Innovative explosion protection concepts for dedusting plants

Confident and safe with Scheuch!
Emissionen 1/2004

PROVEN EXPLOSION PROTECTION SYSTEMS FROM SCHEUCH

Eighty percent (80%) of dust types encountered in industrial dust-extracting applications are capable of exploding. If flammable dust is present in dispersed form and sufficient concentration, and if sufficient oxygen and an ignition source are present, a dust explosion can occur. If ignition sources cannot be avoided with one hundred percent certainty — that is, explosions are permitted — extraction plants must feature “explosion protection design.” This means that the effects of explosive events must be kept to a tolerable level. There are a variety of options available for accomplishing this: decoupling, explosion release, and explosion suppression devices, as well as combinations thereof. Some of these devices fulfill the requirements demanded of so-called protection systems.

“With the exception of components, protective systems are design units that are intended to halt incipient explosions immediately or to limit the area affected by an explosion and that are separately placed on the market for use as autonomous systems.” (Directive ATEX 94/9/EC Article 1)

In detail, these systems are relief devices (e.g., rupture disks, explosion flaps and Q-pipes), suppression devices and decoupling devices. In the case of decoupling devices, a distinction is made between devices intended for pressure and flame de-coupling (e.g., rotary valves, and quick-closing sluice valves) and devices for partial de-coupling. Examples of the latter would be a device for pressure decoupling (e.g., pressure relief stack) or devices for the prevention of flame penetration (e.g., extinguisher barriers).

Decoupling Devices:

Crude gas line — Filter: Explosion protection measure must be implemented using the best available technology. For most applications, the decoupling of the crude gas line — filter is achieved using a non-return valve. The best available technology is described in the publications of the VDMA and professional associations. Alternatively, quick-closing sluice valves, pressure relief stacks or extinguisher barriers, or a combination of both, can also be used for this purpose.

Non-return flap: Airflow keeps this flap open during operation. An explosive event in the filter shuts the flap automatically when the pressure wave occurs. Advantages: Passive system, low cost.

Quick-closing sluice valve: Sensors positioned on each side of the quick-closing sluice valve recognize an incipient explosion and initiate closure of the valve slide. Closure times range from 50 to 150 ms. Advantages: Pipe is hermetically sealed, pressure- and flame-proof
Disadvantages: Active system, cost intensive, requires longer pipes, limited nominal width, the requisite force generated by closing of the slide must be absorbed.

Pressure relief stack: The pressure relief stack uses an explosion door or rupture disk to discharge the flame front and the pressure surge of an explosion directly to the outside atmosphere. This prevents the much feared “flame jet ignition” within the filter. In any case, pressure decoupling takes place via the pressure relief stack; flame decoupling is no longer assured for nominal widths ≥ NW650. In such cases, the flame front can be liquidated by installing additional extinguishing systems. Advantages of the pressure relief stack: Passive system, works in both directions. Disadvantages of pressure relief stack: Pressure loss ranging from 500 to 1000 Pa, flame penetration cannot be avoided in every application.

Extinguisher barrier:

A detector system recognizes an incipient explosion, extinguishes the incipient flame front using a so-called “Q-pipe”. In this case, containment strength through the targeted release of pressure using relief openings.

Decoupling takes place using a rotary valve. Advantages: No pressure loss. Disadvantages: Active system, consequently cost-intensive, no decoupling of the pressure wave.

Filterclean gas line with return air system:

Decoupling takes place either by means of an extinguisher barrier or by means of a significantly less expensive 2 × 50°-deflection device in combination with a rupture disk (Best available technology. Source: Association of the Wood Processing Industry).

Explosion Relief Devices:

Explosion relief of filter cases and containers takes place using certified rupture disks or explosion doors. Dimensions of the required relief area takes place according to VCI 3673 guidelines and the strength of the filter casing must be known. At Scheuch, this is determined through complex pressure tests, the results of which are certified by the TÜV or DMT. The operator must consider the effects of incipient flames and pressure on external areas during the relief process. As a rule, the relief process should only be used as a protective measure if dust and its incineration by-products are non-toxic.

If a filter is positioned in an interior space, or if the available relief area is too small for a filter positioned out of doors, relief can be provided using a so-called “Q-pipe”. In this case, conventional rupture disks are used to relieve the explosive pressure, and the incipient flame front is extinguished by a quenching process. Advantage: Filter can be positioned in work area.

Disadvantages of Q-pipe: Cost-intensive

Explosion Suppression Devices:

Another alternative when filters and containers are located in interior spaces is so-called explosion suppression. A sensor system recognizes an incipient explosion based on pressure behaviour over time. Powder or gaseous extin-

What happens during a dust explosion inside a closed container (e.g., filter casing)?

Once the mixture of dust and air ignites, pressure inside the container increases according to the following characteristics:

The maximum occurring explosion pressure Pmax has an average value of 7 to 10 bar. This contrasts with the container strength, which ranges only from 130 to 420 mbar (typical strength for filter casings or slits). As a protective measure, explosion relief prevents the explosive pressure in the filter from exceeding the container strength through the targeted release of pressure using relief openings. The maximum occurring pressure in the casing is designated Prep,max. The limiting pressure inside the filter can also be achieved through a protective measure called explosion suppression. In this measure, the explosion is extinguished in its initial phase.

Description of pressure profile:

The upper curve describes the pressure profile of a dust explosion inside a closed container. The maximum pressure increase along the rising flank of the curve serves as a measure of the intensity of the dust explosion. Multiplying this value by the cubed root of the container volume results in the so-called KST value. In explosion suppression, the explosion is stopped during its initial phase. The maximum occurring pressure corresponds to the so-called Prep,max value. The container strength must be somewhat greater to prevent destruction of the container. The pressure increase over time behaves in a similar way in the pressure relief method.

Customer consulting:

Because of technical and process-related differences, the selection of the suitable explosion protection measures varies for individual business segments.

The following employees provide consulting services during concept development:

Wood Processing Industry
Atos Burgstaller, Ext. 190
Particle and Fibre Board Industry
Gerhard Wissner, Ext. 173
Iron and Steel Industry
Christian Strauß, Ext. 261
Metals Industry
Johann Desch, Ext. 142
Powder coating plants
Christian Justl, Ext. 421
Explosion protection (general)
Helmut Sahlhammer, Ext. 240

[Diagram of explosion suppression system]
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In detail, these systems are relief devices (e.g., rupture disks, explosion flaps and Q-pipes), suppression devices and decoupling devices. In the case of decoupling devices, a distinction is made between devices intended for pressure and flame de-coupling (e.g., rotary valves, and quick-closing sluice valves) and devices for partial de-coupling. (Examples of the latter would be a device for pressure decoupling, e.g., pressure relief stack) or devices for the prevention of flame penetration (e.g., extinguisher barriers).

Decoupling Devices: Crude gas line — Filter: Explosion protection in protection systems must be implemented using the best available technology. For most applications, the decoupling of the crude gas line – filter is achieved using a non-return valve. The best available technology is described in the publications of the VDMA and professional associations. Alternatively, quick-closing sluice valves, pressure relief stacks or extinguisher barriers, or a combination of both, can also be used for this purpose.

1. Non return flap: Airflow keeps this flap open during operation. An explosive event in the filter shuts the flap automatically when the pressure wave occurs. Advantages: Passive system, low cost.
2. Quick-closing sluice valve: Sensors positioned on each side of the quick-closing sluice valve recognize an incipient explosion and initiate closure of the valve slide. Closure times range from 50 to 150 ms. Advantages: Pipe is hermetically sealed, pressure- and flameproof
3. Pressure relief stack: The pressure relief stack uses an explosion door or rupture disk to discharge the flame front and the pressure surge of an explosion directly to the outside atmosphere. This prevents the much feared “flame jet ignition” within the filter. In any case, pressure decoupling takes place via the pressure relief stack; flame decoupling is no longer assured for nominal widths ≥ NW650. In such cases, the flame front can be liquidated by installing additional extinction barriers.
4. Extinguisher barrier: A detector system recognizes an incipient explosion; extinguishing system must always be coordinated with the propagation speed of the explosion in the pipeline. Advantages: No pressure loss. Disadvantage: Active system, consequently cost-intensive, no decoupling of the pressure wave.
5. Filter: Decoupling takes place either by means of an extinguisher barrier or by means of a significantly less expensive 2x 50°-deflection device in combination with a rupture disk (Best available technology. Source: Association of the Wood Processing Industry).

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Disadvantage of Q-pipes: Cost-intensive

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THE SCHEUCH FILTRATION PLANT AS COMPLETE SYSTEM

The requirements for the national implementation of the ATEX guidelines have been redefined and tightened. Depending on one’s point of view, there are also various ambiguities for the professional world that create uncertainty.

General
With respect to filtration plants, for example, there are many open questions:
- Correct location of the filter plant based on the existing danger of explosion (zone requirement)
- Installation position of the rupture disks: Down below in the area where an explosion might occur?
- Flame range: Under what conditions do the filter’s surroundings protect the filter’s surroundings?
- Are the often proven decoupling measures “check valves” in the crude gas area and “decompression with pressure relief in the clean gas area - adequate according to AT-EX”?
- In the case of relief on the clean gas side, by what factor must the pressure relief surface be increased?

So on and so forth.

Initial Situation / Objective for Scheuch
In the wood processing and wood-based panel industries, stationary filtration plants are design-engineered with explosion protection, usually with explosion pressure relief and decoupling measures. Currently, there are recognised testing options only for rotary valves and pipe non return flaps (Scheuch has already offered tested products for some time) but there are currently no official testing options for other equipment. Even previous testing of pipe non return flaps as an autonomous protective system by the VDI raises doubts with respect to their intended operation. While a flow rate of 20-30 m/s with simultaneous transport of material occurs in actual practice, VDI testing is purely static (without material transport). Questions and concerns about the possibility of applying the testing process to the actual application are thus quite valid.

For this reason, we wanted to allow a complete filtration plant to be tested under practical conditions.

Testing Method
In cooperation with Germany’s Holz BGI, a wood industry trade organisation, Scheuch GmbH of Aurolzmünster therefore commissioned a testing institute with practical testing of a wood dust filter. This institute was the FISA Forschungsgesellschaft für angewandte Technologien in D-68165 Mannheim. A suitable test dust for the existing danger of explosion (Zone 1, Flammengruppe II2D, Explosionsgasgruppe L) was selected in cooperation with the Holz BGI and the testing conditions were set in such a way as to represent a worst-case scenario for the test filter.

To determine the representative test filter, Scheuch calculated proportionality ratios for all filter types and sizes. To calculate the ratios, Scheuch determined and compared the crude gas volumes, clean gas volumes, the filter base free surface area, the filter surface area, maximum air volume, the rupture disk surface area and other factors. In order to carry out testing under practical conditions, a fan with extraction line and a material feeder with metering station were erected. Testing occurred at crude gas dust loads of 50 g/m²·h, 80 g/m²·h, 100 g/m²·h and 150 g/m²·h. Dust concentrations in the filter were determined during filter operation and during the cleaning process. The so-called “test shots” occurred optionally with an empty bunker or with material bunkering.

Prior to actual explosive testing, Scheuch cooperated with the Holz-BGI in determining from the manufacturer’s information the expected maximum dust concentration that can occur in practical operation prior to filtration in filters of the type studied. In addition, we determined the distributions of particle sizes in three representative dust samples taken from wood dust filters located at plants in the wood processing industry.

Results / Findings
Decoupling measures
In all tests with relief on the crude gas side in combination with a non return flap, 90° deflection with upward relief and a rotary valve, there was no propagation of flames or pressure from the filter into the extraction pipe or from the filter discharge into the clean air duct. Therefore, the plant as tested in its entirety - using Scheuch’s construction method - is a suitable device with integrated decoupling when operated in a correspondingly approved manner.

Installation position of rupture disks - Flame range
The series of practical tests confirmed the explosion of unburnt dust from the opened pressure relief outlets. There is a danger of secondary fires and secondary explosions. The range and intensity of the dust expulsion depends on the explosion pressure $p_{ex}$ of the event and the reaction pressure of the relief device.

Previous assumptions, whereby rupture disks positioned as high as possible, with installation heights starting at 8 meters, were thought to eliminate the danger near ground level, could not be confirmed based on the dust discharge and subsequent ignition.

With respect to the range of flames outside our filtration plant, the operator can consider for his risk assessment either the previous calculations according to VDI or alternatively our own flame profile, which is the result of many practical tests.

In summary, it can be said that in the case of many of the “test shots”, the flame range was substantially less than expected and that the pressure development was not so intense as assumed. Despite our reduced flame profiles, filter locations are still often problematical with respect to the range of flames in an explosion. This is especially true when roadways or property borders are located within the flame profile. For this reason, we tested new options for pressure relief during these tests and will soon be able to offer customers who require them filter plants that exhibit even smaller flame profiles with our new protective system.

Lower explosion limit (German: UEL) for Wood Dust
Because the first series of tests with crude gas dust loads of 50 g/m²·h was unable to produce ignition despite ignition energies as high as 10,000 Jules, we examined the lower explosion limit (UEL) more closely. It was found to be approximately 60 g/m²·h as measured with the addition of the most unfavorable dust type (original) in a container with a capacity of 1 m³.

A UEL of 30 g/m²·h, as mentioned in the pertinent literature, could only be achieved by re-screening the dust (impossible in actual practice). Accordingly, a UEL of 30 g/m²·h already includes a safety margin of 50%. With respect to the best available technology, reference should be made here to the view of the Austrian implementation of the cooperation variant of ATEX RL(1999/9) EG, and to its 50% shortfall of the UEL. A holistic safety margin of 50% is unnecessary. The only dust content is relevant when considering an explosive atmosphere. Additional coarse material such as chips or shavings reduces the ignition propensity.

The probability of an event
Despite an unfavorable dust concentration and a correspondingly large ignition source, a dust explosion was not always possible. A corresponding concentration of dust is necessary because of turbulence within the filter. Filter flaps and a slight pressure increase only occurred when crude gas dust loading reached levels of 80 - 100 g/m²·h. An explosive effect according to VDI calculations is extremely unlikely, but not impossible.

Bag bottom and filter bags as pressure barriers
A smaller pressure increase was measured in the clean gas area of the filter than in the crude gas chamber. This led to the realisation that compared with the crude gas volume, the free surface area of the bag bottom plays a key role in determining the value of $p_{ex}$ in the clean gas chamber.

Conclusion
We are able to prove that Scheuch’s IMPLUS filter provides the wood processing and wood based panel industries with a complete system that has now been certified by a recognised German testing institute.

The know-how acquired during the tests will be used for the benefit of our customers with respect to design, consultation and support in connection with explosion zones, the avoidance of ignition sources, design-engineering of explosion protection systems, filter location, decoupling measures, flame range, etc. In this case - explosion protection and fire protection - our expenditures for the practical, basic research have also proven to be worthwhile and we have yet another confirmation for our proposition: “Confident and safe with Scheuch.”
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- Installation position of the rupture disks: Down below in the area where an explosion originates or as high as possible in order to protect the filter's surroundings?
- Flame range: Under what conditions do flame ranges of 35 meters and more occur compared with the crude gas volume, the free surface area of the bag bottom and filter bags as pressure barriers?

Installation of pressure relief outlets. There is a danger of secondary explosions. The range and intensity of the dust expulsion depends on the explosion pressure p_{ac} of the event and the reaction pressure of the relief device.

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Scheuch determined and compared the crude gas volumes, the filter base free surface area, the filter surface area, maximum air volume, the rupture disk surface area and other factors. In order to carry out testing under practical conditions, a fan with extraction line and a material feeder with metering station were erected. Testing occurred at crude gas dust loads of 50 g/m³, 80 g/m³, 100 g/m³ and 150 g/m³. Dust concentrations in the filter were determined during filter operation and during the cleaning process. The so-called "test shots" occurred optionally with an empty bunker or with material bunkering.

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The well-known and significant risk potential resulting from high pressure and long flame ranges of up to 60 m resulted in more frequent attempts to direct venting “upwards” instead of relying on side venting using rupture disks. The limited available pressure venting area on the silo roof makes calculations according to VDI 3673/Appendix A absolutely necessary. The use of this method of calculation nevertheless resulted in such large pressure venting areas in the silo roof that the risk-free installation of separation equipment or maintenance access on the silo roof was possible only to a limited extent.

For this reason, Schuech began a test project with a respected silo manufacturer in order to study and verify the danger zones for pressure venting systems directed to the side and also upwards, much like Schucb’s well-known explosion protection concept for filtration plants.

An additional goal was to expand the reduction formula according to VDI 3673/Appendix A, independently of the maximum silo inlet opening of Ø 300 mm, which proved impractical for the wood processing industry. The sought-after criterion was a maximum quantity of dust.

The dramatically reduced flame ranges and the fundamental and wide-reaching advantages.

Schuech`s new safety concept has fundamental and wide-reaching advantages. Through application of the reduction formula, rupture disks can be reduced by 30%-60% depending on the silo volume and the filling technique. This makes targeted side venting possible.

In addition, this expert opinion can be used for risk assessment in the explosion protection document and provides legal certainty for the operator, providing original Schuech components are used. The dramatically reduced flame ranges and the correspondingly smaller danger areas result in additional operating space that can be used for other purposes (buildings, equipment space, walkways and roadways, property lines) and planners can in the future budget for and use less space in the erection of new silo systems.
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The accumulation of potentially explosive quantities of dust endangers silo installations because the introduction of an ignition source cannot be reliably excluded despite the use of all available technical measures. An explosion creates extremely high pressures that the vessel structures cannot absorb and withstand. For this reason, silos must be equipped with targeted and appropriate venting devices or decoupled using explosion protection techniques.

**New Flame profile demonstrated and verified by Schuech for special filling conditions according to VDI 3673, Appendix A, for pred, max < 300 mbar**

**MAXIMUM SAFETY LEVELS**

The operator is usually also the first person or entity to place silos on the market and according to the ATEX/ Directive PL 1999/92/EG is responsible amongst other things for the interface “Silo/Filling”. This resulted in deficiencies with respect to planning, coordination and implementation between the manufacturers of extraction equipment, who are responsible for the decoupling measures of their components, and the silo builder, who undertakes calculations and structural implementation of the vessel design and its pressure venting system.

Finally, tests were also to be made of the decoupling devices for the pneumatic conveyor systems.

**Objectives**

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**Procedural Overview**

Comprehensive testing was performed last year together with Wölf Systembau of Schams- stein/Austria at the FSA Forschungsgesell- schaft für angewandte Systechnische Entwicklung und Arbeitsmedizin, a well-known research institute based in Mannheim/Germany. Almost a year was required for the planning, development, coordination, execution and analysis of the test explosions. A total of 40 individual tests, carried out under practical conditions using wood dust and different filling variations, were able to substantiate the improvements at first only “suspected” by Schuech with respect to venting surface area and flame range.

**Advantages and Benefits for the Operator**

Scheuch’s new silo safety concept has fundamental and wide-reaching advantages. Through application of the reduction formula, rupture disks can be reduced by 30 - 60% depending on the silo volume and the filling technique. This makes targeted side venting possible.

In addition, this expert opinion can be used for risk assessment in the explosion protection document and provides legal certainty for the operator, providing original Scheuch components are used. The dramatically reduced flame ranges and the corresponding smaller danger areas result in additional operating space that can be used for other purposes (buildings, equipment space, walkways and roadways, property lines) and planners can in the future budget for and use less space in the erection of new silo systems.

**Initial Situation**

With respect to the insertion of material into the silo, one differentiates between “pneumatic filling” - used primarily in the furniture industry - and so-called “free-fall filling”, which is used primarily in the solid wood and wood-based panel industry. The basis for the calculation of pressure venting reductions using...

**Flame profile**

Direct contact with the flame can occur in this area. This area was ascertained through the use of video recordings and was assigned a safety factor. In this area, direct physiological effects on persons in the area are to be feared. Flammable materials in the area can burst into flame and components relevant to the technical safety would be damaged.

**Area 1**

In this area there are no direct effects from the flame, but thermal radiation will cause increased thermal stress for a short period of time. However, experience shows that this does not result in damage to persons or equipment.

**Area 2**

In Area 2 there is exposure only to the flame radiation. However, this is so minimal that no damage to persons or equipment is possible.

**Results**

On the one hand, Schuech was able to find solutions to the existing interface problems of silo systems and, on the other hand, was also able to demonstrate a smaller risk potential. The certified solutions presented now provide operators with the desired level of safety. The advantage of Schuech’s filling variants for wood dust and related types of dust lies in the fact that the potentially explosive amount of dust effectively introduced into the silo, and not the limited silo inlet opening of Ø 300 mm, is now the standard for the calculation of pressure venting according to VDI 3673/Appendix A. In the case of pneumatic filling, this permits a maximum feed pipe diameter of NW 400, or in the case of free-fall filling a maximum dust amount of 5,400 kg/h.

**Advantages and Benefits for the Operator**

Scheuch’s new silo safety concept has fundamental and wide-reaching advantages. Through application of the reduction formula, rupture disks can be reduced by 30 - 60% depending on the silo volume and the filling technique. This makes targeted side venting possible.

In addition, this expert opinion can be used for risk assessment in the explosion protection document and provides legal certainty for the operator, providing original Scheuch components are used. The dramatically reduced flame ranges and the correspondingly smaller danger areas result in additional operating space that can be used for other purposes (buildings, equipment space, walkways and roadways, property lines) and planners can in the future budget for and use less space in the erection of new silo systems.
NEW INFORMATION ABOUT SAFETY

Scheuch has placed a high value in the past few years on the topic of safety in filtration plants and has successfully implemented numerous measures in this regard. This has also been good news for operators of Scheuch filtration plants in the wood processing and wood based panel industries:

The complete IMPULS bag filter program from Scheuch has been ATEX-certified by a recognised testing institute with respect to protection against both explosion and fire; it has also received H3 certification from the Holz-Berufsgenossenschaft with respect to workplace safety issues. Both certifications pertain to the overall filtration system. Scheuch is thus the first company to be H3 certified for its complete row filter program.

H3 Mark

Scheuch’s goal was to ensure levels of residual dust content below 0.1 mg/m³ while achieving the longest possible service life for filter bags, low filter resistance and while avoiding for the operator the costs of ongoing testing.

In order to receive certification in the form of the H3 Test Certificate (BGF-PRÜFZERT-Zeichen H3) issued by the BIA (Berufsgenossenschaftliches Institut für Arbeitsschutz) performed the appropriate tests on a fully implemented IMPULS filtration plant. Upon the conclusion of all measurements, this filtration plant became the first H3-certified stationary filter. The measurements confirm that residual dust levels are reliably below 0.1 mg/m³, which means that the return air is free of Ex-zone requirements.

New information about ATEX certification for the entire system

Previously, extensive testing was performed under actual operating conditions on a wood dust test filter. These tests were carried out in cooperation and consultation with the German Holz-BG at the FSA Forschungsgesellschaft für angewandte Systemsicherheit und Arbeitsmedizin in Mannheim/ Germany.

Roughly a year ago, it was successfully demonstrated that the Scheuch IMPULS filter as a complete system – including the filtration plant and all decoupling measures and dust discharge systems - is ATEX-compliant in the wood processing and wood based panel industries. Because filter locations remain problematic despite the low Scheuch flame profile with respect to the explosion flame range - especially when roadways or property borders are located within the flame profile - Scheuch has added additional new relief options. The efficiency of four different explosion protection concepts with even smaller flame profiles has now been confirmed.

Based on the test results obtained by FSA, Scheuch commissioned a recognised expert to define the danger areas and to describe the limitations. The expert opinion is divided into three areas:

Direct contact with the flame can occur in the area of the flame profile. This area was ascertained through the use of video recordings and was assigned a safety factor. In this area, direct physiological effects on persons in the area are to be feared. Flammable materials in the area can burst into flame and components relevant to the technical safety would be damaged.

In Area 1 there are no direct effects from the flame, but thermal radiation will cause increased thermal stress for a short period of time. However, experience shows that this does not result in damage to persons or equipment.

In Area 2 there is exposure only to the flame radiation. However, this is so minimal that no damage to persons or equipment is possible.

This expert opinion can be used for risk assessment in the explosion protection document. The opinion also confirms that roadways or walkways may be located within the area.

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