The world-leading
Wood pellet certification

EN*plus*® Guidance

Storage for Wood Pellets

EN*plus*® GD UK 3001:2025, first edition

Valid in the United Kingdom

UK Pellet Council
Office 80
Bowman House
Whitehill Lane
Royal Wootton Bassett
Wiltshire, SN4 7DB

E-mail: ukpelletcouncil@pelletcouncil.org.uk

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Foreword

The UK Pellet Council (UKPC) is the National Licensor for the EN*plus*® Quality Scheme in the United Kingdom.

The European Pellet Council (EPC), founded in 2010 and a network of Bioenergy Europe AISBL, is an umbrella organisation that represents the interests of the European wood pellet sector. Its members are national pellet-, or pellet-related associations from numerous countries in and outside of Europe. The EPC provides a platform for the pellet sector to discuss issues that must be managed in the transition from a niche product to a major energy commodity. These issues include standardisation and certification of pellet quality, safety, security of supply, education and training, and pellet quality measuring devices.

Deutsches Pelletinstitut GmbH (German Pellet Institute) (**DEPI**) was founded in 2008 as a subsidiary of Deutscher Energieholz- und Pellet-Verband e. V. (German Wood Fuel and Pellet Association) (DEPV), and provides a communication platform and competence centre for topics related to heating with wood pellets. In 2010, **DEPI** created, in cooperation with German Biomass Research Center Leipzig (DBFZ) and proPellets Austria, the EN*plus*® scheme. In 2011, the trademark rights for all countries, except Germany, transferred to the EPC.

Today, the EPC is the governing body for the EN*plus*® quality certification scheme for all countries except Germany, which is governed by **DEPI**.

This document replaces EN*plus*® GD 3001:2023, first edition (published 13.02.2023) in the UK only and comes into force on 30 April 2025.

Contents

Introduction

The key objective of the EN*plus*® scheme is to manage an ambitious certification scheme that thrives for consistent, high quality wood pellets. The **EN*plus*® logo** allows pellet quality to be communicated to customers and consumers in a transparent and verifiable way.

Wood pellets are a renewable fuel produced primarily from sawmill residues. Wood pellets are used as a fuel for residential heating systems as well as for industrial burners. They are a refined fuel that can be damaged during handling. Due to this, quality management is a necessity and should cover the entirety of the supply chain, from the choice of raw material to the final delivery to the end-user.

The EN*plus*® scheme covers technical properties of pellets, quality management related to the properties of the pellets, and customer satisfaction within the entire supply chain, from pellet production to end use.

The EN*plus*® scheme is primarily focused on the domestic and commercial heating sector, but the EN*plus*® certification is also available to all other actors within the pellet industry.

The 4th major **revision** of the EN*plus*® scheme resulted in a comprehensive change in the structure of the **EN*plus*® documentation**, in parameters for EN*plus*® certified pellets and relating processes, and management system requirements.

This document is part of the **EN*plus*® documentation** that consists of EN*plus*® **standards**, EN*plus*® guidance documents, as well as EN*plus*® procedural documents.

Current versions of the **EN*plus*® documentation** are published on the **official EN*plus*® website**.

The quality of the pellets can also be influenced by final delivery to end-user but also by inappropriate design of end-user storage. This document therefore provides:

a) Technical specifications of the end-user storage that shall be checked by the **trader** delivering the pellets as required by EN*plus*® ST 1001;

b) Technical specifications that have an impact on acceptance of complaints as required by EN*plus*® ST 1001;

c) Guidance for professionals and individuals who plan, build and equip pellet storage and ensure its operation and maintenance.

The term "shall" is used throughout this document to indicate those provisions that are mandatory. The term "should" is used to indicate those provisions which, although not mandatory, are expected to be adopted and implemented. The term "may" indicates permission, whereas "can" refers to the ability of, or a possibility open to, a user of this document.

The terms written in bold characters are defined in the chapter 3. Terms and Definitions.

1. Scope

The document includes provision for storage of pellets by end-users that are applicable to the following entities operating in countries outside Germany and without **EN*plus*® National Licensers**:

a) **Traders** with **small-scale delivery** shall use provisions identified in Table 1 in connection with requirements of EN*plus* ST 1001 for the purposes of identifying obvious defects of end-user storage and investigation of end-user's complaint relating to fines;

b) **EN*plus*® National Licensers** of countries with **small-scale delivery** of pellets shall develop a national storage guideline that would include at least elements identified in Table 1 of the document;

c) End-users of pellets, manufacturers and installers of heating devices and storage facilities should use the document as guidance for designing, building and operating pellets storage facilities.

Table 1: Provisions applicable to **traders** and **EN*plus*® National Licensers**

Chapter	**Traders**	**EN*plus*® National Licensers**
4.2 Delivery	•	•
5.3.1 Parking space for the delivery truck	•	•
5.3.2 **Filling system**	•	•
5.3.3 Accessibility of the **filling system**	•	•
5.3.4 Pellets storage access	•	•
5.4 Discharge and conveyer system		•
5.5 Filling level control		•
5.6 Structural requirements		•
5.7 Ventilation		•
5.8 Fire and explosion protection		•
5.9 Moisture and explosion protection		•
8.2 Expansion of a pellet storage room	•	•
8.3 Ventilation	•	•
9.3 Pellet Delivery	•	•
9.4 Cleaning and maintenance	•	•
9.5 Procedures in the event of malfunction		•
10.2 **Filling system**	•	•

2. Normative references

The following referenced documents are indispensable for the application of this document as defined in its specific requirements. For dated references, only the relevant edition applies. For undated references, the latest edition of the referenced document (including any amendment) applies.

EN*plus*® ST 1001, *ENplus® wood pellets – Requirements for companies*

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

ISO 20023, *Solid biofuels – Safety of solid biofuel pellets – Safe handling and storage of wood pellets in residential and other small-scale applications*

3. Terms and Definitions

3.1 agitator

Conveyor system for the discharge of wood pellets from the warehouse. The pellets are fed to a screw by rotating steel springs at the bottom of the store. Further transport to the furnace can take place with a screw or a suction conveyor.

3.2 ATEX

French abbreviation for ATmospheres EXplosives. Is used synonymously for the **ATEX** directives of the EU for explosion protection. Pellet storage facilities are usually assigned to **ATEX** zone 22.

3.3 auger / screw conveyor

Conveyor system for the discharge of wood pellets from storage. Further transport to the furnace can take place with a screw or a suction conveyor. Differentiation between rigid screw and flexible screw. The distance between the coils and the motor should increase and thus have a gradient. Screw channels without obstacles or restrictions. Pressure relief for the **auger** should be provided.

3.4 blow-in nozzle

Nozzle ("Storz Type A", DN 100), cross-section typically 100 mm, is used for blowing the pellets into storage. The connection for the coupling of the filling hose should be on the outside if possible.

3.5 bulk density

Mass per volume of a loose bed of pellets.

3.6 capacity

Capacity of storage, mass of pellets in tonnes that mathematically fit into the store. The **bulk density**, fill level, and empty volume in storage must be taken into account.

3.7 clutch

Connection piece ("Storz Type A", DN 100) on the nozzle and on the hoses to connect them securely to one another.

3.8 conveyor system

Equipment for transporting pellets into the furnace. Can also include discharge.

3.9 DEPI

DEPI (Deutsches Pelletinstitut GmbH) is EN*plus*® governing body for Germany, certification body responsible for all certification activities within Germany and acts as inspection body within Germany.

3.10 discharge system

Device for removing the pellets from the store. Can also include the transport of the pellets to the furnace.

3.11 dust-proof

Dust-tight separation of the warehouse (walls, entry / exit openings) from the living and working areas. Sealing of the suction system hoses against negative pressure is necessary.

3.12 EN*plus*® International Management

Bioenergy Europe AISBL represented by the European Pellet Council (EPC), is the governing body of the EN*plus*® certification scheme with overall responsibility for the management of the EN*plus*® scheme outside Germany.

3.13 EN*plus*® National Licenser

A governing body of the EN*plus*® certification scheme appointed by **EN*plus*® International Management** to manage the EN*plus*® scheme within a specific country.

3.14 EPDM-Foil

Elastic and wear-resistant film. Suitable material with a low-abrasion surface for impact mats (ethylene-propylene-diene rubber). Can also be made of synthetic rubber.

3.15 FFP

English abbreviation for Filtering Face Piece; denotes the filter class; A dust mask of filter class **FFP2** must be worn when cleaning the pellet storage.

3.16 filling duct

Permanently installed duct for filling storage, can also be used as a ventilation duct if necessary.

3.17 filling nozzle

The entirety of all blow-in and **suction nozzles** in a storage room, possibly only the **blow-in nozzles**, if no extractor is required (see blow-in and **ventilation nozzles**).

3.18 filling system

Entirety of **filling nozzles** and permanently installed filling lines and hoses.

3.19 fine particles

Chips, dust, fragments of pellets falling through a sieve with a perforation of 3.15 mm in diameter.

3.20 gross density

Particle density. Relationship between mass and volume of a pellet, describes the degree of compression of the constituent particles in g / cm³.

3.21 HDPE-Foil

Tear, scratch and wear resistant film. Suitable material with a low-abrasion surface for impact mats (English: High Density Polyethylene, German: Hard Polyethylene).

3.22 hose path

Laying path for the filling hose, which should be as short as possible, without bends and free of obstacles.

3.23 inlay boards

Boards for pressure relief of the door, hatch or entry opening of storage. Are used on the inside of storage in front of the door opening. (see Fig. 19).

3.24 IP

English abbreviation for International Protection; Degree of protection for electrical equipment; Use at least **IP** 54 in the pellet storage (protected against dust in harmful quantities; protected against splashing water).

3.25 larger storage

Pellet storage with a **capacity** of at least 30 tonnes or with frequent deliveries.

3.26 OSB

Oriented Strand Board (German: plate from aligned chips), which is structurally much better suited than conventional chipboard. Due to the rough surface, it is not suitable for paneling the **sloping floors** in the pellet store; on the other hand, very well suited for storage walls.

3.27 pneumatic discharge system

Suction removal; Pellets are sucked out of the pellet store by negative pressure: This can be done from below by **suction probes** or from above by a **suction head**.

3.28 sloping floor

Inclined smooth installation, is used in inclined floor storage.

3.29 small and medium-sized storage

Pellet storage with a **capacity** below 30 t.

3.30 small-scale delivery

A delivery of **bulk pellets** to an end-user that does not exceed 20 tonnes. This excludes deliveries of pellets in **big bags** and **vending machines**.

3.31 suction head

Device for suction extraction from above.

3.32 ventilation nozzles

Nozzle ("Storz Type A", DN 100), cross-section typically 100 mm, to which the pellet supplier's dust bag is connected. Exceptions are fabric silos with air-permeable fabric.

3.33 suction probe

Device for suction extraction from below.

3.34 trader

A **company** trading wood pellets. It can include the storage and / or delivery of pellets.

NOTE: The term "**trader**" also covers the term "**producer**" where the **producer**'s trading activities include **small-scale delivery** or trades pellets procured from other **companies**.

3.35 ventilation caps

Ensure a sufficient exchange of air in the storage room through rain and splash-proof openings with an internal pipe length <2 m or individual calculation according to ISO 20023.

4. Wood pellets – a modern fuel

4.1 Fuel quality

4.1.1 Wood pellets

Pellets are a modern and climate-friendly wood fuel. The firmness of the pellets is achieved mainly by the lignin contained in the wood, sometimes supported by the small addition of vegetable binders such as starch. Wood pellets can be delivered loose by truck or on pallets in bags. Such bagged goods are suitable for pellet stoves and small boilers with an annual requirement of up to two tons of pellets. If the demand is higher, bulk goods should be obtained, which are usually delivered in a truck and blown into the pellet storage.

4.1.2 EN*plus*® certification

To ensure that the pellets also meet the usage requirements, only EN*plus*®-certified pellets should be used. EN*plus*® has stricter requirements for pellet quality and, unlike other certificates, covers the entire supply chain. Both the producer and the supplier of the pellets must be certified in order to be able to offer EN*plus*® pellets in bulk.

EN*plus*® certified pellet dealers have to attend training courses regularly, prove to have suitable **discharge systems** on their vehicles and deal with customer complaints in an orderly manner. To identify the goods, you will receive individual certification and quality marks with a unique identification number that must be included on the customer receipt – this ensures the traceability of the pellets. At each truck filling, reserve samples are taken which can be used as reference samples in the event of complaints.

You can find UK manufacturers and suppliers of high-quality wood pellets as well as further information at https://www.pelletcouncil.org.uk/en-plus-producers-and-traders/.

4.1.3 Quality classes

Wood pellets are available in several standardized quality classes. In the international product standard ISO 17225-2, which has been in effect since 2014, the physicochemical properties of wood pellets for the three quality classes A1, A2 and B are thoroughly described. Here the standard leaves a lot of leeway, and the classes tighten its limit values in the interest of consumer protection.

For pellet stoves and pellet heating systems in the private and commercial sector with a nominal output of up to approximately 100 kW, only pellets of quality class EN*plus*® A1 should be used. EN*plus*® A1 guarantees the lowest ash content, the highest mechanical durability and the lowest nitrogen, sulfur and chlorine content. In addition to the product standard, EN*plus*® also defines a limit value for the ash deformation temperature to avoid the generation of slag on the burner plate of the boiler or furnace.

- **Figure 1**

EN*plus*® certification seal (left) and quality seal EN*plus*® A1 (right)

For large commercial or industrial heating systems, the EN*plus*® A2 quality is also suitable, which may have a higher ash content, lower mechanical durability and lower ash deformation temperature than EN*plus*® A1. Provided that the boiler manufacturer has approved it, EN*plus*® A2 can be used for boilers over 100 kW. Other quality classes can be used subject to approval by the heating equipment manufacturer.

Table 1

Fuel properties of wood pellet

Quality class	ENplus® A1	ENplus® A2	ENplus® B	Unit	Testing standard
Diameter (as received)	6 ± 1, 8 ± 1	6 ± 1, 8 ± 1	6 ± 1, 8 ± 1	mm	ISO 17829
Length (as received)	3,15 ≤ L ≤ 40 (a)	3,15 ≤ L ≤ 40 (a)	3,15 ≤ L ≤ 40 (a)	mm	ISO 17829
Share of pellets with a length < 10 mm (as received) - Category L < 20%, 20%≤ M ≤ 30%, S > 30%	value & category to be stated	value & category to be stated	value & category to be stated	w-%	ENplus® Guidance Document (b)
Moisture (as received)	≤ 10,0	≤ 10,0	≤ 10,0	w-%	ISO 18134
Ash (dry basis)	≤ 0,70	≤ 1,20	≤ 2,00	w-%	ISO 18122
Mechanical durability (as received) (c)	≥ 98,0	≥ 97,5	≥ 97,5	w-%	ISO 17831-1
Bulk density (as received)	600 ≤ BD ≤ 750	600 ≤ BD ≤ 750	600 ≤ BD ≤ 750	kg/m³	ISO 17828
Particle density (as received)	value to be stated	value to be stated	value to be stated	g/cm³	ISO18847
Coarse fines (3,15 mm ≤ FP < 5,6 mm) (as received)	value to be stated	value to be stated	value to be stated	w-%	analysis based on ISO 18846 (d, e, f, g)
Fines (< 3,15 mm) (bulk) (as received)	≤ 1,0	≤ 1,0	≤ 1,0	w-%	ISO 18846 (d, f, g)
Fines (< 3,15 mm) (bags) (as received)	≤ 0,5	≤ 0,5		w-%	ISO 18846 (e, f, g)
Net calorific value (as received)	≥ 4,6 (h)	≥ 4,6 (h)	≥ 4,6 (h)	kWh/kg	ISO 18125
Additives (as received)	≤ 2,0 (i)	≤ 2,0 (i)	≤ 2,0 (i)	w-%	
Nitrogen (dry basis)	≤ 0,3	≤ 0,5	≤ 1,0	w-%	ISO 16948
Sulfur (dry basis)	≤ 0,04	≤ 0,04	≤ 0,04	w-%	ISO 16994
Chlorine (dry basis)	≤ 0,02	≤ 0,02	≤ 0,03	w-%	ISO 16994
Arsenic (dry basis)	≤ 1	≤ 1	≤ 1	mg/kg	ISO 16968
Cadmium (dry basis)	≤ 0,5	≤ 0,5	≤ 0,5	mg/kg	ISO 16968
Chromium (dry basis)	≤ 10	≤ 10	≤ 10	mg/kg	ISO 16968
Copper (dry basis)	≤ 10	≤ 10	≤ 10	mg/kg	ISO 16968
Lead (dry basis)	≤ 10	≤ 10	≤ 10	mg/kg	ISO 16968
Mercury (dry basis)	≤ 0,1	≤ 0,1	≤ 0,1	mg/kg	ISO 16968

Quality class	EN*plus*® A1	EN*plus*® A2	EN*plus*® B	Unit	Testing standard
Nickel (dry basis)	≤ 10	≤ 10	≤ 10	mg/kg	ISO 16968
Zinc (dry basis)	≤ 100	≤ 100	≤ 100	mg/kg	ISO 16968
Ash deformation temperature	≥ 1200	≥ 1100	≥ 1100	°C	ISO 21404 (j)

(a) A maximum of 1% of the pellets may be longer than 40 mm. No pellets longer than 45 mm are allowed.

(b) 100 pellets should be measured (after sieving with a 5,6 mm sieve) for the length distribution mass where only 50 are recommended in the ISO 17829. The results shall be both expressed by the exact value and the category (L, M, S).

(c) At the loading point of the transport vehicle at the production site.

(d) At company gate or when loading big bags or truck for deliveries to end-users.

(e) At company gate, when filling bags (bagged pellets).

(f) The indication “3,15 mm” respective “5,6 mm” designates particles which pass through a round hole sieve with an aperture size of 3,15 mm, respective 5,6 mm, according to ISO 3310-2.

(g) ISO 18846 will be replaced by ISO 5370.

(h) Equal ≥ 16,5 MJ/kg as received.

(i) The amount of additives in production shall be limited to 1,8 w-% while the amount of post-production additives (e.g. coating oils) shall be limited to 0,2 w-% of the pellets.

(j) Ash is produced at 815 °C. All characteristic temperatures listed in ISO 21404 shall be stated in the report.

NOTE: The results are considered conforming if the value reported by the laboratory is within the specified limit.

4.1.4 Bulk density

The **bulk density** (also called apparent or volumetric density) indicates how many kilograms of freely poured pellets fit into a volume of one cubic meter. It depends on the length distribution, the water content and the particle density of the pellets. EN*plus*® allows 600 to 750 kg/m³. In a storage room with a usable volume of 10 m³, about 6.0 to 7.5 tonnes of pellets can be blown in – depending on the **bulk density**.

4.1.5 Fine particles and dust

Fine particles are defined as fragments of pellets that fall through a sieve with a perforation of 3.15 mm in diameter. Dust is created by abrasion of the surface, especially at the broken edges of the pellets. The **fine particles** of coarser particles are mixed in between the pellets. They consist of very small particles, which settle from the air slowly.

Fine particles and dust emerge due to the mechanical stress on the pellets during transport, when they are brought into the storage room and when they are discharged to the boiler. The lower the mechanical durability and the average length, and the higher the mechanical stress, the higher the number of **fine particles** and dust are to be expected.

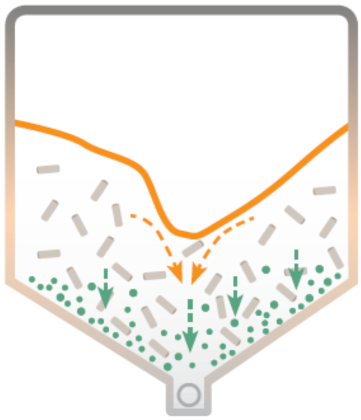
Pellets in the class EN*plus*® A1 may, in bulk, contain a maximum of one percent **fine particles** when the delivery truck is loaded. During the blow-in process, additional **fine particles** emerge, the amount of which increases with the length of the blow-in section and the number of bends in the blow-in duct. EN*plus*®-certified suppliers accept complaints resulting from a **fine particles** amount of more than four percent in the storage room under the following conditions:

a) Compliance with the requirements of this document;
b) Blow-in section (including all **filling ducts**) ≤ 30 m;
c) Remaining quantity before filling < 10% of storage capacity;
d) Less than 20 % of the new delivery removed;
e) Complete emptying & cleaning of the pellet storage every two years.

Due to segregation processes when the pellets are discharged (see Fig. 2), the **fine particles** are concentrated in the lower area of the storage room over time. It should therefore be completely emptied & cleaned at least every two years or every five deliveries – whichever occurs sooner.

Figure 2

Decomposition and accumulation of fine particles in the storage room



Consequence: The pellets in the lower area contain a lot of **fine particles**, which increase with each delivery when the storage is not completely emptied.

Accumulation of fine particles in the removal of pellets

Decomposition at discharge

Fine particles trickle down

Core flow: Edge area is discharged last

4.1.6 Smell and emissions

Depending on the type of wood used, pellets can develop their own odor. The reason for this lies in the so-called extract substances – the wood's own oils, fats and resins – which are activated during the pressing process. In the weeks following this process, the substances are slowly released into the surrounding air and then decompose on contact with atmospheric oxygen. Compared to other wood products, pellets have a large surface, and their cell structure has been heavily stressed by the pressing process. This means that the volatile components are released comparatively quickly – especially with fresh pellets and high surrounding temperatures.

The emissions from wood pellets consist of volatile organic compounds (VOC), carbon monoxide (CO) and carbon dioxide (CO2). For example, the VOCs include terpenes, which are responsible for the "chemical", turpentine-like odor that occurs in rare cases. Some components, such aldehydes and carbon monoxide, are hazardous to health and must therefore not get into living areas. A strong odor inside the building indicates insufficient sealing of the storage and boiler room. In order to rule out any risk, three simple principles must be observed for the pellet storage:

a) Sealing from living and working areas;

b) Proper ventilation (see 5.7);

c) Enter only in compliance with the safety instructions (see 9.2).

The inherent odor of the pellets and the risk of carbon monoxide are highest immediately after the storage room is filled, among other things because of the increase in temperature of the pellets when they are blown in. Both are considerably reduced within two to three weeks.

4.2 Delivery

Wood pellets are usually blown into the storage room from the delivery vehicle. Delivery with tippers or moving-floor trailers, from which the pellets are poured, is only possible in the case of **larger storage** designed for this purpose.

The delivery vehicle has a compressor that generates the conveying air for the blowing process. It is equipped with a calibrated on-board weighing system andinternally coated hoses to minimize friction when blowing in the pellets. Some delivery vehicles have a mobile suction fan with a dust bag whereas others simply use a dust bag and allow the negative pressure caused by the store ventilation pipe to remove the dust into the bag. These components of the vehicles are checked by EN*plus*®-certified suppliers, as is the regular participation of the drivers in training courses on quality-friendly delivery. When EN*plus*® pellets are delivered, the customer receives a delivery report that contains all the important information about the pellets, the blow-in process and the status of the storage room.

When blowing in the pellets using a pressurised silo truck, part of the compressed air is fed into the boiler chambers in order to push them out of the vehicle's silo. Other delivery vehicle types are equipped with an auger and/or a rotary feeder to supply pellets to the pneumatic feeding system. In all cases compressed air is used to accelerate the pellets through the delivery hose in to the store (see Fig. 3). In the case of short blow-in distances, it makes sense to blow in the pellets with little conveying air, while in the case of long distances the amount of air must be increased. The driver is trained to select the appropriate setting for the pressure in the vehicle storage chamber (on a pressurised silo truck) and the amount of conveying air depending on the local conditions including the length & route of the delivery hoses.

To safely blow in the pellets, the operator must switch off the heating system in accordance with the manufacturer's instructions in good time so that there are no more embers in the boiler. During the blow-in process, a slight negative pressure is created in the storage room either by an exhaust fan or the ventilation pipe which removes the conveying air and takes any dust that is generated into the filter bag. If the storage room is leaky, the negative pressure cannot be built up. The pellet supplier is not liable for any damage or contamination caused by a leaky pellet store.

With most fabric silos, the conveying air does not have to be extracted in accordance with the manufacturer's filling instructions. In this case, it must be ensured that the conveying air volume (up to 1,500 m³/h) can reach the outside through windows, doors or other external openings in the installation room.

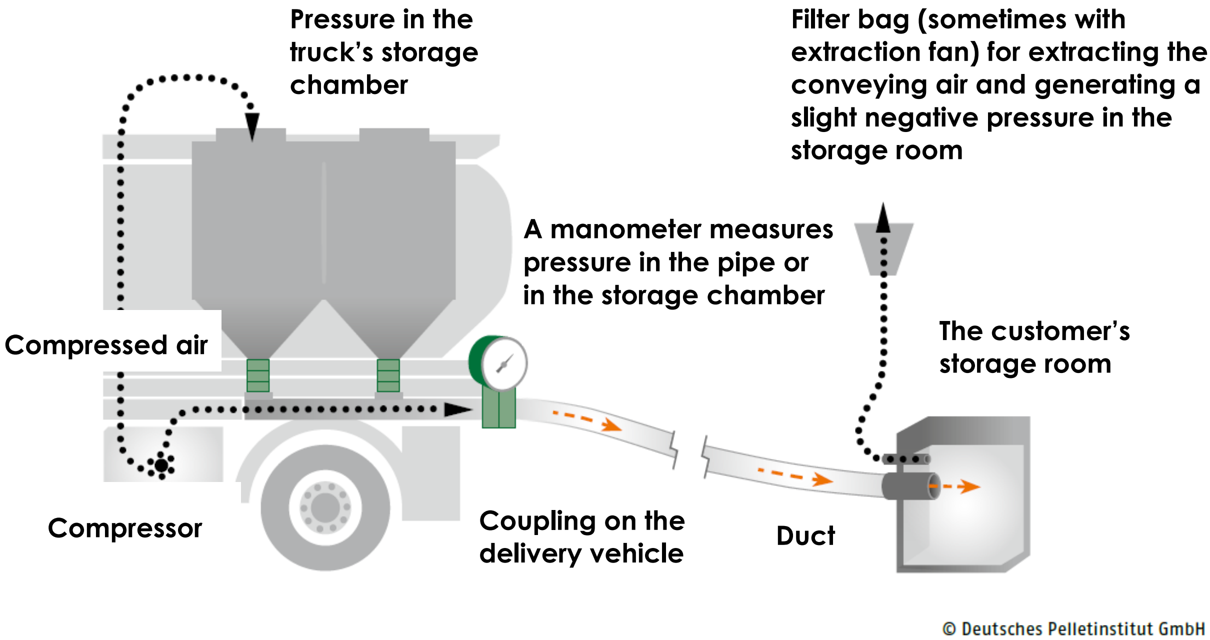
Where the storage room design or condition show obvious non-compliance with this Storage Guideline, the pellet supplier is obliged to inform the operator and may reject the delivery. This also includes consideration of health and safety of the pellet supplier personnel.

Special Case: Bagged Pellets

Bagged pellets are harmless in terms of odour and emissions because they have been stored for some time and the bag reduces the release of emissions. Only sacks that are intended for immediate consumption should be opened.

Figure 3

Blowing in wood pellets



It is advisable to store bagged pellets on pallets in a well-ventilated room in the basement, garage or shed so that they are protected from moisture and UV radiation.

Figure 4

Extraction fan with dust bag

5. Planning a pellet storage room

5.1 Storage type

While converted rooms or outbuildings were almost exclusively used as storage rooms in the early days of pellet heating, prefabricated storage rooms are now increasingly being used for smaller amounts of fuel. In addition, underground storage and silos for outdoor installation offer sophisticated solutions for storing wood pellets outside of the building.

The storage room should be the right size and planned according to the principle of short distances (from the delivery truck to the storage room, from the storage room to the boiler). Statics, fire protection and ventilation requirements must be taken into account. When deciding on a specific storage system, in addition to the connection to the heating boiler, the following aspects should be in the foreground:

a) A short and quality-saving blowing path;

b) A short and quality-saving conveying path between storage and furnace;

c) Adequate storage ventilation;

d) Dust-tight separation from living and working areas;

e) Good accessibility in the event of faults and for cleaning;

f) Sufficient **capacity.**

We recommend the use of prefabricated storage for private customers. As a rule, in addition to the actual storage container, they also contain the filling and **discharge system** for the storage room. In this way, the planning and assembly effort can be significantly shortened compared to the self-made storage. Moreover, structural robustness as well as professional sealing against dust leakage is ensured by the storage manufacturer.

Prefabricated pellet storage facilities are offered in various designs for indoor and outdoor use. For inside use there are air-permeable fabric silos and air-impermeable plastic or metal containers. Outdoors, underground stores made of concrete or plastic can be used as well as silos made of plastic or metal for use above ground.

The advantages of individually built storage rooms lie in the good use of space, the possibility of cost-reducing personal efforts and the good accessibility of the filling and **suction nozzles** in storage rooms with external walls.

The construction should always be planned and carried out by specialists.

- **Figure 5**

Wood pellet system installation companies provide competent advice on pellet storage

5.2 Size

For small pellet heating systems, the storage room should be designed in such a way that it can hold at least a complete annual demand for pellets. This reduces the number of deliveries.

The size of the required storage space depends on the heat demand of the building, which can be found on the building's energy certificate. The specific final energy requirement (see Fig. 6) for heating, hot water and ventilation specified there must then be added and then multiplied by the living space.

Figure 6

Representation of the energy requirement in the energy performance certificate for residential buildings that might be country specific

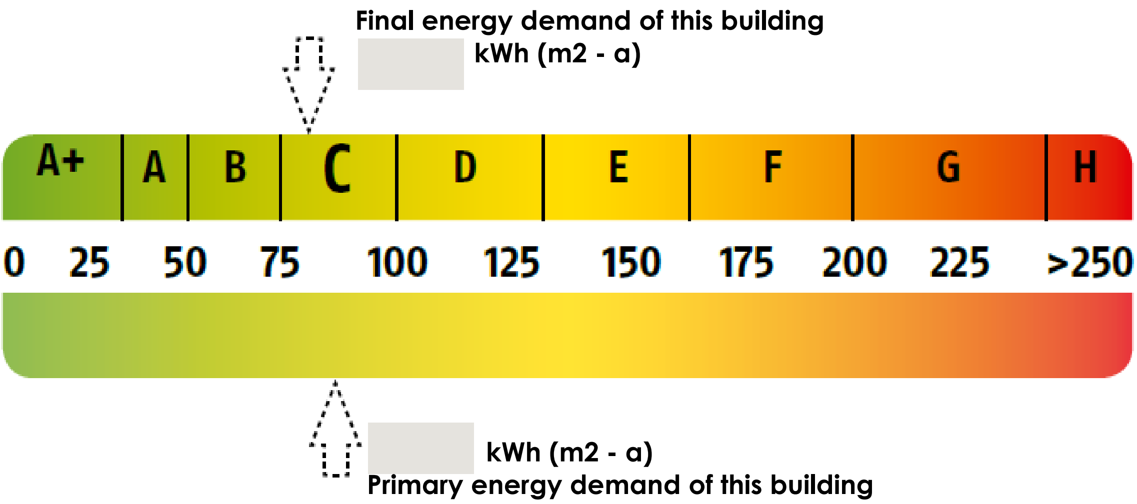


Table 2

Recommended storage sizes for pellet heating systems depending on the heat demand

Heat demand per year	8,000 kWh	15,000 kWh	30,000 kWh	100,000 kWh
Previous heating-oil consumption per year	1,000 l	1,875 l	3,750 l	12,500 l
Yearly pellet demand	2,000 kg	3,750 kg	7,500 kg	25,000 kg
Required storage volume	3.6 m³	6.8 m³	13.5 m³	45 m³
Recommended room size for sloping-floor storage (2 m room height)	3 m²	5 m²	10 m²	34 m²

The annual demand for pellets (weight in kg) corresponds to around a quarter of the heat demand (kWh) (For this calculation, an assumed calorific value of approx. 5 kWh/kg pellets is multiplied by an annual heating efficiency of 0.8). In order not to have to refuel even in colder winters, a safety factor of 1.2 is used. The **capacity** of a pellet storage room in tonnes is also influenced by the **bulk density** of the pellets (see 4.1), which is usually between 650 and 670 kg/m³ and can vary from delivery to delivery.

5.2.1 Rule of Thumb

Storage volume in m³ = annual pellet requirement in tonnes * 1.2 (safety factor) * 1.5 (reciprocal of the **bulk density**).

Because of the distance from the **blow-in nozzle** to the ceiling and the flow properties of the pellet embankment, the total volume of a storage room can never be used. Pellet storage facilities with **sloping floors** can only make use of close to two thirds of their volume for storage.

When converting the heating from oil to pellets, the pellet requirement can be estimated from the previous oil consumption: With the same efficiency of the heating system, the oil consumption in l is multiplied by a factor of two to get the pellet requirement in kg. When replacing an inefficient oil heating system, the pellet consumption can even be up to 20 % lower. The same factor applies to gas heating as to oil. Table II shows the relationship between heat demand and fuel consumption. A 0.8 degree of utilization is assumed in these design examples.

5.3 Location, accessibility and filling system

The storage room should be selected according to the principle of short distances (see Fig. 7). Both the route from the delivery truck to the pellet storage and the delivery route from the pellet storage to the boiler should be kept as short (and straight) as possible. This way, the formation of dust and → **fine particles** is reduced. Blow-in and **suction nozzles** must be provided with sufficient assembly space and must be accessible without danger.

In addition, sufficient storage ventilation must be available and there must be easy access to the storage room (for cleaning and inspection before filling). The provisions of ISO 20023 for the consumer's storage of wood pellets as well as the fire protection requirements of the respective state's fire regulations must be observed.

Accessibility to the storage room should be planned with the following considerations in mind:

5.3.1 Parking space for the delivery truck

a) Suitable parking space for the delivery truck: **Capacity** for an axle weight of up to 10 t, as level as possible, no half-height plants in front of the exhaust (engine runs when blowing in!), no obstruction to the passing traffic;

b) Suitable access: Path width at least 3 m, passage height 4 m, pay attention to weight and turning radius;

c) Short **hose path**, as straight as possible, max. 30 m length to the blow-in port in the storage room (**hose path** including permanently installed **filling duct**);

   Blowing in 6 tonnes of pellets takes approximately 20 minutes without assembly and dismantling. During this time, both the engine of the truck and the compressor are running – therefore, noise protection measures should be considered;

d) Short access to the suction nozzle and power connection (230v, 13A) to ensure that hoses from an extraction fan (where used) do not exceed 6 m in order to ensure efficiency of the air extraction.

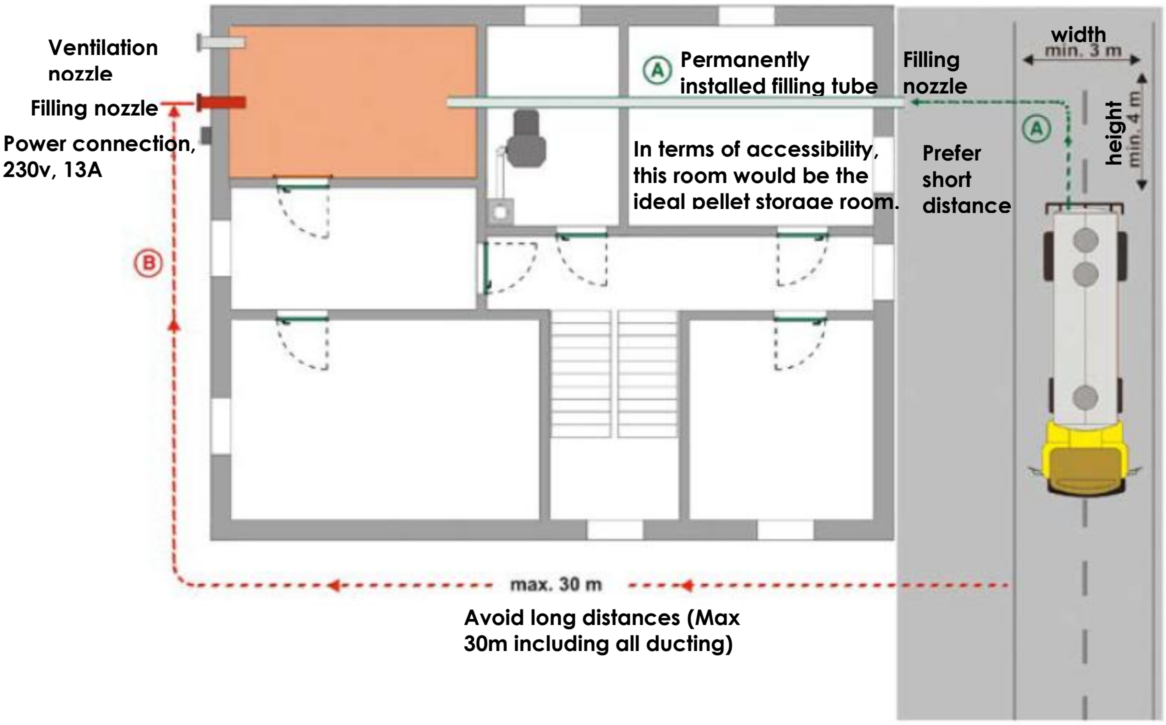
5.3.2 Filling system

The task of the **filling system** is to enable the pellets to be transported in a quality-friendly manner from the **blow-in nozzle** to the storage room. The nozzles of the **filling system** (coupling type "Storz Typ A", DN 100) should preferably be installed on the outside using permanently installed **filling ducts**. The number of **blow-in nozzles** depends on the width and depth of the pellet storage. Moreover, a separate ventilation duct, as short as possible, with a Storz-A connector, must be provided to ensure the negative pressure during the blowing process. Blowing in through the ventilation duct should be avoided, as overpressure could arise in the storage room if pellets are in front of it.

Detailed recommendations for the implementation of the **filling system** can be found in 8.2.

- **Figure 7**

Location and accessibility of the storage room for quality-preserving filling of pellets (top view)



a) The blow-in path is kept short and straight by a permanently installed filling tube. The **ventilation nozzle** and the power supply for the extraction fan (where used) should always be located directly on the outside wall of the pellet storage;

b) A long **hose path** with changes in direction increases the **fine particles** content when filling and should be avoided.

5.3.3 Accessibility of the filling system

a) No obstacles (fences, flower beds) in the hose's path from the parking space of the delivery truck to the **filling nozzle**;

b) Marked blow-in and **ventilation nozzles** lead to the outside. Use permanently installed **filling ducts** for prefabricated storage containers;

c) Individually fused power connection (230V, 13A) near the **ventilation nozzle** for the delivery truck's extraction fan (where used);

d) **Filling nozzle** placed at a maximum height of 2 m. Alternative: safe access via platform or ramp;

e) **Filling nozzle** located in a light well should point 45° upwards. The distance from the nozzle to the ground level should not exceed 25 cm;

f) Provide a working space of at least 50 cm around the internal **filling nozzle**.

5.3.4 Pellet storage access

a) Provide accessibility for maintenance and cleaning, both when empty and partially filled;

b) Access door measuring 200 cm x 80 cm or access hatch measuring at least 80 cm x 80 cm;

c) Place this opening (b) as far away as possible from the blow-in duct (but not opposite the blow-in duct) and the ventilation duct, for cross ventilation when entering the storage room. Ventilation of the storage anteroom;

d) Outward-opening access door and entry opening, fire protection class T30, sealing against dust and room-air leakage, pressure relief on the inside of the door frame with wooden **inlay boards**;

e) One or more small viewing windows made of transparent plastic for visual fill-level control and storage check in the **inlay boards** behind the door (see 5.5);

f) If the requirements for accessibility and ventilation inside the building cannot be met, external storage (silo, underground tank) should be considered.

5.4 Discharge and conveyor system

5.4.1 Types of systems

The technical equipment that gathers the pellets in the storage room and transports them to the boiler is called the discharge and **conveyor system**. It should convey the pellets with minimal disruption and as gently as possible and be easily accessible so that a fault can be repaired even when the storage room is full. Discharge and conveying systems can be divided into mechanically working **screw conveyors** and pneumatic suction conveyors (Table 3). The choice of the **discharge system** depends on the type of pellet storage and the location of the boiler. The most commonly used systems are:

a) Purely mechanical systems with a **screw conveyor** and inclined floors or **agitator** to support removal;

b) Purely pneumatic systems with a closed air circuit that picks up the pellets, either from above with a movable **suction head** or from below via fixed **suction probes** and **sloping floors**;

c) Pneumatic-mechanical combination systems, in which mechanical discharge is combined with suction conveyance to the boiler.

● **Table 3**

Discharge and conveyor systems for small and medium-sized storage

Pellet Discharge	Conveyor system	Use / Properties
Screw	Screw	For sloping-floor storage and trough silos with the discharge side at a short, straight distance from the boiler. Robust and low-noise operation with acoustic decoupling.
	Pneumatic	For sloping-floor storage and trough silos. Conveying lengths up to 25 m and conveying heights up to 5 m.
Agitator	Pneumatic and/or rigid screw	For storage room and flat-bottom silos. Good utilization of space and flexible design of the screw guide.
Suction extraction from above	Pneumatic	For flat storage, underground storage and flat-bottom silos Good utilization of space
Suction probes on the floor	Pneumatic	For sloping-floor storage and prefabricated silos. Without **sloping floors**: unusable residual amount and accumulation of **fine particles** between the **suction heads**.

In the case of pneumatic conveying systems, it can make sense to separate dust via a vacuum device in the return-air tube, so that the flowability of the pellets in the storage room is not impaired. The suction hoses are wearing parts and should be placed so that they are accessible for possible replacement. Abrasion (wear) occurs in the conveying hose, especially in bends. Systems with **suction probes** on the floor of a flat storage facility should be avoided, as an unusable residual number of pellets with a high fine-particle content then remains between the probes and increases susceptibility to failure.

5.4.2 Backflame and backflowing gases

The discharge and conveying system connect the pellet storage with the heating boiler. It must be guaranteed that embers or smoke gases from the boiler cannot get into the storage room via the **conveyor system**. For this purpose, the heating system must be equipped with safety systems such as rotary airlocks and fire dampers, which must withstand a negative pressure of 20 Pa in accordance with ISO 20023. This protection is sufficient if, when the storage room is filled, complete burnout is ensured by switching off the heating in good time (according to 4.2). It should be noted that rotary airlocks are subject to wear and tear and fire dampers can only fulfill their tasks if the closing function is not impaired. Safety devices are to be regularly maintained and checked for functionality. If it is to be possible to fill the storage room with the assistance of an extraction fan while the heating is running, the protective devices must withstand a negative pressure of 300 Pa. Alternatively, an opening of at least 2,000 cm² must be provided in the pellet storage for pressure equalization.

5.5 Filling-level control

The possibility to obtain information about the filling level in the pellet storage, without having to enter it, is helpful for safety reasons as well as for a convenient heating operation.

In the case of individually built storage, the easiest option is to install several small windows or portholes made of safety glass or plastic (Plexiglas) in the boards to relieve the pressure on the door (see Fig. 19). Plexiglas is electrostatically charged and therefore attracts dust. The viewing windows are therefore not suitable for assessing the dust content in the storage room.

Other systems for monitoring the filling level are more complex technical solutions that increase comfort and safety or that enable automated system monitoring. A distinction is made between four functions:

a) Detection and reporting of a specified minimum level in order to place a timely reorder;

b) Continuous level monitoring in large storage (e.g., for housing, business, industry);

c) Determination of the stock of pellets for heating billing (e.g., in apartment buildings);

d) Filling-level limitation when filling the storage room to prevent overfilling. This ensures that the ducts remain free of pellets and that the function of the ventilation cap is not obstructed.

Depending on the requirements and type of pellet storage, different measuring methods can be used for level monitoring. Pressure sensors or capacitive sensors are often used to detect the minimum filling level as well as to limit it. The continuous level monitoring and the determination of the stock can be realized by load cells or ultrasonic systems.

5.6 Structural requirements

The pellet storage must be designed in such a way that it can withstand the weight pressure of the pellets on the floor and walls as well as the overpressure and under pressure conditions on all enclosing surfaces that arise during the blow-in process. The calculation of the individual static requirements for a larger pellet storage and the verification of its steadiness is a task for qualified specialists. For smaller storage rooms, with a maximum inner height of 2.5 m, a structural calculation can be dispensed with if the materials and wall thicknesses described in 6.1 are used. In this case, the only thing to check is whether the floor of the installation room can withstand the weight load. As with any stack or embankment, the weight of the pellets not only acts vertically downwards (towards the floor), but due to the internal friction it also acts in a horizontal direction against the side walls. The pressure on the side walls increases towards the floor.

Table 4

Characteristic values for calculating wall and floor loads

Property	Value	Remark
Bulk density	750 kg/m3	Value according to ISO 20023
Internal friction angle	35°	Typical Value
Overpressure peak	0,03 bar	Value according to ISO 20023

In order to be able to calculate the pressure load on the walls and the floor, the maximum bulk weight of the pellets, the maximum filling height and the angle of internal friction must be considered when planning (see Table 4). In addition, a maximum overpressure of 0.03 bar (300 kg/cm²) must be taken into account for the blow-in process. The storage room must also be resistant to the negative pressure that occurs during this process (exception: silos made of air-permeable fabric).

5.7 Ventilation

In pellet storage, emissions from the pellets or backflow from the combustion system can lead to a harmful concentration of carbon monoxide (CO). To avoid this, adequate ventilation must be provided. The storage may only be entered in compliance with the safety instructions described in 9.2.

The ventilation of storage rooms and airtight storage containers can be either natural or mechanical. Natural ventilation is only permitted if the driving force for the air flow is great enough to overcome the flow resistance of the ducts. Therefore, VDI 3464 and ISO 20023 set requirements for maximum permissible duct lengths, pipe diameters and the free cross-section of the ventilation. For **small and medium-sized storage** with short **filling ducts** (≤ 2 m), lid ventilation via the **filling system** is a safe and the most cost-effective solution.

- **Table 5**

Fire protection requirements for fuel storage rooms and boiler rooms

Fuel storage outside of fuel-storage rooms ≤ 6.5 tonnes pellets	**Fuel storage within fuel-storage rooms > 6.5 tonnes pellets**
No requirements for walls, ceilings and doors. Not permitted in necessary stairwells and corridors, nor in spaces between these and the exit to the outside.	F90 Walls and ceilings, provided they do not adjoin the boiler room. Self-closing doors, opening outwards and class T30, provided they do not open into the open air or the boiler room. Partition wall to boiler room without requirements.
Boiler installation room (≤ 50 kW)	**Boiler installation room (> 50 kW)**
No requirements for walls and ceilings. Insulated and self-closing doors. No further openings to other rooms.	F90 Walls and ceilings. Self-closing doors, opening outwards and class T30, provided they do not open into the open air or the fuel storage. Partition wall to fuel storage without requirements.

If natural ventilation via ventilation ducts with height differences cannot be achieved, mechanical ventilation with a suction fan in a ventilation duct should be provided. The fan can work in regulated intermittent operation and thus ensure a sufficient exchange of air. For this purpose, a correspondingly dimensioned air-supply duct must be provided to prevent smoke gases or embers from being sucked in from the boiler! Alternatively, the function of the fan can be linked to opening the door.

Detailed requirements and recommendations for the implementation of ventilation for the installation room of an air-permeable fabric silo can be found in 6.2, and for storage rooms and airtight storage containers in 8.

5.8 Fire and explosion protection

5.8.1 Fire protection

The fire protection requirements for storage of wood pellets are defined in the national regulations of each country and therefore may differ depending on the country. It is recommended that you take independent advice and do not rely solely upon this document which is for guidance only.

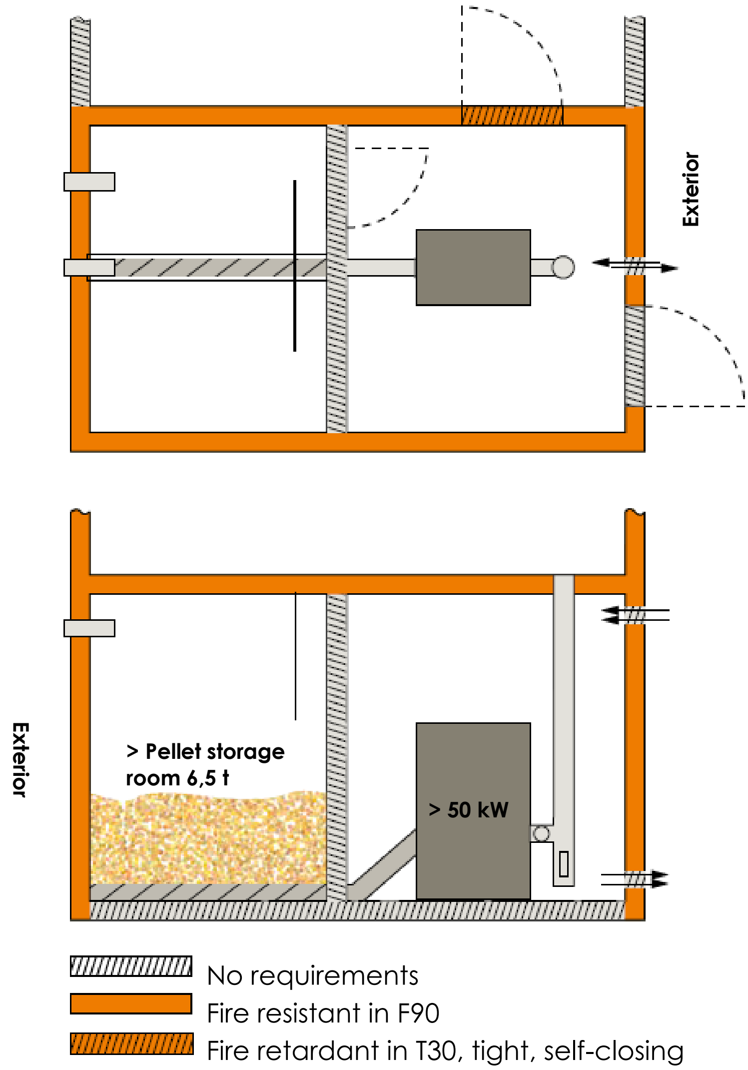
No fire protection requirements are placed on the partition wall between the fuel storage room and the installation room for the heating or boiler room if both are designed as a common fire compartment. In these cases, there is no need for a building-authority-approved isolation for the **discharge system**.

If the heating and the fuel storage room are in different fire compartments, the wall ducts of the **conveyor system** must have fire protection closures approved by the building authorities, and fire protection collars for plastic pipes. For **screw conveyors** in steel pipes, fire-insulating material (mineral wool) that protrudes 30 cm on both sides of the wall should be used due to the lack of building-authority-approved solutions.

- **Figure 8**

Fire protection requirements for the boiler room and pellet storage in a common fire compartment (top view and section)

5.8.2 Explosion Protection



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Pellet storage rooms with a **capacity** of up to 100 tonnes do not require an explosion protection document and also no structural explosion protection. There is only a hazardous situation when the storage is being filled if, in exceptional cases, an explosive powder atmosphere can arise due to the development of dust. To eliminate this risk, the following measures are required:

a) Use of certified pellets to keep the amount of **fine particles** and dust low;

b) Regular emptying and cleaning of the storage room (see 9.4);

c) Professional earthing of both the filling and the **discharge systems;**

d) Lighting and drives for the **discharge system** within the storage room, with approval for **ATEX** zone 22, voltage-free during the filling process;

e) No sockets and exposed electrical cables in the storage room.

5.9 Moisture and wetness

Pellets are hygroscopic. This means that they absorb water when close to damp walls, which causes them to swell and become unusable. Moist pellets can also block the **conveyor system**. Therefore, the following information must be observed:

a) The pellet storage must remain dry all year round. In new buildings, make sure that the floor and walls are already completely dry;

b) The relative humidity in the storage room should not exceed 80% at any time of period of the year;

c) If there is a risk of damp walls (even if temporarily), prefabricated storage should preferably be used, or professional moisture protection should be provided.

6. Prefabricated storage systems

6.1 General

The requirements for pellet quality and storage safety have increased in recent years. They are reliably fulfilled by prefabricated storage systems. For this end, they must be properly set up and operated in accordance with the manufacturer's instructions. The responsibility for this lies with the heating installer. He or she takes over the guarantee for the functional unit, boiler, extraction system and pellet storage. In accordance with ISO 20023, they document the components used and their professional installation in a handover protocol.

Prefabricated storage containers can be set up inside the building as well as on its outside in garages, under carports or, in some cases, freely, as long as the supply to the pellet boiler is guaranteed.

The following sections provide an overview of the different storage systems and instructions on how to set them up (for underground storage, see 7).

Storage containers also require access for storage cleaning and troubleshooting.

6.2 Designs

6.2.1 Types of storage systems

Prefabricated storage is offered in different materials and shapes. Most importantly, air-permeable fabric silos are to be distinguished from storage containers made of air-impermeable fabric, plastic, wood or metal, as there are different requirements for the **filling system** and the ventilation of the installation room. Most fabric silos made from air-permeable material do not need a **ventilation nozzle**, while those made from air-impermeable material do.

Fabric silos consist of a flexible, tear-resistant and **dust-proof** material that is suspended in a metal or wooden frame. They are often equipped with a cone at the bottom for discharging the pellets (cone silo). Other common designs are trough, elastic and flat-bottom silos.

Figure 9a

Fabric silo with steel cone

Figure 9b

Cone silo in modular design

Figure 9c

Cone silo with wooden frame

Depending on the type of storage, the pellets are removed from below with **screw conveyors** / **suction probes** or via a movable suction extractor from above using a **suction head** (see 5.4).

Prefabricated storage is also offered in modular design for **larger storage** quantities. In this case, the extraction systems of the individual silos are connected to one another so that the automatic switching unit of the boiler can be used.

6.2.2 Cone silo

A cone silo can be made of fabric, plastic or metal. The silo tapers downwards (conical shape) to the extraction point, which is located at the lowest point of the silo. The extraction is executed via **suction probes** or with a short, horizontal screw that connects to a suction or a **screw conveyor**. The extraction screw generally does not require any pressure relief. We recommend having the option of blocking or separating the transfer point between the silo and the removal system with a slide.

6.2.3 Trough silo

Trough silos are a variant of the fabric silo, optimized for narrow spaces. The extraction is done either by a screw, which transports the pellets to a suction point or directly to the pellet boiler, or with several **suction probes**.

Figure 10a

Trough silo with screw extraction and transfer to a suction line

Figure 10b

Trough silo with several suction extraction points

6.2.4 Flat-bottom silo

Flat bottom silos are offered in a rectangular or round shape. Most of the available models have a square outline with a side length of 2 to 2.5 meters. For extraction, either a movable **suction head** from above or discharge from below, which is implemented by an **agitator** with screw discharge or **suction probes**, is used. The fact that there are no slopes in the lower area enables good use of space, but the pellets cannot flow to the extraction points solely by means of gravity. Therefore, flat-bottom systems with extraction from below, using simple **suction probes**, cannot be completely emptied. An unusable residual number of pellets will then remain, in which **fine particles** accumulate. There are also flat-bottom silos with a vibration component at the extraction point available, which support the discharge and offer dust separation.

Figure 11a

Flat-bottom silo with suction extraction from above

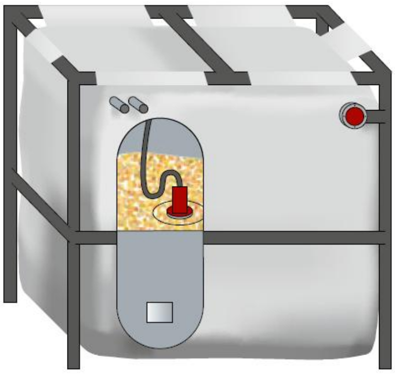


Figure 11b

Example of an air-permeable fabric silo with lifting mechanism and suction extraction from below

Figure 12

Expansion of an air-permeable fabric silo when filled and when empty

6.2.5 Fabric silo with lifting mechanism (lifting silo)

Fabric silos with lifting mechanism combine the good use of space of a flat-bottom silo with the discharge features of a cone silo. They are available with suction or screw extraction. Thanks to the lifting mechanism, the lower part of the silo lowers when loaded and when gradually emptied, it gets lifted again. Thanks to this, when the silo is full, there is little space between the bottom of the silo and the ground of the installation room. The emptier the silo is, the greater will this space become. The developing cone or trough supports the discharge of the pellets and can differ, depending on the manufacturer and a specific model. If a cone or trough is poorly constructed, complete emptying can be achieved with the support of a vibration component.

6.3 Installation:

Prefabricated storage systems are often set up in the basement. The most important requirement is a stable, horizontal subsurface. Otherwise, unevenness must be corrected with a suitable support material (e.g., steel plates). The load-bearing **capacity** of the floor must be designed for point or area loads depending on the type of storage (see 6.2).

The installation room of a fabric silo must not be too humid. Cellar-damp rooms are suitable as installation locations as long as the air can flow around the fabric. The room must be well ventilated to prevent the formation of condensation water.

When setting up an air-permeable fabric silo, its expansion when blowing in must be taken into account. It must be positioned in such a way that it does not collide with objects such as lamps or pipes when fully unfolded. The fabric in the impact area of the pellet jet must not touch walls or fixtures even when it is blown in.

Prefabricated storage systems require sufficient assembly space around the **filling nozzles**. In this way, a narrow connection bend between the **filling nozzle** and the blow-in line or hose can be avoided. The nozzles should be routed to the outside through fixed **filling ducts**. If this is not done, the distance between the **filling nozzle** and the walls should be at least 0.8 m and a maximum reach of 2 m should not be exceeded. The **filling nozzle** must be secured so that it remains horizontal even when the filling hoses are connected. Otherwise, the jet is directed at the fabric in the upper area and will destroy it in a short time.

The material of the **filling system** – including the **filling ducts** – must be conductive and it must be professionally grounded with a 4-mm² cable to the equipotential bonding busbar by an electrician.

In principle, prefabricated storage systems can also be set up outside the building. In addition to the structural requirements on the subsurface, weather influences (e.g., wind, rain, snow load) must be taken into account for above-ground outdoor installation. In addition, protection against UV rays and moisture should be provided.

6.4 Ventilation

The ventilation requirements for the installation room of prefabricated storage systems depend on whether the storage container is air-permeable or air-impermeable. For storage containers made of airtight material, the same ventilation requirements apply as for storage rooms (see 8.3, Table 7). Therefore, only the requirements for air-permeable fabric silos are described here.

- **Table 6**

Ventilation requirements for the installation space of an air-permeable fabric silo (according to ISO 20023)

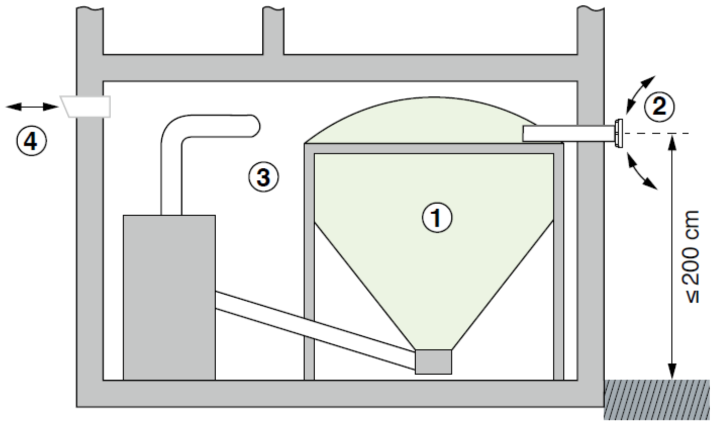
Capacity	Requirements for ventilation of the installation room
≤ 15 tonnes	Ventilation opening to the outside with a free opening of ≥ 15 cm²/t
> 15 tonnes – 100 tonnes	Ventilation opening to the outside with a free opening of ≥ 150 cm² and ≥ 8 cm²/t of pellets
Note for both: A fabric silo without suction connection requires a temporary opening of at least 400 cm2 so that the conveying air can escape when the pellets are blown in.	

The installation room of an air-permeable fabric silo must not be used as a living or working space and requires a sufficiently large ventilation opening to the outside (see Table 6). Regardless of the **capacity** of the storage container, the installation room of a fabric silo, which is not vacuumed when being filled, must have an opening with a clear cross-section of at least 400 cm² so that the conveying air (up to 1,500 m³/h) can escape into the open when the pellets are blown in. When positioning the silo in the installation room of the boiler, the opening for the combustion air of the boiler can also be used to let out the conveying air if it is at least 400 cm² in size (see examples).

6.5 Examples

- **Figure 13**

Ventilation requirements for the installation space of an air-permeable fabric silo (according to ISO 20023)



① Air-permeable fabric silo
② Injection nozzle with ventilating cover
③ Heating chamber
④ Ventilation opening ≥ 400 cm2

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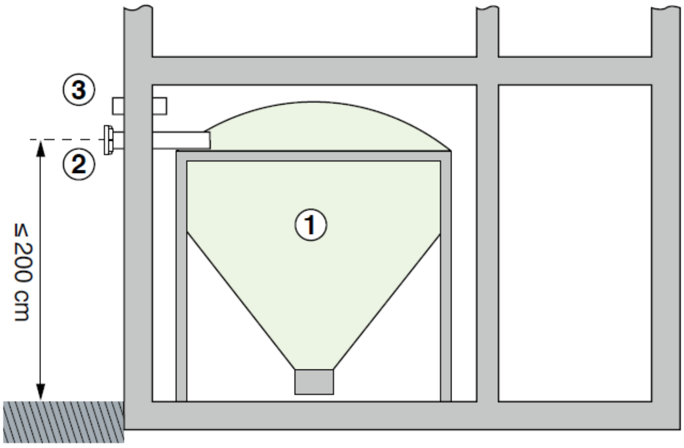
Figure 14

Ventilation solution for air-permeable fabric silos without suction nozzles in an installation room with nozzles leading to the outside



① Air-permeable fabric silo
② Injection port with venting lids with ventilating cover
③ Ventilation opening or suction port

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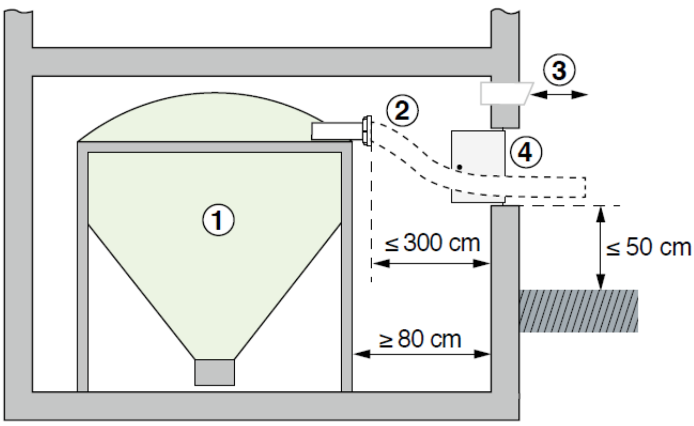
Figure 15

Ventilation solution for air-permeable fabric silos without suction nozzles with filling nozzles in the boiler room



① Air-permeable fabric silo
② Injection nozzle
③ Ventilation opening
④ Window or door for placement of the filling hose during delivery

Note: *Note: Max. 3 m* **hose path** *permitted in the room*

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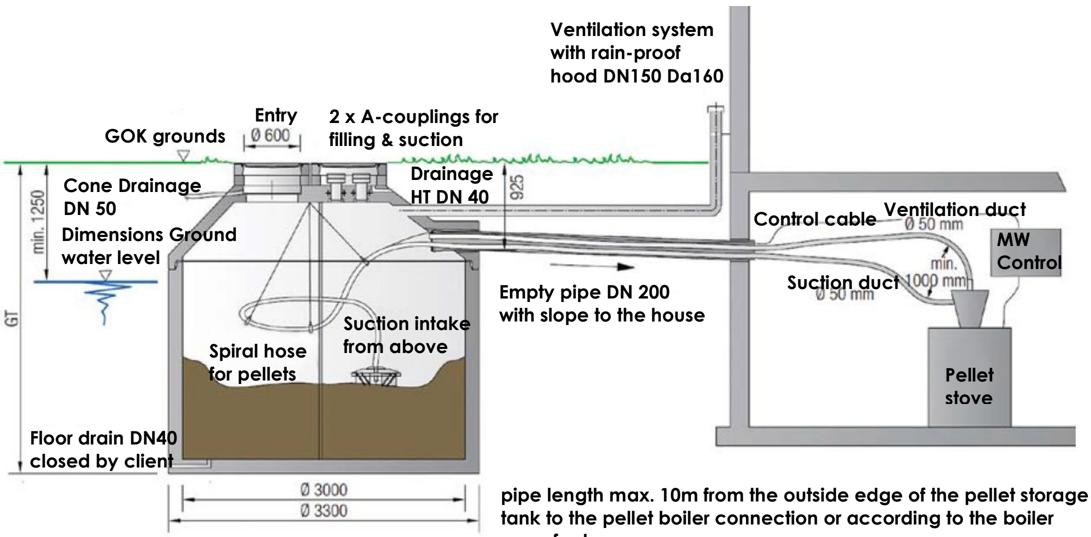
7. Underground storage

Buried pellet storage (underground storage) must meet special requirements. Due to their location, they must be absolutely impervious to moisture and water ingress and be secured against buoyancy by groundwater. An underground storage facility is connected to the boiler system via tubes, in which the suction and return-air ducts of the **conveyor system** run protected and can be replaced at any time.

The temperatures in the underground storage barely change over the course of the year and are mostly below the ambient temperature, which hinders a natural exchange of air. Since the ventilation requirements of ISO 20023 are not applicable to underground storage, it must be mechanically ventilated before entering. Entry into an underground storage facility is only permitted after the CO content has been measured and in the presence of an instructed second person (see also 9.2).

- **Figure 16**

Concrete underground storage facility with suction extraction from above



- **Figure 17**

Plastic underground storage facility with vertical screw conveyor

8. Storage rooms

8.1 Selection and construction:

Mostly cellar rooms are used for storage of wood pellets. However, other rooms, such as garages or attics, can also serve as pellet storage. The selection or construction of the room should be based on the following considerations:

a) Sufficient room size (see 5.2);

b) Short conveyor routes (see 5.3);

c) Appropriate structure (see 5.6);

d) Fulfilment of fire protection requirements (see 5.8);

e) Protection against moisture and wetness (see 5.9);

f) Practical ventilation solution (preferably **Ventilating lids**, see 8.3).

In practice, a rectangular floor plan for the storage room has proven to be well suited. The enclosing walls must be able to cope with the structural requirements by being professionally erected and connected to the surrounding masonry on the ceiling and floor. The installation of glass windows and large plastic panes can be used however, optical or sensor-based level monitoring (see 5.5) is recommended.

The opening should not be behind the impact mat both for safety reason and to have a good view of the storage level. When the ventilation line is different from the filling line, the access to the storage room should be opposite or at a sufficient distance from the mouth of the ventilation line to enable cross ventilation before entering (see Fig. 18).

The size of the access opening to the storage room must allow easy access, for example for cleaning and for visual inspection by the supplier before filling. In the case of larger pellet storage, it is essential to consult a specialist regarding structure and fire protection.

For storage rooms with a **capacity** of up to 10 tonnes and a room height of approximately 2 m, the following wall thicknesses have proven themselves to work as a supporting structure:

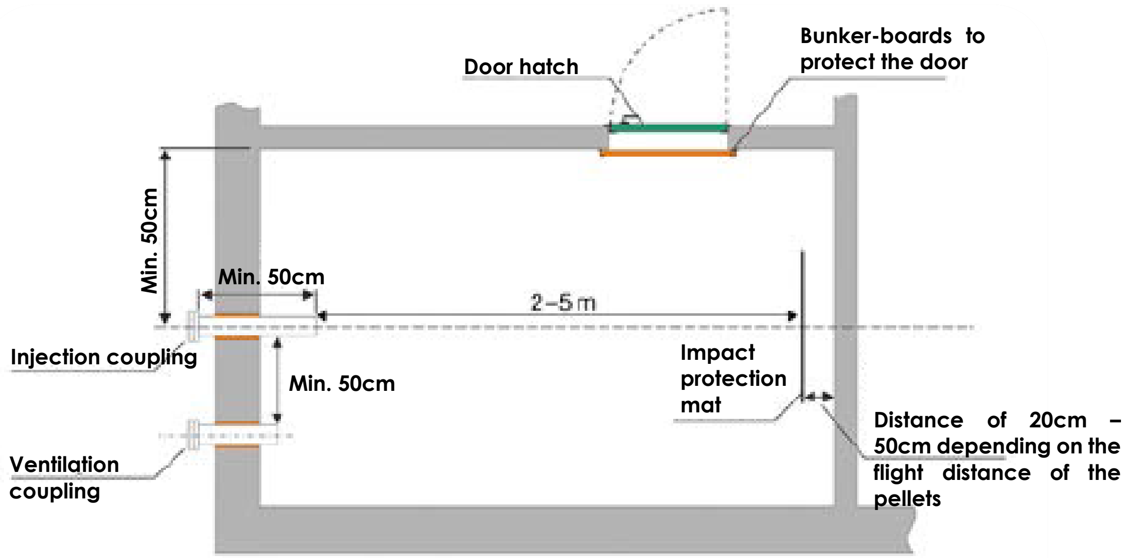
a) Reinforced concrete: 10 cm;

b) Wooden structures: 12 cm beams, distance 62 cm, planked on both sides with multi-layer wooden panels, structural connection to the ceiling, floor and walls.

Already existing load-bearing walls made of masonry bricks with a thickness of at least 17.5 cm (bricked together, plastered on both sides, with corners reinforced and connected to the ceiling) are suitable. Non-load-bearing walls must be checked individually for suitability. Walls made of aerated concrete are not recommended without structural proof.

Figure 18

Floor plan of a pellet storage room (ventilation via filling system)



8.2 Expansion of a pellet storage room

8.2.1 General

The expansion of the storage room includes careful sealing against dust leakage, the interior lining, the installation of the filling and **discharge system**, possibly a separate ventilation solution and the installation of an impact mat, which is absolutely necessary for the gentle in-blow process of the pellets. There must be no electrical installations such as switches, lights, junction boxes, etc. in the storage room. Exceptions are explosion-proof designs or, for example, extraction systems that are specially designed for use in pellet storage. Permanently installed lamps should generally be avoided as they represent a source of danger.

8.2.2 Insulation

To avoid impairment of the surrounding rooms, storage rooms and prefabricated storage areas must be properly sealed off from the living and working areas. Joints and connections in the floors above must also be included. Supply lines or ventilation shafts crossing the storage room should be avoided. Otherwise, these must also be carefully insulated and protected. Wall openings for the filling and **discharge systems** must also be carefully sealed. For sound insulation, wall penetrations and fastenings of moving parts must be designed in such a way that the transmission of structure-borne noise to the structure when filling and removing the pellets is prevented.

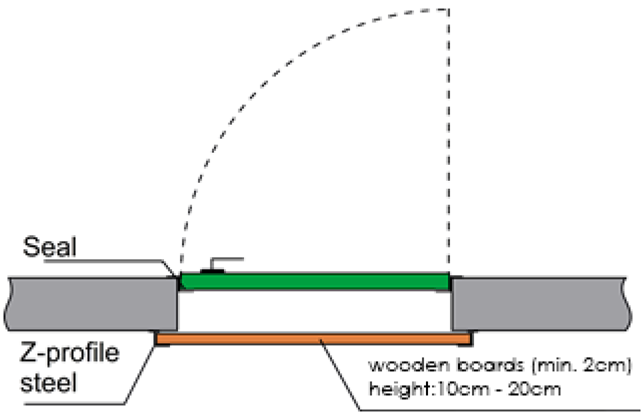
Doors and hatches must be madedust-tight. They must open to the outside and be provided with circumferential insulation. To prevent the pellets from trickling out when the door is opened, **inlay boards** must be attached to the inside of the door frame (see Fig. 19). The height of each board should not exceed 20 cm so that you can easily look into the storage room by removing the upper boards. Door locks should be closed dust-tight on the inside so that the locking function is not impaired by pellet dust. Windows must be approved for this use (ie - safety glass, as pressure peaks can occur).

8.2.3 Interior Lining

Surfaces within the storage room should be smooth to prevent dust from building up. For the same reason, horizontal surfaces should also be avoided. Ceilings and walls are to be designed in such a way that the pellets are not contaminated or damaged by abrasion or detachment.

Figure 19

Pressure relief of the access door/hatch or entry opening (top view)



Existing pipelines, drainage pipes etc. which cannot be removed with reasonable effort, and which could cross the trajectory of the pellets during filling must be clad in a way that favors flow and ensures that they do not break. All wall penetrations must be carefully insulated. If there is a risk of damp floors and walls (even temporarily), appropriate moisture protection must be provided, for example by means of rear-ventilated front-wall formwork.

8.2.4 Sloping floors

Sloping floors lead the pellets to the extraction area. They also enable the storage room to be emptied completely. The following must be observed when selecting the material and setting up the **sloping floors** (see Fig. 20):

a) So that the pellets slide for better emptying, their angle should be at least 45°. The **sloping floor** must have a smooth surface. In practice, three-layered formwork panels or plywood panels and smooth laminate layers have proven their worth. Simple chipboard and **OSB** panels are unsuitable! In the case of permanently low-friction surfaces, smaller angles, at least 35°, may be sufficient;

b) Edges, webs and horizontal contact surfaces should also be avoided to ensure that the pellets slide better and to prevent dust accumulation;

c) For a better weight distribution, the combination of angle bearer with sturdy square timbers has proven to be advantageous. The angle bearer or supports should be attached at a distance of approximately 60 to 70 cm from each other;

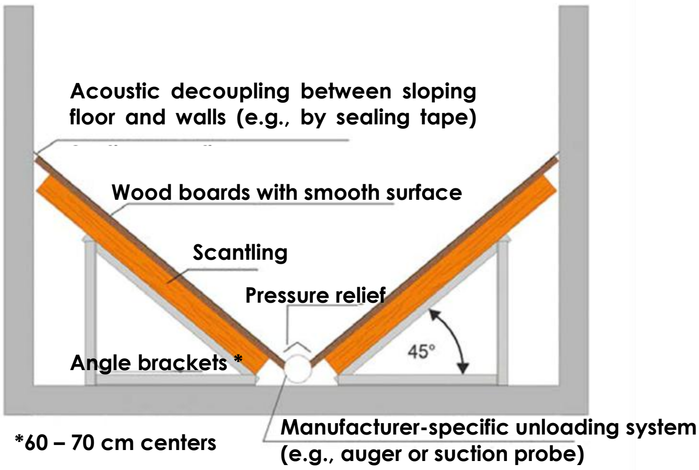
d) For connection to the surrounding walls, the **sloping floors** should be designed in such a way that no pellets or dust can penetrate the empty space and so that, at the same time, acoustic decoupling between the **sloping floor** and the wall is ensured, for example with sealing tape;

e) The connection to the extraction system must be carried out by a specialist and in accordance with the manufacturer's instructions. It is important to ensure that the extraction facility is depressurized in relation to the pellet bed. In the case of extraction screws, rubber pads or vibration buffers serve as noise protection at the fastening points. Fastening materials such as dowels should also be chosen in an acoustic-decoupling design.

NOTE: Flat-bottom storage with **suction probes** on the bottom do not allow the pellets to be discharged completely and favor the continuous accumulation of **fine particles** around the **suction probes**, which hinders the pellets from sliding down. Complete emptying is made possible by **sloping floors** to support the discharge.

- **Figure 20**

Implementation recommendation for sloping floors



8.2.5 Filing system

A pellet storage room requires at least one **blow-in nozzle** and one **ventilation nozzle**. The latter is to be installed with a lateral distance of at least 0.5 m from the **blow-in nozzle** and marked as such on the outside of the cover and tube. If this is not possible, then the masking of the cover is sufficient, provided that it is firmly connected to the nozzle, for example with a chain. The **filling nozzles** ("Storz Typ A", DN 100) must be easily accessible for the supplier and provide sufficient assembly freedom for attaching the filling hose and dust bag. External **filling nozzles** above ground level should be at least 40 cm (splash protection) and no more than 2 m above the ground. If they are above this reach, a safe climbing aid (ramp or platform) must be provided. A single ladder is not sufficient (see 5.3). For work-safety reasons, the pellet supplier is not allowed to fill the storage room in this case! After filling, the nozzles must be closed, preferably with **ventilation caps**.

Filling nozzles in light wells should be provided with an upward 45° bend and allow the filling hose to be attached safely (see Fig. 21).

The optimal number of **blow-in nozzles** depends on the size and geometry of the storage room. When blown in, pellets spread over a wide area and push themselves up from the **filling nozzle** toward the ceiling. From there, an embankment forms with a slope of around 30°. The blow-in and **suction nozzles** on the storage side should be installed in a rectangular room, preferably mounted on the narrower side. If the room is more than 3.5 m wide, it is advisable to install several **blow-in nozzles** at a distance of 1.5 m to 2 m (see Fig. 22).

Figure 21

Requirements for the accessibility of filling nozzles in the open air and in the light shaft

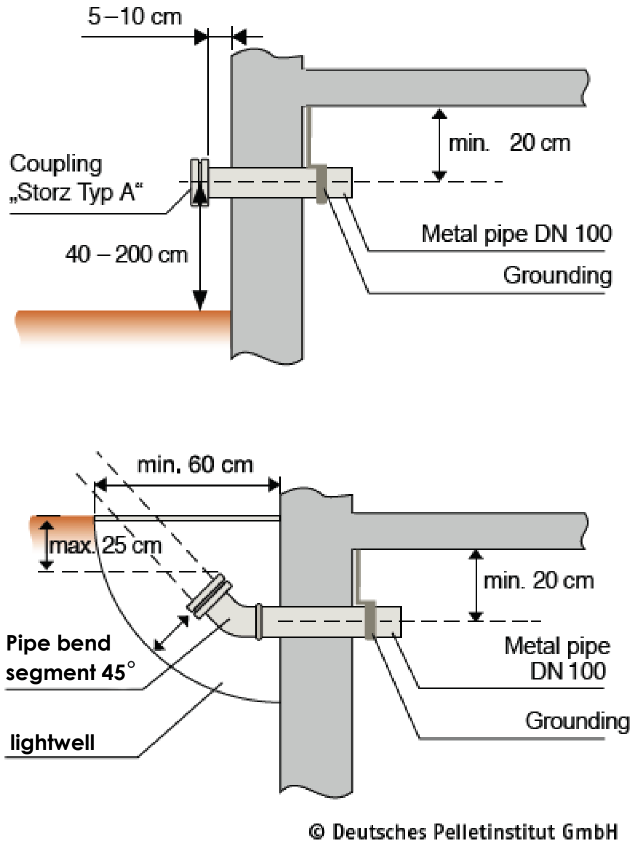
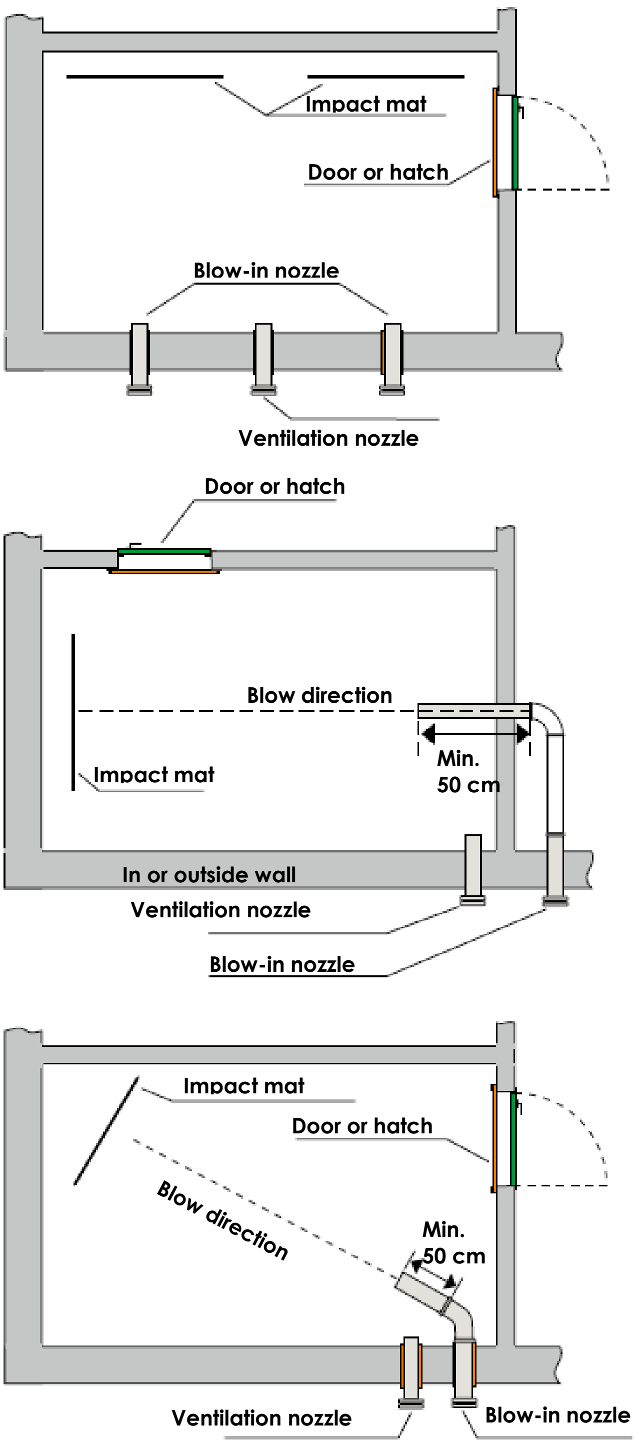


Figure 22

Implementation recommendation for sloping floors



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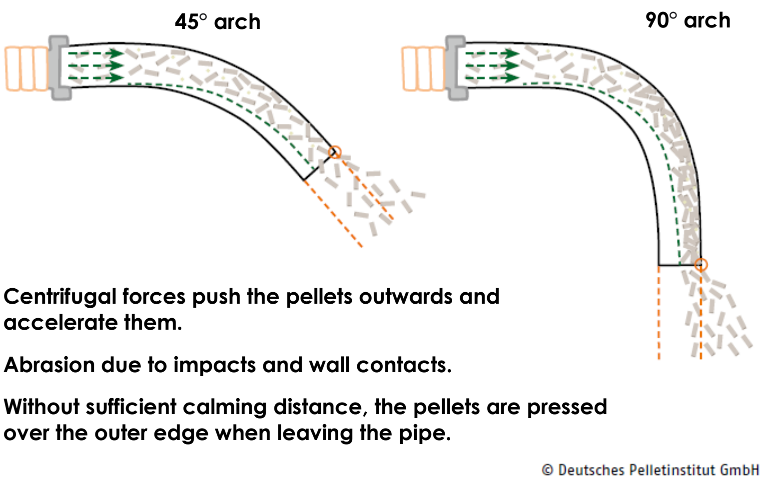
Blow-in nozzles require a distance of 15 to 20 cm from the ceiling (measured between the ceiling and the upper edge of the **filling duct**). Blow-in ducts that protrude more than 30 cm into the room must be attached to the ceiling with a pipe clamp at least every 50 cm. When positioning the blow-in duct, any built-in components in the storage room or the layout of the **discharge system** must be taken into account.

The material of the **filling system** (the **filling nozzles** and ducts) must be conductive and grounded. The nozzles within the storage room are to be provided with a grounding line and professionally grounded with a 4 mm² cable to the equipotential bonding busbar. All ducts and bends should consist of pressure-tight (3 bar) metal pipes with an inner diameter of 100 mm and be smooth-walled on the inside throughout – including all connections. It is important to ensure that individual pipe sections are firmly connected to one another so that they do not come loose due to pressure surges during the filling process.

For absolutely necessary changes of direction, only bends with at least 30 cm radius of curvature (three times the diameter of the **filling duct**) and a subsequent calming section of at least 50 cm length should be used. Due to the centrifugal forces, the pellets are pushed outwards into bends and can hit each other as well as the wall of the pipe – this creates **fine particles** and dust (see Fig. 23).

Figure 23

Flow paths of pellets in bends



8.2.6 Impact mat

The impact of the blown-in pellets on the wall of the storage room must be slowed down by one or more abrasion- and tear-resistant impact mats. This will divert the kinetic energy. Suitable materials for impact mats are **HDPE-foil**, **EPDM-foil** or abrasion-resistant rubber materials with a thickness of at least 2 mm.

Attention: Impact mats made of unsuitable materials (carpets, soft plastic) can cause considerable damage if fibers or rubber residues get into the **discharge system**!

The dimensions for the impact mat are approximately 1.2 m × 1.5 m. It must be large enough to accommodate the entire jet cone. The length must be such that it is not blown under or pushed away. Impact mats that are too long can be jammed and torn off by the pellets. If there are several **blow-in nozzles**, additional impact mats must be attached.

The impact mat must be attached transversely to the blowing direction in front of the wall opposite the **blow-in nozzle** at an appropriate distance. With a free flow path of 5 m for the pellets, the distance to the wall should be at least 20 cm. With a flow path of 2 m, ISO 20023 recommends a distance of 50 cm. Fixing screws, trims and angles must not be caught in the pellet jet.

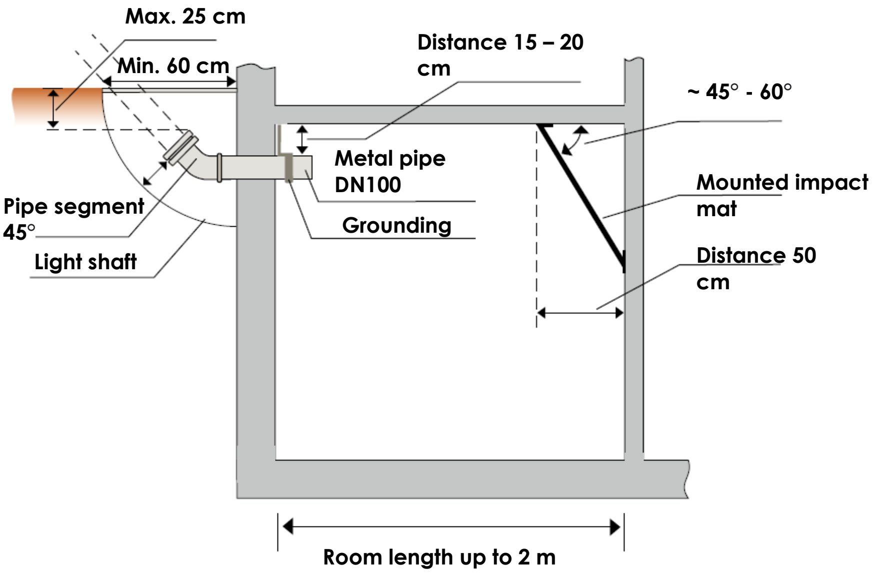
When the storage room is filled for the first time, it should be checked whether the impact mat fulfills its purpose.

8.2.7 Room lengths up to 2 m

In small pellet storage up to approximately 2 m in length, the flow path of the pellets is very short, meaning that they will hit the impact mat in a straight line and at great speed. The impact mat should therefore be placed on a wooden board of the same size (15 mm) and firmly attached between the ceiling and the rear wall at an angle of 45° to 60° (see Fig. 24) so that the pellets slide off. Otherwise, there is a risk that the impact mat will be pressed toward the ceiling by the pellet jet.

- **Figure 24**

Example for short storage rooms



8.2.8 Room lengths greater than 5 m

In the case of storage rooms that are longer than 5 m, two **filling ducts** reaching different distances within the storage room should be used:

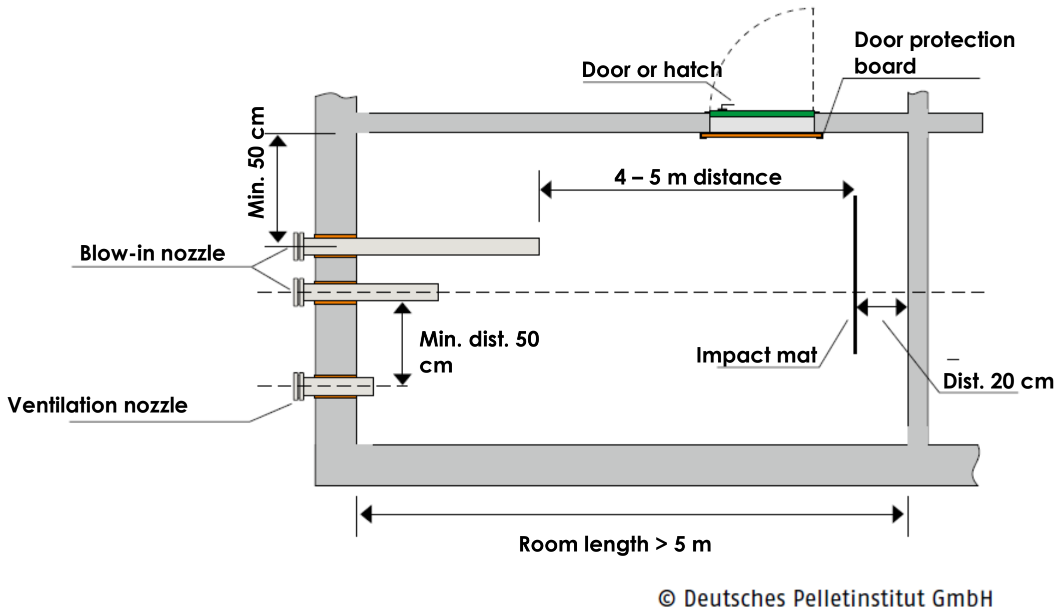
The storage room is first filled through the long **filling duct** from the back to the front and then further through the short **filling duct**. A second impact mat in the longitudinal direction is not required.

The **filling nozzles** must be labeled accordingly (long/short).

The impact mat must be attached to the ceiling at a distance of 20 cm from the rear wall (see Fig. 25).

Figure 25

Example for long storage rooms



8.3 Ventilation

The ventilation of storage rooms and airtight storage containers must be ensured by natural air movement or with a fan and should be ventilated to the outside if possible. For storage with a **capacity** up to 15 tonnes within the building, ventilation in the heating installation room is also recommended. For small pellet storage, it is recommended to have **ventilation caps** at the **filling nozzle**. **Ventilation caps** are available with different ventilation cross-sections and should be lockable in public outdoor areas.

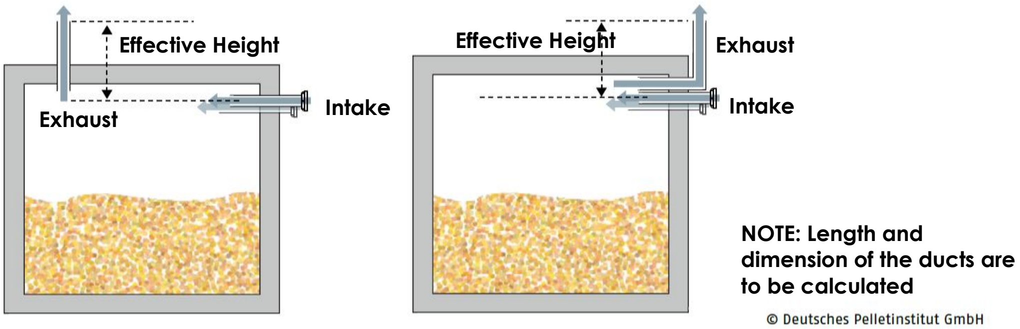
Figure 26

Different types of ventilation caps

Table 7 summarizes the requirements for storage ventilation according to ISO 20023 depending on the distance to be overcome. If the specifications for the permissible duct lengths are to be observed, a natural ventilation solution is preferable to mechanical ventilation with a fan. For ventilation ducts longer than 5 m, an individual calculation of the required ventilation cross-section must be carried out in accordance with the procedure described in ISO 20023. Alternatively, mechanical ventilation must be installed.

Figure 27

Example of storage ventilation using the height difference between the supply- and exhaust-air nozzle.



ISO standard 20023 also authorises solutions which consider the natural ventilation created by the difference of height between the higher-placed exhaust-air nozzle and the storage-side supply-air nozzle (see Fig. 27). The required height difference and the necessary duct diameter must be determined according to this standard.

Table 7

Ventilation requirements for the installation space of an air-permeable fabric silo (according to ISO 20023)

Length of the internal pipe	Ventilation requirements
0 m	Ventilation opening with a free opening ≥ 150 cm² and ≥ 10 cm²/t **capacity**.
≤ 2 m	**Ventilation caps** on at least two nozzles with a free cross-sectional area of ≥ 4 cm²/t **capacity**. External opening at the same height or up to max. 50 cm higher than the inner opening. NOTE: Storage with a **capacity** of ≤ 15 tonnes can also be ventilated into another room if this is not used as a living or workspace and if they have a ventilation opening of ≥ 15 cm² / t for the pellet storage.
≤ 5 m	• At least one pipe or duct for the outflowing air with a cross section of ≥ 100 cm² and ≥ 5 cm²/t **capacity** as well as an external free opening ≥ 4cm²/t at the same height or max. 50 cm higher than the inner opening. • At least one pipe or duct for the inflowing air with a cross-section of ≥ 75 cm² and ≥ 5 cm²/t **capacity** as well as an outer free opening ≥ 4 cm²/t **capacity** at the same height or lower than the inner opening. NOTE: **Filling nozzles** with **Ventilating lids** contribute to the overall cross-section of the incoming air.
All	Individual calculation of the necessary ventilation cross-sections depends on the height difference between the higher-placed external exhaust-air nozzle and the supply-air nozzle in the storage room. NOTE: Calculation according to ISO 20023 is required.
All	Mechanical ventilation to the outside via a pipe fan at the outlet of an exhaust-air duct or pipe. Air exchange rate ≥ 3 x storage volume/hour when coupling the function of the fan with opening the storage door Air exchange rate ≥ 3 x storage volume/day with continuous or intermittent operation of the fan and additional air-supply duct with a free cross-section of ≥ 75 cm²
NOTE: Ventilation for storage with a **capacity** of >15 tonnes is always outdoors. Impermeability to the living and working area of the building required. Not applicable for underground storage	

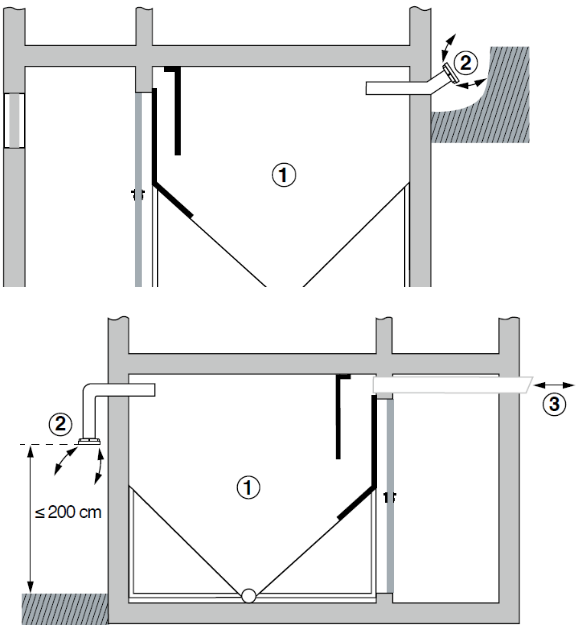
It must also be proven that the pressure difference resulting from the height difference does not affect the operation of the boiler.

When using a ventilation opening or duct (also with mechanical ventilation), it must be taken into account that dust can escape when the pellets are blown in. Ventilation openings and ducts must not be closed and must be protected against the ingress of moisture and insects. If filters or closures are used to prevent dust from escaping during the blow-in process, they must be removed again after blowing in the pellets.

8.3.1 Design Examples

Figure 28

Ventilation solution for pellet storage room with filling nozzle in a light well



① **Pellet storage**

② **Couplings with venting lids**

③ **Air duct**

Note: Because the outer opening of the filling pipe is deeper than the inner opening, a separate ventilation pipe is required.

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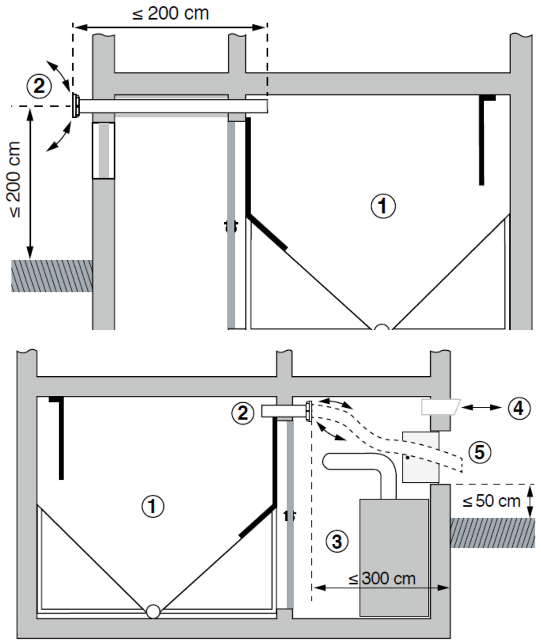
Figure 29

Ventilation solution for pellet storage room with filling duct ≤ 2 m



① **Pellet storage**

② **Couplings with venting lids**

③ **Boiler room**

④ **Boiler room ventilation**

⑤ **Window or door for laying the transport hose for the filling process**

Note: Ventilation in heating room only for storage capacity. Max. 3 m hose path in the room.

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9. Operation of a pellet storage room

9.1 Labelling

The access to a pellet storage room must be provided with safety instructions, which must be followed unconditionally when entering. These also apply to the installation room of prefabricated storage. Corresponding stickers (see Fig. 32) can be ordered free of charge from the **ENplus® International Management:** (enplus@bioenergyeurope.org).

- **Figure 32**

Storage Room Safety Sticker

9.2 Entering the storage room

A pellet storage facility may only be entered for specific activities and then only in compliance with the safety instructions. It is not intended to reside in. Unauthorized persons are generally prohibited from entering the storage room.

Before entering a pellet storage room or a storage container, the heating, including the conveyor and **discharge system**, must be switched off in good time. The time specifications of the boiler manufacturer must be observed! Rule of thumb for heating in one- and two-family houses: switch off the boiler at least one hour before entering the storage room in order to avoid embers remaining in the burn chamber.

It is also important to ventilate the pellet storage room before entering. After 15 minutes of cross ventilation via the access door/hatch or access opening, a permanently naturally ventilated storage can usually be entered. For safety reasons, another person should be present, stay outside the storage room and have visual or at least voice contact with the person inside the storage room. In this way, any CO hazard (see 5.7) can be quickly noticed.

In the first four weeks after filling, the storage room may not be entered. If this should be necessary, the CO content must first be measured with a mobile CO warning device. It is recommended that access during this period is only granted to qualified personnel such as pellet dealers or heating engineers.

If the pellet storage holds more than 15 tonnes – this also applies to all underground storage – it may only be entered with a CO warning device. In this case, the CO warning device must be switched on and worn on the body. A short-term entry into the storage room is permitted for up to 30 minutes at a maximum concentration of 60 ppm. In the event of a longer stay in the storage room, the CO concentration must be below 30 ppm. A CO warning device mounted directly in the storage room gets dirty too quickly and therefore experience has shown that it does not work reliably due to the terpenes contained in the wood, which damage the CO sensors.

9.3 Pellet delivery

9.3.1 First Fill

The first filling of the storage room is the last opportunity to check the storage's design and accessibility for functionality and safety. It is recommended to use the competence of an EN*plus*®-certified pellet supplier. He or she is trained in the assessment of pellet storage and has experience with many design variants. The heating engineer should also be present during the initial filling in order to be able to react to any shortcomings or recommendations identified by the pellet supplier.

In preparation for the initial filling, the handover protocol for the pellet storage should be available. In the case of prefabricated storage, the blow-in instructions from the storage manufacturer must be attached near the **filling nozzle**. After the filling is complete, customers receive a delivery report from their EN*plus*®-certified pellet supplier, which contains all essential information on the delivery process and any obvious weak points in the storage room.

9.3.2 Refill

Before ordering pellets, it should be checked whether the defects recorded in the delivery log of the preliminary delivery have been remedied and whether complete emptying and (if circumstances require) storage cleaning is necessary (see 9.4).

For filling, the heating operator (or an authorized representative) should be on site and switch off the heating at least one hour before delivery or according to the manufacturer's instructions. The pellet supplier may not switch the heating on or off or make changes. Access to the storage room (parking space for the delivery truck, filling & **ventilation nozzles**, power supply for the suction fan (where used) and **hose paths**) must be guaranteed.

9.4 Cleaning and maintenance

Regular, complete emptying and cleaning (if necessary) of the storage facility is a prerequisite for permanently trouble-free and safe heating operation. If the manufacturer does not provide information on the emptying and cleaning intervals, emptying should take place every two years, or annually in the case of large storage rooms that are filled several times during the year – at least after every 5th delivery.

Some pellet suppliers and heating engineers offer cleaning to be carried out before refilling. Immediately before filling, the remaining stock of pellets is sucked out of the storage facility, which is cleaned and then refilled. Please note the following when cleaning:

a) For prefabricated storage, the manufacturer's cleaning instructions apply;

b) Enter storage rooms only in compliance with the safety instructions (see 9.1);

c) Wear a dust mask of filter class **FFP2** and conductive protective footwear;

d) Cleaning with industrial vacuum cleaners of dust class M. From a container size of 50 l and a motor power of more than 1,200W, these must be explosion-proof in accordance with **ATEX** zone 22;

e) Other electrical equipment should have a mechanical degree of protection of at least **IP** 54.

9.5 Procedure in the event of malfunctions

The storage room is the interface between the fuel and the boiler and is therefore essential for convenient and safe operation of the heating system. Many malfunctions in the heating system can be traced back to deficiencies in the storage room design or operation. If, for example, the **conveyor system** to the boiler is blocked due to an increase in **fine particles**, the causes can be varied. Blow-in section, impact mat, the pellet quality of the remaining stock and the new delivery as well as the blow-in process influence the number of **fine particles** in the storage room. It is often impossible to assess what exactly led to the malfunction. The heating operator should therefore rely on certified or trained specialists for both fuel and heating technology and include both in solving the problem.

If there are any doubts about the pellet quality, a sample of the pellets can be taken from the storage room and examined together with the pellet dealer and the heating engineer. The sample size should be at least 1.5 kg. A limit value for **fine particles** only exists if the requirements in Section 4.1 are met.

10. Larger storage

The statements in the previous sections also essentially apply to **larger storage** (> 30 t) or storage with frequent deliveries (>5/year). This chapter therefore only describes the special features of the planning and operation of pellet storage for a heating system of more than 100 kW.

Larger storage can also be realized with prefabricated storage (fabric silos, round silos, GRP silos, underground storage, etc.) as well as with the expansion of storage rooms. Underground storage or free-standing outdoor silos are often a safe and inexpensive solution.

- **Figure 34**

Example of an enclosed pellet silo for outdoor installation

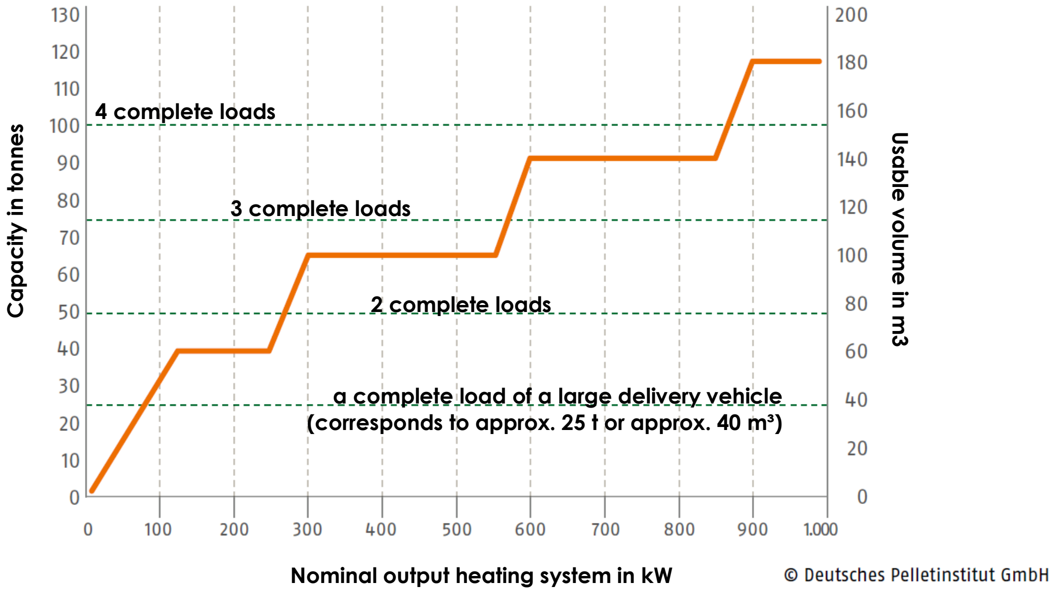
In the case of **larger storage** rooms, mechanical ventilation can in some cases be the cheaper option due to the lower construction expense compared to natural ventilation using separate ventilation ducts. In order to safeguard the ventilation solution in **larger storage** rooms, the installation of a stationary CO warning device in the access area to the storage facility is recommended, provided this is within the building.

10.1 Size

As a rule, **larger storage** rooms are supplied with delivery quantities of a complete truck of ca. 25 tonnes (40 m³). Since the storage facility is not completely emptied before each delivery, the **capacity** should be ca. 60% greater than the payload of the delivery truck. If the storage room is designed for vehicles with a payload of 25 t, the storage room should hold a total of approximately 40 tonnes in order to ensure that heating can continue even in the event of delivery delays. The lower effort of a complete delivery usually also reduces the delivery costs.

Figure 35

Storage-size recommendations



10.2 Filling system

The **filling system** of a **larger storage** is subject to great stress and should therefore always be made of metal and with an appropriate material thickness. For those stores with a long, permanently installed ventilation duct, the mobile suction fan of the pellet supplier (where used) can no longer perform its task. In such cases, a stationary extraction system with a dust filter should be provided, which runs during the pellet delivery. It is also possible to create another opening to the outside so that the conveying air can escape. The requirements described in the previous chapters for a gentle blow-in process of the pellets also apply to **larger storage** rooms: the shortest possible ducts, a nearby parking space for the delivery truck, and avoidance of arches in the **filling system**. Pellets can also be blown into a silo with a height of 20 m if the pipe is straight or has only a few changes in direction.

Blowing in a full load of wood pellets can take up to two hours. During this time, both the truck engine and the compressor are running. Therefore, noise protection should be taken into account when planning the storage room (parking space for the delivery truck), especially in the case of sensitive objects such as residential buildings, hotels and hospitals.

As an alternative to blowing in the pellets, delivery with moving-floor trucks can also be a sound solution. The pellets are then poured in instead of blown in. If it is not poured directly into an underground bunker, it is important that the **discharge system** has sufficient **capacity** to minimize the downtime of the truck.

10.3 Discharge system

A different discharge technology is often used for **larger storage** rooms than for smaller storage rooms. It must both enable good utilization of space and be very robust and fail-safe, which would often not be economical for small systems. The recommended discharge variants are described in Table 8.

Table 8

Ventilation requirements for the installation space of an air-permeable fabric silo (according to ISO 20023)

System	Profile
Central screw with sloping-floor	Two w-shaped sloping shelves. Only suitable for storage with heating systems of < 200 kW. Robust, inexpensive and low-maintenance system, but with little space utilization. Alternate complete emptying possible. 
Suction extraction from above	A **suction head** moves over the surface of the stored pellets and removes the pellets independently and in layers from above. Suitable for heating systems < 300 kW and storage volumes of up to 90 m³. 
Spring-core discharge	A spring core is driven by the extraction screw or independently. The transport screw can feed the pellets directly to the boiler. Only suitable for square or rectangular storage rooms of heating systems of < 300 kW, low-maintenance and inexpensive. 
Articulated-arm discharge	Articulated arms push the pellets toward the discharge screw. Suitable for circular or square silos of heating systems of < 500 kW. A residual number of pellets will always remain at the bottom of the silo. 
Central discharge	An extraction screw that turns slowly in a circle conveys the pellets to the center of the storage room for discharge. Suitable for circular silos and heating systems of > 500 kW. 
Moving-floor discharge	Hydraulically driven push rods move ladder frames. This will move the pellets to a **screw conveyor** at the end of the storage room. Powerful and robust system for heating systems of > 500 kW. 

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