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**Solid biofuels — Safety of solid biofuel pellets — Safe handling and storage of wood pellets in residential and other small-scale applications**

*Biocombustibles solides — Sécurité des granulés de biocombustible solide — Manutention et stockage en toute sécurité des granulés de bois dans des applications résidentielles et autres applications à petite échelle*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 238, *Solid biofuels*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

There is a continuous global growth in production, storage, handling, bulk transport and use of solid biofuels especially in the form of pelletized biofuels.

The specific physical and chemical characteristics of solid biofuels, their handling and storage can lead to a risk of fire and/or explosion, as well as health risks such as intoxication due to exposure to carbon-monoxide, asphyxiation due to oxygen depletion or allergic reactions.

There is a risk of injury or death associated with pellet storage, so safety measures shall be implemented. The possibility of fire and explosion incidents is a clear indicator that safety needs to be prioritized, first of all for human safety but also because interruptions in energy supply can have significant consequences. The market confidence in solid biofuels as a secure energy source may be jeopardized and financial losses due to business interruptions could occur. Difficulty to obtain insurance coverage will also increase.

As part of the determination and the assessment of risks for solid biofuels, defined test methods and standards are established or need to be developed. However, the ageing and degradation due to handling and storage of solid biofuels in particular environments will affect the characteristics. The consequence of this change of characteristics is that safety margins need to be established in relation to the actual analysis results.

For small scale applications and handling of small quantities of pellets up to 100 t, requirements of this standard support end-users not educated in safety aspects or requirements of solid biofuel handling. Health risks are associated with the quality of the fuel and therefore controlling the fuel quality reduces the risks, particularly of dust emissions. Logistics and the handling of the pellets play a major part in maintaining quality and are therefore also addressed in this standard.

Generally, facilities at end users with a storage capacity <100 t are covered by this document and larger stores will be covered by ISO 20024<sup>1)</sup>. However, storage capacity alone is not a good enough parameter on which to decide which standard to apply. A trader or larger end user might have a number of small storage facilities but may have a greater throughput of pellets during the entire year but with frequent filling and reclaiming or packaging. Depending on the characteristics of a specific facility, all of the principles covered in this document should be considered but all or only some parts of the systems/equipment described in ISO 20024 will be relevant.

A competent assessor should have knowledge and experience commensurate with the complexity of the facility (knowledge of solid biofuels is required) before selecting which standard and which clauses are applicable to the facility being considered.

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1) Under preparation. Stage at the time of publication ISO/CD 20024:2018.

# Solid biofuels — Safety of solid biofuel pellets — Safe handling and storage of wood pellets in residential and other small-scale applications

## 1 Scope

This document provides principles and requirements for the safe handling and storage of wood pellets in residential and other small-scale applications. It covers the supply chain from loading of the delivery truck, requirements of delivery trucks, connections to the end-user's store and the delivery process. It also covers the design and construction of pellet storage systems. This document addresses risks of fires, dust explosions, off-gassing, oxygen depletion, damage to appliances and buildings through swelling of pellets and other health risks. It is applicable to wood pellets according to ISO 17225-2.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16559, *Solid biofuels — Terminology, definitions and descriptions*

ISO 17225-2, *Solid biofuels — Fuel specifications and classes — Part 2: Graded wood pellets*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

EN 13237, *Potentially explosive atmospheres — Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres*

## 3 Terms and definitions

For the purposes of this document, terms and definitions given in ISO 16559 and EN 13237, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

### 3.1 General terms

#### 3.1.1

##### **combustible dust**

finely divided solid particles, with a particle size of 500 µm or less in nominal size, which may form explosive mixtures with air at standard atmospheric pressure and temperatures

Note 1 to entry: This includes dust and grit as defined in ISO 4225.

Note 2 to entry: The term 'solid particles' is intended to address particles in the solid phase but does not preclude a hollow particle.

[SOURCE: ISO/IEC 80079-20-2:2016, 3.1]

### 3.1.2

#### **finer**

**F**  
small sized particles in fuel below a certain pre-defined size, here less than 3,15 mm

Note 1 to entry: The amount of finer can be different after completion of production, bagging, transportation, unloading, distribution etc.

[SOURCE: ISO 16559:2014, 4.90, modified — “usually” replaced by “here” to indicate exact limit.]

## 3.2 Terms related to transportation and delivery

### 3.2.1

#### **bulk transport**

pellets transported loose, typically in tippers, walking floor trucks, other trucks with closed cargo area or *blower trucks* (3.2.2)

### 3.2.2

#### **blower truck**

vehicle with a pneumatic discharge system using compressed air

Note 1 to entry: Examples of blower trucks include silo-trucks and rotary feeder trucks.

### 3.2.3

#### **silo truck**

fully pneumatic *blower truck* (3.2.2) where pellets are loaded into special pressurised compartments emptied by applying compressed air and using compressed air for pellet conveying

### 3.2.4

#### **rotary feeder truck**

truck where pellets are discharged by gravity via a rotary valve (or star valve) into the stream of compressed air for pellet conveying

### 3.2.5

#### **day hopper**

hopper directly linked to the automatically stoked heating boiler

Note 1 to entry: Typically a day hopper holds a few days of pellet fuel up to 1 t. The filling of the hopper is a batch operation.

### 3.2.6

#### **closing cap**

cap made of metal or plastic, which seals the *connectors* (3.2.7)

### 3.2.7

#### **connector**

permanently installed coupling made of aluminium-alloys or steel, with a gasket ring for pressure and suction operation, which functions in the filling of the *pellet store* (3.3.2)

Note 1 to entry: There are different uses for connectors, such as filling and suction.

### 3.2.8

#### **delivery hose**

temporary connection between the pellet *blower truck* (3.2.2) and the fill connector of the pellet store during the pneumatic delivery process

### 3.3 Terms related to storage

#### 3.3.1

##### **sloping floor**

construction in the store that allows the fuel to be fed by gravity to the conveying system

Note 1 to entry: The aim is to achieve storage that completely drains without any intervention.

#### 3.3.2

##### **pellet store**

room, container or other place where pellets are stored by the end-user before combustion

Note 1 to entry: Pellet stores can be self-built or pre-fabricated.

#### 3.3.3

##### **small pellet store**

pellet store with a capacity of less than 15 t

#### 3.3.4

##### **individual customized store**

pellet store that is individual custom-made into a building often including existing structures like walls

Note 1 to entry: Individual customized stores may be self-built by end-users.

#### 3.3.5

##### **pre-fabricated store**

storage system built by specialist companies, erected at the end-user's premises

#### 3.3.6

##### **fill pipe**

connecting pipe, which connects the fill *connector* (3.2.7) with the pellet store

#### 3.3.7

##### **small bag**

bag for pellets with a typical filling weight between 8 kg and 25 kg

#### 3.3.8

##### **big bag**

flexible intermediate bulk container (FIBC) made of flexible fabric that is designed for storing and transporting bulk materials with a capacity of 500 l and above

## 4 General

### 4.1 Product requirements

This document was developed to promote the safe handling, storage and combustion of pellets conforming to the fuel properties of ISO 17225-2, Classes A1, A2 and B. If other fuel types are used the principles contained herein might not apply.

A data sheet for wood pellets issued by the manufacturer/supplier may provide more specific information with regards to the product delivered, quality, safety and health aspects during handling and storage.

### 4.2 Hazards associated with amounts of pellets $\leq 100$ t

Pellets react in their environment in different ways, especially with air and moisture and they are also sensitive to mechanical stress. To avoid hazards it is important to store and handle pellets accordingly.

The hazards associated with pellet storage in small-scale applications can be summarized, but are not limited to the following categories:

- a) intoxication or oxygen depletion caused by volatile components that may accumulate through biological degradation or originate from backflow of flue gases;
- b) risk of explosions and fire due to accumulation of dust and fines as a result of physical stress and decomposition;
- c) risk of fire and smouldering due to self-ignition processes or burn-back;
- d) damage to storage structures and buildings due to swelling of pellets caused by water.

More information concerning the listed hazards is compiled in [Annex A](#).

### 4.3 General requirements for storage and handling of pellets

All handling and transport equipment shall be designed to minimise damage to the pellets. Abrasion of pellets and consequential formation of fines shall be minimized.

Dust emissions to the environment shall be kept as low as possible. Fines and dust accumulate on flat and inclined surfaces. These surfaces and other places where fines may accumulate shall be minimized. Unavoidable areas where fines may accumulate shall be cleaned regularly, see [6.1.4](#).

Accumulation of carbon monoxide (CO) and volatiles in closed storage facilities shall be avoided by proper ventilation of the facilities.

Wood pellets shall be protected against humidity and moisture. They shall be kept dry at all times.

If pellets of other quality or diameter are used, the vehicles, conveyors and storage containers shall be thoroughly cleaned of any previously handled products.

NOTE Requirements for large storage facilities (>100 t), packing and loading systems are provided in ISO 20024.

## 5 Requirements for safe transport and delivery of pellets

### 5.1 General

The requirements will differ depending on how the pellets are delivered to the end-user:

- a) Bulk pellets for residential and other small-scale applications are typically delivered by blower trucks. For requirements for this type of delivery, see [5.2](#).
- b) If bulk pellets are delivered by tippers or walking floor trucks and are unloaded at the end-customer into a trough or a bunker, see [5.3](#).
- c) If other vehicles are used for bulk transport the suitability of the transport system shall be evaluated.
- d) If pellets are delivered in big bags, see [5.4](#).
- e) If pellets are delivered in small bags, see [5.5](#).

In all cases the pellets shall be protected against moisture (e.g. rain, snow or condensate) throughout the transportation process as well as during loading and unloading.

Loading of trucks is only permitted when the pellet temperature is less than 40 °C. If the ambient temperature exceeds 35 °C, a pellet temperature up to but not exceeding 45 °C is acceptable. Heating of pellets in the truck shall be minimized e.g. by using bright/reflective surface on the outside of the truck. Heating can also be caused by using hot compressed air, which raises the temperature of the pellets.

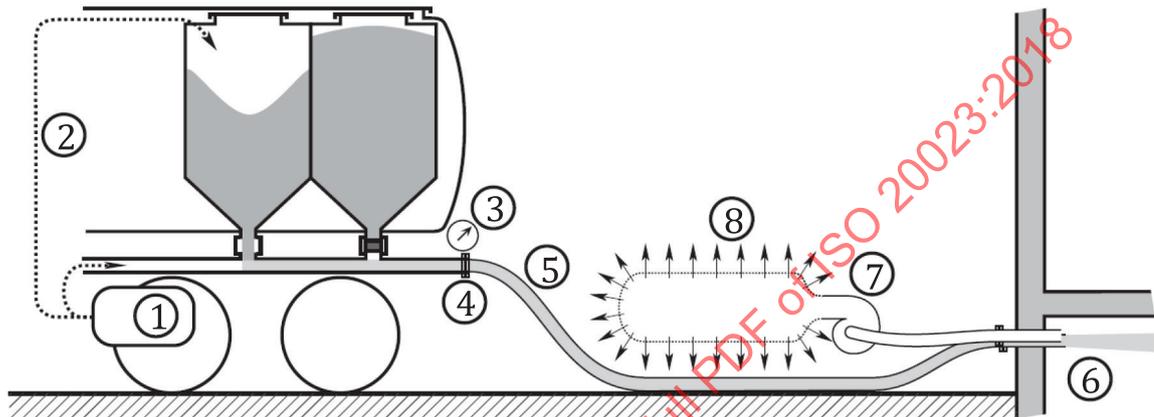
The specification of the pellets shall be in accordance with ISO 17225-2 and shall be stated on all delivery documentation and invoices.

All pellet handling areas shall be strictly non-smoking areas and have no open flames.

## 5.2 Requirements for bulk delivery by blower trucks

### 5.2.1 Transport vehicles and their operation

To help the understanding of the following paragraphs, see [Figure 1](#).



#### Key

- |   |   |   |  |
|---|---|---|--|
| 1 | compressor  | 6 | end-user's pellet store  |
| 2 | pressurisation of storage cell  | 7 | suction fan with filter sock to extract the blower air and create a slightly negative pressure in the pellet store |
| 3 | pressure gauge measures pressure in the discharge pipe or in the storage cell | 8 | exhaust air  |
| 4 | coupling on blower truck  |   |  |
| 5 | delivery hose   |   |  |

**Figure 1 — Operating principle of the blowing process using a silo truck**

Mechanical damage of pellets caused by transport vehicles shall be minimized. Blower trucks shall be equipped with a low abrasion blowing feed system. Low abrasion may be obtained by using coated hoses. Sharp edges between hoses shall be avoided. The trucks should be equipped with a compressor that provides air for blowing the pellets. Where required, blower trucks shall have a mobile fan to extract the supply air from the storage facility during blowing. Explosion protection for the mobile fan is not required if only used outdoors. The capacity of this suction fan shall exceed the capacity of the blowing system of the vehicle. The extracted air shall be filtered (e.g. by fabric filter) to limit dust emissions to the environment. The connected filter bag shall be checked for fouling and shall be protected from rain or be made from water resistant material in order to ensure a necessary negative pressure in the pellet store during the blowing process.

Some stores do not need suction of the blowing air. Filling instructions provided by the manufacturer of these stores shall be followed. Where no suction is required, the blowing air (<math>< 1\ 500\ \text{m}^3/\text{h}</math>) has to exit through windows, doors or other openings, so that the pressure in the room where the pellet store is located does not increase significantly. Openings should have a size of at least  $400\ \text{cm}^2$ .

A blower truck shall be constructed so that the increase in fines is as low as possible. While testing the suitability of a truck the increase of fines shall be less than 2 % where:

- the pellets have a mechanical durability of 98,5 % ( $\pm 0,3\ %$ ),

- the delivery hose shall be 18 m long and there is one 45° bend (radius = 2,5 times the pipe diameter) in the fill pipe,
- the distance between the tube end in the store/test facility and the opposite wall is 3 m,
- the impact mat is 50 cm in front of the rear wall,
- the delivery rate has a mass flow of 15 t/h ( $\pm 1$  t),
- the minimum quantity of fuel to be blown for this test is 500 kg.

The actual fines content in the end-user's store depends on many additional factors to those during testing (e.g. impact of driver/operating staff competence, blowing distance, height differences, bends, construction and dimensions of the pellet store) and can exceed the 2 % increase limit expected from the testing of the transportation vehicle.

Locally used reducing and connecting couplings should be part of the equipment on board the truck. The hose couplings shall be free from obstructions that would cause damage to the pellets. Only electrically conductive delivery hoses shall be used for the filling. Where the delivery hoses have a coating, the breakdown voltage shall be below 4 kV. The delivery and vent hoses shall dissipate static (earth leakage resistance  $R_E \ll 10^6 \Omega$ ). Hoses shall be marked or be clearly visible when crossing traffic areas like sidewalks or bicycle paths.

The blower truck shall be equipped with an earthing system. Blower truck doing part deliveries of the loaded pellets to end-users shall be equipped with calibrated certified on-board weighing system.

The truck storage cells shall be securely closed immediately after loading the truck.

Only trucks properly operated, maintained and with well-kept blowers/compressors shall be deployed. Storage cells, hoses, fans, filters and other equipment shall be clean and shall be inspected regularly by the operating staff according to the manufacturer's instructions and good practice.

In difficult delivery situations where high temperatures in the blowing air and pellets can cause problems such as long distances between the truck and fill connector and/or high ambient temperatures ( $>30 \text{ }^\circ\text{C}$ ), the blower trucks should use cooled air. The blower trucks should either use cooled air as a technical measure (compressor cooler) or optimize the temperature through organizational measures (e.g. delivery in the early morning when it is still cool).

### 5.2.2 Filling end-user storage systems

When filling a pellet store there are two options:

- a) When the customer is on-site or deliverer has been provided with access:
  - If required by the filling instructions of the manufacturer, the customer shall turn off the combustion system in appropriate time before the delivery of the pellets. This needs to be confirmed by the customer before delivery.
  - The exact period of time before the delivery takes place should be given in the boiler instructions.
  - The customer will confirm to the driver that the boiler has been turned off for the required period.
- b) When the customer is absent:
  - The customer can give a written instruction that delivery can be made safely without turning the boiler off.
  - Where the delivery operative has no information on the length of time the boiler has been turned off and there is no written instruction from the end-user to carry out the delivery the pellet supplier shall not fill the pellet store.

To help the understanding of the described options when filling a pellet store, see [Figure 2](#).

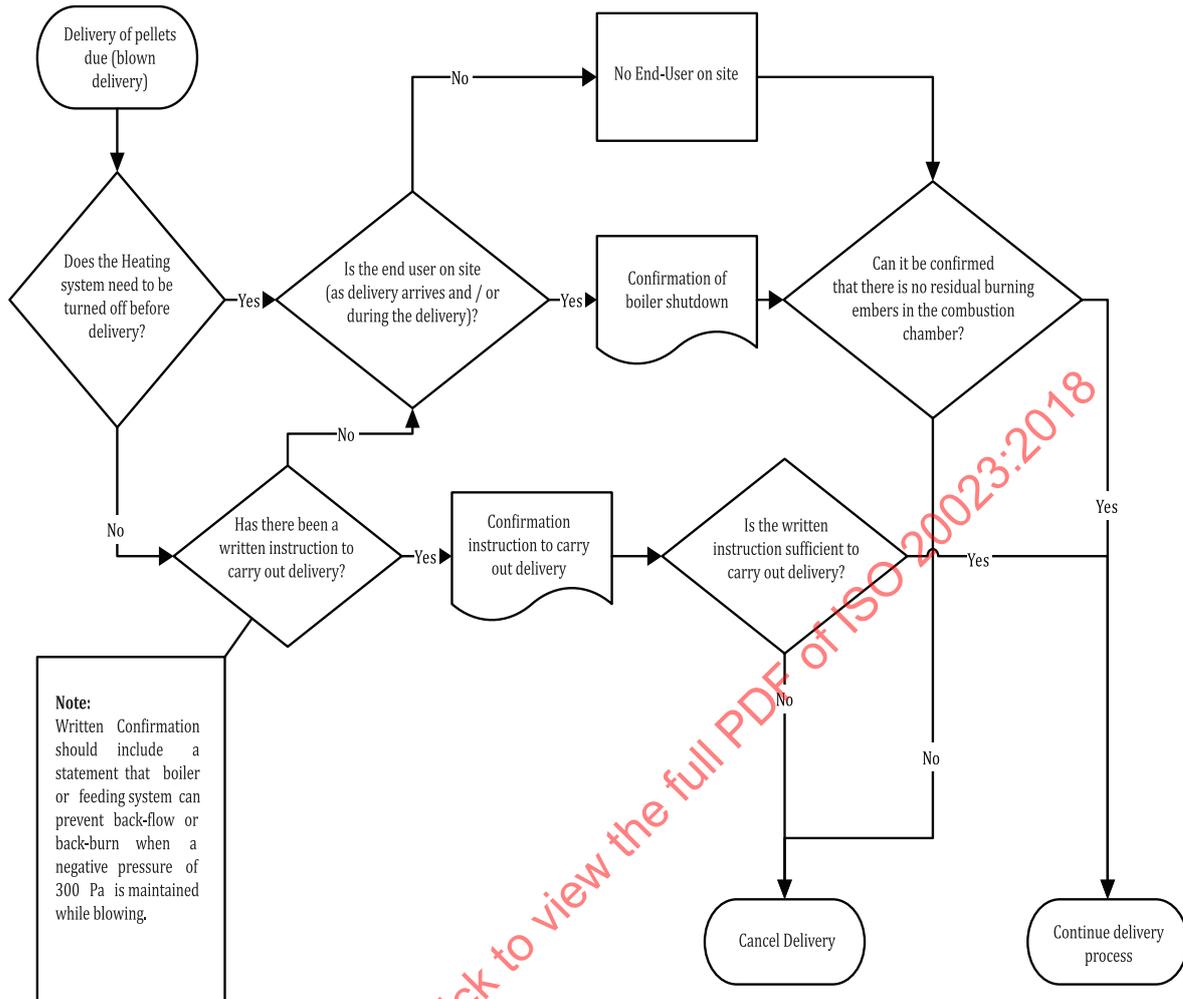


Figure 2 — Filling of end-user store

Before filling an end-user pellet store a checklist shall be filled in by the delivery staff, see an example of a checklist in [Annex E](#). The checklist shall include at least the following information:

- a) Boiler switched off; YES/NO/UNKNOWN. If the boiler has not been turned off, and there is no written instruction that delivery can be made safely without turning the boiler off, no delivery shall be performed.
- b) Pellet store inspected; YES/NO.
- c) Nature and estimated amount of remaining pellets in the store, if possible.
- d) Obvious defects and observations which may cause safety hazards.
- e) Suction fan used; YES/NO.
- f) Fill connectors are properly earthed; YES/NO/UNKNOWN. If proper earthing is not ensured at the connectors, the earthing system of the blower truck shall be used.
- g) Length of hose used (in metres).

The checklist shall be included in the delivery documents and may be included in the delivery note.

The filling instruction for the pellet store shall be clearly visible for the pellet deliverer.

If local arrangements are unfavourable e.g. too many bends in the filling lines, blowing distances >30 m or disadvantageous layout of pellet store, excessive fines can arise. Such issues shall be documented on the checklist and should be explained to the customer.

NOTE Particle segregation will occur during storage and delivery, and the results can be seen on the slope in the lower area of the storage. The appearance of a dusty surface of the pile is not an indication for the total fines content in a pile.

### **5.3 Pellets delivered in bulk tipped into troughs or bunkers**

When pellets are delivered by tippers or walking floor trucks into a trough or bunker, the reception facility shall meet the following requirements:

- a) be covered except during delivering of pellets;
- b) be at least 0,5 m wider on either side of the tail gate of the discharge chute to collect all pellets during unloading;
- c) where grating is used it shall be constructed of bars with rounded edges.

### **5.4 Pellets delivered in big bags**

Pellets may be delivered in big bags (FIBC) with or without a discharge spout. Preferably bags with four lifting loops should be used. Forks used for handling big bags shall have rounded edges to avoid damage to the bag.

Big bags without a discharge spout delivered to an end-customer will usually be emptied manually by taking out small amounts. They shall be closed between withdrawals to protect the pellets from moisture and contamination.

Big bags with a discharge spout shall have a discharge spout with a diameter  $\leq 300$  mm. The lacing cord for closing the discharge spout shall be connected to the big bag and shall not be cut open to avoid contamination of the pellets with cord ends. These bags may also be used as a fuel store that feeds directly into the heating system.

### **5.5 Pellets delivered in small bags on pallets**

Pellets in small bags on pallets shall not be stored outdoors in direct sunlight. Pallets shall be covered with a protective covering and be recovered after withdrawal of bags from the stack.

Outdoor storage in direct sunlight may be done if the packaging material is UV resistant and weatherproof. A loaded pallet with pellets may be damaged by animals, e.g. birds, foxes and rats, when stored outdoors.

Pellet bags shall be stored unopened. Bagged pellets are safe from gaseous emissions in terms of health impacts if one bag is opened at a time and loaded into the pellet store or day hopper.

## **6 Requirements for bulk storage systems**

### **6.1 General requirements**

#### **6.1.1 Location of pellet store**

The blower truck shall be able to get sufficiently close to the connectors to minimize damage to the pellets during the filling process. The access route shall be adequate for the kind of transport vehicles that are used. The minimum road width and minimum clearances for heavy trucks according to national regulations shall be guaranteed. The turning radius, gross weight of the vehicle, the gradient of the roads and winter conditions should be considered.

When filling the pellet store with a blower truck, a hose length of 30 m shall not be exceeded. The total pipework including hose, connectors and pipework in the facility should not exceed 35 m. Connectors shall be easily accessible.

### 6.1.2 Quality control of installation

Pellet stores shall be installed and operated according to this standard and the manufacturer's instructions. It is recommended that the installer of the heating system also installs the pellet store and is therefore responsible for smooth operation of the whole system. Even if the pellet store is not built by the installer, he shall check the pellet store before the first pellet delivery. The results of the check shall be handed over to the end user, as given in [Annex D](#).

### 6.1.3 Construction requirements

Walls and all construction elements shall be designed to withstand the load in all directions (horizontal as well as vertical). For calculating loadings the maximum bulk density of pellets of 750 kg/m<sup>3</sup> and pressure fluctuations of max. 3 000 Pa overpressure during filling operations should be considered. Pipes and connectors shall be earthed. All surfaces of equipment which can charge statically, including walls and conveyors in direct contact with pellets or related dust, shall be electrostatically dissipative or be connected to earth.

### 6.1.4 Measures to reduce the accumulation of fines

Pellet stores shall be designed and constructed to prevent and/or reduce the accumulation of fines. Ideally owners and/or operators should not need to enter pellet stores. However, for most systems it is recommended to empty the pellet store completely and clean up at regular intervals. If not otherwise stated by the manufacturer, pellet stores should be cleaned thoroughly at least once every 2 years or every fifth delivery, whichever comes first. If cleaning is required, manufacturers of storage systems, boilers and conveying systems shall provide cleaning instructions.

**NOTE** An accumulation of fines at the bottom of the pellet store can cause problems with the pellet feeding system and/or the boiler. Fines in the pellet store are caused mainly by mechanical stress during pellet delivery. Bends in the pipework, inadequate impact mats, obstacles in the route of the pellets, a high pellet velocity and a low solids loading factor (e.g. a low volume of pellets travelling along the delivery hoses) during blowing increase the amount of fines. As a result of particle segregation processes in the store, fines will concentrate over time at the bottom of the pellet store.

### 6.1.5 Protection against moisture and water

Pellet stores shall be protected against penetration of moisture during filling and storage. Condensation shall also be prevented.

Where flooding is considered a risk, the pellet store should be positioned, designed and built in such a way as to prevent ingress of water, washing away (the whole building), and swelling of the stored pellets (if water does enter the store), which could cause harm or damage to people, equipment and the storage construction.

### 6.1.6 Prevention of dust movement

The pellet store shall be dust tight relative to adjacent spaces. In particular a dust tight construction of the door and hatches shall be achieved.

### 6.1.7 Noise protection

The extraction/conveying system and all components shall be constructed to avoid structure-borne noise.

With respect to noise emissions of the truck compressor it shall be considered during the planning of the pellet store's location and where the truck will park during delivery. As an example, a delivery of 25 t by blower truck might last up to 3 h.

### 6.1.8 Installation

Electrical devices or cabling shall not be installed in the pellet store unless essential to the operation of the store.

If electrical equipment is required, it shall comply with regulations for explosion protection (e.g. European approval for ATEX zone 22; North America: Class II Division 2) and shall not heat up to more than 60 °C if malfunctioning. For the construction of electrical systems in explosion risk areas the requirements of national regulations, manufacturer's instructions and/or relevant standards (e.g. EN 60079-14<sup>[20]</sup>, IEC 60364<sup>[21]</sup> or NFPA 70<sup>[22]</sup>) shall be followed.

All electrical installations, pipes or other installations shall be flush-mounted or shall be insulated appropriately and be protected against mechanical damage.

### 6.1.9 Fire protection

Requirements for fire protection of the pellet store area shall be observed in accordance with national regulations.

### 6.1.10 Explosion prevention

If measures for primary and secondary explosion prevention according to this standard are implemented, then systems for explosion protection for end-user stores are not required<sup>[3]</sup>.

Due to abrasion, dust formed during handling of wood pellets may form an explosive atmosphere. If all requirements of this standard and organizational measures are observed, the risk of ignition sources<sup>[4]</sup> <sup>[5]</sup> may be excluded such that, during normal operation, a safe state is achieved (e.g. in Europe for ATEX Zone 22). In case there are deviations from this document e.g. with respect to the design of the store or with respect to the circumstances of the delivery, explosion protection measures may be necessary.

### 6.1.11 Protection and measures against burn-back and back gassing

Basic principles for the design, construction and operation of biomass-fuelled thermal energy systems shall be observed<sup>[1]</sup>.

For boilers that are not capable of operating during the filling process, the boilers shall be switched off before filling and early enough to guarantee that no residual fuel or pockets of embers are left in the combustion chamber of the boiler or firing system. The boiler manufacturer shall provide information on how to avoid the occurrence of burn-back.

Where the system is designed for filling during operation of the boiler (e.g. when double star wheel feeding system is used), this shall be clearly marked at the fill connectors.

To avoid burn-back and back-gassing the following requirements shall be followed:

- a) The heating system shall be shut off before pellet delivery with no residual fuel or embers left in the combustion chamber. The feed system shall be required to withstand a partial pressure of 20 Pa. Where embers are still in the fire chamber, the feeding system shall prevent the suction of gases from the boiler system to the pellet store.

NOTE Negative differential pressures of up to 20 Pa may occur between the boiler system and the store where poor design and / or weather conditions affect the operation of the overall combustion system.

- b) Where the heating system cannot be shut off during the blowing process, due to e.g.
  - the combustion system or the amount of fuel in the combustion chamber being too large, or
  - because embers are still present in the combustion chamber and prevent shut-down, and
  - the store has no ventilation opening(s) according to d),

the burn-back prevention system in the feeding system shall withstand a negative differential pressure of 300 Pa.

- c) Where the heating system is shut off during the blowing process but the embers are still present in the combustion chamber after shut-down, and the store has no ventilation opening(s) according to d), the sealing device shall withstand a negative differential pressure of 300 Pa.
- d) If the sealing device cannot withstand a negative differential pressure of 300 Pa and the boiler cannot be shut down during the blowing process, due to e.g.
- combustion system issues,
  - the amount of fuel in the combustion chamber being too large, or because of,
  - embers being still present in the combustion chamber,
  - and the fact that fuel blowing requires suction of blowing air (up to 1 500 m<sup>3</sup>/h),
- pressure compensation is required. For a pressure compensation an opening of 2 000 cm<sup>2</sup> to the outside is required.
- e) If none of the cases a) to d) are applicable, a suction fan shall not be used.

To avoid high under-pressures (up to 300 Pa) in the store during the filling process the suction fan shall only be started immediately before the blowing starts.

There are heating systems that exhaust the blowing air through ventilation openings. Such systems shall include measures to avoid dust emissions to the environment.

#### 6.1.12 Extraction systems

Extraction systems for transport of the pellets from the store to the combustion chamber shall be constructed to minimize damage to the pellets. A packing and/or grinding motion shall be avoided.

Extraction systems shall be accessible for maintenance from outside the pellet store as far as possible. Extraction systems shall not heat up to more than 60 °C in standard operation. In case of malfunction it shall not become an ignition source.

The extraction system typically consists of conveying from the pellet store (e.g. augers), hopper(s) and safety devices (e.g. rotary valve). The safety devices shall limit the suction of gases from the combustion chamber to the pellet store to a maximum rate of 1 m<sup>3</sup>/h for a pressure difference of 20 Pa.

NOTE EN 15270 [23] for pellet burners needs a maximum 1 m<sup>3</sup>/h for a pressure difference of 5 Pa.

#### 6.1.13 Fill connectors and piping

The connectors should preferably be at the outside at the end of permanently installed filling pipes. If permanent pipes are not possible the connection should be close to an opening such as a cellar window or door. Manoeuvring clearance shall be provided for coupling the fill hose.

The connectors shall be at a maximum height of 2 m so that filling hoses can be connected safely. Otherwise safe access by a ramp or a platform shall be provided.

Pipes shall be as short and have as few bends as possible. All changes in direction should be realised with as few bends as possible and sufficient straight distance on either side of a bend. The last section of the fill pipe shall be straight for at least 500 mm.

Pipes and connectors shall be conductive and capable of being earthed with an inner diameter of 100 mm and shall not be able to twist. All pipes shall be earthed. Pipes shall withstand a maximum pressure of 3 bars.

If no national standard exists, fill connectors shall be suitable for blowing and suction operation. The dimensions of the suction coupling shall be identical to the fill coupling.

NOTE Different types of suction couplings are used in different regions, e.g. in Europe “Storz A” (inner diameter 100 mm)<sup>[2]</sup> or in North America “Camlock” (4”).

The blowing and suction connectors shall be permanently and distinctively labelled as blowing or suction connector.

Connectors shall be closed with caps. The caps may contain ventilation openings. The caps shall be tight fitting with the connectors. The caps shall be lockable or require special purpose tools to open. Boiler manufacturer’s instructions shall be observed.

The connector caps shall be re-attached after the completion of the filling process.

#### 6.1.14 Electrical outlet for suction fan

An earthed AC socket shall be accessible in the immediate vicinity of the fill connections where suction fans are required.

NOTE For most countries across Europe CEE 7/7; 230 V, 16 A.

#### 6.1.15 Ventilation

Ventilation outlets should lead to the outside of the building in all possible cases. If this is difficult to achieve, the ventilation can exceptionally lead into a well-ventilated room (e.g. boiler room). In these cases, the installer of the equipment shall provide a ventilation concept to the end user, ensuring that the ventilation of the store is equivalent to direct ventilation to the outside at all times of the year. In newly built storage rooms ventilation outlets shall always lead directly to the outside.

The ventilation in the pellet store shall be checked by the installer before the first pellet delivery. A document showing the result of the check shall be handed over to the end user. [Annex D](#) shows the minimum requirements of such a hand-over document.

The pellet store shall be sealed dust tight from living or work place areas of the building. Rooms containing a pellet store made of air-permeable fabric (e.g. fabric containers) shall have ventilation opening to the outside. Such rooms shall not be used as living or working space.

Ventilation shall be designed to maintain a maximum CO concentration of 300 ppm in stores which are sealed dust tight from the living area of the building and a maximum CO concentration of 30 ppm in other rooms (e.g. boiler room) containing an air-permeable fabric store.

Ventilation shall ensure that an air exchange occurs between the pellet store and outside air. Ventilation should be provided with the least possible pressure drop. Where a natural thermally-driven supply and/or exhaust air flow is not sufficient, forced ventilation shall be installed.

Ventilation shall be designed to avoid burn-back and back-gassing (see [6.1.11](#)). Boilers and/or extraction systems shall be designed to avoid burn-back and back-gassing due to small pressure differences between combustion chamber and store caused by e.g. level differences <6 m (between combustion chamber and ventilation opening) or natural reasons (e.g. wind and storms). In case of forced ventilation or ventilation openings with a level difference of >6 m to the combustion chamber of the boiler, a rotary valve using auxiliary air (or any other equivalent construction) between the combustion chamber and the store is required. In order to keep the chimney effect low in the event of a fire inside the store, the effective level difference between the air inlet into the store and the air outlet of the exhaust shall not exceed 6 m.

Ventilation openings shall be protected against precipitation into the storage facilities. The ventilation openings shall be designed such that ventilation is active after filling and that dust emissions to the environment during filling are minimized.

**NOTE** If ventilation openings or ducts are used, there is a risk of dust emissions during filling even if suction fans are used. When filters or caps are used to reduce dust emissions during filling, they need to be removed after filling to enable ventilation.

Recommendations for the design of the ventilation for a room containing an air-permeable fabric store are compiled in [Table 1](#) and for individual custom-made stores and pre-fabricated stores impermeable to air in [Table 2](#). For requirements for ventilation of a store into another room, see [Table 3](#).

Underground stores usually have lower temperatures than ambient most of the year. This prevents natural ventilation occurring and high CO concentrations can build up in such tanks. Before entering such an underground store forced ventilation is required e.g. by portable fans.

**Table 1 — Ventilation requirements for a room not used as living or working space containing an air-permeable fabric store**

Holding capacity of the store	Ventilation requirements
≤15 t	Ventilation opening from the installation room to the outside with a free cross-section of at least 15 cm <sup>2</sup> /t holding capacity of the store. For non-boiler rooms: volume of the installation room at least 4 times higher than the volume of the store.
>15 t	Installation in a separate storage room only, requirements see <a href="#">Table 2</a> .

**Table 2 — Ventilation requirements for stores exclusively used for pellet storage with ventilation to the outside only (not suitable for underground stores)**

Ventilation distance	Ventilation system	Requirements
ventilation opening	natural ventilation	The ventilation opening should have a free cross-section of more than $\geq 150 \text{ cm}^2$ and $\geq 10 \text{ cm}^2/\text{t}$ of holding capacity of the store and a free cross-section of grid $\geq 8 \text{ cm}^2/\text{t}$ of holding capacity of the store.
fill/suction pipes and connectors $L \leq 2 \text{ m}$	natural ventilation	Ventilated caps on a minimum of two connectors with a total free cross-section of $\geq 4 \text{ cm}^2/\text{t}$ holding capacity of the store. Opening to the outside shall be on the same level or maximum of 50 cm higher than the inside opening.
pipes and/or ducts $2 \text{ m} < L \leq 5 \text{ m}$	natural ventilation	Exhaust air (see <a href="#">Figure B.1</a> ): One or more pipes or ventilation ducts on the same level or $\leq 50 \text{ cm}$ higher than the inside opening with a total cross-section of $\geq 100 \text{ cm}^2$ , $\geq 5 \text{ cm}^2/\text{t}$ of holding capacity of the store and with a free cross-section of grid $\geq 4 \text{ cm}^2/\text{t}$ of holding capacity of the store. Opening to the outside shall be on the same level or maximum of 50 cm higher than the inside opening. Incoming air (see <a href="#">Figure B.1</a> ): One or more pipes or ventilation ducts on the same or lower level than the outside opening with a cross-section of $\geq 75 \text{ cm}^2$ , $\geq 5 \text{ cm}^2/\text{t}$ of holding capacity of the store, and openings with a free cross-section of grid $\geq 4 \text{ cm}^2/\text{t}$ of holding capacity. Total cross section may include filling pipes with ventilated caps on the outside connectors. Outside level of the filling pipe may be lower than the inside level.
pipes and/or ducts all	natural ventilation	Two or more filling pipes with ventilation caps downwards to store, or incoming air via two or more filling pipes with ventilation caps and exhaust duct upwards, or incoming duct and exhaust duct upwards. Required cross section and heights to be calculated. Pipe length $< 5 \text{ m}$ , <a href="#">Figure B.2</a> in <a href="#">Annex B</a> may be used for a simplified dimensioning. For longer pipes or ducts calculation may be done by using formulae in <a href="#">Annex B</a> .
pipes and/or ducts	forced ventilation	By a fan mounted in the exhaust air pipe or duct to the outside only. Air exchange rate $\geq 3/\text{h}$ of the total volume of the storage if the function of the fan is interlocked with the store room door in such a way that the fan operates only when the door is opened. Air exchange rate $\geq 3/\text{d}$ for permanent or intermediate ventilation. Separate air supply to the store with a free cross section of $\geq 75 \text{ cm}^2$ in case of permanent or intermediate ventilation.

**Table 3 — Requirements for ventilation of a store into another room which is not used for living or working, only in existing buildings and not for new buildings**

Ventilation distance	Holding capacity of the store	Requirements
fill/suction pipes and connectors $\leq 2 \text{ m}$	$\leq 15 \text{ t}$	Ventilation opening from the intermediate room to the outside with a free cross-section of at least $15 \text{ cm}^2/\text{t}$ holding capacity of the store. From the store to the intermediate room ventilated caps on a minimum of two connectors with a total free cross-section $\geq 4 \text{ cm}^2/\text{t}$ holding capacity of the store without any vertical bends.

### 6.1.16 Safety instructions

Safety instructions shall be placed permanently and in a clearly visible position on all access hatches and doors to the pellet store. It shall identify the hazards when entering the store and shall provide instructions for safe entry. Recommended safety instructions are found in [A.5](#).

The safety instructions label shall include the following information:

- a) Unauthorized entry is forbidden.
- b) Safeguarded access to the pellet store only.
- c) Smoking, fire and other ignition sources are forbidden.
- d) Dangerous CO-concentrations are possible.
- e) Cross-ventilation is required at least 15 min prior to entry and such ventilation is to be maintained while there is a person in the pellet store.
- f) Injury hazard from moving parts (e.g. augers, agitator, spring arm).
- g) Boiler shall be switched off prior to entry of the pellet store.
- h) For pellet stores larger than 15 t: Enter store only with a personal CO detector.
- i) During the first four weeks after a pellet delivery: Enter the pellet storage only with a personal CO detector.

### 6.1.17 Access to storage

Pellet stores shall be accessible for maintenance and cleaning. They shall be equipped with an access door or hatch that can be opened whether the store is full or empty.

For fabric stores with a capacity up to 8 t no doors or hatches are required but they shall have an access opening for cleaning and sampling with an inner diameter of  $\geq 300$  mm easily accessible and a maximum distance from the extraction point of 1,5 m. For fabric stores with more than one suction probe, one opening per probe is required.

For customized pellet stores one or more dust tight access doors (2 000 mm  $\times$  800 mm) are recommended to provide best access for maintenance and fire-fighting even if the lower part of the door opening is blocked by a sloping floor. If a door is not possible, hatches may be used, min. 800 mm  $\times$  800 mm. Buried pellet stores require standard manhole pits.

## 6.2 Individual custom-made pellet stores

### 6.2.1 Construction requirements

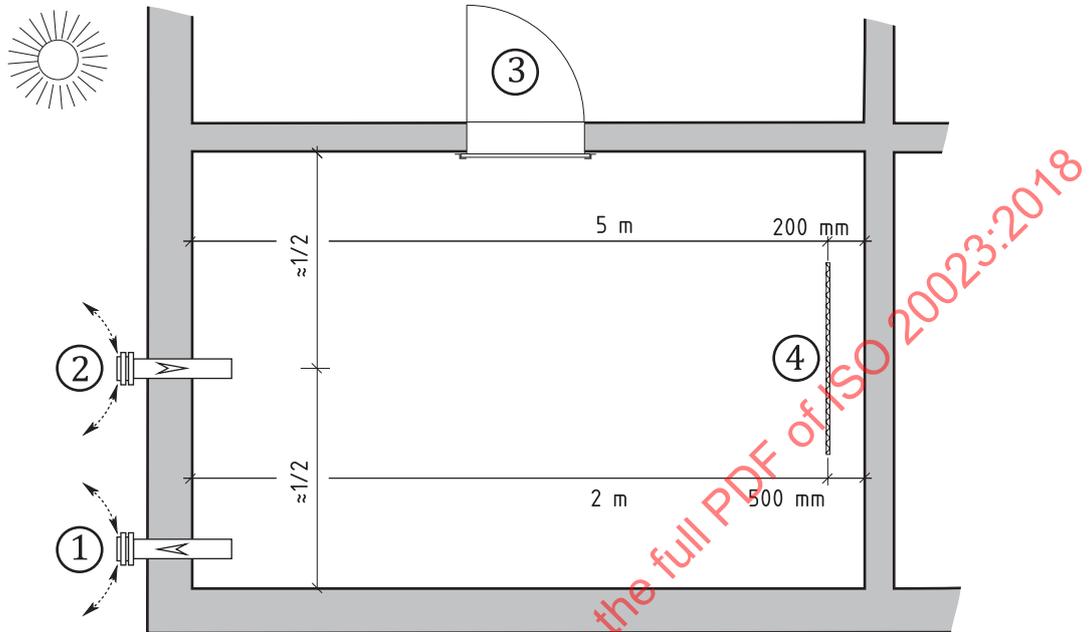
Individual custom-made pellet stores shall be designed and constructed to ensure the store and the surroundings are safe and structurally sound and shall be built in compliance with building codes. All connections to existing brickwork, corners and cavity shall be dust tight.

Consideration of the hygroscopic nature of pellets shall be taken during the design and construction of the pellet store. For the avoidance of collapsing, where there is a risk of water ingress, such as from leaking pipes or during extinguishing fires, special attention shall be made to avoid damaging structural supports. When suspended sloping floor (see [Figure 4](#)) is not used (e.g. a solid flat floor) the risk of damage to the building is significantly higher and particular consideration shall be included in the design of the store.

Ceiling, walls and floor shall be constructed to avoid fuel contamination. Contamination often occurs when there is abrasion or peeling.

Fire resistance classes of construction materials shall be in compliance with the requirements of national legislation.

The ideal pellet store should have a rectangular floor plan. The connectors should be placed on the narrow side. The pellet store should consist of at least one outside wall where the connectors should be located. See [Figure 3](#) and [Figure 4](#) as examples, for further examples see [Annex C](#).

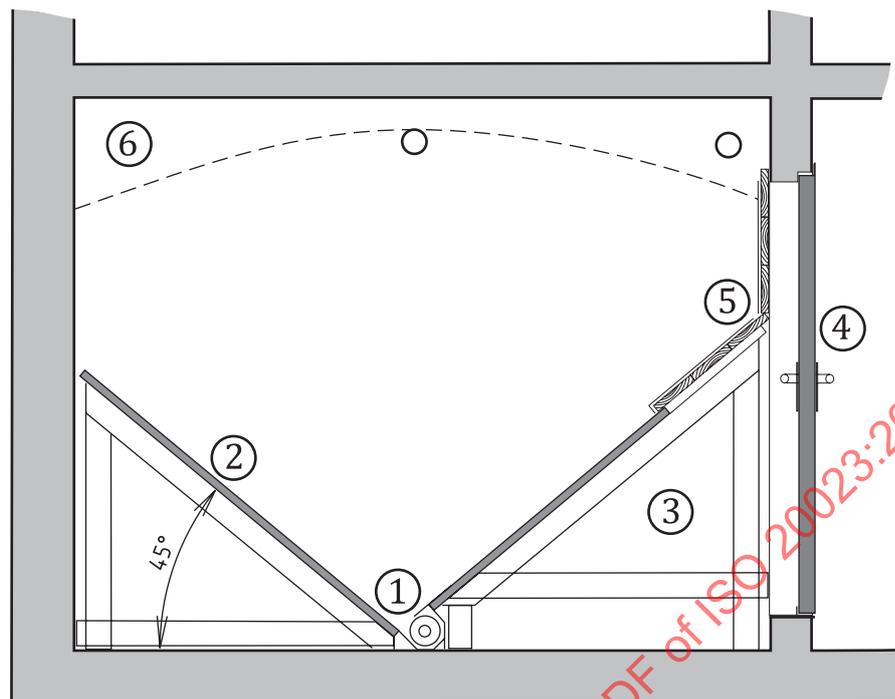


**Key**

- 1 suction connector
- 2 blowing connector
- 3 access door
- 4 impact protection mat

NOTE Ideally the blowing connector is located in the centre line of the store.

**Figure 3 — Plan view of a typical pellet store**



#### Key

- 1 extraction system
- 2 sloping floor 45° to empty store completely (35° to 45°; below 45° only with extremely low friction surfaces, see 6.2.4)
- 3 supporting construction to discharge the load into the ground, not into the walls
- 4 access door
- 5 removable boards
- 6 empty space

NOTE A certain amount of empty space, i.e. non-useable volume results from the built-in sloping floor and above the stored pellets.

**Figure 4 — Cross section of a pellet store with a sloping floor**

#### 6.2.2 Fill connectors

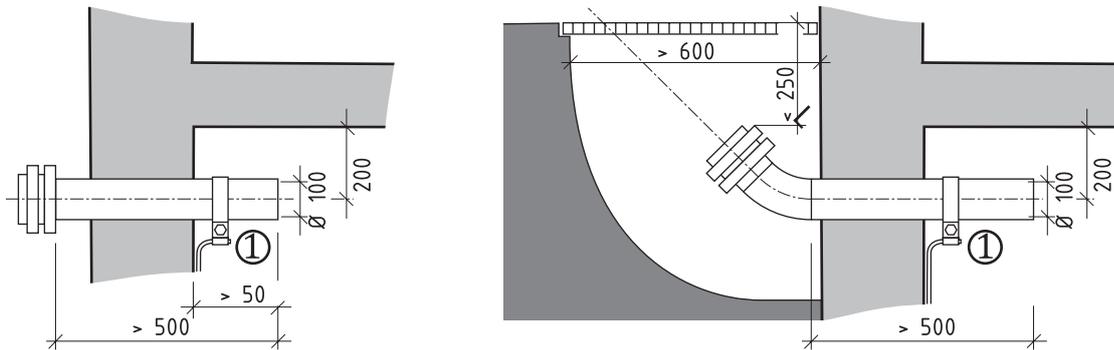
The fill connectors shall be mounted on the same wall and at least 200 mm below the ceiling (measured between the ceiling and the center of the pipe). The pipe shall extend into the store by at least 50 mm to enable earthing. The straight length of the blowing connector should not be shorter than 500 mm total length (see Figure 5).

The suction connector shall be permanently labelled as the suction connection point. The blowing connector should be placed in the centre of the wall in pellet stores filled from the short side, see Figure 3.

If filling is done from the long side then both connectors mounted at quarterly points along the wall shall be used. For large pellet stores, a third connector for better ventilation and also for better filling should be installed, see examples in Annex C.

Connectors mounted in basements below ground with a light well (connection access) shall be oriented upwards by means of one bend so that the connection points are freely accessible, see Figure 5.

Dimensions in millimetres



**Key**

- 1 earth connection with clamp

**Figure 5 — Straight connector (left) and a connector in light well (right)**

**6.2.3 Impact protection mat**

Abrasion and tear-resistant impact protection mat(s) shall be installed and maintained. The protection mat shall be attached perpendicular to the incoming pellets, in front of the wall opposite to the fill connectors.

Fixing screws, slats and brackets should be installed in such a way that they do not interfere with the pellet stream into the pellet store. The impact protection mat has to be placed vertical to the incoming stream of pellets at these distances:

- For short rooms with a blowing distance of 2 m to 5 m approximately 50 cm in front of the wall.
- For longer rooms approximately 20 cm in front of the wall.

Impact protection mats will move due to the air flow and/or impact of blown pellets. It is important that the mat cannot float on the pellets, which can occur with higher volumes of air flow, such as, when there are two or more deflector mats next to each other (e.g. for more than one filling pipe). Care should be taken to avoid the mat being torn down by the weight of the pellets.

**6.2.4 Sloping floor**

The angle of the sloping floor should preferably be 45°. Smaller angles between 35° and 45° are only suitable if surfaces are extremely low friction and particularly smooth e.g. melamine-coated flooring. Sloping floors shall not deform under static load and shall have a smooth, abrasion-resistant surface. The supporting construction shall distribute the load directly to the ground. Loads shall not be transferred to the outside walls unless the walls are specifically designed to bear the loading.

For pellet stores with auger extraction the connection between sloping floor and conveyors shall not transfer structure-borne noise to neighbouring walls or floors.

In order to allow unimpeded flow of pellets into the auger system, edges and ridges are to be avoided.

[Figure 4](#) illustrates the typical layout plan for a pellet store.

For larger pellet stores and filling distances of >5 m a room height of >3 m is required and/or an additional longer filling pipe.

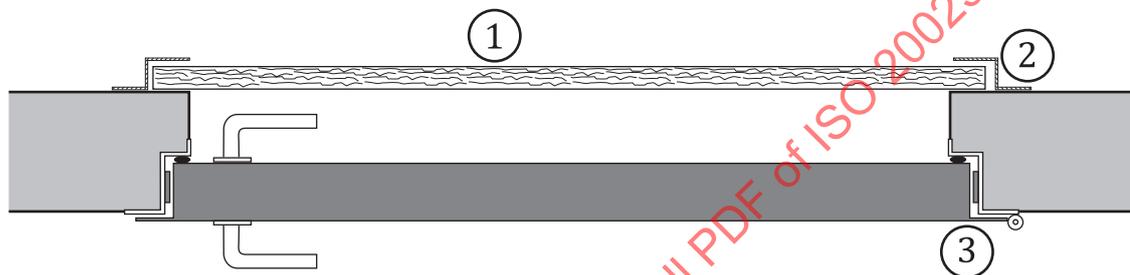
**6.2.5 Access hatch/door to pellet store**

For exact dimension of hatch or door see [6.1.17](#).

The position of the access should preferably be located at a maximum distance from the filling pipes for best ventilation in case of entering the store. The room the access hatch/door leads to shall be ventilated through doors or windows to the outside.

Doors and hatches shall open outwards, shall be dust tight and shall be fire-protected (e.g. in Europe fire resistance class EI<sub>2</sub> 30 according to EN 13501-2[6]). Pressure relief boarding (see [Figure 6](#)) shall be provided to the inner side of the access point to withstand the loads exerted by the stored pellets, such that entry to the pellet store is always possible. The pressure relief may consist of wood boards, or tongue-and-groove boards, which are placed horizontally in the support profile (e.g. Z shaped metal framing).

[Figure 6](#) illustrates the typical construction design in cross-section of a pellet store access door. The door shall be capable of opening from the inside. The pressure relief boards on the inner side of the door reduce the spilling of pellets after opening the access door. The possibility for visual inspection through a sight window is recommended.



#### Key

- 1 pressure relief wooden boards with tongue-and-groove on the inner side of the door (e.g. 30 mm thick)
- 2 Z shaped metal framing
- 3 access door with perimeter gasket for fire and dust resistance

**Figure 6 — Example of a typical construction of a pellet store access door (top view)**

## 6.3 Pre-fabricated storage systems

### 6.3.1 General

Typically, pre-fabricated commercially manufactured storage systems reduce planning and installation efforts significantly compared with individual custom-made pellet stores. They are available in many designs, materials, shapes and sizes and can be installed in cellars, under carports, in tool sheds, as underground tanks and in the open (see manufacturer's instructions).

The store shall have an access with a minimum diameter of 300 mm easily accessible regardless if store is empty or filled. This access may be used for:

- a) cleaning of store;
- b) removing pellets in an emergency (e.g. for a breakdown of pellet conveying system);
- c) for pellet quality control and sampling; or
- d) for manual filling with small bags for protection against freezing when bulk delivery is not possible.

The store shall be designed and installed to ensure as complete discharge of pellets as possible during use, maintenance or emergencies. The residual fuel that cannot be automatically removed from the store shall not exceed 2 % of the rated tank volume.

All electrically conductive parts of the tank, including the store cover, all connection fittings, and the fuel feed system shall be grounded to earth. Since electrostatic charge is a risk of ignition of dust, the

store shall be constructed so that any electrostatic sparking is prevented. The store manufacturer shall provide instructions regarding electrostatic protection when supplying the store.

### 6.3.2 Requirements regarding the site, indoor systems

Pre-fabricated pellet stores usually need a solid and level base. The base shall be suitable to carry the static loads at the contact points for the weight of storage system and maximum capacity of pellets. Pre-fabricated fabric stores shall not touch the walls. The air in the pellet store shall have a relative humidity of less than 80 %. The pellet store shall be ventilated to prevent the accumulation of CO and other volatile compounds when the container is made of permeable material e.g. fabric containers.

Many storage systems need sufficient distance between the surrounding walls, ceiling, floor and other fixtures and fittings to create a full system, such as, lamps, electrical connections and pipes. On the coupling side of the pellet store, a distance of at least 80 cm should be kept between the store and the walls. It is recommended that filling pipes lead to connectors outside the building.

Fabric stores may also need space to expand into during the filling process. In some cases the fabric is inflated at the beginning of the blowing process, so that the hanging fabric lifts upwards before the pellets enter the store. In general, the inflated fabric should not touch fixtures and fittings nor should it be restricted by the height of the ceiling, except when explicitly allowed by the fabric store manufacturer.

Fill connectors shall be positioned so that pellets hit the strengthened fabric areas and do not damage the seams.

### 6.3.3 Requirements regarding the siting of outdoor installations

Some pre-fabricated pellet stores may also be installed outside a building. With exterior installations consideration should be made for one or more of the following: wind load, UV protection, rain and other water issues and snow loads.

### 6.3.4 Ground connection (earth)

The storage system has to be earthed to divert the electrostatic charge that is created when the pellets are blown in.

### 6.3.5 Filling instructions

Filling instructions for the pellet store should be easily visible for the delivery driver and others loading the store. As there are many different filling systems, the instructions shall be in enough detail for the specific system to be filled safely and should be provided by the pellet store manufacturer.

### 6.3.6 Fabric store

Minimum clearances between walls and ceiling should be observed to guarantee accessibility for assembly and disassembly of the store. The clearance should also take account of protection of the fabric against damage due to abrasion on the wall.

Storage systems are offered in a variety of materials and shapes, typically round, square or rectangular and with different widths, lengths and heights. Fabric stores frequently have a cone on the lower part for pellet extraction. Other common designs include trough silos, elevating silos and silos with a flat bottom. The pellets are discharged either from the bottom via a conveyor screw (auger) or a suction device, or through a flexible vacuum device from the top.

The pipe of blowing connector shall extend into the fabric container by a few centimetres and shall not end within the fabric collar for the connector pipe.

If the fabric store has only one fill pipe, the room in which the fabric store is placed needs an additional ventilation opening of at least 400 cm<sup>2</sup> leading to the outside in order to enable the feed air to leave the

store during the blow in process. If this additional opening is closed by e.g. a flap, this flap shall open automatically in case of over pressure.

### 6.3.7 Underground store

Underground pellet stores shall fulfil additional requirements for confined spaces. The requirements include:

- a) The store shall be constructed to withstand static loads during and after construction of the tank. The store is usually made from concrete or plastic and shall be of joint-free construction.
- b) The store and the store cover shall be produced from corrosion and weather resistant materials.
- c) The construction materials shall prevent entry of moisture into the tank and any covers shall provide a water-tight seal.
- d) The tank shall be securely fixed to stop floating caused by rising groundwater.
- e) The tank shall be furnished with a domed top cover that includes an access hatch that can withstand foot or vehicle traffic where necessary.

Blowing connectors typically attached to the domed top cover shall be placed in a position freely accessible and mounted to enable unhindered filling and suction of the tank.

A protective duct containing the feed system hoses and other cables is required from the dome of the tank to the heating room.

The store shall be fitted with a suitable fuel feeding system that enables transfer of pellets from the store to the combustion system when the manhole cover is closed and fittings are sealed. Since the static pressure on the pellets is often high in the extraction area, the system may require rotation, vibration, air or agitation to loosen pellets.

## 7 Health protection aspects

### 7.1 Entering a pellet store

#### 7.1.1 General

The installer of the storage room equipment shall inform the end user about the correct design and construction of the pellet store and about correct entry procedures.

Pellet stores should only be entered following safety procedures. Boiler and pellet supply systems shall be turned off. Sufficient ventilation shall be provided before entering the store. Supply of fresh air shall be ensured during the entry. The pellet store shall be ventilated for at least 15 min before being entered (e.g. cross-ventilation from the access door or access hatch). The access point shall be kept open while persons are working in the pellet store and ventilation shall be maintained while working in the store.

A safety instructions label (an example can be found in [A.5](#)) shall be placed permanently and in a clearly visible position on the outside of the access point.

Pellet stores shall only be entered in the company of a second person who stays outside the hazard zone as an additional safety measure. The attendant should always have eye contact or at least voice contact with the person inside the store, which will help when initiating a rescue during an emergency. In case of an emergency situation the second person shall call for help and NOT enter the pellet store. Persons entering a pellet store should be familiar with the hazards and safety measures (e.g. via the product information sheet).

For entering a pellet store >15 t a personal warning device shall be used. The CO detectors should be fastened to the person entering the store in such a manner that the acoustic alarm can be heard by the person using it. Where gas detectors are used they shall be function-tested by a certified inspection

body and approved for CO monitoring. CO detectors shall be calibrated at regular intervals according to the manufacturer's instructions. Between calibration tests, care shall be taken to ensure that the instruments maintain their effectiveness and retain their function (e.g. no sensor poisoning by the room atmosphere). This should include storing and using the detector in a manner that does not damage its ability to detect CO as per the manufacturer's specification.

The requirements for personal CO detectors are:

- a) A measuring range of 0 ppm to 500 ppm<sup>2)</sup>.
- b) The alarm and warning function shall be by a multi-tone audible signal, visual alarm and additional vibration.
- c) IP 56 rated detectors (according to IEC 60529) are suitable means for entering the storage environment.

The use of a dust mask with a P2 (EN 143<sup>[24]</sup>) or N95 (US NIOSH<sup>[14]</sup> Standard) filter is recommended.

### 7.1.2 Requirements for small pellet stores up to 15 t

Following a new delivery of pellets and for a period up to 4 weeks, the pellet store shall only be entered after prior testing of the atmosphere for CO. After the 4-week period, it is typical that continuous natural ventilation of the pellet store (ventilated caps/ventilation opening see 6.1.15) and cross-ventilation for a minimum period of 15 min prior to entry will be sufficient to meet the CO exposure value of  $\leq 60$  ppm for an exposure duration of 30 min.

### 7.1.3 Requirements for pellet stores >15 t and/or underground stores

Pellet stores shall only be entered after prior testing of the atmosphere for CO. If the CO level has not fallen below the prescribed threshold after 15 min cross-ventilation, a fan (e.g. vacuum cleaner) should be used.

While inside the pellet store, persons should permanently wear a personal CO detector that is set to an upper alarm threshold of 60 ppm. The lower alarm threshold should be set to 30 ppm where this function is provided by the detector.

Entry of the pellet store for short periods (maximum 30 min) is only recommended when the CO level in the pellet store is  $\leq 60$  ppm. At CO levels of  $>60$  ppm, the storage room shall be left to ventilate until the CO level has dropped sufficiently.

Due to the airtight construction, high CO concentrations can occur in underground stores. For this reason, underground stores shall only be entered after sufficient ventilation and after measuring the CO concentration. A second person shall be present at all times outside the store. Where national regulations for operating in confined spaces are available, these shall be followed, otherwise best practice for entry, exit and work inside the store shall be observed, see References [7][8].

## 7.2 Stationary CO monitors

Stationary CO monitors installed in the pellet store should be avoided because:

- a) these instruments will be damaged during the pellet delivery process (pressure variations and fines), and
- b) the aromatics present in the wood tend to damage chemical sensors within a short period.

Stationary CO monitors may be installed in the boiler rooms or in other adjacent rooms.

---

2) 1 ppm = 1  $\mu\text{g}/\text{kg}$ .

### 7.3 Equipment used in stores

When using electrical cleaning devices (industrial vacuum cleaners) to avoid the risk of explosion, devices shall:

- a) be free of internal sources of ignition;
- b) be constructed to IP 54 in accordance with IEC 60529.

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## Annex A (informative)

### Hazards associated with pellets

#### A.1 Volatile compounds

##### A.1.1 General

Wood pellets release volatile organic and inorganic compounds. They include carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and volatile organic compounds (VOCs) and these emissions may cause health risks or inconvenience for customers due to malodour (especially aldehydes, organic acids).

##### A.1.2 Effect/toxicity of CO

Carbon monoxide is a colourless, odourless and tasteless, non-irritating toxic gas. With respect to pellets it may either be formed by incomplete combustion (smouldering fire) usually due to a malfunctioning system or mistakes during filling of the store or it may be formed by a natural chemical or biological degradation of wood compounds. Elevated CO concentrations due to naturally occurring reactions of wood are usually no hazard in ventilated areas or stores but may be a hazard in airtight stores or with large volumes of pellets.

Carbon monoxide is easily absorbed through the lungs. As compared to oxygen CO has a 250 to 300 times stronger affinity to the Fe<sup>2+</sup> ion in haemoglobin, its primary toxic effect is due to the displacement of oxygen from the haemoglobin. Carbon monoxide combines with haemoglobin to form carboxy-haemoglobin (CO-Hb) in the blood, resulting in oxygen starvation of the tissues, the poisoning symptoms increasing with increasing CO-Hb content of the blood. Oxygen starvation of the tissues leads to acute functional problems and damage to brain, heart blood circulation and nervous systems. CO-Hb formation is a reversible process that is dependent on the initial level in the blood, the physical activity level, the personal constitution, the carbon monoxide concentration in the ambient air and the exposure duration.

Examples of CO exposure limits in different countries are provided in following tables and clauses:

**Table A.1 — CO exposure and its effects on the human body during physical work, Austria<sup>9)</sup>**

Exposure concentration	Exposure duration	Effect
30 ppm	more than 8 h	No effect
100 ppm	more than 3 h	Headache, vertigo, nausea
300 ppm	more than 1 h	Headache, vertigo, nausea
	more than 3 h	Unconsciousness
800 ppm	more than 45 min	Headache, vertigo, nausea
	>1 h to 2 h	Unconsciousness
	>2 h to 3 h	Death
3 200 ppm	>5 min to 10 min	Headache, vertigo, nausea
	>10 min to 20 min	Unconsciousness
	>1 h	Death

**Table A.2 — CO exposure during physical work, Germany<sup>[10]</sup>**

Exposure concentration	Limit
30 ppm	Work place exposure limit
60 ppm	Short time exposure for 15 min

**Table A.3 — CO exposure limits for residential indoor atmospheres, public spaces and work places not involving the handling of hazardous materials, Germany<sup>[11]</sup> based on the WHO recommendations**

Exposure	½ h	1 h
Guide value [ppm]	87	30
Guide value [mg/m <sup>3</sup> ]	100	35

In the US several different sources for assessing occupational exposure limits are used.

The National Institute for Occupational Safety and Health (NIOSH) recommends an exposure limit of 35 ppm (8 h TWA) and a ceiling of 200 ppm<sup>[14]</sup>.

U.S. Department of Labor, Occupational Safety & Health Administration OSHA 1917.24(a): Exposure limits. The carbon monoxide content of the atmosphere in a room, building, vehicle, railcar or any enclosed space shall be maintained at not more than 50 ppm (0,005 %) as an 8 h average area level and employees shall be removed from the enclosed space if the carbon monoxide concentration exceeds a ceiling of 100 ppm (0,01 %)<sup>[13]</sup>.

American Conference of Governmental Industrial Hygienists (ACGIH) recommends a limit of 25 ppm TWA Time Weighted Average. This is the level of CO (in ppm) that a person has been exposed to on average over some period of time (usually 8 h)<sup>[19]</sup>.

**Table A.4 — Limit values of Class 2 Acute Exposure Guideline Levels (AEGl) of U.S. Environmental Protection Agency<sup>[12]</sup>**

Class	10 min	30 min	1 h	4 h	8 h
AEGl2 in ppm	420	150	83	33	27
AEGl2 in mg/m <sup>3</sup>	480	170	95	38	31

**Table A.5 — Limit values in Finland<sup>[18]</sup>**

Exposure	15 min	8 h
CO [ppm]	75	20
hexanale [ppm]	10	—

### A.1.3 Oxygen depletion and carbon dioxide

The formation of CO and CO<sub>2</sub> from the wood pellets is caused by the reaction of some of the wood components with oxygen. The oxidation results in oxygen depletion which can be rapid at elevated temperatures and reach dangerous low levels. The CO<sub>2</sub> is displacing air (oxygen) and increasing CO<sub>2</sub> levels making you breath faster and thus increases the uptake of CO. It is of vital importance that storage spaces and communicating spaces are ventilated not only to eliminate CO but equally important to replenish the oxygen content. It is possible to measure both CO and oxygen levels at the same time (combined meter), for practical purposes measurements of CO alone is a sufficient indicator.

#### A.1.4 Emissions of volatile compounds

Although mechanisms of formation are not fully understood the origin of emissions is mainly due to:

- Microbial breakdown of wood: microbial activity contributes to CO and VOC emissions from wood during storage primarily in connection with the self-heating and spontaneous ignition of wood. In early stages of microorganism-induced self-heating mainly CO<sub>2</sub> is formed. At a later stage at elevated temperatures (>70 °C) also CO formation is observed. Microbial breakdown only occurs in moist storage conditions as the low water content of pellets according ISO 17225-2 prevents microbial activity.
- Auto-oxidation of wood components (e.g. fatty acids): auto-oxidation of components naturally present in wood attributes to oxygen depletion and the formation of CO, CO<sub>2</sub> and VOC's. The chemical reactions occur already before the pellet production process and are generally associated with the decay of wood.

In closed containers a defined saturation concentration of CO, CO<sub>2</sub> and VOC's occurs in the bulk and the space above the wood pellets over time accompanied by a decline of the oxygen concentration in the gas space. Parameters influencing the emission levels include:

- a) Temperature: The CO concentration in the gas space of the container will rise exponentially with increasing storage temperature between 20 °C and 55 °C.
- b) Wood species: Pellets produced from wood species rich in fats and fatty acids such as pine wood release more CO compared with species low in fat and fatty acids such as spruce wood.
- c) Storage conditions: The concentration of substances available for auto-oxidation decrease with storage time, at the same time emissions will also decrease with time. The decomposition reactions are a function of the temperature, the presence of oxygen which is influenced by air movements in the storage space induced by openings to spaces and pressure differences between storage and atmosphere.
- d) Moisture: Moisture or penetration of water into storages may cause microbial activity and subsequent emissions.
- e) Surface area: Mechanical stress during pellet handling generates fines and fresh fracture faces where reactive wood constituents will be available for reaction with air (oxygen). This initiates decomposition reactions leading to elevated emissions from the pellets.

#### A.2 Fines and dust

Pellets always contain a fraction of fines. According to ISO 16559 fines are particles <3,15 mm. With respect to health and safety only the dust part of this fraction is of concern. Suspended dust generated during handling (filling and loading operations and any other manipulation) may involve health risks. Suspended dust may also form an explosive environment.

It may be assumed that constructive explosion protection for storage of wood pellets up to 100 t is not required, as long as measures listed in this document are observed which should guarantee that explosions can technically and organizationally be safely avoided with measures of preventive explosion protection (primary and/or secondary explosion protection)<sup>[15]</sup>.

#### A.3 Uncontrolled ignition and smouldering

When pellets are in contact with hot surfaces or hot air uncontrolled ignition or a smouldering fire may occur. Typical sources are:

- a) Hot surfaces: light bulbs or any other light source in pellet storage areas or other electrical equipment especially motors and other moving parts. Due to the often enclosed environment and

good insulation properties of pellets light sources with usually low surface temperatures may also lead to a local heating above the critical temperature to form a smouldering fire.

b) Hot air and sparks:

- 1) from compressors of blower trucks;
- 2) burn-back or suction of gases from the combustion system to the storage system when the pressure in storage facilities (such as induced by suction fan of blower truck) is lower than the under pressure created by the chimney draft and boiler exhaust fan.

**A.4 Decomposition and swelling**

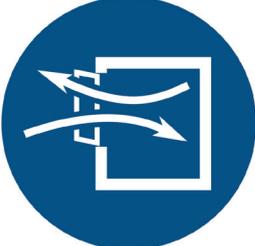
Pellets slowly decay over time and disintegrate into the original particles. This process causes an increasing fraction of fines but also an increased space requirement. Decomposition is increased with increasing exposure to moisture. In case of flooding of a pellet storage area, water uptake and swelling process is fast and leads to significant forces during expansion which may destroy storage facilities, even building structures. Thus, it shall be assured that permeation of water to pellet storage areas are safely avoided or a respective volume for swelling of pellets is provided at least.

**A.5 Example of a safety instructions label for pellet stores which should include symbols and descriptions**

Pellet store		ISO Ref. No.
	Dangerous CO-concentrations possible, do not enter during the first four weeks after a new pellet supply	W001-7010
	Unauthorized entry is forbidden, keep door closed	P001-7010
	Smoking, fire and other ignition sources are forbidden	P002-7010
<p><sup>a</sup> This safety sign is subject to registration/co-ordination through ISO/TC 145/SC 2 and is thus likely to be modified.</p>		

Pellet store		ISO Ref. No.
	Ensure continuous ventilating to the outside atmosphere; e.g. via ventilated caps, openings or fan	a
	Injury hazard from moving parts; e.g. augers, agitator	P015-7010
	Boiler shall be switched off prior to entry and/or filling of the store	M021-7010
<p><sup>a</sup> This safety sign is subject to registration/co-ordination through ISO/TC 145/SC 2 and is thus likely to be modified.</p>		

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Pellet store		ISO Ref. No.
	Ventilation is required for minimum 15 min. prior to entry (open door and filling caps); ventilation is to be maintained during entry	a
	Entry only with second person outside. In case of accident first call ambulance: Tel:.....	a
	For stores >15 t: Enter store only with a personal CO detector	M048-7010
<p><sup>a</sup> This safety sign is subject to registration/co-ordination through ISO/TC 145/SC 2 and is thus likely to be modified.</p>		

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## Annex B (informative)

### Model calculation for different cases of store ventilation

Model calculation for different cases of store ventilation are compiled in this annex.

Some assumptions are necessary for ventilation calculation:

- a) Research indicates that a maximum CO production rate of 0,5 mg/kg pellets per day may be assumed some days after production<sup>[9]</sup> of pellets. CO production is highest for fresh produced pellets and declines with time. CO production rate vary between wood species and increases with content of fatty acids in the wood.
- b) Natural ventilation is driven by differences in density between the atmosphere inside the store and outside (well-ventilated room or to the outside). The difference of density is caused by a difference of temperatures. Therefore, a good ventilation may be expected in winter since temperature in store is usually much higher than outside. In summer when inside temperature is lower than outside temperature during daytime, ventilation will only happen during night-time. A temperature difference of 5 °C for a period of 12 h/day is a suitable assumption for most cases.
- c) Ventilation openings as well as horizontal ventilation pipes and ducts without vertical bends using natural draught operate in both direction. Therefore, the active ventilation time can be assumed to be 100 %. The effective height H for natural draught is equal to half of the height of the pipe, duct or opening.
- d) Effective level difference H: A level difference is required for a natural ventilation. The measurement of the effective level difference is shown in [Figure B.1](#).

EXAMPLE 1

For dimensioning with pipe pressure losses

Content of store	$Q =$	60 t	
Emission of 1 kg pellet in 24 hours	$E_{24} =$	0,50 mg/24h kg	
Active time related to total time	$f_t =$	50 %	
Density of carbon monoxide at 1,013 bar and 20 °C	$\rho_{CO} =$	1,165 kg/m <sup>3</sup>	
Emission: $E = E_{24}/24 \cdot 1\,000/f_t/\rho_{CO}$	$E =$	35,77 m <sup>3</sup> ·10 <sup>-6</sup> /h·t	
Maximum concentration of CO in storage	$C_{CO} =$	300 ppm	
Air exchange per t of storage: $V_t = E/C_{CO}$	$V_t =$	0,119 217 93 m <sup>3</sup> /h t	
		Incoming air	Exhaust air
Air exchange: $V = V_t \cdot Q/3\,600$	$V =$	0,001 987 m <sup>3</sup> /s	0,001 987 m <sup>3</sup> /s
Inside diameter of pipe	$d_p =$	0,1 m	0,1 m
Number of pipes	$n_p =$	2 -	1 -
Length of pipes	$L_p =$	5 m	5 m
Number of bends	$n_b =$	2 -	2 -
Free grid cross-section related to the pipe cross-section	$f_g =$	0,38 -	0,80 -
Density of air at 1,013 bar and 15 °C	$\rho_{15} =$	1,226 6 kg/m <sup>3</sup>	
Density of air at 1,013 bar and 20 °C	$\rho_{20} =$		1,204 9 kg/m <sup>3</sup>
Kinematic viscosity of air at 1,013 bar and 15 °C	$\nu_{15} =$	0,000 014 66 m <sup>2</sup> /s	
Kinematic viscosity of air at 1,013 bar and 20 °C	$\nu_{20} =$		0,000 015 13 m <sup>2</sup> /s
Free cross-section of pipes: $A_p = d_p^2 \cdot \pi/4 \cdot n_p$	$A_p =$	0,015 7 m <sup>2</sup>	0,007 9 m <sup>2</sup>
Velocity in the pipe: $v_p = V/A_p$	$v_p =$	0,126 m/s	0,253 m/s
Reynolds number: $Re = v_p \cdot d_p/\nu$	$Re =$	863 -	1 664 -
Friction factor $\lambda$ for laminar flow $Re < 2\,320$ $\lambda = 64/Re$	$\lambda =$	0,074 -	0,038
Roughness k of tube wall for dusty surface	$k =$	0,000 2 m	0,000 2 m
Friction factor $\lambda$ for turbulent flow $Re > 2\,320$			
approximation proposed by Moody: $\lambda = 0,005\,5 \cdot [1 + (2 \cdot 10^4 \cdot k/d_p + 10^6/Re)^{0,333}]$			
Pressure loss for pipe: $\Delta p_p = \lambda \cdot L_p/d_p \cdot \rho/2 \cdot v_p^2$	$\Delta p_p =$	0,036 4 Pa	0,074 1 Pa
Resistance coefficient $\zeta_b$ for bend	$\zeta_b =$	0,15 -	0,15 -
Pressure loss in bends: $\Delta p_b = v_p^2 \cdot \rho/2 \cdot \zeta_b \cdot n_b$	$\Delta p_b =$	0,002 9 Pa	0,011 6 Pa
Resistance coefficient $\zeta_g$ for grid	$\zeta_g =$	0,20 -	0,20 -
Dynamic pressure + Pressure loss grid: $\Delta p = (v_p/f_z)^2 \cdot \rho/2 \cdot (1 + \zeta_g)$	$\Delta p_g =$	0,081 6 Pa	0,072 3 Pa
Total pressure loss each line: $\Delta p = \Delta p_p + \Delta p_b + \Delta p_g$	$\Delta p =$	0,120 9 Pa	0,158 0 Pa
Required level difference: $\Delta h = \Delta p/(\rho_{15} - \rho_{20})/9,81$	$\Delta h =$	0,57 m	0,74 m

**Total required effective level difference  $H = \Delta h_I + \Delta h_E$   $H = 1,31$  m**

Measured between air inlet into the store and outlet to the atmosphere.

The maximum effective level difference between the air inlet into the store and the exhaust outlet shall not be higher than 6 m (see 6.1.15).

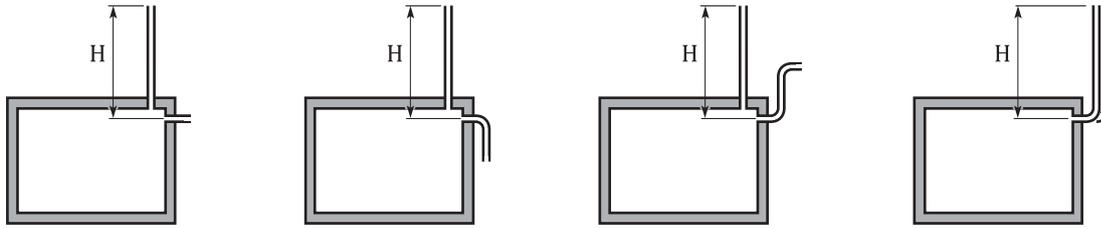


Figure B.1 — Effective level difference for natural ventilation

In the case of wall openings or horizontal pipes, the effective height  $H$  is equal to half the opening or pipe diameter (or vertical light height of the opening).

The above presented calculation has been used to draw the graph in Figure B.2, for dimensioning of ventilation pipes or ducts vertically up with a max. length of 5 m:

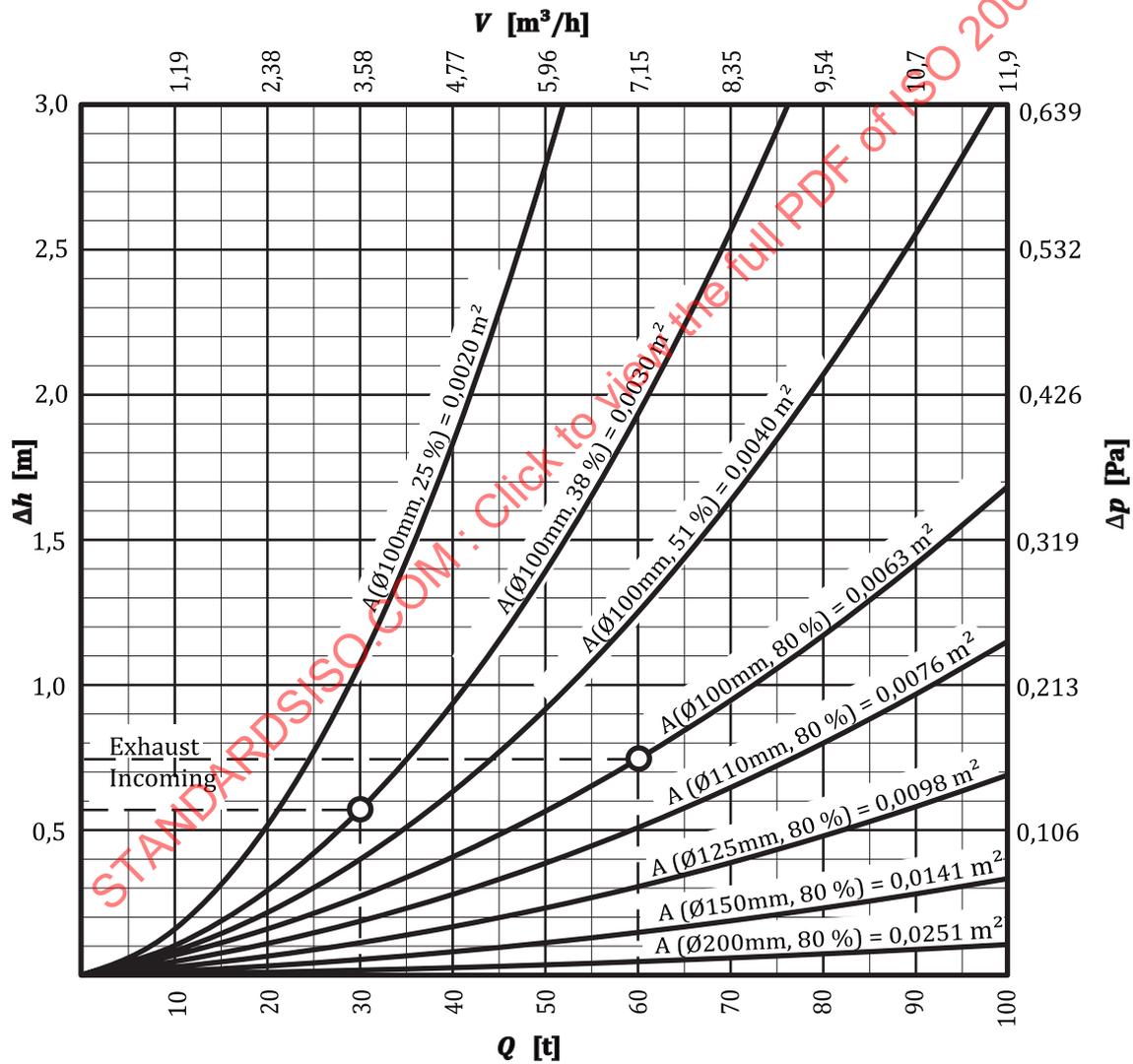


Figure B.2 — Dimensioning of ventilation pipes or ducts vertically up with a max. length of 5 m

The required heights for incoming and exhaust line shall be taken separately from this diagram and are summarized to obtain the total level difference  $H$ .

## EXAMPLE 2

For a store with 60 t of holding capacity

Incoming air via two filling pipes, 30 t for each pipe.

Pipe maximum length 5 m, Ø 100 mm, 30 cm<sup>2</sup> free grid cross-section.

$\Delta h_{\text{Incoming}} = 0,57$  m, found in the diagram

Exhaust air via one ventilation pipe, 60 t,

Pipe maximum length 5 m, Ø 100 mm, 63 cm<sup>2</sup> free grid cross-section.

$\Delta h_{\text{Exhaust}} = 0,74$  m, found in the diagram,

Total required effective level difference H between incoming into store and exhaust to atmosphere:

$$H = \Delta h_{\text{Incoming}} + \Delta h_{\text{Exhaust}}$$

$$H = 0,57 \text{ m} + 0,74 \text{ m} = 1,31 \text{ m}$$

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## Annex C (informative)

### Examples for store designs

#### C.1 Size of storage

It is recommended that small pellet stores (for boilers <50 kW, as typically used in single family houses) should be capable of holding fuel for approximately one heating season. The pellet demand for one heating period may be calculated on basis of the heating load of the building or for refurbished heating systems from the fuel consumption of the previous heating system.

NOTE 1 A fuel requirement for one heating season can be estimated between 0,6 m<sup>3</sup> and 0,7 m<sup>3</sup> pellets per kW heating load. The heating load may be calculated according to EN 12831<sup>[16]</sup>.

NOTE 2 1 m<sup>3</sup> of pellets corresponds to a mass of approximately 650 kg.

NOTE 3 Pellet demand in kilograms is approximately twice the heating oil consumption in litres.

NOTE 4 For most storage systems the total volume of the room or system is not usable. For customized built pellet stores approximately one third to one half of the room volume is not available for storage e.g. the empty space below the sloping floor.

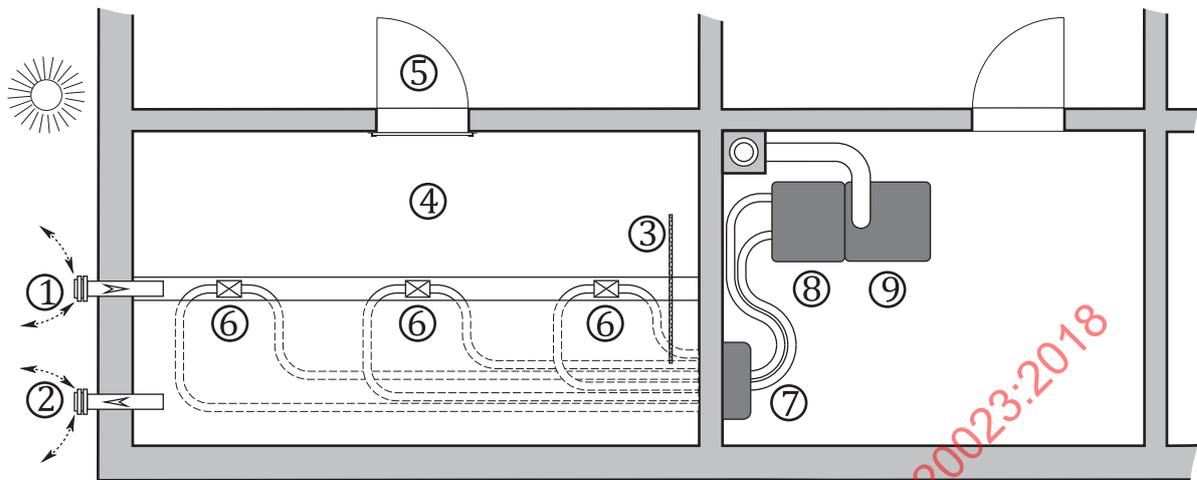
For larger combustion systems the size should be defined according to local requirements but should be able hold more than a full truck load to allow purchase of full truck loads.

If a standard arrangement is not possible based on the particular room geometry, a special solution can be devised in consultation with a qualified business (e.g. on the long side of the pellet store – two fill connectors or one diagonal-fill option). [Figure C.1](#) shows the recommended location of two blowing connectors on the long side of a pellet store.

For pellet stores with a height of up to approximately 2,5 m a total pressure of 3 000 Pa may be used to calculate static requirements for the construction of walls (see also [6.1.3](#)). This force includes the force of pellets stored and all forces for stores filled by blower trucks (initial filling pressures with eventual pressure shocks when unloading blower trucks).

For pellet stores higher than 2,5 m forces need to be calculated individually. If a store is built by supporting walls only it requires either a sloping floor or another possibility for pressure release to deflect the force of expanding pellets in case of water ingress (e.g. firefighting, flooding).

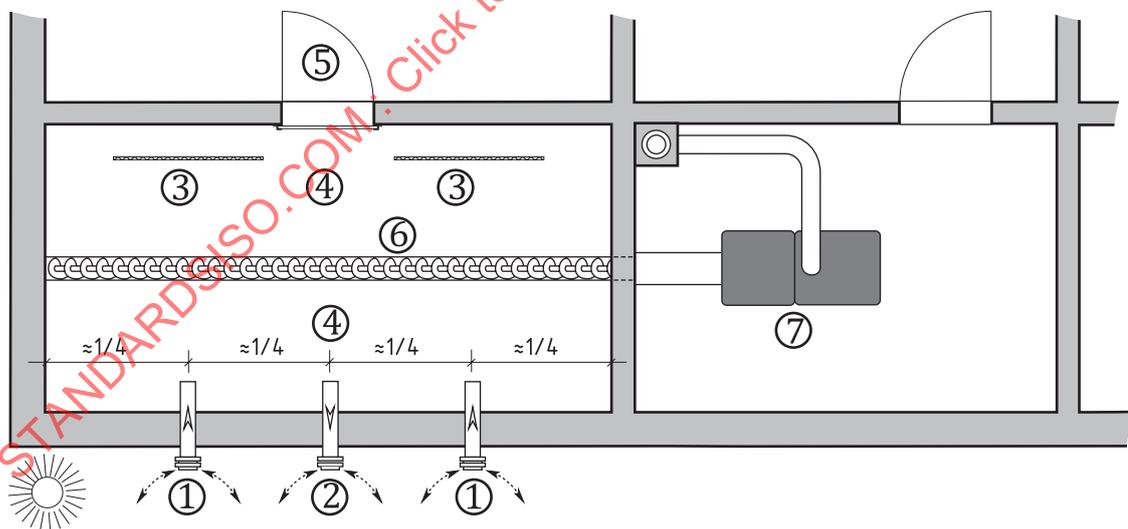
C.2 Layout examples



Key

- |   |                       |   |                  |
|---|-----------------------|---|------------------|
| 1 | blowing connector     | 6 | suction probes   |
| 2 | suction connector     | 7 | probes switchbox |
| 3 | impact protection mat | 8 | day hopper       |
| 4 | sloping floor         | 9 | boiler           |
| 5 | access door           |   |                  |

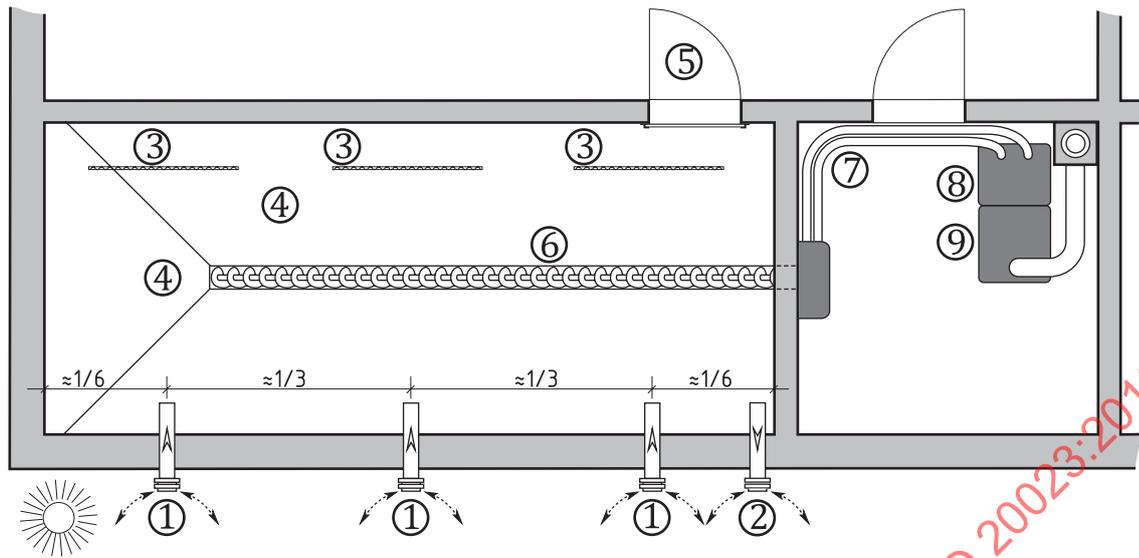
Figure C.1 — Plan view of a store with connectors at the small side and boiler with a suction extraction



Key

- |   |                        |   |                |
|---|------------------------|---|----------------|
| 1 | blowing connector      | 5 | access door    |
| 2 | suction connector      | 6 | screw conveyor |
| 3 | impact protection mats | 7 | boiler         |
| 4 | sloping floor          |   |                |

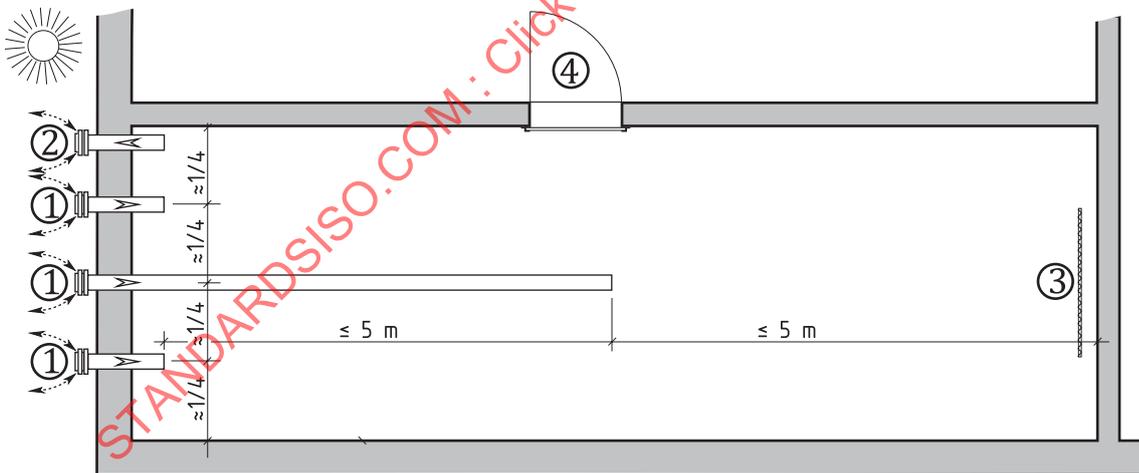
Figure C.2 — Plan view of a store with connectors at the long side and boiler with a screw extraction



**Key**

- |                          |                    |
|--------------------------|--------------------|
| 1 blowing connector      | 6 screw extraction |
| 2 suction connector      | 7 suction conveyor |
| 3 impact protection mats | 8 day hopper       |
| 4 sloping floor          | 9 boiler           |
| 5 access door            |                    |

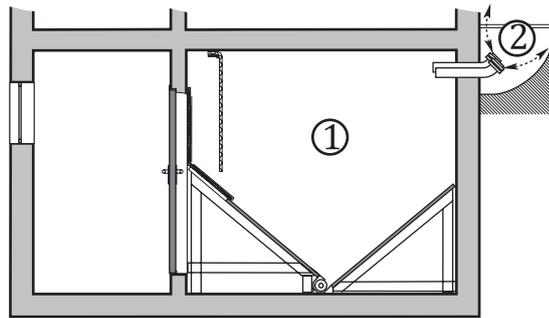
**Figure C.3 — Plan view of a store with more than 2 blowing connectors at the long side and boiler with a combination of screw extraction and suction conveyor**



**Key**

- |                     |                          |
|---------------------|--------------------------|
| 1 blowing connector | 3 impact protection mats |
| 2 suction connector | 4 access door            |

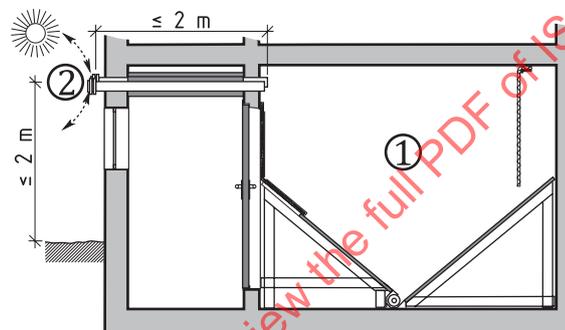
**Figure C.4 — Plan view of a pellet store longer than 6,0 m and connectors at the small side**



**Key**

- 1 pellet store
- 2 connectors with ventilation caps

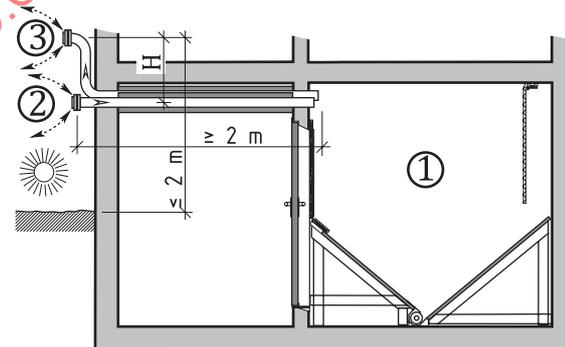
**Figure C.5 — Pellet store with short fill pipes using ventilation caps**



**Key**

- 1 pellet store
- 2 connectors with ventilation caps; With longer fill pipes than 2 m see [Figure C.7](#)

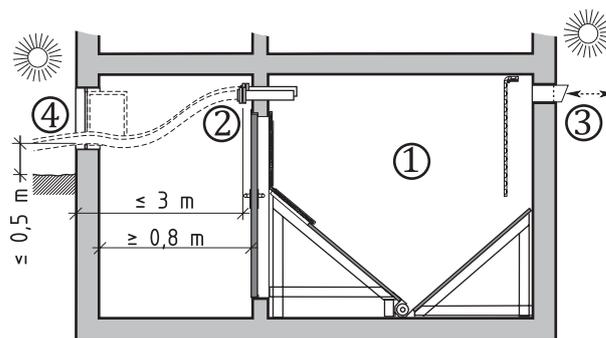
**Figure C.6 — Pellet store with fill pipes up to 2 m using ventilation caps**



**Key**

- 1 pellet store
- 2 blowing connector with ventilation cap
- 3 suction connector with ventilation cap, level difference H has to be calculated using diagram or formulas of [Annex B](#)

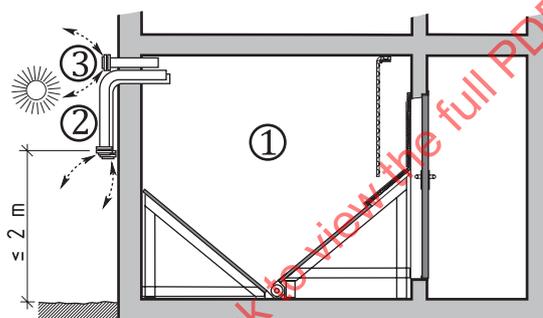
**Figure C.7 — Pellet store with fill pipes longer than 2 m using ventilation cap**



**Key**

- 1 pellet store
- 2 connectors with airtight caps
- 3 ventilation opening
- 4 window or door is required to line the delivery hoses from the truck to the connectors inside

**Figure C.8 — Pellet store with connectors inside the house needs ventilation openings**



**Key**

- 1 pellet store
- 2 connectors with ventilation cap
- 3 ventilation pipe with connector and ventilation cap, has to be horizontal without bend, can be closed with an airtight cap during blowing in of pellets

**Figure C.9 — Store with fill pipes outside downward using ventilation caps**