Fact Sheet

Using Windbreaks to Manage Odor from Livestock Facilities

Purpose

The purpose of this fact sheet is to help raise awareness of the opportunity to include windbreaks in the management of animal production facility odors. Also discussed are factors important to deciding if a windbreak is appropriate, as well as considerations for design.

Introduction

Over the past few decades, odor management has become an increasingly important issue in the livestock and poultry industries nationwide. The face of rural America has changed as production trends have shifted from small, diverse operations throughout the country to greater concentrations of large scale confined animal operations resulting in larger animal production facilities producing greater quantities of manure. The increased quantity of manure has the potential to produce more intense odor, more frequently and for longer duration.

At the same time, more people from urban areas have moved further out into rural areas. Numerous conflicts and legal actions have arisen throughout the country as a result of concerns about the impact these facilities have on quality of life, health, the environment, real estate values, communities and neighbor relations. The increased potential for litigation and conflict has resulted in a greater effort to manage odor emissions from livestock production facilities.

About Windbreaks

A windbreak is a planting of trees or shrubs designed to modify wind flow. NRCS has promoted windbreaks for the better part of the last century for a number of purposes that range from reducing soil erosion from wind, to managing snow, to protecting farmsteads, to storing carbon. Today people are beginning to explore the potential benefits windbreaks have for managing odor.

USDA NRCS Photo Gallery

Windbreaks serve many purposes. They have commonly been used to protect farmsteads and operations from harsh winter winds.

What is a windbreak?

A windbreak is a planting of trees or shrubs made up of either single or multiple rows of vegetation grown to form a wind barrier.

Windbreaks can…

- *reduce wind erosion*
- *manage snow*
- *protect farmsteads*
- *store carbon*
- *reduce odors*
- *increase habitat*

Stand downwind from a windbreak on a windy day and their benefits are immediately apparent. A windbreak creates a protected zone on the downwind side that extends from 2 to 5 times the height of the vegetation. Reduction in wind speed, to some degree, can extend up to 10 times the height of the vegetation.

About Livestock Odor

In livestock production, odors come primarily from land application areas, livestock operations with buildings or open lots, manure treatment/storage facilities or manure transport systems (Auvermann, 2002). Of these sources, surface application of hog manure is often cited as the biggest offender, followed by poultry and cattle feeding operations.

As the manure breaks down, hundreds of chemicals and chemical compounds are produced that combine to create that familiar manure smell. There is a general consensus that once these gases are emitted, if they travel any distance, they are primarily transported as attachments to dust particles.

'Large quantities of airborne dust are often found in and around animal confinement buildings' (Tyndall, 2000). The dust originates from a number of sources including feed, bedding materials and the animals themselves. Windbreaks have the potential to filter dust and reduce the movement of odor. While the limitations and benefits of using windbreaks to manage odor have yet to be fully evaluated, limited research and anecdotal evidence suggest that windbreaks can be effective tools in managing odors from livestock and poultry operations.

Odor Management Techniques

The animal production industry employs a variety of techniques to manage odor emissions from livestock and poultry facilities. The three main strategies for controlling livestock and poultry odor are:

1. *Prevention of odor through feed and manure additives, solid liquid separation, manure aeration and general good housekeeping*
2. *Capture and destruction of odorous chemicals using chemical scrubbers and biofilters*
3. *Collection, dispersion & dilution of odorous chemicals using windbreaks and shelterbelts (Tyndall, 2000)*

Windbreaks and Odor Management

As wind blows across a windbreak, a number of interactions occur that are beneficial not only for the management of wind and snow, but also for the management of odors. (Figure 1) These **interactions** include:

1. **Creation of zones of protection**
2. **Creation of an area of turbulence**
3. **Filtration**
4. **Redirection of the wind**

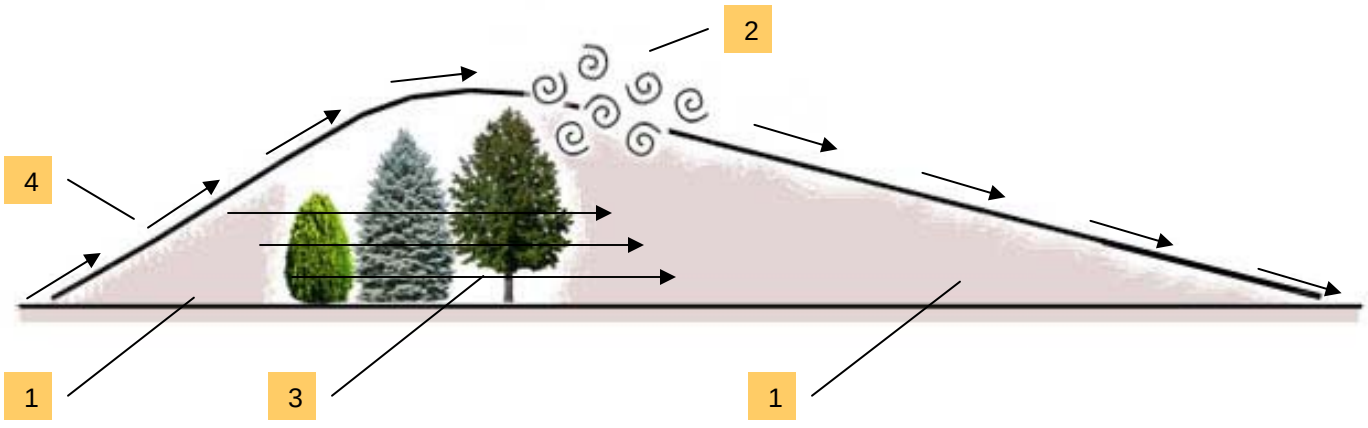

Figure 1 - Wind interacts with a windbreak in a number of ways.

These interactions can be used to manage dust and odors by designing and constructing windbreaks to:

1. Prevent odors and dust particles from being picked up by wind
2. Encourage deposition of dust particles that transport odors
3. Intercept and filter odors and dust particles already airborne
4. Disperse and dilute odors

Zone of Protection

The areas of still air or **zones of protection** created on the leeward side of a windbreak and a small zone of protection on the windward side are the most commonly recognized attributes of a windbreak. On the leeward side, the side downwind of a windbreak, an effective zone of protection extends for a distance of 2 to 5 times the height of the windbreak. A less effective but still significant reduction of wind speeds will exist up to 10 times the height of the windbreak. The zone of protection is most often used to protect farmsteads from strong winter winds. For managing odors, the zone of protection can be used to both **prevent odors from being picked up by the wind** and to encourage **deposition of dust particles** already carrying odors. (Figure 1)

Wind borne dust moving past odor sources such as open manure storage tanks, lagoons, open lots or fields where manure has recently been applied can pick up and transport odorous gases from these surfaces. Windbreaks located upwind of these odor sources would create a zone of protection to help prevent the dust and odors from being picked up and transported. (Figures 2 & 3)

Figure 2 – Open lots can be a source of particulates and odor.

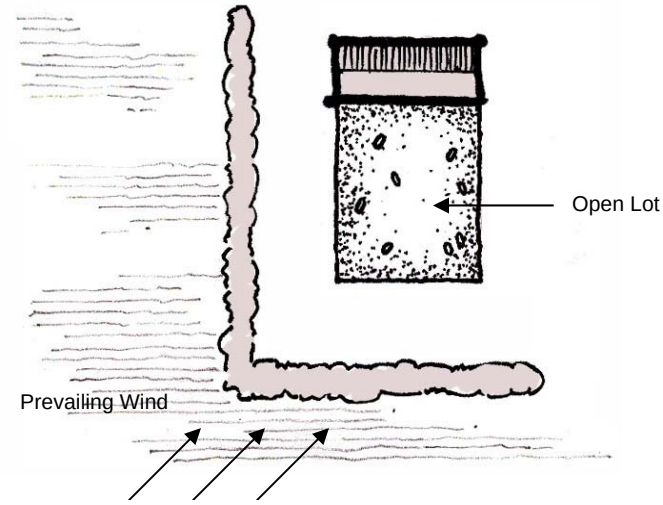

Figure 3 – A windbreak planted upwind of an open lot can reduce the movement of particulates and odor.

The decreased wind speed in the **zone of protection** can also be used to encourage **deposition** of dust particles carrying odors in the same way that windbreaks encourage the deposition of snow. The zone of protection created by a windbreak located downwind of an odor source promotes deposition of dust particles carrying odors. Deposition occurs when heavy dust particles drop out in the slower moving air.

Windbreak as Filter

When wind moves through a windbreak, the windbreak acts as a filter, trapping particulates. The leaves, branches and trunks of the vegetation **intercept and filter** dust and odor. Research suggests that vegetation such as conifers with complex leaf shapes and greater surface area collect particles more efficiently than deciduous vegetation.

Air that passes over dust and odor sources such as solid manure storage or fields where manure has recently been applied, or air that has been exhausted from mechanically vented livestock confinement buildings, will likely pick up dust and odors. Windbreaks can be located downwind of these odor sources and exhaust systems to **intercept** odor particles, **filtering** the air. (Figures 4 & 5)

Figure 4 – A windbreak in central Illinois is planted to filter particulates and odor exhausting from fans.

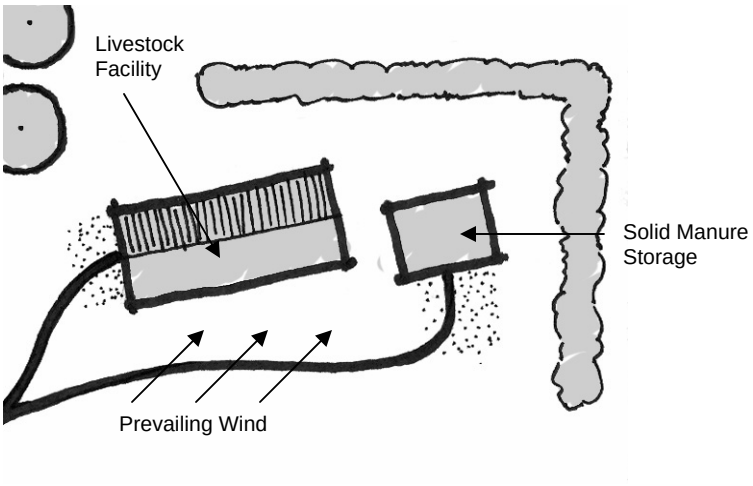

Figure 5 – Windbreak planned to filter and promote deposition of particulates coming from solid manure storage.

In addition, **filtration** can be used to **intercept** dust particles before they pass over a field where manure has been applied. Dust particles that adhere to the surface of leaves and branches are then not available to pick up or transport odors from fields where manure has been applied. At the same time the windbreak filters out dust particles about to blow across a field, a zone of protection is also created on the downwind side where deposition can occur and where reduced wind speeds will not pick up additional odor particles. (Figures 6 & 7)

Figure 6 – Windbreaks can act as filters for wind carrying particulates and odor. In addition, the zone of protection created by the windbreak prevents odors from being picked up and encourages dust particles to drop out downwind of the windbreak.

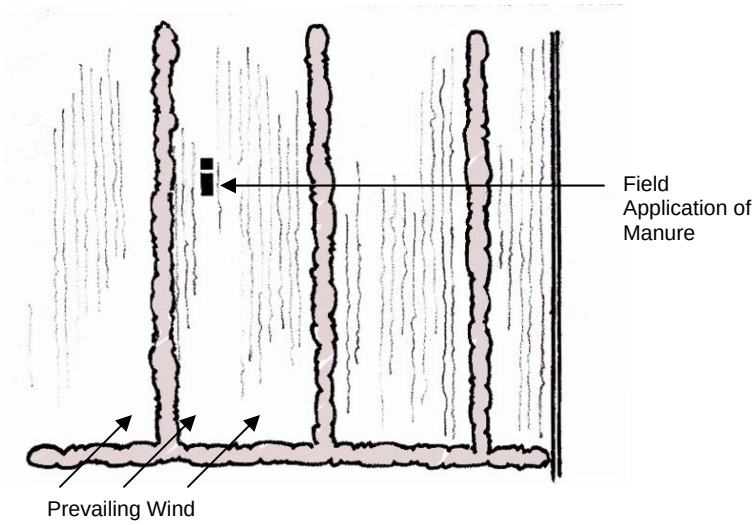

Figure 7 – Windbreak installed to prevent wind erosion. The windbreak also filters air as it moves through the windbreak, encourages deposition of particulates and prevents particulates from being picked up.

Turbulent Zone

In addition to the zone of protection, a turbulent zone is created at the top of a windbreak.

Once odors have been picked up from sources such as a production building or an open manure storage tank, a windbreak can redirect the wind up and over the trees, lifting dust and odors up into the lower atmosphere above people and residences where they would be regarded as offensive. At the same time, the turbulent zone at the peak of the windbreak has the potential to **dilute** and **disperse** odors, reducing their intensity and concentration. (Figure 8)

As wind is pushed up over the windbreak, air compresses and then expands while passing the crest of the windbreak creating an area of turbulent air. (Figure 1) Although not conclusive, the turbulence causes some of the air stream to mix into adjacent layers of air in the lower atmosphere allowing for some odor dispersion. Engineering models have shown that the turbulence contributes to a slower release of particulates into the downwind air stream diluting the odor plume.

Figure 8 – The turbulent zone of a windbreak has the potential to dilute and disperse odors picked up from sources such as manure storage tanks.

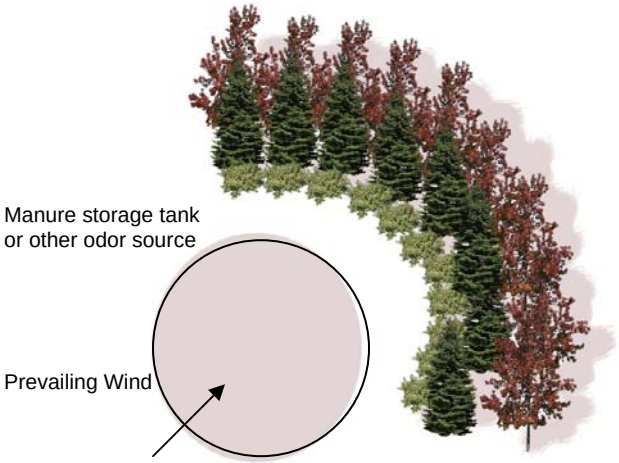

Figure 9 – Windbreak directs air stream into lower atmosphere and turbulent zone, diluting and dispersing odors.

Wedge Shaped Windbreak

Some research has indicated that wedge shaped windbreaks, with the tip of the wedge facing into the prevailing wind, can push airstreams higher into the atmosphere. (Tyndall, 2000)

A row or rows of shrubs, conifers and deciduous trees planted in combination would create a wedge shaped windbreak that would grow quickly, have branches and leaves at ground level and reach great heights.

Key Considerations for Windbreak Design

Understanding the benefits and limitations of using windbreaks to manage odor from animal manure is necessary to determine whether or not a windbreak is appropriate for a given odor management need or management style.

Benefits
For many, windbreaks are a familiar technology. For years NRCS has promoted and landowners have grown windbreaks. People know what they are. Many know how to establish and how to maintain them. Once established, they require regular maintenance to manage grass and weeds, monitor plant health and perform renovation when necessary. However, maintenance is generally minimal.

In addition, one windbreak has the potential to offer multiple benefits. At the same time a windbreak is working to manage odor from livestock facilities, the windbreak can also be working to conserve energy, reduce soil erosion, manage snow, provide shelter for livestock, habitat for wildlife and create visual screens.

As a windbreak screens unsightly facilities, appearance of the operation can be improved by softening buildings and visually breaking up the operation. The aesthetic benefit can be one of the most important benefits of a windbreak. Improved appearance has the potential to help maintain and improve relations with nearby residents.

Finally, compared to other technologies, windbreaks can be a low cost component of an odor management plan.

Limitations
Windbreaks alone will not completely prevent odor problems associated with animal manure. Depending on the odor management needs of a particular site, a windbreak may need to be used in conjunction with other odor management tools such as good housekeeping, food & manure additives, chemical scrubbers and bio-filters.

Another limitation of windbreaks is the time required for a windbreak to become fully functional. Windbreaks designed according to NRCS standards are considered to be at a fully functional height at 20 years. However, partial closure is achieved earlier and some benefit is realized before that point. Windbreaks that include fast growing deciduous trees can be functioning within as little as 5-10 years and reap aesthetic and screening benefits within just a few years. The public relations benefit of these windbreaks can occur immediately.

Planning Considerations

Once the decision has been made to use windbreaks, the following considerations will help determine where windbreaks could be located to effectively manage odor.

- Where are odors coming from?
- When are odors most likely to occur?
- Where are people located for whom odor would be a concern?
- What is the prevailing wind direction?
- From what direction does the wind blow during time(s) of year when odors are likely to be an issue?

The information is then used to identify locations where windbreaks could be located.

Potential locations should then be evaluated against other criteria such as snow deposition, location of utilities and other on-site infrastructure, ventilation requirements, movement of vehicles, aesthetics and possible future development.

The following section outlines design considerations important for locating a windbreak for odor management and selecting vegetation, as well as other general considerations.

Design Considerations

Prevailing Wind Direction

Prevailing wind direction is important in the design of any windbreak. Not only necessary to understanding the movement of odors, knowledge of the prevailing wind direction is also important for managing snow deposition and building ventilation. For accurate local information on prevailing winds in Illinois, refer to the Illinois State Climatologist Office's website - www.sws.uiuc.edu/atmos/statecli/Roses/wind_climatology.htm.

Snow Deposition and Roadways

Windbreaks should be located so snow deposited near them does not interfere with nearby roadways or buildings, inhibit onsite movement of vehicles, nor pose health or safety problems.

Identifying where snow will accumulate is important. Most of the snow deposited near a windbreak is deposited on the leeward side, within a distance that is 1 to 4 times the height of the windbreak. Snow also accumulates on the windward side for a distance of 1 to 2 times the height of the windbreak.

In addition, deep snowdrifts form closer to dense windbreaks. As windbreaks become less dense, snow settles progressively farther away and is distributed more evenly.

Drainage patterns of snowmelt must be taken into consideration. Drainage of snowmelt from the windbreak should not flow into the livestock area or cause erosion.

Building Ventilation

Air movement around buildings should be maintained for animal and worker health and to allow ventilation systems to work properly.

For mechanically ventilated systems, trees can be planted relatively close. The closer the vegetation is to the odor source the more effectively it reduces odors. However, the health of the trees, prevention of back pressure on fans and snow deposition must all be taken into consideration when determining the distance between the ventilation system and the windbreak.

With mechanically ventilated systems, the health of the trees is generally of primary concern. Exhaust from fans increases transpiration in vegetation making them vulnerable to desiccation. In addition, accumulation of debris and the gases exhausted by fans creates a harsh environment for vegetation to grow.

For naturally ventilated systems, the concern is typically with prevailing summer winds. Trees planted in the path of prevailing summer winds may interfere with needed summer air flows. Many producers prefer no vegetation on the side of the building from which prevailing summer winds come.

Root Systems

There is some concern that root systems of vegetation may damage artificial or natural liners of earthen pits or lagoons, resulting in leakage into the surrounding soil and waterways. If planting near such structures, the rooting habits of the species should be considered.

Likewise, location of subsurface drains should be considered during planning. If planting near subsurface drains is unavoidable, non-perforated conduit should be installed in the area where tree planting is planned.

Where concerns exist about competition between a windbreak and an adjacent field for water and nutrients a root plow can be used to sever roots and reduce competition. Root pruning will impact tree growth and must be done with care. Root pruning should be done at the drip line to minimize negative impacts and only one side should be pruned in a given year. Wait until the tree has reached the desired height before root pruning.

Vegetation

Field and farm windbreaks most commonly use conifers. Conifers are trees and shrubs bearing needles and cones and are mostly evergreen. Conifers have a large leaf surface area and generally maintain their branches all the way to the ground. Conifers create the densest windbreaks for blocking winds. These characteristics are useful for capturing particulates and for blocking winds that can pick up odors. However as a group, conifers tend to be slower growing than deciduous trees. The species favored by producers using windbreaks to manage odor are often fast growing deciduous trees such as hybrid willows, poplars and maples.

Deciduous trees, trees that lose their leaves in the winter, tend to grow faster and reach greater heights than conifers. To capture the benefits of conifers, deciduous trees and shrubs, both types of trees as well as shrubs may be planted in combination. Shrubs also tend to grow quickly.

- Tree and shrub species selected must be adapted to the soils, climate and site conditions. For information on species selection refer to the Conservation Tree/Shrub Suitability Index in the Natural Resources Conservation Service electronic Field Office Technical Guide - http://efotg.nrcs.usda.gov/treemenuFS.aspx. For additional information on vegetation characteristics refer to USDA's PLANTS Database at http://plants.usda.gov.

- Diversity of species in a windbreak lessens the negative impact of potential disease or pest outbreaks - problems which can devastate a windbreak composed of only one species. However, trees should be spaced so deciduous trees don't overtop conifers. Deciduous and coniferous trees should not be planted in the same row.

- Maximize particulate trapping by selecting species with high leaf surface roughness (leaf hairs, leaf veins, and small leaf size), complex leaf shapes, large leaf circumference to area ratios and medium to rapid growth rates.

Techniques are available to reduce the amount of time needed to establish a functioning windbreak.

- Supplemental watering and control of competition from grasses and weeds are critical for fast establishment and growth. Mulch, such as landscape fabric, herbicides and mowing are commonly used to control grass and weeds. Mowers can cause considerable damage and mortality to seedlings. Care should be taken if mowing is used.

- Fast growing species may be selected, such as hybrid poplars, willow and some maples. However, producers planting fast growing species need to be aware that their windbreaks will likely require replacement or renovation in 10-20 years. Faster growing tree species are often shorter lived.

- Trees within a row can be planted on a tighter spacing to achieve quicker results. However, thinning and removal of trees will be necessary as the windbreak matures, to prevent trees from dropping their lower limbs and creating holes in the windbreak.

- Larger stock can be used, such as air-root pruned potted planting stock. For more information on air-root pruned potted stock, see "Container grown" planting stock in NRCS practice standard TREE/SHRUB ESTABLISHMENT (612). A complete copy of the standard can be found at http://efotg.nrcs.usda.gov/treemenuFS.aspx.

- Poultry facilities using windbreaks to filter exhaust from fans commonly plant larger stock (8-10') to improve success rates. Seedlings often succumb to desiccation and the accumulation of debris & ammonia exhausted from buildings.

- Staggering tree spacing, so the trees of one row will be planted opposite the openings in the adjacent row, will decrease the time needed for a windbreak to be effective.

Density

All windbreaks impact airflow. Windbreaks promote deposition of dust particles, uplifting and dispersion of odors and filtering of wind. Higher density windbreaks are planted to encourage uplift as well as dispersion and deposition of dust particles. Lower density windbreaks are planted to encourage filtering by allowing more wind to pass through.

Factors that determine density include:

- Tree species
- Growth rates
- Spacing between trees
- Number of rows planted
- Rows that are staggered or are not staggered
- Time of year (Deciduous vegetation)

All of these factors can be manipulated to make a windbreak more or less dense.

Enhancing Aesthetics

Improved aesthetics and improved neighbor relations are often some of the most important benefits windbreaks provide. Windbreaks visually impact the overall rural landscape in addition to improving the appearance of the individual farmstead.

Trees add diversity and visual interest to the landscape and become part of the overall landscape pattern or structure. Vegetation can help soften and visually break up buildings, making them appear smaller and less industrial, as well as screen them from view.

Closer up, characteristics such as the form, color, texture and layout shape the windbreaks appearance and aesthetic. A curvilinear layout can help to blend a windbreak into the landscape. Deciduous trees, coniferous trees, and shrubs planted in the same planting have a different appearance and different texture than a windbreak planted with only coniferous trees or deciduous trees. Showy flowers and brilliant fall foliage add interest during the spring, summer and fall. Colorful fruit and the green of coniferous trees add color to the winter landscape.

Habitat Considerations

Windbreaks enhance wildlife habitat by providing shelter and food. If transfer of disease between wildlife and confined livestock, particularly poultry, is a concern, the risks and benefits of the windbreak need to be evaluated.

An argument exists that windbreaks have the potential to reduce airborne transmission of disease from one facility to another by capturing and preventing pathogens from moving downwind. In addition, there have been instances where raptors have taken up residence in windbreaks helping to keep down rodent populations.

Selecting vegetation that does not provide food or shelter preferred by wildlife may be one way to minimize the potential of disease transfer while realizing the benefits of a windbreak.

NRCS Windbreak Standard 380

For more detailed information on windbreak design refer to NRCS Windbreak/Shelterbelt Establishment Standard (380) and the NRCS Illinois Windbreak Manual. Many of the design considerations mentioned above are discussed in more detail in the standard. All standards referenced in the document are available at http://efotg.nrcs.usda.gov/treemenuFS.aspx.

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