

ANIMAL WELFARE

Title: Depopulation of Swine by Inert Gassing Utilizing the Livetec Systems Nitrogen Foam Delivery System **NPB #20-099**

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Introduction:

The three key response goals to a disease outbreak are to: (1) detect, control, and contain the disease in animals as quickly as possible; (2) eradicate the disease using strategies that seek to stabilize animal agriculture, the food supply, the economy, and to protect public health and the environment; and (3) provide science- and risk-based approaches and systems to facilitate continuity of business for noninfected animals and non-contaminated animal products ¹

While prevention and bio-exclusion of a disease is everyone's goal, there is no doubt that depopulation is a necessary and effective means of response to protect the swine industry and pork supply. The American Veterinary Medical Association (AVMA) defines depopulation as the rapid destruction of a population of animals in response to urgent circumstances with as much consideration given to the welfare of the animals as practicable.² According to the National Animal Health Emergency Management System (NAHEMS) the goals of depopulation are to (a) provide humane treatment of animals at all times until they are culled; (b) select and use an acceptable form of depopulation to be executed as quickly, efficiently, and humanely as possible; (c) minimize the negative emotional and psychological impact on animal owners, caretakers, and the public; (d) prevent adulterated or potentially adulterated meat products from entering the food chain; and (e) prevent or mitigate disease spread within the country.¹

However, there are multitude of factors that must be considered in selection and utilization of mass depopulation techniques. Historically it has proven extremely difficult to effectively and efficiently conduct even small depopulations of swine using traditional euthanasia methods for localized disease outbreaks such as H1N1, PED(v), TB, etc. Issues have included lack of equipment, supplies (cartridges, CO₂ tankers, etc.), trained labour, physical/mental exhaustion, psychological impacts (caring/killing paradox), disease spread, business continuity, etc. There is a need for equipment and techniques that have been scientifically validated, with robust, practical protocols developed in advance of an incident, to ensure safe and efficient deployment and fast resolution for the industry.

Several techniques (mechanical, electrical, pharmacological, gaseous and firefighting foam) have been employed for mass depopulation of swine and poultry in an emergency, each of which present practical challenges and raise welfare concerns. There is a requirement to depopulate large numbers of animals safely in as short a time as possible. As an example, for poultry, the use of a gas (e.g. bulk CO₂ delivered as a liquid that then sublimates) in houses has been advocated, as it eliminates the need to handle the animals, a vital advantage if worker health is at risk. However, unlike some other

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methods of killing, it is not instantaneous as research shows that birds remain conscious for significant periods and may experience respiratory distress. In addition, whole house gassing with free gas, requires significant preparations and is not applicable to much of the US industry with naturally ventilated barns.

An alternative method for whole house depopulation is the use of firefighting foam (Figure 1a), which has been tested and conditionally approved in the United States for use on some poultry species in specific circumstances.² Application of foam has several potential advantages including reducing the number of people in contact with the animals and as an alternative to the use of CO₂, which may be in short supply in the event of a major disease outbreak. The firefighting foam used is medium density with small diameter bubbles. It operates as a euthanasia agent by rapidly occluding the airways of birds causing death by hypoxia.³ However due to practical and welfare concerns surrounding this approach, use of firefighting foam for depopulation of larger animals is not considered acceptable. Hypoxia due to exposure to inert gases (Nitrogen, Argon, etc) for the euthanasia, slaughter and depopulation of swine and poultry has been evaluated and deemed acceptable worldwide. The AVMA states that inert gases are not detected by poultry and can be effective with containerized gassing methods or in whole-house situations.² However, inert gases have not traditionally been used for whole house gassing because of the practical impossibility of sealing the house or shed to the extent required to adequately eliminate oxygen (<2%). The use of high expansion gas-filled water based foam containing an inert gas presents a method of delivering gas into the shed or container where animals are held. It is a method of anoxic killing, since as the foam envelopes the animal, oxygen is effectively eliminated, and the animal will die by anoxia. The foam matrix contains a majority of bubble of a diameter of 0.75 inches or greater. The physical properties of the bubbles, by virtue of its high expansion ratio (greater than 250:1) and surfactant composition, means that it can effectively fill a space or open container without the need to seal it (Figure 1b).



FIGURE 1a Medium density firefighting foam



FIGURE 1b High expansion nitrogen gas filled foam

Livetec Systems have been involved in research and development of high expansion gas filled foam systems since 2007 and are currently leaders in the field. Our original work with the University of Glasgow Veterinary School and the Royal Veterinary College, London established the principle that exposure of poultry to inert gas delivered to the bird in a high expansion water-based foam, had potential to be an acceptable method of depopulation.⁴ These initial trials with individual birds provide proof of principle that submersion in nitrogen filled high expansion foam provides a highly effective and humane method of euthanasia. Physiological observations and measurements of oxygen in the foam show that unlike previous application of medium expansion foam in the US, the method of

killing is anoxia with nitrogen gas, not occlusion of the airway. This is corroborated by post-mortem examinations in which no evidence of tracheal occlusion with foam was found.

Immersion in high expansion foam filled with nitrogen achieved a rapid death, with broadly similar responses in all poultry species tested. Evidence showed that death was due to anoxia from exposure to nitrogen gas within the foam bubble matrix and there was no occlusion of the airways. There was little behavioral response to immersion in air filled high expansion foam as a control. Once submerged exposure to less than 1% oxygen is immediate. Behavioral responses included headshaking, loss of posture and vigorous wing flapping characteristic of anoxic death. Mean time to loss of consciousness was 30s in hens and 18s in broilers and death resulted between 50 and 65 seconds.⁴

Following this initial work larger scale systems were developed, capable of whole house gassing of poultry in their sheds using nitrogen gas instead of traditional carbon dioxide. The prototype system was completed in 2013 with industry funded trials. Demonstration trials and active deployments have been carried out in multiple facility types and production systems. The Livetec Systems Nitrogen Foam Delivery System (NFDS) produces 5000 – 6000 m³ (176,573-211,888 Cu ft) of finished foam per hour delivered through patented nitrogen foam generators. Each generator produces 50 m³/1765 Cu ft per minute, the residual oxygen within the foam matrix is less than 1%.

Deployment for Pigs

The use of inert gasses for euthanasia, slaughter and as a depopulation method for pigs has been extensively studied and has been approved by the European Union since 2009. Likewise, the AVMA has deemed that hypoxia resulting from exposure to inert gas mixtures is acceptable with conditions for euthanasia of pigs, however highlighting that it is typically not practical in farm situations.⁵ Research into the use of nitrogen filled foam for the euthanasia of pigs, (weaners, slaughter weight and adult) is being currently being conducted by institutions in Europe. Our own collaborative work in the USA funded by the NPB was unfortunately delayed due to COVID travel restrictions.

Preliminary research from Sweden indicates that pigs exposed to nitrogen foam lose posture within 60 seconds and are motionless around 131 seconds and showed no strong aversion to the foam.⁷