Health and Safety Executive OC 400/10

Field Operation Division

To

Agricultural Inspectors

FCG Specialist Inspectors (Occ Hyg)

Employment Medical Adviser

NITROGEN DIOXIDE AT SILAGE CLAMPS

This OC replaces NIGM 09(Ag)/1992/10. It describes the hazards presented by nitrogen dioxide gas (NO_2) at silage clamps, identifies major risk factors and suggests practical control measures.

BACKGROUND

1 The hazards presented by nitrogen dioxide ($NO_{2)}$ and other harmful gases in tower silos are well known. It is now apparent that oxides of nitrogen can also be generated in and released from the more conventional clamps seen in the United Kingdom. Incidents involving human ill-health and animal death have been investigated, and a local project involving detailed assessment of clamp filling and measurement of gas levels at various sites has identified significant risk factors. During that project, levels up to 500 times the short term exposure limit (OES) for NO_2 were found and prohibition notices served.

CHEMISTRY AND EFFECTS

2 Oxides of nitrogen (including NO_2 gas) are generated when nitrate rich grass is cut for silage before the nitrate is converted to protein. Once in the clamp, when rapid fermentation occurs and the pH drops, the nitrogen from the dissolved nitrate is released as a mixture of nitrous and nitric oxides. On contact with air the latter oxidises to nitrogen dioxide. The NO_2 appears to be released within 12 to 72 hours of ensiling the grass. Yellowing of the grass in pockets, at edges etc may indicate the presence of NO_2.

3 NO_2 is heavier than air, has a bleach-like smell and is brown in colour. It is freely soluble in water to form nitric acid. If the gas is inhaled, it dissolves in the surface moisture of the respiratory tract and acid can cause severe and irreparable lung damage. Eye irritation results from a similar process. Exposure to large doses can be fatal and regular limited exposure may lead to chronic respiratory symptoms.

4 The 8-hour and 10-minute occupational exposure standards for NO_2 are 3ppm and 5ppm respectively.

RISK FACTORS

5 The main risk factors are described in paras 6-10.

High non-protein (ie nitrate) nitrogen levels in the grass

6 These are related to high levels of nitrogen applied as fertilizer (slurry, farmyard manure or artificial) to the growing crop especially when that fertilizer is poorly utilised by the grass. Dry weather early in a season followed by heavy rainfall shortly before harvesting will encourage late nitrogen uptake and poor conversion to protein. Many farmers sample grass before mowing, to quantify levels of protein, dry matter (DM), fibre etc. Such analysis can also determine whether applied nitrogen has been utilised adequately. A level of <0.01% (fresh weight) Nitrate-N indicates a reduced NO_2 risk.

Grass dry matter

7 Where DM is high (ie low water content) from, for example, dry growing conditions before harvest, a long wilting period, or use of a conditional mower, then compaction during clamping can be more difficult, leading to higher oxygen levels within the clamped grass. The greater amounts of NO_2 generated will not readily be dissolved in moisture (because of the low water content within the clamp) and are more likely to be released as gas. Having a high target DM to limit effluent production will therefore increase the risk of NO_2 release.

Clamp working practices

8 Very fast high output machines such as self-propelled harvesters may result in a faster supply of grass to the clamp, less efficient rolling and increased air content increasing the risk of NO_2 generation. The capacity and type of the machine used for compaction and the skill/commitment of the operator are also important.

Poor clamp sealing

9 This allows both air contact and NO_2 release. A well sealed clamp will virtually eliminate NO_2 release and reduce silage loss around the edges.

Ventilation

10 Open and well ventilated clamps have been shown to have low NO_2 levels (if any) above the sheeting and minimal risk. Conversely very high levels have been found above the clamp sheet and in pockets at enclosed, poorly ventilated clamps. Clamps within fully clad buildings housing animal accommodation or enclosed areas which people enter are more likely to present a serious risk. Enclosed buildings with only one unclad end may lead to higher NO_2 levels at the closed end as a result of air movement of the gas. Since NO_2 is more dense than air, the gradient of a clamp may also create pockets of the gas.

CONTROL MEASURES

11 Practical control measures will be related to the 5 risk factors identified. Occupiers may control

the risk of NO_2 at source by changing their growing and ensiling practices, particularly clamp rolling and sheeting efficiency.

12 Occupiers can improve clamp ventilation in enclosed buildings by removing cladding sheets, using Yorkshire boarding or opening sheeted gates during the risk period after ensiling. Ventilation will also help to disperse any fume generated by the engine of the vehicle used for compaction.

13 Occupiers may need to prohibit entry to the clamp building during the risk period, and remove animals from nearby enclosed accommodation entry into which may put humans at risk from NO_2. If entry is to be prohibited, suitable signs will be necessary.

ACTION BY INSPECTORS

14 At visits, Inspectors should draw attention to the risks of NO_2 generation during silage making and suitable control measures especially where clamps are identified in poorly ventilated situations.

15 The Livestock and Stationary Machinery NIG welcome details of any further incidents, including investigation reports if available.

Cancellation of instructions

16 NIGM 09(Ag)/1992/10 - cancel and destroy.

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ASI headings

Agriculture: nitrogen dioxide: silage: silos: storage