear of the trailer for extra stability. The unit should be

grounded for extra security by connecting the copper ground wire to the ground lug on the restrainer leg to the copper ground rod that should be driven into the ground a minimum of three feet. Note, if operating the unit in the winter with frozen ground, it is suggested to drill a 0.5” hole to a point below the frost line to make it easier to drive the ground rod into the ground. The ground around the ground rod should be fully wet down prior to energizing the unit. With all breakers on the trailer turned to the off position, the 5 wire electrical leads (3 hot, 1 neutral, and 1 ground) should be connected by a qualified person to either the power source (3 phase 220-volt generator or on-site power supply). Using the supplied voltage testers, multiple spots on the trailer should be checked for stray voltage prior to turning on the breakers or anyone being on the unit. The unit should be checked for stray voltage again once the breakers for the hydraulic motor/pump are flipped on. The motor on the hydraulic drive unit has arrows labeled on it to indicate the proper direction for the motor to rotate. Should the motor rotate in the opposite direction, any 2 of the 3 hot wires can be switched to make the motor rotate in the proper direction. The restrainer belts should be turned on and allowed to move for a few minutes to warm up. Each side of the belt should be timed to ensure the belts are running at the same speed to ensure the pigs move through the unit smoothly. If the speed of the belts are different, it should be adjusted. The speed of the restrainer should be set such that it ensures the pigs maintain a complete electrical circuit for a minimum of 3 seconds. The minimum and maximum speed will therefore be different depending on the length of the pigs with smaller pigs needing a slower speed to ensure a 3 second contact. Once these steps are complete, the unit is ready to run.

Trailer operation: It is recommended to have one person loading pigs into the lead up chute on the trailer. The pigs can either be wet down in the lead up ramp by a person or hoses/sprinklers can be set up to do this step automatically. Ideal pig flow into the restrainer should be such that pigs do not try to stack on top of each other. One person located on the trailer can control both the flow of pigs into the restrainer and the controls to the restrainer and the electricity for the euthanasia. This person should/can immediately stop the unit if a pig is not fully electrocuted prior to discharge from the restrainer. Ideally another person should be stationed at the front of the trailer to check for proper euthanasia and they can stop the unit via the breaker box should they identify a need to stop the unit. Further personnel/vehicle needs are for the removal of the carcasses once they exit the trailer. This can be accomplished either by using loader buckets placed to catch/scoop carcasses and place them into rendering trucks. If mass depopulation is occurring, efficiency of the operation will be increased by placing a portable conveyor belt under the discharge slide to catch the carcasses and deposit them directly into waiting rendering trucks.

Validation of unit: All pigs were monitored for vocalization, gasping/agonal breathing, corneal reflex, and menace test to aid in confirmation of insensibility and death. Further, ECG leads were applied to each pig following discharge from the restrainer with a hand-held ECT monitor used to monitor for the absence of the QRS complex to aid in the confirmation of death. The unit was placed into operation on four occasions as modifications were made to the unit. The first three deployments were at UNL’s swine research facility and the fourth deployment was at a commercial cooperator site. During the first deployment, six pigs were euthanized with size ranging from 125 pounds to 440 pounds. Each pig was placed into the unit one at a time to allow for confirmation of insensibility and death and to allow for ongoing analysis after each pig. Modifications were made as necessary after each pig. As the first pig did not make sufficient contact with the electrical contacts, captive bolt was used as a secondary euthanasia method. Adjustments were made to the height and resistance of the hot paddles for better contact. All other pigs did not need a secondary method of euthanasia. Modifications made during/after this run included adding straps to ensure a “tighter”

contact with electrical paddles, removal of plastic at the bottom of the hot paddles to help maintain a better electrical contact as pigs moved through/under the paddles, wrapping the bottom of the hot paddles with stainless steel to ensure contact as pigs moved through the unit/under the paddles, designed and installed the 36" bar for negative electrical contact, and reduced the height of the exit ramp to allow the pigs to not hang up upon exit. The second deployment was tested on 5 pigs ranging in weight from 135 pounds to 550 pounds. All pigs were euthanized with the single step hands free electrocution process as designed. Modifications suggested from this deployment included moving the negative contact bar slightly further under the restrainer, from being 1.25" of the pipe exposed to 0.75" exposed. Additional modification was needed on the exit slide to keep carcasses from hanging up on the ramp and a transition slide was needed. Replacement of the hydraulic motor on the driver side of the restrainer was needed as a seal went out during this test. Deployment of the trailer for a third time was for a single boar weighing 500 pounds to validate the placement of the negative contact bar and the exit of the carcasses from the unit. The boar was euthanized with the single step hands free electrocution process as designed and the boar exited the unit without hanging up. The fourth deployment of the trailer was the largest conducted with 48 pigs. No weights were gathered but were estimated to have a weight range of 140 pounds up to approximately 600 pounds. Set up time was roughly one hour to have the unit fully operational. Forty-five pigs were euthanized with the single step hands free electrocution as designed including all pigs weighing over 300 pounds. The three pigs that were not euthanized with the single step process did not ride in the restrainer as designed. Two of the pigs jumped up on the side of the restrainer belt prior to losing contact with the floor with their front legs and thus did not make a complete head to heart electrical circuit. Modification to the hold down bars and a shortened decline ramp into the restrainer will prevent this from happening in the future. The third pig that was not euthanized with the single step electrocution was a "bloater pig." The large belly on this pig caused the pig to rock forward and not come in contact with the electrical contacts properly. This indicated the lower size limit of the unit to be more based on the natural width of the pigs rather than actual weight.

The width between the two restrainer sides should be set to 6" (minimum current distance of the unit) for pigs weighing between 125 pounds and ~400 pounds. Pigs at the bottom end of this weight range should be put into the unit with caution as the width of the pig is important to keep them from falling through. For pigs over ~400 pounds, the restrainer should be widened to 8" for the larger pigs to "ride" lower in the v-belt. Large (width) sows and boars tend to "ride" higher in the restrainer thus changing the angle of the contact with the hot paddle. The hot paddle is adjustable in both the distance from the negative contact bar and the height up and down in the restrainer. For animals weighing less than ~350 pounds, the hot paddle should be slid as close to the negative contact bar as possible. For animals weighing over ~350 pounds, the negative contact bar should be slid as far away from the negative contact bar as possible ensuring the larger animals are in sufficient contact with the negative contact bar prior to engaging the hot paddle and thus decreasing the incidence of "hot wandling." The ideal height of the hot paddle should be set such that it first contacts the bridge of the nose vs the nose itself. This ensures a more stable contact as pigs tend to go rigid when electricity is applied and that motion pushes the hot paddle causing a momentary loss of contact with the hot paddle if the hot paddle touches the tip of the nose first.

Results:

Due to complications with university policy on payments (amount of time to make payments typically in the range of 3 weeks) and the university slowdowns with almost all accounting personnel working remotely due to COVID-19, the mobile unit did not get completed for its first

trial run to occur until October 12, 2020. COVID-19 slowdowns also held up the replacement hydraulic motor for a month after it was noted that the blown seal had no replacement part available. Therefore, the unit was not completed in time to assist producers that needed to euthanize pigs due to COVID-19 packing plant slowdown/closures (Objective 2.) While short, at this time, of testing 302 pigs for objective 1: “validate an AVMA-approved method of humane euthanasia for on-farm application, to ensure the same standard of welfare is met during mass depopulation events that is provided under federally regulated conditions in slaughter plants,” the 60 pigs that the unit has been validated on shows that the mobile unit is fully capable of single step hands free euthanasia on pigs ranging in size from 125 pounds to up to the ~600 pounds tested thus far. Most encouraging to the investigators is the ability of the electrical contacts to maintain good contact on moving pigs as indicated by the unit’s ability to even make good contact through thick coarse hair of several Duroc boars. Additionally, given the validation to date, the investigators fully believe the mobile unit can be copied by other companies and government agencies to aid in mass depopulation events of swine to meet objective 3. The Nebraska Department of Agriculture has been so thoroughly impressed with the operation of the unit that they are purchasing the unit from the National Pork Board to keep in state for depopulation emergencies. This means that the checkoff dollars that funded the project will be returned in full to the National Pork Board for funding additional projects while having a fully operational unit ready should the need arise.

Comments from farm staff at both locations were highly positive. Staff at both locations noted how humane the process is for the animal with the pigs being rendered instantly insensible and dead with this method and the lack of blood, kicking, squealing as compared to their current methods of captive bolt/gunshot. Staff at both locations preferred this hands-free single step electrical euthanasia to their current methods. We have open invitations to return to either location to perform further validation of the unit.

Discussion:

The most important contribution this project has to pork producers is the validation of hands-free single step electrical euthanasia in a mobile unit on pigs ranging from 125 pound to ~600 pounds. The lower limit of the unit is dependent on the width of the restrainer belts and thus with closer widths future trailers and have a lower weight limit. The upper weight limit is determined by the width of the animal and their ability to fit into the restrainer. While pork producers now have access to one operation unit, the process that has been undertaken on this project ensures the unit can be copied by other companies/government agencies to make their own unit(s). The unit being fully mobile, weighs just 13,040 pounds fully operational, and can be pulled by a ¾ ton or 1 ton pickup, making it easily deployable should the need arise for its use. This allows for onsite euthanasia in the event of a foreign animal disease outbreak or it can be set up at a regional site. The fact that it does not require a human to apply the euthanasia holds great promise for worker mental health. Additionally, as it is extremely quick and bloodless, the visual aspects are also of importance for worker mental health. The unit also is designed in such a way to minimize the number of workers needed on site and reduces the need for workers to move animals. In a mass depopulation situation where the unit has a conveyor belt set up to offload the pigs into waiting rendering trucks, humans will not have to handle the carcasses and will only need to get live pigs onto the unit much the same as they do when loading a truck to transport animals to a harvest plant. All told, this is a safe, highly effective mobile unit that can perform hands free single step electrical euthanasia with minimal staff needed and to perform a necessary task in the most humane and mentally acceptable manner possible.



Figure 1. The complete unit ready for transport.



Figure 2. View from under the restrainer showing the negative contact bar for the left legs and the hot paddles suspended in the center of the restrainer.



Figure 3. Top view of the negative contact bar with the original negative paddle still in place.