Reuse of building materials

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Guide to the documentation of performance

SINTEF

REBUS Reuse of Building materials – a User perspective



Preface

The construction industry generates a good deal of waste, and both rehabilitation and new construction require large quantities of building materials. At present, building materials in use are mostly new and also to a large extent manufactured from virgin raw materials.

Reuse of building materials can provide environmental benefits that are essential for the sustainable management of resources. However, reuse of a building material presupposes that it is suitable for reuse, in other words that it does not impair the quality of the finished building, compared with using new materials. This guide provides advice about how to assess building materials for reuse.

The guide is part of the research project, **REBUS (REuse of Building materials – a USer perspective**). The objective of the research project is to develop new knowledge to enable the more effective reuse of building materials.

Oslo, 22, April 2022

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REBUS

REBUS Reuse of Building materials – a User perspective

https://www.sintef.no/projectweb/rebus/

How to use the guide

This document provides guidelines for the reuse of interior glass walls, windows, doors, ventilation installation components and sanitary equipment. It has been written for the use of consultants, project owners and building contractors who wish to include reused products in building projects.

The guide is limited to the assessment of materials used for the same purpose as their original one, for example the reuse of a window as a window. If one is to reuse materials for a new purpose, for example using windows to construct interior glass partition walls, a product's suitability for the new purpose must be documented.

Good building materials are a fundamental requirement for good buildings. Used building materials may lend themselves well to reuse, both in the same building and in new buildings. However, how does one distinguish building materials that have reached their end of life because of damage or changed building codes, or whose content constitutes health or environmental hazards, from building materials that are still suitable for use? This guide provides the answer. For each building material we have described:

- the principal materials constituting the product and how quality can deteriorate with time
- the potential for repair if damage is found
- the building material's properties (performance) and how they can be documented (documentation methods)

The tables showing properties and documentation methods are long. Not all properties are relevant to all applications. Relevant properties are determined during the design of the building. The guide describes how to decide on the properties that must be documented:

- ***Visual examination.*** Thorough visual examination can reveal a lot about a building material, for example by detecting visible wear and damage, or labelling providing information about the manufacturer, production year and product properties. This guide describes what properties can be determined by means of visual examination, what one should look for and (where appropriate) how to interpret what one sees.
- ***Testing of properties*** can be carried out according to the same standards as the testing of a corresponding new building material. However, many test methods are destructive and result in the building material being unusable after testing. This quickly becomes a problem if a building material is only available in a limited quantity. One must also test a larger number of samples because the properties of individual samples can be expected to vary. Alternatives to destructive testing are still in short supply but will hopefully be developed as reuse becomes more common.
- ***Original documentation.*** The original documentation is indispensable if one wishes to avoid destructive testing. Some properties are retained well over time, while others change. In the case of properties that can change – indicated in the guide by the words "Reuse without retesting" the assistance of a technical expert is needed to assess whether they have remained unchanged. Test methods change too. If the test method is based on an expired standard, the assistance of an expert will be needed to decide whether it is still appropriate.

Whether a building material is new or used, its documentation calls for professional knowledge of each type of building material. This guide cannot replace such expertise but may assist in developing know-how if desired.

The guide describes how to document the properties of reused building materials. Photo: SINTEF Community

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Interior glass partition walls

Examples of interior glass walls. Photo: SINTEF Community

General remarks

Interior glass partition walls are extensively used in office premises and are part of the soundproofing. Soundproof glass can be combined with safety glass and fire-resistant glass. In addition to areas of glass, a wall may have dados and other opaque areas.

Soundproofed glass partition walls are produced from laminated glass or tempered, monolithic glass.

Glass used in fire-resistant glass walls is often produced with hydrogel between glass panes. Alternatively, it may be ceramic tempered monolithic glass that reduces heat radiation. Interior fire-resistant glass walls are usually of all-glass construction without frames and with vertical, fire-rated silicone seams.

Glass in interior glass partition walls under normal room climate conditions does not age. The same applies to aluminium frames. Rubber gaskets may become stiff and plastic wedges and frames may become brittle. Woodwork needs more maintenance if it is to remain attractive. An occasional coat of paint is to be expected.

Assessment for reuse

Assessment of interior glass partition walls for reuse must include assessment of the condition of the frames, gaskets and sealing strips. Worn or damaged components may be replaced.

The dimensions of the glass partition wall, i.e. the width and height of the frame and the numbers of units of the given dimensions are necessary information. The sound reduction and, if relevant, fire rating must also be specified.

One challenge connected with the reuse of glass partition walls is that thinner glass was previously used compared to modern glass partition walls. The reason for the use of thicker glass is that requirements are stricter.

In the past, tempered glass was often used in glass partition walls because it is slightly cheaper than laminated glass. Tempered glass cannot be cut into small pieces as this will damage the glass.

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Profiles and frames	Profiles and frames of interior glass partition walls are usually made of wood or aluminium.	Impact or other mechanical loading can damage the frames and window pane. If the window pane is broken, it must be replaced. In the case of minor damage to the frames, the damaged part may be replaced or repaired. A plastic frame may have become brittle.
Glass	The glass may be homogeneous or consist of several layers separated by laminating film.	The physical properties of float glass and tempered glass do not change over time. *Soundproof glass* R_w = 30 dB is achieved by using: • laminated glass panes of 10.76 mm thickness (5 mm glass + 5 mm glass + 2 × 0.38 mm lamination). In the past, 6.38 mm laminated glass was used. • tempered 10 mm thick monolithic glass. In the past, 6 mm glass was used. *Safety glass* These days, 10.76 mm laminated glass or at least 10 mm tempered glass is used if better soundproofing is required. The construction is as for soundproof glass. *Fire-resistant glass* Fire-resistant glass is labelled as such. Often two glass panels are used, either 4 mm or 6 mm, separated by hydrogel. Alternatively, ceramic tempered monolithic glass is used.
Installation joints	Installation joints are of elastic joint compound or EPDM rubber.	Installation joints must be airtight to achieve satisfactory soundproofing. A thin sealing strip between the panes is often enough. Check that the joint has not hardened. When using elastic joint compound, it will be necessary to clean and wash the glass before reuse.

Example of labelling on interior glass walls. Photo: SINTEF Community

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD	COMMENTS
Year of manufacture	Information from initial purchase	
Materials and construction	• Visual examination • Original documentation	Must include: • Glass: Tempered glass (NS-EN 12150-2) and fire-resistant glass are often labelled. • Laminated glass (NS-EN 12543-2): two glass layers can be seen. • Profiles and frames: wood or aluminium • Format and layout of glass panes
Colour, surface treatment and decoration	• Visual examination • Colour code	Description of glass decoration: sandblasted, acid-etched, silk printed (thermally hardened ceramic inks) or foil (plastic film attached to glass). Decorating foils can be removed by heating and pulling off. Sandblasted, acid-etched and silk printed glass can easily be restored to an untreated glass surface.
Dimensions	Tape measure or similar	Height and width of frames and glass panes.
Fire rating	Certificate	Fire resistance shall be certified. Classification according to NS-EN 13501-2. Reuse without retesting requires verification by the manufacturer or certifying body that the property is unchanged.
Sound reduction index, R_w	• Original documentation • Retesting	Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged. Sound reduction index can be retested in a laboratory according to NS-EN ISO 10140-2:2010 and is assessed according to NS-EN ISO 717. Alternatively, the sound insulation can be assessed according to NS-EN 12758 and NS-EN 14351-1.
Safety glass rating	Original documentation	Safety glass is classified according to NS-EN ISO 12543-2 for laminated glass or NS-EN 12150-2 for tempered glass
Substances harmful to health and the environment	If substances harmful to health and the environment are suspected: send to a laboratory for chemical analysis to confirm or rule out the presence of such substances	It is not common to find substances harmful to health and the environment in old interior glass partition walls. Glass partition walls with insulating glass from before 1994 may use sealants containing environmentally hazardous substances such as phthalates and PCB.
Condition	Visual examination	Description of profiles, frames, glass and installation joints: As new or with varying degree of visible wear. Glass – de-lamination: The glass becomes less transparent, i.e. visibly slightly white in a de-laminated area compared to elsewhere.

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of the building.

Further reading

Central standards

- NS-EN 12758:2019
  Glass in building – Glazing and airborne sound insulation – Product descriptions, determination of properties and extension rules
- NS-EN 14351-1:2006 + A2:2016 + NA:2017
  Windows and doors – Product standard, performance characteristics – Part 1: Windows and exterior doors
- NS-EN 13501-2:2016
- Fire classification of construction products and building elements – Part 2: Classification using data from fire resistance tests, excluding ventilation systems
- EAD 210005-00-0505
  Internal partition kits for use as non-loadbearing walls
- NS-EN ISO 12543-2:2021
  Glass in building – Laminated glass and laminated safety glass – Part 2: Laminated safety glass
- NS-EN 12150-2:2004
  Glass in building – Thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard
- NS-EN ISO 10140-2:2010
  Acoustics – Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation
- NS-EN ISO 717-1:2013
  Acoustics – Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation

See https://standard.no/ (standards) and https://www.eota.eu (EAD)

Specifications in the SINTEF Building Research Design Guides (*Byggforskserien*)

- 524.331 Lydisolering i kontorlokaler [524.331 Sound insulation in office premises]
- 571.951 Bygningsglass [571.951 Glass in building]
- 571.957 Vinduer og glassvegger med brannmotstand [571.957 Fire-resistant windows and glass walls]

See https://www.byggforsk.no/byggforskserien

Windows, patio doors, exterior doors and interior doors



Examples of windows. Photo: SINTEF Community

Windows

General remarks

Windows have an expected service life of 20 to 60 years. The service life is limited by insulating glass. Ageing as a result of climatic impacts will depend on sun exposure, wind impact and driving rain. In many areas of Norway, climate stress is greatest on south- and west-facing façades. Large windows are subject to strong wind pressure. Frames, sashes, glass and fittings must be strong enough to withstand wind loads. Systematic maintenance of windows also improves their technical condition.

Assessment for reuse

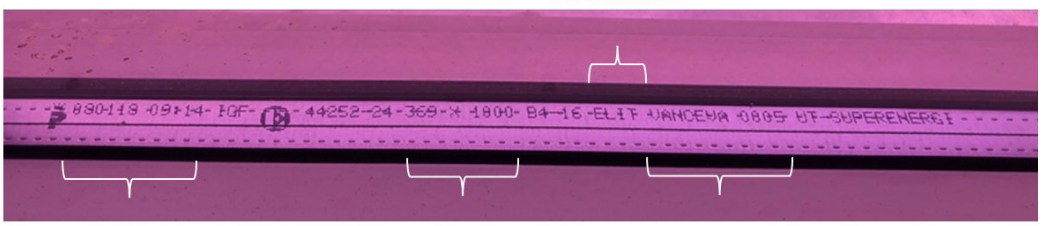
Assessment of windows before reuse must include consideration of the condition of frames and sashes, seals, fittings and insulating glass. Worn or damaged components can be replaced and other maintenance such as lubrication of fittings can be carried out.

The format of windows, i.e. width and height of casings and the number of windows of given sizes are important information. In addition, the opening mechanism must be specified (side hinged, top hinged, sliding hinged, turning/tilting hinged).

The construction of the insulating glass, the material in the frame and sash and the fittings on the window, such as handles, child proofing and window locks, may decide where the window can be reused.

As windows are an essential part of a building's climate screen, they should be both impervious and well insulated. Properties such as the U value and water- and airtightness must be documented in the event of reuse. For larger dimensions, it is also important to document that the window is strong enough to withstand wind loads.

Older windows can have considerable reuse value because of the requirements for building conservation and façade design in classified buildings.



In the case of insulated windows, information about the production year, manufacturer and properties is often printed on the insulating glass spacer.

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Frame and sash	Frame and sash is made of wood, wood with external sheathing of aluminium or PVC, aluminium, PVC or steel	Frame and sash are crucial for sealing and mechanical strength. Wood is affected most by climate and has the greatest maintenance requirement if it is to retain its properties. Wooden windows must be painted regularly to prevent damage caused by moisture and sunlight. Damaged sealing strips are easily replaced, and damage to the frame or casing of wooden windows can be repaired.
Insulating glass	Insulating glass normally have two or three layers of glass, assembled with an airtight space between them. The space is filled with gas, normally argon. The gas in the space improves the heat insulating properties.	The seal of insulating glass can fail (punctured window). Condensation then forms between the glass panes and the glass fogs up. Puncturing affects the view out and the admission of daylight, but only affects the U Value to a small extent. No good solutions exist for lasting repair of this damage. Insulating glass can be replaced. In most windows manufactured after the year 2000, the insulating glass is glued to the frame/sash as a safeguard against burglary. In the event of replacement, the pane must therefore be cut out of the frame.
Fittings (hinges, window locks, catches, handles and childproofing)	Fittings may be made of galvanised steel, stainless steel, natural anodised aluminium or powder coated aluminium.	Fittings are crucial for sealing and mechanical strength. Repeated wind loads can result in worn fittings, impairing the mechanical strength of the window. Wear of the fittings and inadequate maintenance can eventually reduce wind- and watertightness. Stainless steel fittings withstand severe climate stress. Fittings of natural anodised aluminium can corrode in contact with pressure impregnated wood, but otherwise will withstand severe climate stress. Galvanised fittings survive best in areas with low climate stress. Fittings can be lubricated and damaged parts can be replaced.
Seals	Seals around insulating glass that is exposed to sunlight are manufactured from EPDM rubber. Seals between the sash and frame may be of EPDM rubber, PVC, silicone or composites of various plastics, such as polyethene and polypropene.	Seals are crucial for watertightness, airtightness and sound insulation. Ageing of seals can reduce water- and airtightness over time. Plastic materials degrade with time. Seals can lose their flexibility and sealing ability. The sealing ability can also be impaired by repeated opening and closing of a window, or if a seal is exposed to moisture and freeze/thaw cycles. Joints and corners in a seal are particularly vulnerable to the formation of leaks. Damaged seals can be replaced. To achieve good airtightness, seals must be selected with the same moulding shape as the original ones.

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD[2)]	COMMENTS
Year of manufacture	Visual examination	The year of manufacture and manufacturer's name are often printed on the spacing strip between the glass panes of an insulated window.
Materials and construction	• Visual examination • Original documentation • Colour code • Tape measure or similar	• Construction of the insulating glass (number of glass panes, glass thickness, distance between panes). In newer insulating glass, this information is stated on the spacer • Materials in the frame and sash • Fittings (hinges, window locks, catches, handles and childproofing) • Colour and type of surface treatment • Format and layout of glass sections
Dimensions	Tape measure or similar	Width and height of frame
Opening principle	Visual examination	Specify hinge type (sash window, sliding hinged, turning/tilting hinge), hinged (top, bottom, side) and whether the window opens inwards or outwards.
Fire resistance	Certificate	Fire resistance shall be certified according to NS-EN 16034. Reuse without retesting requires verification by the manufacturer or certifying body that the property is unchanged.
Sound reduction index, $R_w + C_{tr}$	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
U-value	• Original documentation • Calculation	The U-value can be calculated on the basis of a drawing of the window and the construction of the insulating pane. Ageing has little effect on the U-value. The Norwegian regulations relating to technical requirements for building work (Byggteknisk forskrift) specify minimum U-values for windows.
Watertightness	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Airtightness	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Wind load	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Safety glass rating	• Visual examination • Original documentation	Safety glass is classified according to NS-EN ISO 12543-2 for laminated glass or NS-EN 12150-2 for tempered glass.
Light transmittance, L_t **Solar factor, g-value**	• Visual examination • Original documentation	The light transmittance can be printed on the separating insulating glass spacer.
Substances harmful to health and the environment	Chemical analysis: • Handheld XRF (chlorine) • Laboratory	Substances in insulating windows known to be harmful to health and the environment: • Insulating glass manufactured from 1975 to 1976 (in Norway) and up to 1979 (foreign manufacturers) may contain PCB. • Insulating glass from 1970 to 1990 can contain chlorinated paraffins in adhesives and sealing strips.
Condition	Visual examination	Description of frame/sash, gaskets and sealing strips, fittings and insulating glass: as new or with varying degree of visible wear

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of a building.

[2)] New windows shall be documented according to NS-EN 14351-1. The test methods specified in NS-EN 14351-1 can be used for retesting windows before reuse if alternative methods have not been developed and verified.



Examples of patio doors. Photo: SINTEF Community

Patio doors

General remarks

Patio doors include side-hinged terrace doors and sliding doors. They have the same properties as windows, as well as properties of doors. Patio doors are used as doors from a room to a balcony, terrace or garden. Side hinged doors may open inwards or outwards. Sliding doors may have an inside or outside sliding part. Insulating glass is used in the window area.

Assessment for reuse

Assessment of patio doors for reuse must include the year of manufacture and an assessment of the condition of the door, frame, seals, fittings and insulating glass. Worn and damaged components can be replaced and other maintenance such as lubrication of fittings can be carried out.

The format of patio doors, i.e. width and height of the frame and the number of doors of given dimensions are important information. In addition, the opening method (side hinged, inward/outward opening, sliding, folding) must be specified. In the case of side hinged doors, whether the door is left or right hinged must also be stated.

The design of the door sill must be specified. In buildings with universal design, the requirement is a sill height of 25 mm or less. In buildings with universal design, the opening force of doors must be documented.

Both the inner and outer glass of patio doors and side lights must be made of safety glass. This must be documented before reuse. Glass type is often printed on the separating strip in an insulated pane. Safety glass may also be labelled by the manufacturer by sandblasting the classification in the glass surface.

Other important information that may decide whether a door can be reused is the construction of the insulating glass, the material of the door leaf and frame, and what fittings the door has, such as handles, espagnolettes, locks and door brakes.

The service life of patio doors equals to that of windows, i.e. 20 to 60 years. As patio doors are an essential part of a building's climate screen, they should be both draught-free and well insulated. Properties such as the U-value and wind and rain resistance must be documented in the event of reuse. For larger dimensions, it is also important to document that the door is strong enough to withstand wind loads.

The year of manufacture, manufacturer's name and the properties are often printed on the insulation glass spacer.

Glass thickness (inner and outer glass) is 6.38 mm: 2 × 3 mm glass + 0.38 laminate between glass sheets. The laminate (ES) reduces thermal radiation. 4 mm glass in the space between inner and outer glass. Space on each side is 16 mm.

Production date and time

Inner and outer glass of laminated energy glass

Manufacturer

Dimensions of the insulated pane: Width × height in mm

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Frame and door leaf	Frame and door leaf are made of wood, wood with external sheathing of aluminium or PVC, aluminium, PVC or steel. The panels often consists of internal and external layers separated by insulation.	Frame and sash are crucial for sealing and mechanical strength. Wood is affected most by climate and has the greatest maintenance requirement if it is to retain its properties. Wooden doors must be painted regularly to prevent damage caused by moisture and sunlight. Damaged sealing strips are easily replaced, and damage to the frame or casing of wooden doors can be repaired. Dado panels can also be replaced.
Door sill	The sill is made of wood, aluminium or glass fibre reinforced plastic.	Door sills are exposed to wear.
Insulating glass	Insulating glass normally have two or three layers of glass, assembled with an airtight space between them. The space between the glass panes is filled with gas to improve the insulating properties. Both the inner and outer glass pane of patio doors and side lights must be made of safety glass.	The condition of the insulating glass affects the view outside and the admission of daylight. The seal of insulating glass can fail (punctured window). This causes condensation to form between the glass panes. Insulating glass can be replaced. In most patio doors manufactured after the year 2000, the insulating glass is glued to the frame/sash as a safeguard against burglary. In the event of replacement, the pane must therefore be cut out of the sash.
Fittings (hinges, window locks, catches, handles and childproofing)	Fittings may be made of galvanised steel, stainless steel, natural anodised aluminium or powder coated aluminium.	Fittings are crucial for sealing and mechanical strength. Wear of fittings and inadequate maintenance can eventually reduce wind-proofing and imperviousness to rain. Stainless steel fittings withstand severe climate stress. Fittings of natural anodised aluminium can corrode in contact with pressure impregnated wood, but otherwise will withstand severe climate stress. Galvanised fittings survive best in areas with low climate stress. Fittings can be lubricated and damaged parts can be replaced.
Seals	Seals around insulating glass that is exposed to sunlight are manufactured from EPDM rubber. Seals between the door and frame may be of EPDM rubber, PVC, silicone or composites of various plastics, such as polyethene and polypropene.	Seals are crucial for watertightness, airtightness and sound insulation. Ageing of seals can reduce water- and airtightness over time. Plastic materials degrade with time. Seals can lose their flexibility and sealing ability. The sealing ability can also be impaired by repeated opening and closing of a window, or if a seal is exposed to moisture and freeze/thaw cycles. Joints and corners in a seal are particularly vulnerable to the formation of leaks. Damaged seals can be replaced. To achieve good airtightness, seals must be selected with the same moulding shape as the original ones.

Documentation of properties in connection with reuse

PROPERTY[1]	DOCUMENTATION METHOD[2]	COMMENTS
Year of manufacture	Visual examination	The year of manufacture and manufacturer's name are often printed on the spacing strip between the glass panes of an insulated window.
Materials and construction	• Visual examination • Original documentation • Colour code • Tape measure or similar	Description: • Construction of the insulating glass (number of glass panes, glass thickness, distance between panes). This information is often printed on the spacer. • Materials, door leaf and frame • Fittings (hinges, locks, catches, handles and ventilation safety catches) • Colour and type of surface treatment • Format and layout of glass sections • Weight
Dimensions	Tape measure or similar	Width and height of frame. Width and height of glass pane
Sill height	Tape measure or similar	Height to sill
Opening principle	Visual examination	• Side hinged door: Specify hinging configuration, hinge side and whether the door opens inwards or outwards. • Sliding door: Specify if the door has an inner or outer sliding section.
Fire resistance	Certificate	Fire resistance shall be certified according to NS-EN 16034. Reuse without laboratory retesting requires verification by the manufacturer or certifying body that the property is unchanged.
Sound reduction index, $R_w + C_{tr}$	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
U-value	• Original documentation • Calculation	The U-value can be calculated on the basis of a drawing of the window and the construction of the insulating pane
Watertightness	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Airtightness	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Operating force	• Original documentation • Retesting	Retesting can be carried out in the field. Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged
Safety glass rating	• Visual examination • Original documentation	Safety glass is classified according to NS-EN ISO 12543-2 for laminated glass or NS-EN 12150-2 for tempered glass. The rating is often printed on the spacer strip in the insulated window or on the glass.
Light transmittance, L_t **Solar factor, *g*-value**	• Visual examination • Original documentation	The light transmittance value can be printed on the insulating glass spacer.
Substances harmful to health and the environment	Chemical analysis: • Handheld XRF (chlorine) • Laboratory	Substances in insulating glass known to be harmful to health and the environment: • Insulating glass manufactured from 1975 to 1976 (in Norway) and up to 1979 (foreign manufacturers) may contain PCB. • Insulating glass from 1970 to 1990 can contain chlorinated paraffins in adhesives and seals.
Condition	Visual examination	Description of frame, sash, sill, door leaf gaskets and sealing strips, fittings and insulating panes: as new or with varying degree of visible wear

[1] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of the building.

[2] New windows shall be documented according to NS-EN 14351-1. The test methods specified in NS-EN 14351-1 can be used for retesting windows before reuse if alternative methods have not been developed and verified.



Examples of exterior doors. Photo: SINTEF Community

Exterior doors

General remarks

Exterior doors are generally side hinged. They may open either outwards or inwards. The life expectancy of exterior doors is estimated to be 20 to 40 years. As they are an essential part of a building's climate screen, they must be both impervious and well insulated. If an exterior door is to be installed without a covering structure, such as a roof overhang, it must have the same properties as a patio door. If a door is to be protected by a covering structure, it may be less water resistant, as the roof extension will protect it from rain. Because the watertightness of most exterior doors is lower than that of windows, they must be installed under a covering structure or roof overhang.

Assessment for reuse

Assessment of exterior doors for reuse must include consideration of the condition of the door leaf, frame, seals, fittings, sill and insulating glass. Worn or damaged components can be replaced and other maintenance such as lubrication of fittings can be carried out.

The format of exterior doors, i.e. width and height of frame and the number of doors of given dimensions are necessary information. Whether the door is left or right hinged must also be stated.

The design of the door sill must be specified. When used in buildings with requirements for universal design, step-free access and a sill height of 25 mm or lower are mandatory. The operating force must be less than 30 N.

Both the inner and outer glass of exterior doors and sidelights must be made of safety glass. This must be documented before reuse. Glass type is often printed on the insulating glass spacer. Safety glass may also be labelled by the manufacturer by sandblasting the classification in the glass surface.

Other important information that may decide whether a door can be reused is the format and layout of glass panes, the construction of the insulating glass, the material of the door and frame, and what fittings the door has, such as handles, security locks and kick plates.

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Frames	Frames are made of wood, aluminium, PVC or steel.	The frame is essential to provide sealing and mechanical strength. Wood is affected most by climate and has the greatest maintenance requirement if it is to retain its properties. Wooden casings must be painted regularly to prevent damage caused by moisture and sunlight.
Door leaves	Older doors are often of solid wood. The leaf of wood frame doors consists of outer and inner panels in wood separated by insulation. The door leaf of newer doors consists of an inner and outer panel of PVC, aluminium or separated by insulation.	The door leaf is essential for sealing and mechanical strength. A door leaf must be maintained according to the manufacturer's specification. Damage to covering panels must be repaired. Wood framed doors with covering panels of MDF may have moisture damage if the paint covering is damaged. Newer wood frame doors have fully glued panels which cannot be replaced.
Door sill	The sill of wooden exterior doors is made of hardwood or a combination of hardwood and aluminium. In doors made of PVC, aluminium or steel, the sill is made of the same material as the frame.	The sills of doors that have been used a lot may be badly worn. If a sealing strip is fitted to the sill, instead of the door leaf, the strip is often damaged by use. The sill is glued or sealed to the casing to keep out rain. In the event of dismantling and transport, the seal may be damaged. In the event of reuse, it is recommended to lay a string of sealing compound between the sill and the casing to improve rain resistance.
Insulating glass	Insulating glass normally have two or three layers of glass, assembled with an airtight space between them. The space between the glass panes is filled with gas to improve the insulating characteristics. Both the inner and outer glass of exterior doors and sidelights must be made of safety glass.	The condition of the insulating glass affects the view outside and the admission of daylight. The seal of insulating glass can fail (punctured window). This causes condensation to form between the glass panes. Puncturing does not affect the U-value. Insulating glass can be replaced. In most patio doors manufactured after the year 2000, the insulation glass is glued to the frame/casing as a safeguard against burglary. In the event of replacement, the panes must be cut out of the casing.
Fittings (hinges, locks, catches and handles)	Fittings may be made of galvanised steel, stainless steel, natural anodised aluminium or powder coated aluminium.	Fittings are crucial for sealing and mechanical strength. Air and watertightness are impaired by worn fittings. Stainless steel fittings withstand severe climatic impacts. Fittings of natural anodised aluminium may corrode in contact with pressure treated woodwork, but otherwise withstand severe climatic stress. Galvanised fittings survive best in areas with low climatic stress. Fittings may be lubricated. Damaged fittings can be replaced.
Seals	Seals around insulating glass that is exposed to sunlight are manufactured from EPDM rubber. Seals between the door and frame may be of EPDM rubber, PVC, silicone or composites of various plastics, such as polyethene and polypropene.	Seals are crucial for watertightness, airtightness and sound insulation. Ageing of seals can reduce water- and airtightness over time. Plastic materials degrade with time. Seals can lose their flexibility and sealing ability. The sealing ability can also be impaired by repeated opening and closing of a window, or if a seal is exposed to moisture and freeze/thaw cycles. Joints and corners in a seal are particularly vulnerable to the formation of leaks. Damaged seals can be replaced. To achieve good airtightness, seals must be selected with the same moulding shape as the original ones.

Documentation of properties in connection with reuse

PROPERTY[1]	DOCUMENTATION METHOD[2]	COMMENTS
Year of manufacture	• Visual examination • Information from initial purchase	If the door is fitted with insulating glass, the year of manufacture and manufacturer's name are often printed on the spacing strip between the glass panes.
Materials and construction	• Visual examination • Original documentation • Colour code • Tape measure or similar	• Construction of the insulating glass (number of glass panes, glass thickness, distance between panes). • Materials in the door leaf, frame and sill • Fittings (hinges, locks, catches, handles and burglary prevention devices) • Colour and type of surface treatment • Format and layout of glass panes
Dimensions	Tape measure or similar	Height and width of frame and glass panes
Sill height	Tape measure or similar	Height of sill
Opening principle	Visual examination	Inward or outward opening door
Hinging	Visual examination	Left or right as seen from the hinge side
Fire resistance	Certificate	Fire resistance shall be certified according to NS-EN 16034. Reuse without retesting requires verification by the manufacturer that the property is unchanged.
Sound reduction index, $R_w + C_{tr}$	• Visual examination • Original documentation	The sound reduction index is often printed on the inside of the door casing or on the edge of the door leaf. Reuse without retesting requires verification by the manufacturer that the property is unchanged.
U-value	• Original documentation • Calculation	The U-value can be calculated on the basis of a drawing of the door and the construction of the insulating pane. Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Watertightness	• Original documentation • Retesting	Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Airtightness	• Original documentation • Retesting	Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Operating force	• Original documentation • Retesting	Re-testing can be carried out in the field. Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Safety glass rating	• Visual examination • Original documentation	Safety glass is classified according to NS-EN ISO 12543-2 for laminated glass or NS-EN 12150-2 for tempered glass. The rating is often printed on the spacer strip in the insulated window or on the glass.
Light transmittance, L_t **Solar factor, g-value**	• Visual examination • Original documentation	The light transmittance value is often printed on the insulating glass spacer.
Substances harmful to health and the environment	Chemical analysis: • Handheld XRF (chlorine) • Laboratory	Substances in insulating windows known to be harmful to health and the environment: • Insulating glass manufactured from 1975 to 1976 (in Norway) and up to 1979 (foreign manufacturers) may contain PCB. • Insulating glass from 1970 to 1990 can contain chlorinated paraffins in adhesives and seals.
Condition	Visual examination	Description of leaf/frame, seals, fittings and insulation glass: as new or with varying degree of visible wear

[1] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of a building.

[2] New exterior doors shall be documented according to NS-EN 14351-1. The test methods specified in NS-EN 14351-1 can be used for retesting exterior doors before reuse if alternative methods have not been developed and verified.



Examples of interior doors. Photo: SINTEF Community

Interior doors

General remarks

Interior doors are generally side hinged. They differ from exterior doors in that they are not constructed to withstand climate stress such as wind and rain. Neither are they insulated in the same way as exterior doors.

Assessment for reuse

Assessment of interior doors for reuse must include consideration of the condition of the door leaf, frame, sash, seals and fittings. Worn or damaged components can be replaced and other maintenance such as lubrication of fittings can be carried out.

The format of an interior door, i.e. the width and height of the frame and the number of doors of given dimensions are necessary information, as is whether the door is left or right hinged.

The design of the door sill must be specified. When used in buildings with requirements for universal design, step-free access and a sill height of 25 mm or lower are mandatory. The operating force must less than 30 N.

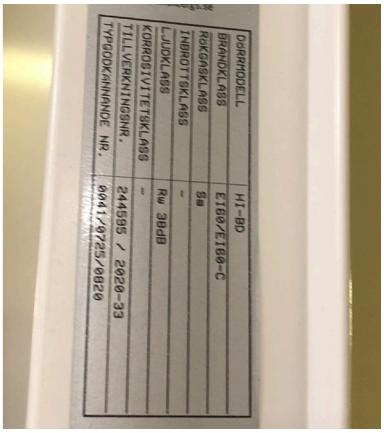
Interior doors and sidelights must be fitted with safety glass. This must be documented before reuse. Safety glass may also be labelled by the manufacturer by sandblasting the classification in the glass surface.

Wired glass has previously been used in interior doors. Wired glass panes can represent a personal safety hazard. Doors fitted with this type of pane should be upgraded with safety glass to achieve satisfactory personal safety.

Other important information that may decide whether an interior door can be reused is the format and layout of glass panes, the construction of the glass pane, the colour, the material of the door and casing, and what fittings the door has, such as handles and kick plates.

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGING AND REPAIR OF DAMAGE
Frame and door leaf	The most common materials found in frames and door leaf are wood, aluminium, glass and steel.	Wood in a humid indoor climate has the greatest maintenance requirement if it is to retain its properties. Steel may be prone to corrosion in certain types of indoor climates. Doors that have been fitted between rooms with different levels of humidity may become warped as a result.
Door sill	The sill is usually of the same material as the frame. In the case of wooden doors, a hardwood such as oak is often used in the sill.	Wooden sills can be subject to considerable wear if the door has been in frequent use.
Glass panes	Glass panes in interior doors are usually single glazed.	The glass pane is usually affected very little by use.
Fittings (hinges, locks, catches and handles)	Fittings may be made of galvanised steel, stainless steel, natural anodised aluminium or powder coated aluminium.	Fittings on doors that are opened frequently may be damaged by wear. Fittings in doors used in a corrosive environment such as swimming baths may be subject to corrosion. Fittings may have to be replaced because of wear. Fittings may be lubricated.
Seals	Newer interior doors and doors with sound insulating or fire resistant properties are fitted with seals between the door leaf and the casing. Seals between a door leaf and casing may be of EPDM rubber, PVC, silicone or composites of various plastics, such as polyethene and polypropene.	Plastic materials degrade with time. Seals can lose their flexibility and sealing ability. Repeated opening and closing of a door may also impair its sealing function. Joints and corners in a seal are particularly vulnerable to the formation of leaks. Damaged sealing strips can be replaced. To achieve good airtightness, seals must be selected with the same moulding shape as the original ones.



Sound insulating or fire resistant properties are often indicated by labelling on the frame or outer edge of the door. Photo: SINTEF Community

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD[2)]	COMMENTS
Year of manufacture	Information from initial purchase	
Materials and construction	• Visual examination • Original documentation • Colour code • Tape measure or similar	• Materials in the door leaf, frame and sill • Fittings (hinges, catches and handles) • Colour and type of surface treatment • Format and layout of glass panes • Glass type (wired glass, safety glass) • Labelling in glass pane • Kick plate
Dimensions	Tape measure or similar	• Width and height of casing and door leaf • Clearance and width
Sill height	Tape measure or similar	Height of sill
Opening direction	Visual examination	
Operating force	• Original documentation • Retesting	Can be tested in the field. Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Resistance to hard impacts, rigidity and vertical loading	• Original documentation • Retesting	Non-destructive testing if testing is passed. Destructive testing if testing fails.
Airtightness	• Original documentation • Retesting	Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Separation between two different climates	• Original documentation • Retesting	Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Fire resistance	Certificate	Fire resistance shall be certified according to NS-EN 16034. Reuse without retesting requires verification by the manufacturer or certifying body that the property is unchanged.
Sound reduction index, R_w	• Original documentation • Retesting	Reuse without retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Substances harmful to health and the environment	If content of substances that are hazardous to health and the environment is suspected: Send to laboratory for chemical analysis to confirm or rule out content of such substances.	Before chemical analysis the substance or substances to be analysed must be identified.
Condition	Visual examination	Description of frame, sill, door leaf gaskets and sealing strips, fittings and insulating panes: as new or with varying degree of visible wear

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of a building.

[2)] New interior doors shall be documented according to NS-EN 14351-1. The test methods specified in NS-EN 14351-1 can be used for retesting interior doors before reuse, if alternative methods have not been developed and verified.

Further reading

Central standards

Standards for testing and documentation of windows, patio doors, exterior doors and interior doors.

- NS-EN 14351-1:2006 + A2:2016 + NA:2017
  Windows and doors – Product standard, performance characteristics – Part 1: Windows and exterior doors
- NS-EN 14351-2:2018
  Windows and doors – Product standard, performance characteristics – Part 1: Interior doors
- NS-EN 16034:2014
  Pedestrian doorsets, industrial, commercial, garage doors and openable windows. Product standard, performance characteristics. Fire resisting and/or smoke control characteristics
- NS-EN 12150-2:2004
  Glass in building – Thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard
- NS-EN ISO 12543-2:2021
  Glass in building – Laminated glass and laminated safety glass – Part 2: Laminated safety glass

See https://standard.no/

Specifications in the SINTEF Building Research Design Guides (Byggforskserien)

- 533.102 Vinduer. Typer og funksjoner [533.102 Windows. Types and functions]
- 533.132 Vinduer av tre [533.132 Wooden windows]
- 533.153 Vinduer av PVC [533.153 PVC windows]
- 533.151 Vinduer av aluminium [533.151 Aluminium windows]
- 533.202 Ytterdører av tre [533.202 Wooden exterior doors]
- 533.242 Vindusdører. Typer og egenskaper [533.242 Patio doors. Types and properties]
- 534.141 Lydisolasjonsegenskaper til dører [534.141 Sound insulating properties of doors]
- 571.951 Bygningsglass [571.951 Glass in building]
- 571.953 Isolerglass. Typer og konstruksjoner [571.953 Insulating glass. Types and constructions]
- 571.956 Sikkerhetsruter [571.956 Safety glass panes]
- 571.957 Vinduer og glassvegger med brannmotstand [571.957 Fire-resistant windows and glass walls]
- 700.320 Intervaller for vedlikehold og utskifting av bygningsdeler [700.320 Frequency of maintenance and replacement of building components]

See https://www.byggforsk.no/byggforskserien

Ventilation



Examples of ducts and duct fittings. Photo: SINTEF Community

Air duct systems – ducts and duct fittings

General remarks

Spiral ducts are a rigid, cylindrical tubes. They are manufactured in fixed lengths and standard diameters from 63 mm to 1250 mm. SINTEF does not recommend diameters less than 100 mm.

Rectangular ducts are often used in utility rooms, as large main ducts and in parts of the system where space is limited. They are usually joined using joint slide profiles and sealed. Outer surfaces may be painted.

Assessment for reuse

Rigid steel ducts and duct fittings (bends, branches, etc.) are suitable for reuse. Flexible ducts are rarely suitable for reuse, as they are easily deformed and punctured. Old ducts made with abestos must be disposed of as hazardous waste.

Rectangular ducts are often specially adapted to a building in terms of dimensions and rigidity and are therefore less amenable to reuse.

Cylindrical ducts and duct fittings can usually be dismantled. Ducts and duct fittings from the early 1990s have good tolerance and compatibility with new components. Older ducts and duct fittings with standard dimensions are made of slightly different material and have different actual dimensions. They are therefore not suitable for reuse. Tolerances can easily be tested relative to newer ducts and fittings.

Full duct lengths, standard T-junctions and other branches can be reused, whereas slide-on pieces and other adapted variations are generally not suitable, as they are often modified, glued or have screw holes.

Duct insulation is easily perforated and often installed using tape. The insulation is often not suitable for reuse. Duct suspension fittings (perforated strips) are also unsuitable for reuse. Attachments for suspension of ducts are very solid and can be reused.

Materials, ageing and repair of damage

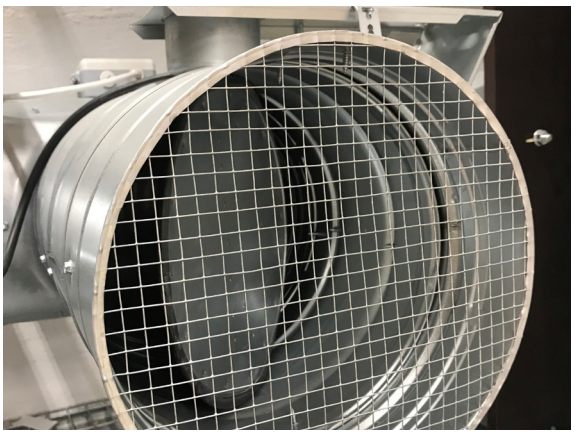
COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Ducts	Ducts made of galvanised steel.	Ducts become dirty, especially on the exhaust side. Ducts may be deformed. Assembly screws and air flow measurements may have left small holes in the ducts. Perforation for inspection hatches, etc, impairs the reusability of ducts. Ducts can be washed. Duct fittings with screw holes can lead to leaks, but they can be reused if old holes are sealed or joints are taped over during re-installation. Ducts with screw holes at the end can be cut and the remaining length can be reused.
Duct fittings	Duct fittings made of galvanised steel.	Duct fittings become dirty. Duct fittings may be cleaned if necessary.
Gaskets	Gaskets are made of rubber.	Cylindrical duct fittings often have rubber gaskets at joints. The gasket deteriorates with time and the seal is impaired if it hardens or is damaged. Defective gaskets can be replaced.

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD	COMMENTS
Year of manufacture	Information from initial purchase	
Manufacturer	Original documentation	Ducts and duct fittings are not usually labelled.
Dimensions and tolerances	• Tape measure or similar • Original documentation • Visual examination and assessment based on building year	Deteriorate in use. Tested according to NS-EN 1505 (rectangular ducts) or NS-EN 1506 (cylindrical ducts)
Materials	Visual examination	Materials in ducts and duct fittings, including gaskets
Airtightness class and rigidity	• Original documentation • Airtightness testing of installations	Norwegian products are of airtightness class C (cylindrical) and B (rectangular) or better. Normal use will not reduce the airtightness class. Airtightness class is tested according to NS-EN 1507 (rectangular ducts) or NS-EN 12237 (cylindrical ducts) Reuse without retesting is possible in co-operation with the manufacturer or other party that can verify that the characteristic is unchanged.
Fire resistance	Fire safety requirements are met by fire insulation of ducts and fire seals/ dampers at boundaries between fire zones.	Normal use does not impair the fire resistance of ducts and duct fittings. Fire resistance is tested according to NS-EN 1366-1 (ventilation ducts) or NS-EN 1366-8 (smoke exhaust ducts) and is classified according to NS-EN 13501-3.
Cleanliness	• Visual examination • Gel tape	Cleanliness is assessed according to NS-INSTA 800-1. Sampling and assessment are described in the SINTEF Building Research Design Guides (*Byggforskserien*), Nos. 752.250 and 752.251.[2)]
Substances harmful to health and the environment	• Visual examination • Laboratory (if asbestos is suspected)	Steel ducts do not present a hazard. Asbestos can be present in ventilation ducts and gaskets manufactured before 1985. If asbestos is suspected to be present, send a sample to a laboratory for clarification.
Condition	Visual examination	Characterisation of ducts, duct fittings and gaskets: as new or with varying degree of visible damage.

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of the building.

[2)] https://www.byggforsk.no/



Examples of dampers. Photo: SINTEF Community

Dampers and other regulating units

General remarks

Leaf dampers are usually used in cylindrical duct systems and louvre dampers in rectangular duct systems. The diameter of cylindrical ducts can be up to 650 mm, but dampers are mostly used in dimension 100-315 mm. Basic properties that are normal for ducts and duct fittings also apply to dampers. Pressure drop and noise are documented as parameters for design. Airtightness class is important, based on what a damper is to be used for. Airtightness class is specified from 0 to 4, according to NS-EN 1751. There are no requirements for the airtightness of balancing dampers but shut-off dampers usually are of airtightness class 3 to 4.

Assessment for reuse

Fixed dampers – balancing dampers – are adjusted to a desired, fixed position during balancing and are left in this position. Leaf dampers are most common, but some iris dampers and sliding dampers are found. Dampers with little wear can easily be reused after cleaning and operational checking. Rubber gaskets for fitting in ducts shall be checked for damage and ageing.

Some VAV dampers are leaf dampers fitted with actuators (damper motors) that control opening between two positions. The damper itself shall be assessed in the same way as a balancing damper. The actuator should be assessed in consultation with the manufacturer.

Dynamic DCV dampers combine a flow measuring station with a damper. While the damper part is robust, the measuring station must receive regular maintenance. The measuring cross must be cleaned with compressed air to remove dust if the unit is to measure air flow correctly. To adjust correctly, a dynamic damper has limiters for both maximum and minimum air flow. Earlier generations (from around 2010) were not able to adjust to such low air flows (air velocity over cross-sectional area) as new generations can. When designing, it is not unusual to select a dynamic damper that is too large and this must be replaced to achieve correct adjustment. Although there is awareness of this risk, there is still potential for reusing almost new dampers if they cannot be exchanged by the supplier. These require only simple checking for cleanness and damage. Dampers used for a long period need more thorough checking.

The majority of products on the market are fitted with Belimo activators, which are robust and reliable. The damper and activator must be set up for correct adjustment of the damper position and angle. They must be function tested and inspected. Adjustment of the actuator may be controlled by air pressure with analogue communication or optimally using digital communication.

Fire dampers shall be inspected in the same way as other dampers. Fire safety features, such as closing mechanisms, should also be checked.

Materials, ageing and repair of damage

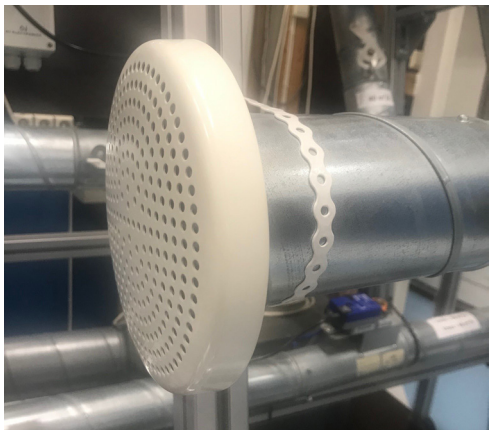
COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Fixed regulating damper	Damper is made of galvanised steel. Gasket made of rubber.	Fixed regulating dampers are robust and are subject to little wear. Dampers become dirty with time. The rubber gasket for installation in a duct may be damaged or aged. Dirty dampers can be cleaned. Rubber gaskets can be replaced.
Dynamic dampers	Damper is made of galvanised steel.	Dampers become dirty, especially on the exhaust side. The flow measuring cross is specially exposed, impairing the correct measurement of air flow. Incorrect air flow results in incorrect adjustment of the damper, with imbalance and unstable adjustment of the installation. Dirty dampers and measuring crosses can be cleaned (with compressed air).
Damper actuators for dynamic dampers	Damper actuators are made of plastic and metal and contain electronics.	Damper actuators shall be function tested. Defective? Correct type? The actuator can be replaced.
Fire dampers	Fire dampers are made of galvanised steel.	Fire dampers are controlled separately, especially with respect to the actuation mechanism.

Examples of labelling. Photo: SINTEF Community

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD	COMMENTS
Year of manufacture	Information from initial purchase	The products are often labelled with the date of manufacture.
Manufacturer, type and model	• Original documentation • Visual examination	The products are usually labelled with the name of the manufacturer, type and dimension.
Communications protocol motor	• Original documentation • Visual examination	VAV/DCV damper: ModBus, BACnet, KNX
Dimensions	• Tape measure or similar • Labelling	Dimensions are specified according to duct size.
Materials	• Original documentation • Visual examination	The standard is galvanised steel or aluminium in damper blades.
Noise generation	• Original documentation • Retesting	The property normally deteriorates little. Possible co-operation with the manufacturer that can verify that the properties are unchanged. Re-testing according to NS-EN ISO 5135
Airtightness class	• Original documentation • Airtightness testing of installations	Airtightness class tested according to NS-EN 1751. Reuse without retesting is possible in co-operation with the manufacturer or other party that can verify that the characteristic is unchanged.
Aerodynamic testing	• Original documentation • Retesting	Aerodynamic characteristics tested according to NS-EN 1751. Reuse without retesting is possible in co-operation with the manufacturer or other party that can verify that the characteristic is unchanged.
Cleanliness	Visual examination	Clean before reuse
Function	Functional testing according to manufacturer's routines	Does the damper function as intended? Connect actuator: does it function as intended?
Fire resistance	• Original documentation • Retesting	Only applies to fire dampers. Retesting according to NS-EN ISO 1366-2. Reuse without retesting requires verification by the manufacturer or certifying body that the property is unchanged.
Substances harmful to health and the environment	If the presence of substances that are hazardous to health and the environment is suspected: Send to laboratory for chemical analysis to confirm or rule out content of such substances.	Normally none
Condition	Visual examination	Description of damper includes actuator, gaskets for joints and screw holes. As new or with varying degree of visible wear

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of the building.



Examples of air terminal devices. Photo: SINTEF Community

Air terminal devices

General remarks

Air intake terminal devices supply a room with fresh air. Different types of air terminal devices are used for rooms with mixing ventilation and rooms with displacement ventilation. Exhaust air terminals draw polluted air out of the room.

Air terminal devices are usually linked to cylindrical ducts of standard dimensions from 100 to 315 mm diameter. Documentation of characteristics such as pressure drop across the terminal device, throw distance and generated noise is important for the correct design, adjustment and resulting indoor climate.

Assessment for reuse

Air terminal devices are suitable for reuse if they are in good condition and their moving parts function correctly. Exhaust air terminals are particularly vulnerable to dust and dirt. Thorough cleaning is important.

Air terminal devices usually use rubber gaskets for attachment to ducts. A plenum box is often fitted immediately before the air terminal device. Some intake air terminal devices are fitted with movable nozzles.

Plenum boxes often have integral sound absorbent in the form of a thin sheet of polyester or similar. These may loosen with time. The correct plenum box must be used, with a suitable air terminal device if the k-factor is to be correct. See the product documentation.

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGEING AND REPAIR OG DAMAGE
Air terminal device	Air terminal device are made of galvanised steel and may be powder coated.	They may become dirty or discoloured, especially exhaust vents. Air terminal device can be washed
Moving nozzles	Moving nozzles are often made of plastic.	The nozzles may become stuck in position or damaged. Nozzles can be replaced.
Gasket for connection to ventilation duct	Gaskets are made of rubber.	The gaskets deteriorate with age. Gaskets can be replaced.
Plenum box with sound absorbent	The plenum box is made of galvanised steel. The sound absorbent often consists of thin polyester sheets.	The sound absorbent is glued in place. The glue may detach from the plenum box. Sound absorbent deteriorates with time. The plenum box may become dirty. The plenum box can be washed and new sound absorbent fitted.

Labelling of plenum box and terminal device.
Photo: SINTEF Community

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD	COMMENTS
Year of manufacture	• Information from initial purchase • Labelling	Air terminal device are often labelled with their date of manufacture.
Manufacturer	• Original documentation • Labelling • Visual examination	Air terminal device are often labelled with the name of their manufacturer.
Type and model of air terminal device and/or plenum box	• Original documentation • Visual examination	Plenum boxes are usually labelled with the name of the manufacturer, type and dimensions. Vents may be labelled with the name of the manufacturer, type and dimension.
Dimensions	• Tape measure or similar • Labelling	Specified according to the dimension of the duct
Materials	• Original documentation • Visual examination	Materials in valves, plenum boxes and gaskets for connecting to ventilation duct
Noise generation	• Original documentation • Retesting	Properties normally deteriorate little. Original documentation can usually be used. Co-operate with, for example, the manufacturer, if there is doubt if the characteristic is unchanged Retesting according to NS-EN ISO 5135 after replacement of sound absorbent.
Ventilation testing and classification	• Original documentation • Retesting	Properties normally deteriorate little. Original documentation can usually be used. Co-operate with, for example, the manufacturer, if there is doubt if the characteristic is unchanged Retesting according to NS-EN 12238, NS-EN 12239 (mixing) or NS-EN 12589 (displacement)
K-factor	• Original documentation • Visual examination	Appropriate properties of vents with pressure extraction. Properties normally deteriorate little. Original documentation is used. Co-operate with, for example, the manufacturer, if there is doubt if the characteristic is unchanged
Cleanliness	Visual examination	
Function	Functional testing according to manufacturer's routines	Inspect damper, nozzles and other moving parts.
Substances harmful to health and the environment	If the presence of substances that are hazardous to health and the environment is suspected: Send to laboratory for chemical analysis to confirm or rule out content of such substances.	Before chemical analysis the substance or substances to be analysed must be identified.
Condition	Visual examination	Description of vents and plenum chambers, including gaskets and screw holes: As new or with varying degree of visible wear

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of the building.

Further reading

Central standards

Standards for testing components in ventilation installations:

- NS-EN 1366-1:2014 + A1:2020
  Fire resistance tests for service installations – Part 1: Ventilation ducts
- NS-EN 1366-2:2015
  Fire resistance tests for service installations – Part 2: Fire dampers
- NS-EN 1366-8:2004
  Fire resistance tests for service installations – Part 8: Smoke extraction ducts
- NS-EN 1505:1997
  Ventilation for buildings – Sheet metal air ducts and fittings with rectangular cross section – Dimensions
- NS-EN 1506:2007
  Ventilation for buildings – Sheet metal air ducts and fittings with circular cross section – Dimensions
- NS-EN 1507:2006
  Ventilation for buildings – Sheet metal air ducts with rectangular section – Requirements for strength and leakage
- NS-EN 1751:2014
  Ventilation for buildings – Air terminal devices – Aerodynamic testing of damper and valves
- NS-EN 12237:2003
  Ventilation for buildings – Ductwork – Strength and leakage of circular sheet metal ducts
- NS-EN 12238:2001
  Ventilation for buildings – Air terminal devices – Aerodynamic testing and rating for mixed flow application
- NS-EN 12239:2001
  Ventilation for buildings – Air terminal devices – Aerodynamic testing and rating for displacement flow applications
- NS-EN 12589:2001
  Ventilation for buildings – Air terminal units – Aerodynamic testing and rating of constant and variable rate terminal units
- NS-EN ISO 5135:2020
  Acoustics – Determination of sound power levels of noise from air-terminal devices, air-terminal units, dampers and valves by measurement in a reverberation test room
- NS-EN ISO 13501-3:2005+A1:2009
  Fire classification of construction products and building elements – Part 3: Classification using data from fire resistance tests on products and elements used in building service installations: fire resisting ducts and fire dampers
- NS INSTA 800-1:2018
  Cleaning quality – Part 1: System for establishing and assessing cleaning quality

See https://standard.no/

Specifications in the SINTEF Building Research Design Guides (Byggforskserien)

- 552.351 Fordeling av ventilasjonsluft i rom [552.351 Distribution of ventilation air in rooms]
- 752.250 Rengjøring av ventilasjonsanlegg. Metoder, utstyr og prosess [752.250 Cleaning ventilation installations. Methods, equipment and processes]
- 752.251 Rengjøring av ventilasjonsanlegg. Tilsmussing og rengjøringsbehov [752.251 Cleaning ventilation installations. Soiling and cleaning requirements]

See https://www.byggforsk.no/byggforskserien

Sanitary equipment

Examples of different types of porcelain wash basins. Photo: SINTEF Community

Wash basin

General remarks

The expected service life of wash basins is 50 to 75 years. The expected service life of the wash basins is longer than the expected service life of wash basins stopper or water trap. Different materials age and wear differently. Water quality, temperature fluctuations and the use of chemicals and cleaning agents can also affect the expected service life. A typical cause of functional failure is cracks or fracture caused by impact or manufacturing flaws.

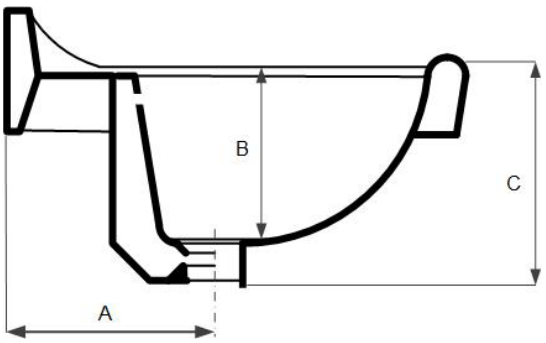
Assessment for reuse

Assessment of wash basins for reuse must include consideration of the washbasin, stopper including gaskets, and the water trap. Worn or damaged components can be replaced and other maintenance such as removal of limescale and discolouration can be carried out. If necessary, minor damage to the surface finish can be repaired.

The dimensions of the wash basin (width, depth, height) and the method of suspension are important factors affecting reuse. Whether the wash basin has an overflow hole should also be stated.

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Basin	Basins are made of porcelain, plastic composite, stainless steel, glass or glazed pottery.	With time, cracks may appear in the glaze of porcelain. This can result in absorption of liquid and form a breeding ground for bacteria. A typical cause of water leaks is large cracks in the material caused by impact or manufacturing flaw. Cracked washbasins should not be reused. Minor damage to the surface finish can be remedied using a suitable repair kit. Wear in ceramic glaze can be checked using a spirit-based felt pen: If the ink is easy to remove, the glaze is probably in good condition. Limescale or discolouration can occur in used equipment but does not necessarily affect its function. Limescale can be removed using dilute acid, such as household vinegar.
Bottom stopper and gasket	Metal washbasin stopper in stainless steel is common Mechanical (pop-up) or manual stoppers are sealed by a rubber or plastic O-ring.	Gaskets can become brittle and lose their sealing ability. Worn gaskets can be replaced.
Water trap	The water trap is made of plastic or metal. Rubber gaskets	Gaskets can become brittle and lose their sealing ability. Worn gaskets can be replaced. Alternatively, the full water trap can be replaced.



Measurements of basin with built-in overflow:
A – Distance from wall to drain
B – Internal depth
C – External depth with muff, excluding back

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD[2)]	COMMENTS
Year of manufacture	• Information from initial purchase or building year	
Materials and construction	• Visual examination • Original documentation	• Material • Colour and type of surface finish • Overflow (external or built-in type) • Format and number of holes for tap fittings (corner basin, single, double basin, etc.)
Dimensions	Tape measure or similar	• Width, projection, height • Diameter and location of tap holes • Diameter of bottom outlet – normally 1" (25.4 mm) or 1 1/4" (31.75 mm)
Suspension method	Visual examination	Type of suspension and attachment method (supporting bracket or bolts), cabinet washbasin, drop-in or pedestal.
Resistance to external load	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Water drainage	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Resistance to temperature changes	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Resistance to chemicals and dyes	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Wear and scratch resistance	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Potential for cleaning	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Overflow capacity	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Substances harmful to health and the environment	If substances harmful to health and the environment are suspected: send to a laboratory for chemical analysis to confirm or rule out the presence of such substances Chemical analysis: • Handheld XRF (lead)	Before chemical analysis the substance or substances to be analysed must be identified. Older ceramic glaze and imported ceramics can contain lead.
Condition	Visual examination	Description of washbasin, including surface finish, suspension, bottom outlet with gaskets and U-bend: as new or with varying degree of visible damage (cracks, scratches, lime scale, stains/ discolouration, etc.)

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of the building.

[2)] New washbasins shall be documented according to NS-EN 14688. The test methods specified in NS-EN 14688 can be used for retesting washbasins before reuse if alternative methods have not been developed and verified.

Bathtubs

Examples of bathtubs in enamelled steel with removable skirt. Photo: SINTEF Community

General remarks

The expected service life of bathtubs 25 to 75 years. Different materials age and wear differently. A typical cause of functional failure is breakage caused by mechanical loading.

Assessment for reuse

Assessment of bathtubs for reuse must include consideration of the tub, frame, legs, drain with gaskets and plug and overflow if fitted. Worn or damaged components can be replaced and other maintenance such as removal of limescale and discolouration can be carried out. If necessary, minor damage to the surface finish can be repaired.

It is important to know the dimensions of the bathtub (width, height, depth and internal water depth) and bathwater capacity when reusing. It must also be specified whether the bathtub is fitted with an overflow, is free-standing or is intended for enclosure.

Materials, ageing and repair of damage

COMPONENT	MATERIAL	AGEING AND REPAIR OF DAMAGE
Bathtubs	Bathtubs are made of enamelled steel, acrylate composite, glass-fibre reinforced polyester, stainless steel, enamelled cast iron or glazed porcelain.	Dirt, sand, particles, etc. can abrade surface finish. Lime scale or discolouration can occur in used equipment. Worn surface finish can be treated with, for example, polish and then rinsed thoroughly. Minor damage to the surface finish can be remedied using a suitable repair kit. Dilute acid such as household vinegar can be used to remove lime scale.
Frame, legs and panels	Stainless steel, powder coated, hot galvanised sheet / aluminium mouldings, etc.	
Drain with plug and gasket	Drain made of plastic or metal Mechanical (pop-up) or manual plugs are sealed with a rubber or plastic O-ring.	Gaskets can become brittle and lose their sealing ability. Worn gaskets can be replaced. Alternatively, the entire drain can be replaced.

Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD[2)]	COMMENTS
Year of manufacture	Information from initial purchase or building year	
Materials and construction	• Visual examination • Original documentation	• Material • Colour and type of surface finish • Overflow (external or built-in type) • Format and location
Dimensions	Tape measure or similar	• Width, depth, height • Internal water depth • Capacity (bathwater volume) • Diameter and location of drain
Installation method	Visual examination	Specify type: free-standing or for enclosure, with removable legs
Potential for cleaning – appearance of surfaces	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Water drainage	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Stability of bathtub base	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Resistance to chemicals and stains	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Resistance to temperature changes	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Substances harmful to health and the environment	If the presence of substances that are hazardous to health and the environment is suspected: Send to laboratory for chemical analysis to confirm or rule out the presence of such substances.	Before chemical analysis the substance or substances to be analysed must be identified. Older ceramic glaze and imported ceramics can contain lead.
Condition	Visual examination	Description of bathtub, including surface finish, frame and drain: as new or with varying degree of visible wear (cracks, scratches, worn surface finish, limescale, stains/discolouration, rust, etc.)

[1)] Some properties are only relevant in connection with certain applications. Relevant properties are determined during the design of the building.

[2)] New bathtubs shall be documented according to NS-EN 14516. The test methods specified in NS-EN 14516 can be used for retesting bathtubs before reuse if alternative methods have not been developed and verified.

WC suits

Example of a wall-mounted WC suit (P-trap) and a floor-mounted WC suit (S-trap) with cistern. Photo: SINTEF Community

General remarks

The expected service life of WC suits is 25 to 75 years. The WC pan and cistern (excepting internal components) are expected to have a longer expected service life than the WC float valve (inlet valve) and bottom valve (outlet valve). Typical causes of functional failure are wear of the toilet fill valve or bottom valve and cracks in the material caused by impact or manufacturing flaw.

Assessment for reuse

Assessment of WC suits for reuse must include consideration of the toilet pan, cistern, ball cock, bottom valve and attachment. Worn or damaged components can be replaced and other maintenance such as removal of lime residue and discolouration can be carried out. If necessary, minor damage to the surface finish of the WC pan can be repaired.

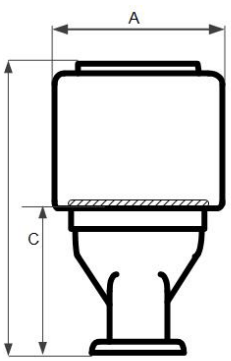
When reusing, it is important to know the dimensions of the WC suit (width, height, depth and seat height), the attachment method, the type of water trap and whether there is a separate cistern. The flush volume must also be specified. WC suits manufactured before about 2000 have significantly larger flush volume (6-9 litres) than modern WC suits (2-4 litres). This also entails that the shape of older water traps generally means greater water volumes are necessary for clean flushing. When using older WCs, greater water consumption must be weighed up against the benefits of reuse.

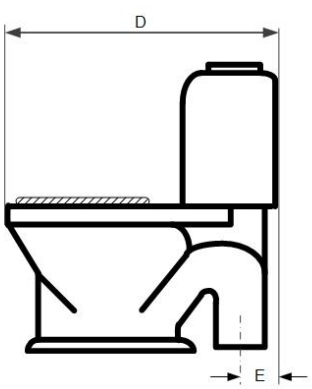
Materials, ageing and repair of damage

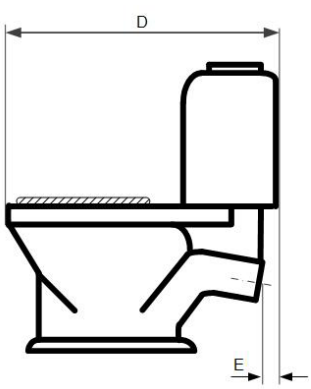
COMPONENT	MATERIAL	AGEING AND REPAIR OG DAMAGE
WC pan	WC pans are made of porcelain or stainless steel.	With time, cracks may appear in the glaze of porcelain. This can result in absorption of liquid and form a breeding ground for bacteria. A typical cause of water leaks is large cracks in the material caused by impact or manufacturing flaw. Cracked WCs should not be reused. Minor damage to the surface finish can be remedied using a suitable repair kit. Wear in ceramic glaze can be checked using a spirit-based felt pen: If the ink is easy to remove, the glaze is probably in good condition. Lime scale or discolouration can occur in used equipment but does not necessarily affect its function. Lime crust can be removed using dilute acid, such as household vinegar. Lime scale that blocks the flushing edge openings can affect the function of the WC.
Cistern	Cisterns are made of porcelain or stainless steel. Gaskets between WC pan and cisterns are made of rubber.	See ageing of WC pan. The gasket between the toilet bowl and the cistern may become brittle and lose its seal with time. A worn gasket can be replaced, assuming it is possible to find a new one that fits.
Toilet seat	Toilet seats are made of plastic, Bakelite or wood. Hinges are of plastic or metal.	Hinges can wear out with time. A worn toilet seat can be replaced, assuming it is possible to find a new one that fits.
Float valve (inlet valve)	Float valves are made of metal or plastic. Gaskets are made of rubber.	Gaskets can become brittle and lose their sealing ability. Lime scale can accumulate in the valve with time, impairing its function. A worn float valve can be replaced, assuming it is possible to find a new one that fits. Before about 1980, float arms with spherical floats were normal. Modern valves have a different design.
Bottom valve (outlet valve)	Bottom valves are made of metal or plastic. Gaskets are made of rubber.	Gaskets can become brittle and lose their sealing ability. Lime scale can accumulate in the valve with time, impairing its function. A worn bottom valve can be replaced, assuming it is possible to find a new one that fits.

Dimensions of WCs with base connection (S-trap) and side connection (P-trap). WCs with side connection angled at 45 degrees to the right or left (Q-trap) also exist, but are not shown here.

A – width
B – height
C – seat height
D – depth
E – distance from back to drain centre







Documentation of properties in connection with reuse

PROPERTY[1)]	DOCUMENTATION METHOD[2)]	COMMENTS
Year of manufacture	Information from initial purchase or building year	
Materials and construction	• Visual examination • Original documentation	• Material • Colour and type of surface treatment • Installation: wall mounted (bolts or frame), floor-mounted (bolts or adhesive) • Type of water trap (S, P or Q) • Double or single flush • Location of ball cock (inlet valve) • Format and location • Prepared for fitting of grab handle
Dimensions	Tape measure or similar	• Width, depth, height • Seat height • Drain muff diameter
Water seal height	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Flushing properties	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Water absorption	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Resistance to external load	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Function and reliability of float valve	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Flush volume	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Seal against leaking between cistern and bowl	• Original documentation • Retesting	Reuse without laboratory retesting requires verification by, for example, the manufacturer, that the property is unchanged.
Substances harmful to health and the environment	If the presence of substances that are hazardous to health and the environment is suspected: Send to laboratory for chemical analysis to confirm or rule out the presence of such substances. Chemical analysis: • Handheld XRF (lead)	Before chemical analysis the substance or substances to be analysed must be identified. Older ceramic glaze and imported ceramics can contain lead.
Condition	Visual examination	Description of toilet and any cistern, with ball cock and bottom valve: as new or with varying degree of visible wear (cracks, scratches, worn surface finish, lime scale, stains/discolouration, etc.) and function of valves

[1)] Some properties are only relevant in connection with certain applications. Relevant characteristics are determined during the design of the building.

[2)] New toilets shall be documented according to NS-EN 997. The test methods specified in NS-EN 997 can be used for retesting toilets before reuse, if alternative methods have not been developed and verified.

Further reading

Central standards

Standards for testing sanitary equipment:

- NS-EN 14688
  Sanitary appliances – Wash basins – Functional requirements and test methods
- NS-EN 14516
  Baths for domestic purposes
- NS-EN 997
  WC pans and WC suites with integral trap

See https://standard.no/

Specifications in the SINTEF Building Research Design Guides (*Byggforskserien*)

- 700.330 Levetider for sanitærinstallasjoner i boliger [700.330 Lifetimes of sanitary equipment in home]

See https://www.byggforsk.no/byggforskserien

Guidelines for reuse

FCRBE (Facilitating the Circulation of Reclaimed Building Elements in North-western Europe) has prepared guidelines for the reuse of sanitary equipment:

- 5.10 Toilet bowl
- 5.11 Wash basins
- 5.12 Suspended urinals

See https://www.nweurope.eu/projects/project-search/fcrbe-facilitating-the-circulation-of-reclaimed-building-elements-in-northwestern-europe/news/reuse-toolkit-material-sheets

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 ISBN: 978-82-536-1766-4 (pdf).
Principle design: Cathrines cmykeri. Production: SINTEF Academic Press. Photo and illustrations: SINTEF Community