Case Study : Ventilation Accident in a Pig Finishing Building

Animals	Finishing pigs, near finish weight
Number of animals	~900
Loss	35 + growth loss of remainder
Duration of ventilation loss	56 hours
Ventilation system	ACNV curtains with fans
Location	Midwest US
Cause of loss	Operator error

Description

The building concerned holds finishing pigs which were close to slaughter weight.
Natural ventilation curtains were switched off in the fully closed position and left this way for approximately 56 hours.

The ventilation system has fans, but these are only used for low level ventilation during colder weather. The main ventilation is natural ventilation curtains on either side of the building.

The control system was set up so that fans are switched off during curtain operation stages, though they can switch back in at higher temperatures. This was set so that fans come back in if temperature rises to 30ºF above Set Temperature (in this case, approximately 98ºF.) The system has an over temperature alarm, but this was set to such a high value that it was not triggered during the incident.

Whilst selecting and removing pigs of target weight, curtains were closed using the manual override setting on the controller, and then the curtain motors were switched off, with the curtains in the fully closed position.

It's not clear why this practice was adopted. The decision to close curtains may be due to the poor regulation achieved using natural ventilation, due to the fact that the curtains are positioned identically throughout the whole building. This leads to large temperature variations within the building - typically 10ºF between sensors, and often up to 20ºF

With curtains in controller override, fans are automatically enabled, so during this period (of around 5 hours), temperatures in the building were normal.

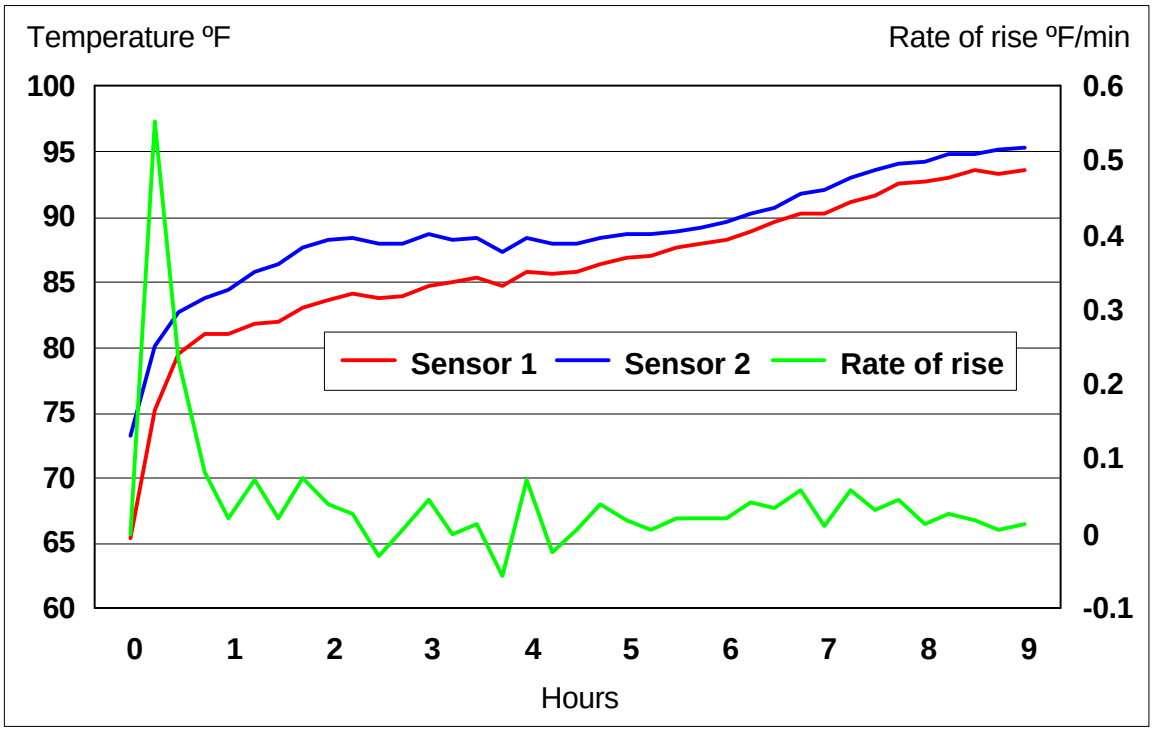
On completing the task just after midday on Friday, the controller was returned to automatic operation, but the curtains were still switched off.

Whether through accident, oversight or misunderstanding, it is clear from logging that the building was left in this condition for around 56 hours (until Sunday evening at about 7:45pm). At this time, curtain motors appear to have been switched on again, and temperature soon returned to normal.

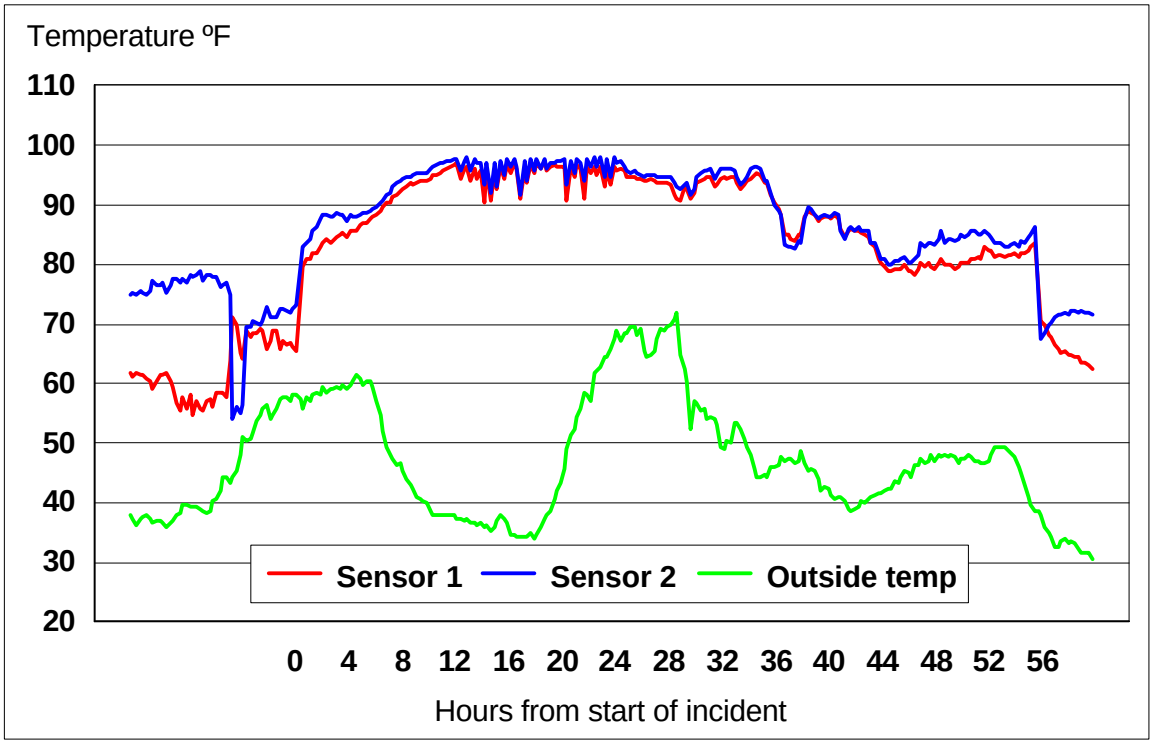
The following morning, 35 pigs were found to be dead. This is a surprisingly small number considering the considerable time which had elapsed without effective ventilation, and during which extreme temperatures were experienced.

With no ventilation, temperatures rose. Left as it was, curtains were closed and unable to operate. Fans could be switched on by the controller, but with the settings as they were, would not switch on until room temperature reached about 98ºF.

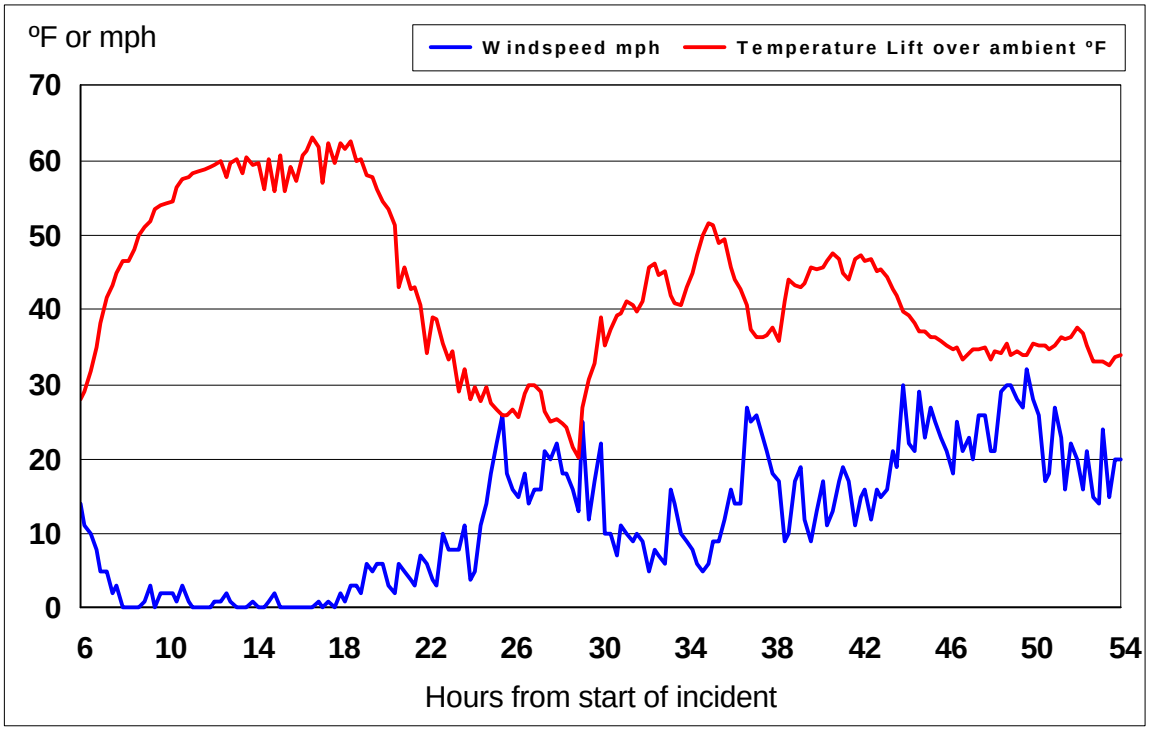
As in previously recorded incidents, the initial rate of temperature rise was high (over 0.5ºF per minute), but this not sustained. Within an hour, the rate of rise fell to below 0.1ºF per minute.



After about 12 hours, room temperature was high enough to cause fans to switch on. Due to a switching band, they would remain on only until (sensed average) room temperature dropped to about 94ºF. This cycle (up to 98, down to 94ºF) was repeated for around 12 hours or so.



Fan ventilation - albeit with limited capacity, and only dropping the room temperature marginally - may have alleviated pig suffering somewhat by relieving humidity, and may have contributed to the remarkably high survival rate from this incident.
The situation was roughly stable, about 60ºF hotter than ambient, for around 12 hours. Thereafter (about 24 hours or so into the incident), temperature began to fall. This appears to be due to a rise in wind speed - previously low.



This higher wind speed resulted in establishing a certain (low) ventilation rate, and it can be seen that temperature lift above ambient (indicative of ventilation rate) is inversely related to wind speed, though winds from different directions have varying effects.

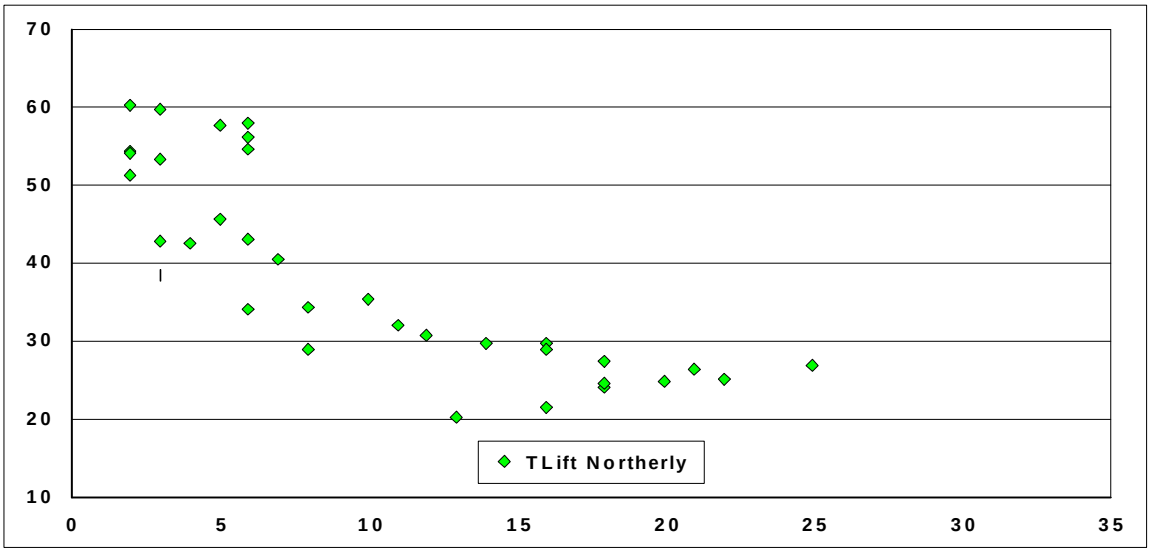
On the following page, wind direction has been roughly classified into North East or South (no winds recorded from the West), and the relation between temperature lift and wind speed indicated. During the incident, winds started mild and northerly, swinging around to the south and much stronger, before finally easing and veering to the north again.

It appears that the building is more exposed - or more sensitive - to winds from the North, as this has a greater effect in reducing temperature lift than other directions. For example, a 20 mph wind from the south gives around 38º temperature lift, whilst the same speed wind from the north results in only a 25º temperature lift.

However, ventilation in this way (relying as it does on small leaks in the building)) might be due to localised effects such as pressure differences and direction of apertures. (Also, it cannot be certain that the anemometer is correctly oriented.)

Evidently, even in a building which is intended to be relatively well sealed, wind causes significant leakage. In this incident, this has turned out to be fortunate, but - bearing in mind that the building is used for young animals, with a considerable heating requirement - better attention to sealing and wind protection is indicated. Heat output of the pigs in the building is of the order of 150 kW, but gives only a 25ºF temperature lift over ambient in a 20 mph wind without any supplementary ventilation. Clearly, massive heating input would be needed for young animals in cold and windy conditions with this rate of leakage.

According to logged data, the fogger was running (with a time cycle) for the duration of the incident. If so, it may well have contributed to survival. However, it is not certain whether or not it was switched on (electrically, or water mains turned on).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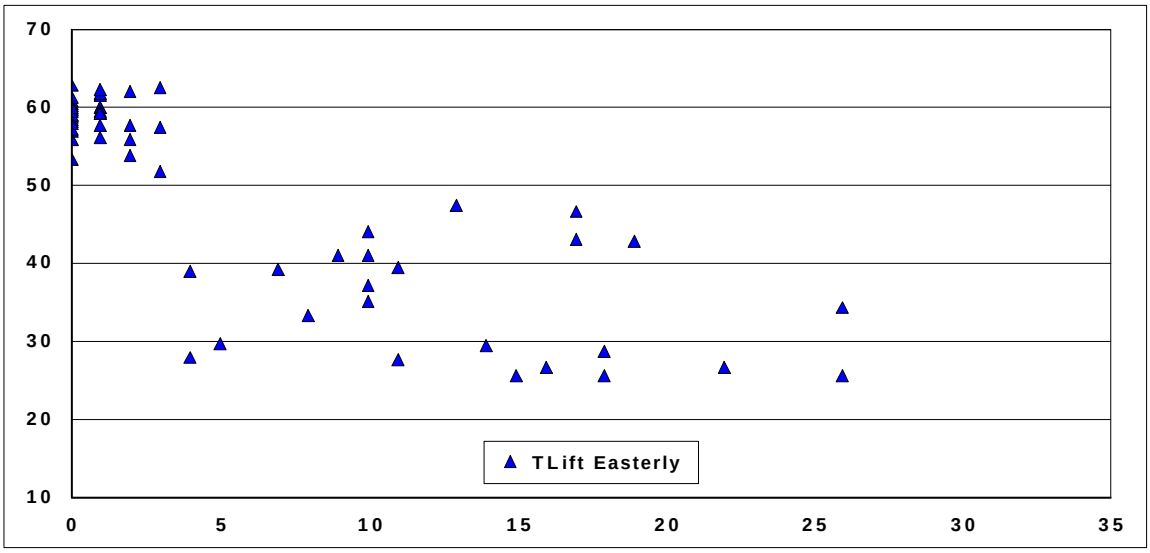
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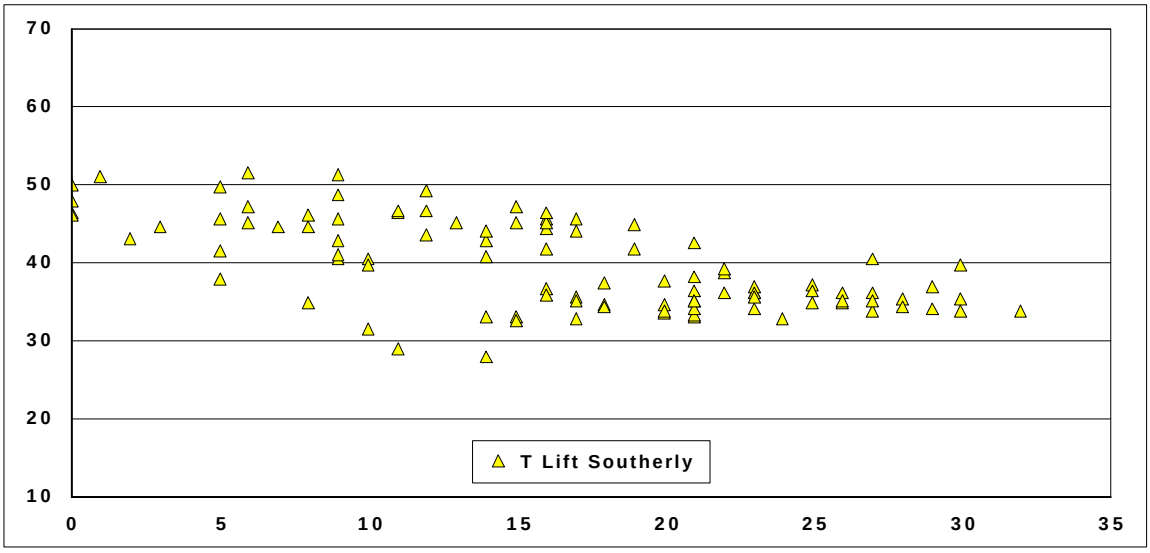
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Discussion

As with any accident, there are several causes, each of which in isolation was not fatal, but produced a tragedy in combination. If the curtain motors had been switched on , if the fan offset had been smaller, if the building had been visited sooner, if the alarm had been set.

The most remarkable fact is the extremely small number of animals which died, considering the circumstances - a building of pigs at maximum weight, left to its own devices for 56 hours. That so many lived is something of a tribute to the extreme desire to survive shown by the humble pig, as compared to other livestock species.

Whilst considering the cost of the incident, however, the cost in impact on the survivors will in all probability be much greater than the cost of the dead pigs.

Factors which may have lead to such a high survival rate (over 96%) should be considered, as well as those which lead to the accident. Some ventilation - even a tiny amount - may have been a factor, and foggers - if functional - would certainly have contributed. The fan restart feature in the controller was probably significant, though the trigger level setting was excessive. The high wind speeds for a good part of the incident were extremely fortuitous.

It's not suggested that buildings should be deliberately built badly so as to allow leakage. However, it does suggest that even small and grossly undersized magnetic drop out flaps (undersize by stack effect calculations, that is) increase survival times to a significant degree in moderate winds.

A crucial lesson is that any system is only as good as the way that it is used, and this appears to have been the general failing in this case.

The greater the flexibility that a system provides in operation, the greater care that must be taken to avoid errors. It's a mental trap to think only in terms of what goes wrong, since this misses opportunities to get a better result. But it is important to consider both the upside and the downside in a particular course of action.

To take a couple of easy examples in this case -
The curtain motors have a switch, presumably to allow them to be switched off for routine maintenance, adjusting cables and so on. This was used in this case, though for what reason is unclear. When taking the action to switch them off, what thought - if any - was given to making sure they would be switched on again afterwards?
The alarm has temperature settings which allow a wide range of setting for a range of circumstances. Clearly, this will also allow setting to values completely inappropriate for some situations, as here.

There is no real substitute for a detailed management plan, with each step carefully considered in terms of both positive and negative benefits. In drawing up such a plan, managers should take specialist advice, but should not rely solely on generalised schemes, instruction manuals, or expect a plan for their own site to be provided by equipment manufacturers. Specific and repeated training and exercises with on site staff are essential.