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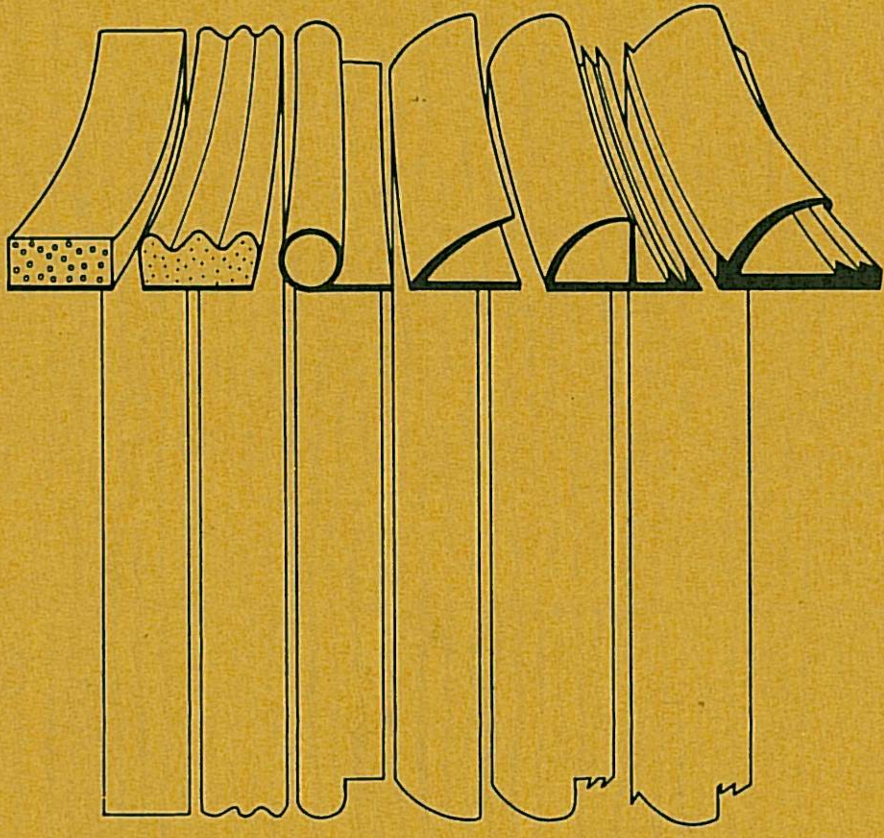
PROJECT REPORT 39

Norwegian Building Research Institute

Tore Gjelsvik,
Siri B. Berg and Tor Steinar Johansen



Building Gaskets

Oslo/Trondheim 1988

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by

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Preface

Building gaskets constitute an important part of the modern building technology. They are first of all used in windows and doors, in dry glazing systems and in joints in large panel buildings, but a number of other possibilites does exist.

The Trondheim Division of the Norwegian Building Research Institute started their activities on building gaskets in 1959. For many years, sealants, gaskets and jointing problems belonged to their main working areas. Problems dealt with have covered classification of sealants and gaskets and other types of jointing materials, test methods and test programmes, systems for selection of gaskets as well as design of joints.

A number of publications has been presented over the years. In the present report, the accumulated knowledge has for the first time been put together in one single publication. This is at the same time an up-graded version of the material, including new knowledge and recent experiences.

Tore Gjelsvik at the Trondheim Division has been responsible to the examination of a vast material and concentration into one single report. He has been assisted by Siri B. Berg and Tor Steinar Johansen.

The costs have partly been covered by the Royal Norwegian Council for Scientific and Industrial Research (NTNF).

Oslo/Trondheim, September 1988

Åge Hallquist

Åge Hallquist

Summary

Gaskets are important in present-day building technology. A wide range of products is available, with highly different properties and applications. Classification of the products is difficult, but a general classification of gaskets has been developed and used with good results.

Many properties of gaskets are interesting to know. As a result, testing is usually complicated and comprehensive. In the present report a high number of properties is discussed briefly and useful test methods given together with suggested evaluation of the results.

Correct use of gaskets is quite as important as good products. Joints have to be designed the right way, preferably with two-stage seals. Type of gasket has to be selected and correlated to the joint width; movements and tolerances or deviations taken into account. Correct joint shape and jointing details as well as proper workmanship are also important points.

Different types of gaskets have different possible applications. Suitable main application areas are given for the different types of gaskets according to the general classification. The interesting properties for each combination of type of gasket with main application area are judged. The results are summarized in four tables. These can form the basis of test programmes. Results from testing of 14 selected types of gaskets are also presented.

A reference list is given. Up-to-date English versions of the NBI test methods are included as the last chapter.

1 Gaskets in buildings

Sealing the joints is an important part of the modern building process. A wide range of materials is available for this purpose. Classification of all the different products is difficult, but a general classification system for jointing materials for building constructions does exist (1). This will be used as a basis here.

In the classification system, the jointing materials are divided into the following six main groups or sorts:

Main group 1	Caulks
Main group 2	Strips and beads
Main group 3	Sheet materials
Main group 4	Rigid fillers
Main group 5	Sealants
Main group 6	Gaskets

The main groups are further divided into a number of subgroups, and the latter again into a number of types. **Table 1** is showing the subdivision of main group 6, gaskets. It should be pointed out that the numbering in Table 1 does not imply any kind of quality gradation with regard to rising or falling number. Attempts have been made to put the groups and types in a logical order, but still the numbering is more or less arbitrary and mainly for identification purposes.

Building gaskets are always more or less resilient and are supplied preformed and ready to use. They base their sealing properties on an elastic deformation of the gasket material. To perform their intended function over time, gaskets must be kept under a certain pressure continuously, and must consequently also exercise a certain counterpressure.

A selection of typical building gaskets on the Norwegian market (1988) is shown in **Fig. 1.**

Gaskets can be used as air barrier or rain screen. It is also possible to design double gaskets which serve as air barrier as well as rain screen. In such cases, each part of the gasket performs one function. The alternative solution, one single and simple gasket with air and water barrier combined at the same point, has been tried, but has always turned out to be dubious in the long run.

The most important field of use for gaskets in buildings is for the time being as air barrier between sash and frame in windows and doors (I). Other important areas are as air barrier in joints in large panel wall systems (II), as mounting strips in glazing (III) and as rain screen in joints with a two-stage seal (IV). More details will be found in the available literature (2) (3) (4).

Table 1
Sub-division of main group 6, gaskets

61	Metal gaskets	611 612	Metallic strips Metallic strips combined with fibre or sponge material
62	Fibrous gaskets	621 622 623	Gaskets of woven organic material, sometimes combined with a core of open-cell sponge etc. Gaskets of impregnated wool felt Gaskets of pile of wool, nylon etc.
63	Gaskets of open-cell sponge	631 632 633	Gaskets of open-cell sponge, without glue or with glue on one side only Gaskets of open-cell sponge, glue on two opposite surfaces Gaskets of open-cell sponge, impregnated with asphalt etc.
64	Gaskets of closed-cell sponge	641 642	Gaskets of closed-cell sponge, without glue or with glue on one side only Gaskets of closed-cell sponge, glue on two opposite surfaces
65	Resiliant gaskets of solid rubber, plastics etc.	651 652	Compression gaskets of various cross-sections (tubes etc.) Sliding gaskets of various cross-sections

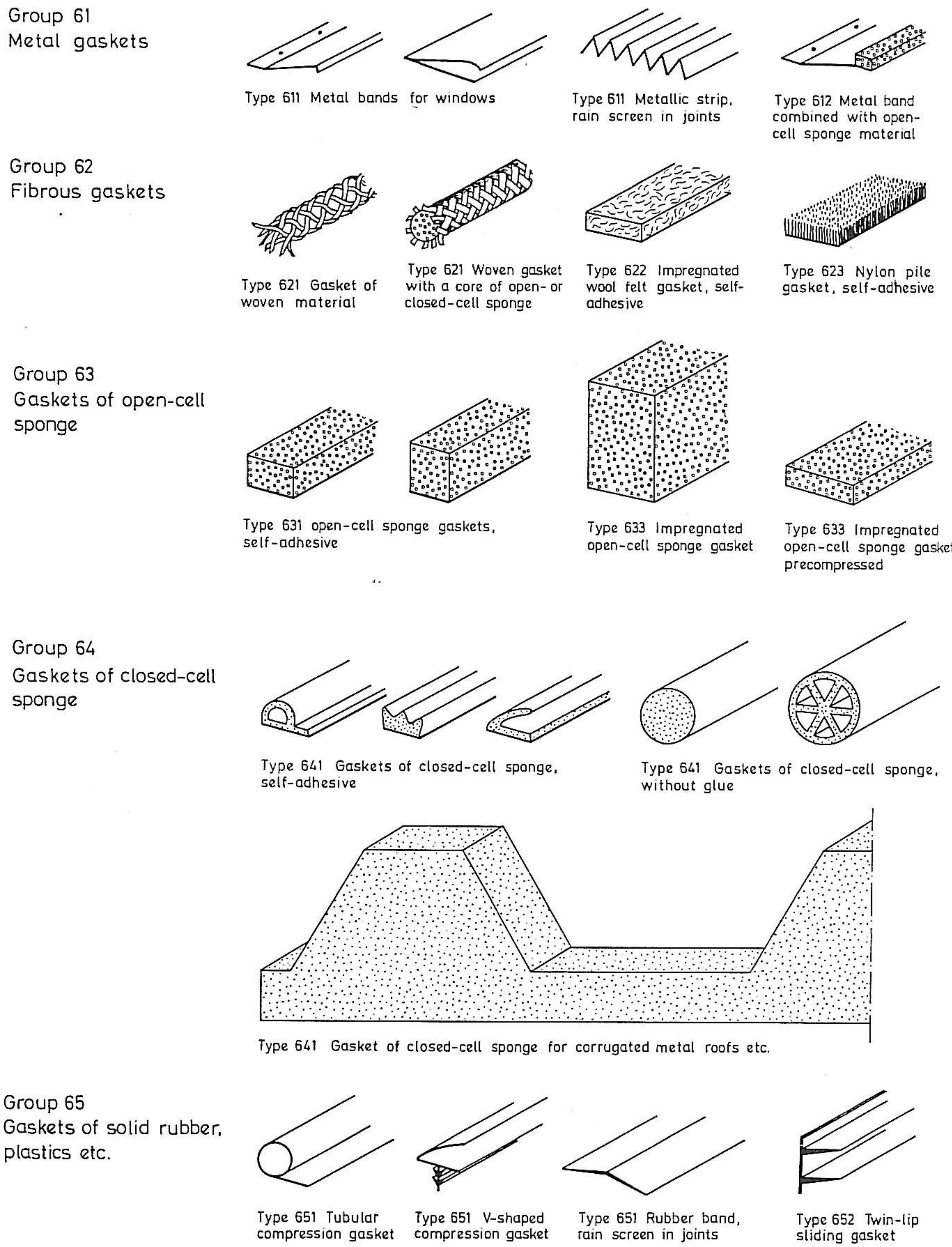

Fig.1. Examples on typical building gaskets

2 Testing of properties and evaluation of results

The primary function of a building gasket is to seal. It must seal well, and it must do so for a sufficiently long time. To be able to fulfill the primary functional requirements, it is also necessary that the gasket fulfills a number of secondary requirements derived from the primary. Due to the large selection of shapes and materials available, every single gasket has to be considered separately and the test methods adjusted to the type of gasket in question. In the following, the individual properties are described and discussed as far as possible. The succession is following the CIB master list (5). The information given has partly been taken from available literature (4), (6), (7), (8), (9), (10), (11), but is partly also a result of new developments and more recent experiences.

2.01 Shape (CIB 3.2)

A building gasket is always supplied as a factory-made product with a certain shape and size. The cross-section is of vital importance for the gaskets ability to perform well. The shape and dimensions must consequently be closely controlled. There are, however, different repuirements to accuracy control at the manufacturer and the user. The manufacturer must control the shape very closely, and needs advanced equipment to do so. The user only need to check that he has got the right product. Normally this can be done with a slide rule or a micrometer.

The size and shape are given by the manufacturer as a drawing of the appropriate product, with the important dimensions set out with tolerances. This presentation should be compulsory.

2.02 Volume (CIB 3.2)

Gaskets are in general lightweight products. For this reason, the size of the packages can sometimes be very great, in spite of low weight. Information about the volume is in such cases interesting in connection with transport, storing and handling of the products. It is up to the manufacturer to give appropriate information.

2.03 Weight (CIB 3.3)

The density of the gasket material is usually not an interesting property, but the mass or weight per running meter can be useful to know in certain cases. Gaskets are normally lightweight products, but gaskets for large panel wall systems can sometimes be so heavy that the weight will make them difficult to handle. For products like this, the weight per meter gasket should be declared.

Testing is done by weighing a measured length of gasket. The result is given as weight per running meter.

2.04 Colour (CIB 3.4)

Gaskets are often made in different colours, e.g. black, white, grey and brown. The colour may influence the quality of the product. Appropriate information on available colours and possible differences should be given by the manufacturer.

2.05 Smell, toxicity (CIB 3.4)

Building gaskets are supplied as vulcanized and cured products ready for use. In spite of this, they may give off certain smells when kept or used indoors. People working in ware-houses where large quantities of gaskets are stored, may feel a varying degree of discomfort due to smells given off by the gaskets. For gaskets used in buildings, the smell tends to disappear after a while, especially by adequate ventilation. In general, building gaskets do not seem to result in any serious smell or toxic problems.

2.06 Deformation resistance (CIB 4.02)

Building gaskets have, as previously mentioned , a certain size and shape in the unloaded initial state. They base their sealing function on an elastic deformation. For this reason, they must be able to be compressed or deformed with reasonably heavy loads. This requirement is valid for the first loading as well as possible later unloadings and reloadings, for instance by opening and closing of

Fig.2. Equipment for testing of deformation resistance

windows. The resistance to deformation is measured at normal temperature 296 K (+23 °C) as well as at least one lower temperature, e.g. 278 K (+5 °C).

Testing of deformation resistance is carried out according to test method NBI-71, 1988. This is a revised edition of the Nordic test method NT Build 108 (1979), using new and more advanced test equipment, **Fig. 2.** The testing should cover the deformation range where the gasket is expected to fulfill its functions. Gaskets with a deformation stop should be tested until the stop is reached. The results are presented in a diagram showing the deformation as a function of the deformation force. An example of this type of diagram is shown in **Fig. 3.**

The diagram can be used in two different ways. One way is to read the force needed to deform the gasket to a point in the center of what is expected to be its normal functional range. This is done in order to obtain a first general impression of how easily deformed the gasket is. The second way is to take out the deformation obtained at the maximum acceptable deformation load. This gives the lower limit in the functional range of the gasket. The upper limit is found from the air penetration, as indicated in point 2.12.

The evaluation of the results will partly be depending on the actual use of the gasket, as given in **Table 2.**

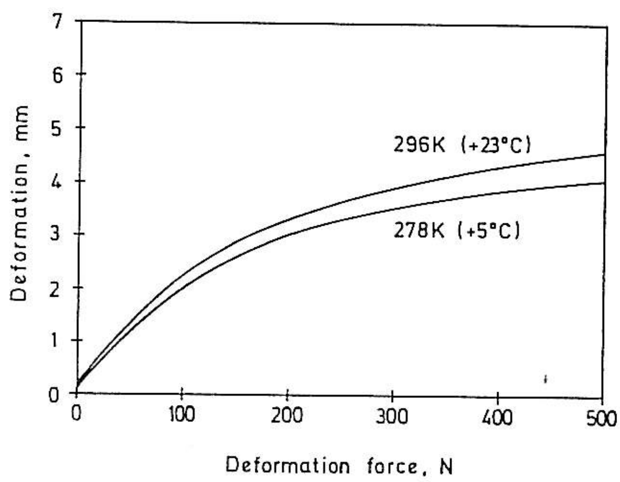

Fig.3. Deformation versus deformation force at 278 K (+5 °C) and 293 K (+23 °C)

The deformation resistance of a building gasket is given as the deformation force in N/m neccessary to obtain the normal degree of deformation (usually 25%). The complete deformation versus deformation force diagram is given to make it possible to take out the lower limit in the functional range of the gasket.

Table 2
Evaluation of deformation resistance

Field of use		Deformation force in N/m at normal degree of deformation 1)	Quality level
I	Air barrier in windows and doors	≤ 65 2)	Excellent
		> 65 - ≤ 100	Good
		> 100 - ≤ 200	Acceptable
II	Air barrier in joints in large panel wall systems	≤ 200	Excellent
		> 200 - ≤ 300	Good
		> 300 - ≤ 400 3)	Acceptable
III	Mounting strip for glazing	≤ 100	Excellent
		> 100 - ≤ 250	Good
		> 250 - ≤ 400	Acceptable
IV	Rain screen in joints with a two-stage seal	≤ 100	Excellent
		> 100 - ≤ 250	Good
		> 250 - ≤ 400 3)	Acceptable

Comments to Table 2:

1) The normal degree of deformation is usually 25% of the unloaded height of the gasket. Manufacturers of products with a completely different deformation characteristic have to give appropriate information.

2) Building gaskets with a deformability better than or equal to 65 N/m at 25% deformation are very easy to deforme. Windows and doors with gaskets like this can usually be opened and closed easily by handicapped persons. The improved deformability is, however, often obtained at the sacrifice of air tightness. A proper balance of the deformability and the air tightness has thus to be done.

3) With special mounting tools, deformation forces higher than 400 N/m may be acceptable.

2.07 Closing force for windows and doors (CIB 4.02)

The force required to close a door can be found by testing according to Norwegian Standard NS 3153 (12). There are certain relations between the closing force as measured according to this test method and the resistance to deformation according to test method NBI-71, 1988. For this reason, it is usually sufficient to measure the latter. In special cases, the real force needed to close a door can be measured according to the first-mentioned method. The same procedure can also be used for windows, but the test method has to be modified and adapted to the type of window.

The recommended maximum closing force is 20 N.

2.08 Stretch resistance (CIB 4.02)

Building gaskets are frequently stretched when they are installed, contrary to the mounting instructions. Later on, the gaskets tend to go back to their original shape again. The result will be openings in all the joints, unless the gaskets are fixed in the ends of the individual lengths with tacks, staples or similar. An alternative is to cut the gaskets with an overlength, and install them with a certain degree of compression.

Self-adhesive gaskets are usually not fixed by any other means than their own glue. Gaskets like this have to be reinforced to avoid unacceptable stretching during the mounting sequence. The reinforcement can be in the gasket itself or in the backing material with the glue.

Testing of stretch resistance is carried out according to test method NBI-158, 1988. The testing implies that a piece of gasket is stretched and the elongation measured at different force levels up to a maximum force of 40 N.

The evaluation of the results is given in **Table 3**.

Stretch resistance is given as percentage stretch at 20 N as well as 40 N stretching force.

2.09 Tear resistance (CIB 4.02)

Some types of gasket materials are more sensible to tear propagation than others. Critical situations may occur with gaskets stapled to wooden substrates.

Testing of tear resistance is carried out according to test method NBI-159, 1988. The gasket is fixed to a wooden substrate by means of staples or similar according to the instructions given by the manufacturer, and the tear strength found by pulling the gasket.

A tear resistance ≥ 20 N is usually considered as acceptable.

Tear resistance is given as the breaking load during the tearing test.

2.10 Hardness (CIB 4.02)

For elastic materials, there is a certain relationship between modulus of elasticity and hardness. For practical reasons, the hardness is frequently measured and stated instead of modulus.

Hardness measurements are usually carried out by the gasket manufacturer on test pieces specially made for this purpose. Similar measurements are only exceptionally taken on a finished gasket or on pieces cut from a gasket. The measurements are made with a hardness meter according to NT BUILD 005, corresponding to ASTM D 2240 Shore Durometer type A2. The instantaneous hardness value as well as the 15 seconds value is given. The hardness can be measured before and after aging.

Hardness can also be measured as ^{o}IRH (International rubber hardness degrees) according to ISO Standards. The hardness measured as ^{o}IRH does in general correspond very well with the hardness measured as ^{o}Shore A.

The hardness measured on gasket materials is usually in the range 20 to 80 ^{o}Shore A. Gasket manufacturers are taking hardness measurements regularly on their gasket materials. A quality grading based on measured hardness is, however, not possible, as the gasket quality is also a function of the shape (cross section) of the gasket.

It is up to the gasket manufacturer to state the hardness of his gasket materials.

2.11 Abrasion resistance (CIB 4.02)

Only sliding gaskets have had real abrasion problems. Useful test equipment and test method to study the problem do exist (7). Sliding gaskets are, however, no longer widely used, and testing of

Table 3
Evaluation of stretch resistance

Field of use		Elongation at 20 N	Elongation at 40 N	Quality level
I	Air barrier in windows and doors	≤ 0,2 %	≤ 0,4 %	Excellent
		> 0,2 - ≤ 0,3%	> 0,4 - ≤ 0,6%	Good
III	Mounting strip for glazing	> 0,3 - ≤ 0,5%	> 0,6 - ≤ 1,0%	Acceptable

this property is not so interesting any more. Abrasion of sliding gaskets may also be kept under close control by suitable joint design. Information on possible abrasion of such gaskets and suitable means for avoiding this, is for the time being considered to be the responsibility of the gasket manufacturer.

2.12 Compression set (CIB 4.02)

Most of the available types of building gaskets are made from materials with mainly elastic properties and only a smaller degree of plasticity. When gaskets like this are kept compressed and deformed for a longer period of time, they will get a certain degree of plastic deformation, i.e. compression set. Since the building gaskets base their ability to seal on an elastic deformation and a sustained counter-pressure against the joint surfaces, they need to have a high degree of elasticity. If the plasticity is too high, the compression set may be so high that the gaskets can hardly follow the joint movements. In extreme cases, the gaskets may even fall out of the joints.

Testing of compression set is carried out according to test method NBI-72, 1988. This is a revised edition of the Nordtest method NT BUILD 109 (1979), using new and improved test equipment, **Fig. 4.** The testing is done by keeping the test specimens compressed for a certain time at specified temperature. The samples are then unloaded and kept at a given relaxation temperature. The compression set is calculated from the dimensional measurements before, during and after the compression. Usually compression set is measured one hour after unloading, but other relaxation times may be used, e.g. 24 hours.

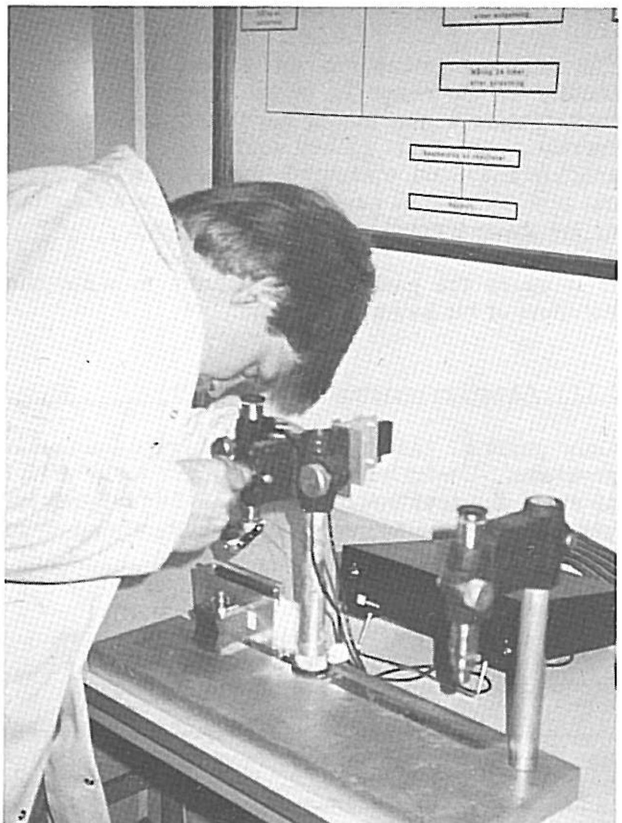

Fig.4. Optical/electrical equipment for measuring gasket heights

The results are given as per cent compression set. The following **Table 4** is valid for all types of gaskets and fields of use.

Table 4
Evaluation of compression set

Compression set, %, read after a relaxation time of one hour at 296 K (+23 °C)

Compressed 24 h at 343 K (+70 °C)	Compressed 168 h at 296 K (+23 °C)	Quality level
0 - ≤ 30	0 - ≤ 15	Excellent
> 30 - ≤ 45	> 15 - ≤ 30	Good
> 45 - ≤ 60	> 30 - ≤ 45	Acceptable

Results from tests at other compression and relaxation temperatures and times are for the time being difficult to evaluate.

Compression set is given in per cent as a whole number, and is always related to the temperatures and periods used.

2.13 Shrinkage, creep (CIB 4.02)

Building gaskets may be stretched when they are mounted. In cases like this, the gaskets will later on have a tendency to go back to their original size. This contraction may lead to openings in all the joints, unless the gaskets are secured by tacks, staples or similar fastening devices at the ends of the individual lengths. Even when the gaskets are not stretched during mounting, there may be internal stresses derived for instance from the extrusion processes. Internal stresses like that may be released over time and result in shrinkage or creep. Finally the gasket material itself may shrink due to aging processes. The final result is a contraction of the gaskets due to shrinkage and creep. This contraction is most conveniently studied during the testing of resistance to accelerated weathering, see point 2.26.

2.14 Fatigue (CIB 4.02)

Gaskets should be able to perform their functions for a specified period of time. In normal use, the gaskets are subjected to a varying degree of deformation due to changes in temperature, humidity etc. To be able to fulfill their intended functions, the gaskets must be able to take these deformations without loosing their elastic properties. Compression set and other possible changes must not reach an unacceptably high level.

A cyclic movement test for gaskets has been felt

Table 5
Evaluation of results from combustibility tests

General result	Burnt part mm	Burning time s	Burning speed mm/s	Quality level
Non-combustible				Excellent
Self-extinguishing	< 25	< 10		Good
Self-extinguishing	≥ 25	≥ 10		Acceptable
Combustible			≤ 1,0	Acceptable

desirable, but so far nobody has produced a suitable test method. The immediate need for testing seems for the time being to be covered by the testing of compression set, se point 2.12.

2.15 Combustibility (CIB 4.03)

All known types of building gaskets are combustible, with the exception of metallic strips, type 611 (Table 1). The degree of combustibility will depend upon the material composition. This property is interesting at least for fire doors and similar, but information is also of general interest. Testing has to be carried out to find out whether a gasket may be classified as non-combustible, self-extinguishing or combustible. In most cases even burnt part, burning time or burning speed has to be measured and recorded. Test methods are also available for checking other fire properties as smoke release and development of toxic or corrosive gases, but these properties are usually of minor interest in this connection.

Fire testing of building gaskets is carried out according to test method NBI-73, 1988. This is a revised edition of the Nordic test method NT BUILD 105 (1979). The results are evaluated as given in **Table 5**. This table is valid for all types of building gaskets and all fields of application.

The results are first of all given by the general terms "non-combustible", "self-extinguishing" or "combustible". For self-exstinguishing gaskets, the burnt part and burning time are also given, for combustible gaskets the burning speed.

2.16 Air penetration (CIB 4.04)

To make a joint with a building gasket sufficiently tight against air and gas penetration, the following points have to be taken into consideration:

- that the gasket itself is sufficiently homogeneous and air tight when it is compressed to a point in its functional range
- that the gasket has good elasticity and is acting on the joint surfaces with a counterpressure of the right order
- that the joint surfaces are sufficiently smooth to avoid leaky spots between the gasket and the surfaces
- that the special grooves used for mounting some types of gaskets are given the right shape to avoid leaks through the grooves
- that all gaskets joints, especially in the corner connections and crossings, are made in the right way.

In general, the joints sealed with building gaskets are sufficiently air tight for use in domestic buildings. Under more extreme conditions, for instance in gas producing industries, the situation may be completely different. In war time, poisonous gases might be used. From a tightness point of view, air-raid shelters are particularly important. For air-raid shelters, it is recommended to use building sealants instead of gaskets whenever possible.

Testing of air penetration of building gaskets is carried out according to test method NBI-74, 1988. This is a revised edition of the Nordic test method NT BUILD 110 (1979), using new and improved test equipment, **Fig. 5.** The gaskets are squeezed between two plane surfaces, with the corner joints made as prescribed by the manufacturer/supplier. The air penetration is measured at different degrees of deformation and at a number of different superpressures. Spot leaks are localized, for instance with a smoke gun. The air penetration is also measured with the corner joints sealed with putty or similar material. In this way, the corner

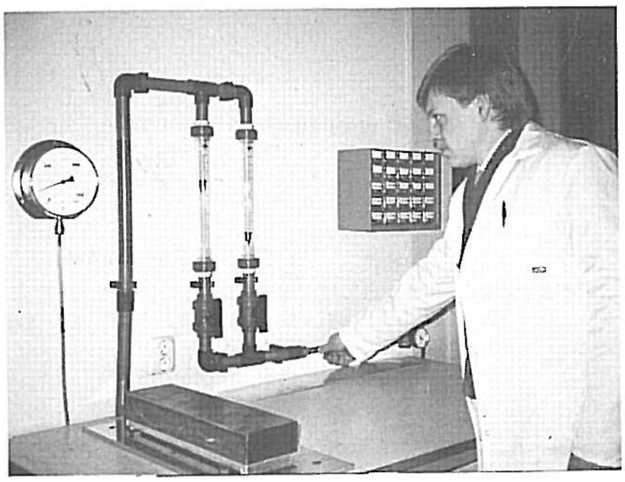

Fig.5. Equipment for measuring air penetration

Table 6
Evaluation of air penetration

	Field of use	Air penetration m³/mh at à superpressure of 700 Pa	Quality level
I	Air barrier in windows and doors	$\leq 0,5$	Excellent
.II	Air barrier in joints in large panel wall systems	$> 0,5 - \leq 1,0$	Good
III	Mounting strip for glazing	$> 1,0 - \leq 2,0$	Acceptable
IV	Rain screen in joints with a two-stage seal	No requirements	

leaks are separated from the leaks through the gasket itself.

The evaluation of the test results will depend upon the intended function or field of use of the gasket. The grading in **Table 6** is for gaskets compressed to a point in their normal functional range. The figures are taken as average for four meters of gasket and four corners. Consentrated leaks at certain leak points are not accepted.

The air penetration can be presented as a diagram showing the leakage rate in m^3/mh as a function of the superpressure. The diagram will then have a number of curves, one for each deformation or compression grade of the gasket. More convenient is to show the air leakage rate in m^3/mh at 700 Pa as a function of the deformation. A typical diagram of this type is shown in **Fig. 6.** In this case, curves for tests with normal corner joints as well as sealed corners can be shown together and easily compared. The diagram can also be provided

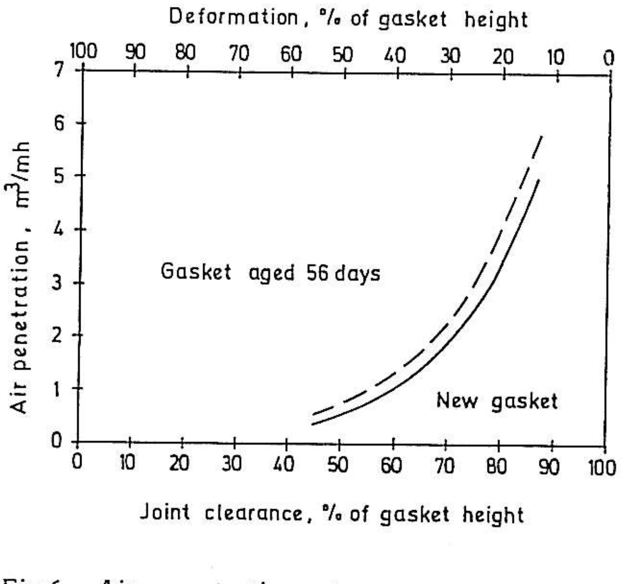

Fig.6. Air penetration at a super-pressure of 700 Pa as a function of the deformation, before and after 56 days of accelerated aging

with results from tests on gaskets subjected to accelerated weathering, see point 2.26.

In addition to the diagram, information has to be given about possible spot leaks or other special observations.

The upper limit in the functional range of a gasket is found from diagrams of the type shown in Fig. 6, where the results from the accelerated weathering tests are taken into consideration.

2.17 Water vapour penetration (CIB 4.04)

Building gaskets are rarely used as a separate seal against water vapour penetration. Some types of gaskets have a very low diffusion resistance, as fibrous gaskets group 62 and open-cell sponge gaskets group 63. Other types of gaskets are basically diffusion tight, such as the gaskets of solid rubber or plastics group 65. Due to difficulties with uneven substrates as well as corner joints and other gasket connections, it is, however, very difficult to achieve a proper diffusion seal, even with the best gaskets.

Water vapour penetration tests can be carried out on test pieces prepared with gasket and joint shape as specified. Test method DIN 53122 or similar. The testing has to be adapted to the gasket and the results evaluated accordingly.

2.18 Ozone resistance (CIB 4.04)

Many types of rubber are seriously influenced by ozone. This gas will attack the double bonds in the main chain of the material. The result will be a harder body with surface cracks. These ozone cracks may later on propagate through the material.

Testing of the influence of ozone on building gaskets can be incorporated in more complex aging cycles. It is more convenient, however, to test the ozone resistance separately on test pieces specially prepared from pressed sheets of the rubber material in question. Standardized test methods and equipment, **Fig. 7**, can then be used (13).

Fig.7. Ozone resistance test equipment

The ozone resistance of solid rubber materials is tested according to SIS 16 22 10, corresponding to ISO 1431-1972. The testing is carried out with special test pieces stamped out of a sheet of the rubber material to be tested. The test pieces are mounted with varying degree of extention, from 7% to 80%, and exposed to air containing ozone.

Normal consentrations are 50 pphm and 200 pphm. The time that will elapse untill the first cracks are observed, is recorded. Through a regression analysis, the extension resulting in ozone cracking after 96 hours, is calculated.

This test method can not be used for closed-cell sponge materials. Gaskets made of such materials can be ozone tested according to modified test methods, for instance SS 24 37 05, but the basis for evaluating the test results is, for the time being, insufficient. The same applies to results of modified tests carried out with gaskets of solid rubber.

The evaluation of results from ozone testing is difficult. Table 7 is showing a proposed grading of solid rubber materials for resilient gaskets, group 65.

The ozone resistance of a solid rubber material for resilient gaskets is given as a whole number indicating the percentage extension when ozone cracking will occur after 96 hours at a specified ozone concentration.

Table 7
Evaluation of ozone resistance

Elongation resulting in ozone cracks after 96 hours, %		Quality level
Ozone 50 pphm	Ozone 200 pphm	
> 80	> 40	Excellent
> 56 - ≤ 80	> 28 - ≤ 40	Good
> 40 - ≤ 56	≥ 10 - ≤ 28	Acceptable

2.19 Water absorption (CIB 4.04)

Building gaskets are partly used in positions where they are subjected to driving rain. It it then important that the gaskets do not absorb so much water that they get unacceptable properties a.s.o. Water absorption can also come from condensation.

Testing of water absorption is carried out according to test method NBI-102, 1988. This is a revised edition of the Nordic test method NT BUILD 106 (1979). Samples of the gaskets are submerged in water, and the influence studied by weighing, measurements of dimensions as well as visual observations.

A proper evaluation of the results from water absorption tests has so far proved to be difficult, due to the limited experience available. Information on water absorption is consequently given for information only. For gaskets of closed-cell sponge material, this information is compulsory.

2.20 Rain penetration (CIB 4.04)

Gaskets used as rain barriers in joints with a two-stage seal, have to stop water from entering the joints in unacceptable amounts. The performance of the gasket is for rain barriers not only dependent on the gasket ifself, but also on a number of details in the design of the joint where the gasket is used. Testing is then only possible when a fully detailed joint design is available. In some cases, however, the driving rain test can be conveniently substituted by a water penetration test under static pressure.

Rain penetration is studied according to test method NBI-103, 1988. This is a revised edition of the Nordic test method NT BUILD 107 (1979). During the driving rain test, visual observations are made on the possible penetration of water. It is also important to note the point of time for the observations, the stresses used, and how far into the test assembly the water has penetrated. Testing is interesting for gaskets used as mounting strips for glazing (field of use No. III) and as rain screen in two-stage joints (field No. IV).

The evaluation of a driving rain test is usually leading to the result "passed" or "not passed".

The results of a rain penetration test shall clearly specify whether the testing was passed or not.

Special experiences recorded during the test shall also be given.

2.21 Water penetration under static pressure (CIB 4.04)

Requirements to tighthess against liquids under pressure have to be put for joints in water retaining structures, in building substructures and in traffic areas as runways, roads, bridges etc. In general, building sealants are recommended for such applications. Gaskets are, however, used from time to time, in spite of the difficulties involved in making joints sufficiently tight.

No well established and standardized test method is available for studying the water penetration in joints sealed with gaskets in such structures. A NBI-method has been used occasionally on a tentative basis. The experiences with this test method are promising, and will form the basis for a coming new test method.

2.22 Resistance to solvents, salt spray, cleaning agents and other chemicals (CIB 4.04)

Joints with gaskets are frequently subjected to contact with various types of chemical agents. Alcalies can for instance be leached out of concrete, and may combined with humidity or free and running water, influence the performance of the gaskets in the joints. In some cases, as in windows, the gaskets can get in contact with solvents, cleaning agents, salt water etc.

Test method NBI-75, 1988, can be used to check the resistance of gaskets to solvents, salt water, cleaning agents etc. which they may get in touch with periodically for shorter periods of time. This test method is a revised edition of the Nordic test method NT BUILD 111 (1979). The testing is carried out by dipping short pieces of the gaskets for a short time in the liquids used. This procedure is repeated a number of times. The samples are checked visually, and weight and dimensions recorded as far as possible.

The basis for the evaluation of the results is given in **Table 8**. This table is valid for all types of building gaskets and all fields of application.

Resistance to solvents, salt spray, cleaning agents and other chemicals is given by the figures for the measurable changes as well as a description of the visible observations.

Table 8
Evaluation of resistance to solvents etc.

Measurable changes	Visible changes	Quality level
0 - ≤ 2 %	No significant	Excellent
> 2 - ≤ 5 %	No significant	Good
> 5 - ≤ 10 %	Minor	Acceptable

2.23 Contact and migration stain (CIB 4.04)

Building gaskets have to serve in combination with a number of other building materials, without suffering from any detrimental reactions. Compatibility is a general problem, but for gaskets it is most pronounced for products in contact with painted or varnished surfaces, plastics and similar. In cases like that, migration of chemical constituents may occur and result in discolouration, exudation and sticky surfaces. The present standards distinguish between two types of discolouration. Contact stain is defined as a staining of the contact area when a gasket is pressed against a painted surface at an elevated temperature. Migration stain is similarly defined as a possible staining outside the contact area, in some cases visible only after ultraviolet radiation. Both types of staining are in many cases unwanted, for instance in openable windows.

Testing for contact and migration stain is carried out according to test method NBI-104, 1988. This is a revised edition of the Nordic test method NT BUILD 112 (1979). The method is based on ISO 3865-1977, method A (14). The testing is giving information about possible staining as well as other possible unwanted reactions.

Testing is done with typical and representative types of paints and varnishes. Usually a semi-glossy white alkyd paint and a glossy white polyurethane paint are used.

The results are given by figures according to the scale presented in ISO 3865-1977:

0 No discolouration
1 Faint discolouration
2 Moderate discolouration
3 Heavy discolouration

The evaluation of figures given according to this scale is as shown in **Table 9**.

Staining of painted and varnished surfaces is given by figures according to the scale used in ISO 3865. If necessary, a closer description of the discolouration and other possible observations is also given.

2.24 Influence of high and low temperatures (CIB 4.06)

The majority of building gaskets will get harder and stiffer at low temperatures and softer and more flexible at high temperatures. The only practical exception is metal bands, type 611.

At low temperatures, the gaskets are more difficult to compress or deform than at higher temperatures. This is specially true for some types of gaskets made of plastics. The gaskets will also loose a part of their elasticity as well as a part of their ability to follow changes in joint size easily.

At high temperatures, the gaskets are easier to compress. On the other hand, the possibilites for permanent deformation and compression set are considerably increased. In some cases the gaskets might as well get sticky, shrink, crack a.s.o.

Most types of gaskets are not damaged by freezing. Exceptions are gaskets with an open porous structure, as fibrous gaskets group 62 and open-cell sponge group 63. These types may be partly broken if they are freezing in wet condition. Substantial forces are needed to open windows with frozen wet gaskets (10). Such windows are preferably not opened.

The need for testing of building gaskets at high and low temperatures is in general well covered by testing of compression set and resistance to accelerated weathering, see the points 2.12 and 2.26. A simple low temperature flexibility test has, however, been found to be a useful supplement. This test consists of a simple flexing by hand at 253 K (-20 °C), as described in test method NBI-160, 1988. The results are given as passed/not passed.

2.25 Sound penetration (CIB 4.08)

The primary and always decisive requirement to all types of insulation against air-borne sound is that all parts of the structure has a sufficiently low air penetration. Possible investigation of the sound insulating properties of a building gasket is in general well covered by air penetration studies according to point 2.16.

2.26 Durability (CIB 4.10)

Structures where gaskets are used, should, if possible, be detailed to permit the gaskets to be replaced. Gaskets are usually expected to last for many years, and it is not considered acceptable that they have to be replaced with short intervals. The aging resistance or weather resistance of the gaskets is consequently an important property. This is specially due for gaskets used outdoors, for instance in large panel wall systems and for glazing. The gaskets have to retain their sealing properties, especially with regard to resistance to air penetration. They must not get unacceptable changes as great shrinkage, compression set, cracking, sweating, stickiness etc.

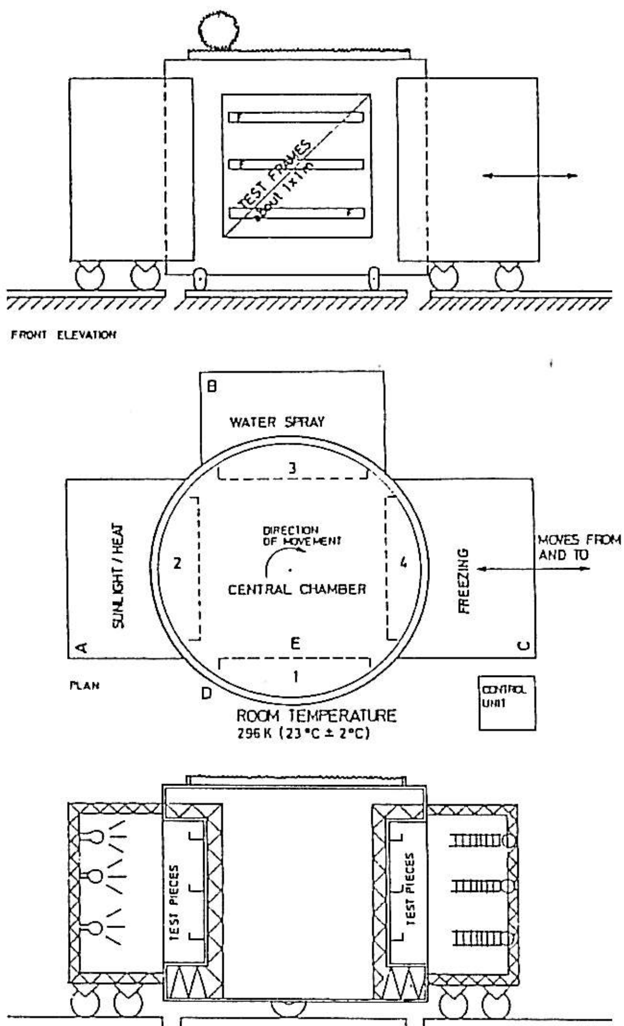

Fig.8. Apparatus for accelerated weathering of building materials and components

It is very difficult to compose a realistic aging or weathering cycle. Building materials are under practical conditions subjected to highly varying stresses. There are differences between gaskets used outdoors and those used indoors or hidden in the structures. Outdoor exposure will also differ from one place to another, from year to year, with

Table 9
Evaluation of contact and migration stain

Field of use	Contact stain	Migration stain	Quality level
I Air barrier in windows and doors	0	0	Excellent
	1	1	Good
	2	2	Acceptable
II Air barrier in joints in large panel wall systems	0 - 2	0 - 2	Excellent
	3	3	Good
III Mounting strip for glazing	0 - 1	0	Excellent
IV Rain screen in joints with a two-stage seal	2	1	Good
	3	2	Acceptable

Table 10
Evaluation of weather resistance

	Field of use	Air penetration m^3/mh at a superpressure of 700 Pa	Visible and measurable changes	Quality level
. I	Air barrier in windows and doors	≤ 1,0	No significant	Excellent
II	Air barrier in joints in large panel wall systems	> 1,0 - ≤ 2,0	Small	Good
III	Mounting strip for glazing	> 2,0 - ≤ 4,0	Small to moderate	Acceptable
IV	Rain screen in joints with a two-stage seal	No requirements	No significant Small Small to moderate	Excellent Good Acceptable

the orientation, degree of exposure etc. Accelerated weathering can then only give an indication about the expected average natural weathering within a certain area over a long period of time.

The Trondheim Division of the Norwegian Building Research Institute has developed a special apparatus for accelerated weathering of building materials and components (15) (16), **Fig. 8.** This has been used for 20 years with good results in general. In this apparatus, the samples are subjected to a test cycle consisting of radiation from sun lamps at simultaneous heating to an elevated temperature, followed by wetting with a water spray, cooling and freezing, and subsequent thawing at room temperature. The cycle is repeated every four hours. Other types of accelerated aging equipment also exist. A useful alternative to accelerated aging has so far not been presented.

Testing of the aging resistance or weather resistance of building gaskets is carried out according to test method NBI-76, 1988, in test equipment as described in NBI-83, 1983 (17) and NBI-83, 1988. The test pieces used are partly the same as those used for air penetration studies, see point 2.16, partly new ones. The air penetration is measured before and after aging, the test pieces are inspected visually, and weight and dimensions are measured as far as possible. The testing time is 112 days for gaskets exposed to the outdoor climate in practical use and 56 days for gaskets used in more sheltered locations. This testing is expected to correspond to about 5 years of natural exposure. The upper limit in the functional range of a gasket is taken from a diagram of the same type as in **Fig. 3,** when the air penetration after aging is taken into consideration.

The results are evaluated as given in **Table 10.**

Durability is given as the results of the aging tests, i.e. visible and measureable changes as well as air penetration before and after aging. The exposure time is also given.

2.27 Paintability (CIB 4.10)

Experiences collected over many years indicate that building gaskets should not be overpainted. These experiences have also been confirmed by laboratory tests (10). Sometimes the paint or varnish is not drying properly, but remains sticky, and the gasket material itself may also be damaged. In other cases, the paint will dry out, but can be discoloured, crack, flake off etc. The possible unfavourable reactions are innumerable.

Information about the paintability of building gaskets is interesting, in spite of the fact that overpainting is not recommended, as overpainting might occur by a mistake. It is also possible that new types of gaskets may be developed, with better paintability than the present types.

Table 11
Evaluation of results from paintability testing

Figure	Visual judgement	Quality level
0	No really unfavourable reactions, but possibly undesirable secondary reactions as flaking of the paint without damage to the gasket	Acceptable
1	Undesirable reactions as for instance retarded paint drying	Acceptable in certain cases
2	Unfavourable reactions as paint remaining sticky and possibly discoloured	Not acceptable
3	Very unfavourable reactions as paint remaining very sticky and discoloured	Not acceptable

Testing of paintability is carried out according to test method NBI-161, 1988. Short pieces of the gasket to be tested are given one and two coats of five selected types of paint and varnish, and inspected visually for possible changes.

Table 11 is showing the evaluation of the results. This table is valid for all types of gaskets.

Information on paintability is given by a figure 0 - 3 for each type of paint or varnish tested.

2.28 Serviceability (CIB 4.10)

Gaskets are available in a number of different types and qualities. Most of them have an expected service life much shorter than the building as such. For this reason, it is desirable to have possibilities to change the gaskets. In openable windows and doors, this is usually an easy job. Difficulties may, however, occur with gaskets mounted in grooves. In other types of building constructions, change of gaskets may be difficult or even impossible.

The prevailing possibilities of changing the gaskets should be taken into account when gaskets are chosen for a given purpose. The results obtained in the durability testing, see point 2.26, may form an important part of the base for making this decision.

3 Joint design

One of the most important aspects of joint sealing is to size the joints correctly and to select a suitable jointing material. The joint width must not be less than a certain minimum width and not more than a certain maximum width. Otherwise the material will not function properly. This is also true for building gaskets. It is important to know in detail all factors that influence the joint width, especially the joint movements as well as deviations and tolerances. The latter is something which is frequently overlooked. Many designers seem to forget that things in practice will not look exactly as they have shown on their drawings. It is not possible to produce the individual parts without certain deviations in dimensions, angles, edges, planes etc. The assembly of the individual parts is also subject to certain deviations.

Matters like these are ususally very important when building with panels and other types of large prefabricated components. The deviations can here be of vital importance, especially for the joints. In practice, the conditions can vary somewhat, dependent on the production technique used. A typical example is shown in **Fig. 9**. It is here assumed that the panels are ordered to a spesific size termed "basic panel". The panels are planned to be mounted between set out lines to form a basic joint with a certain joint width. In practice the size of the panel will vary somewhat,

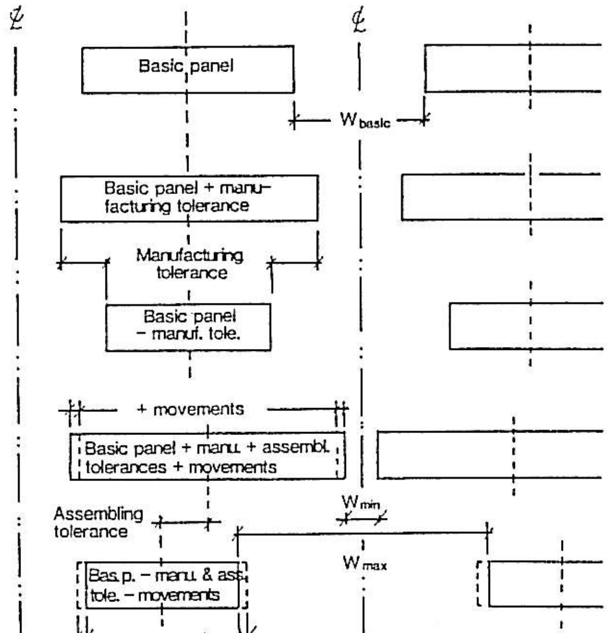

Fig.9. Manufacturing and assembling tolerances and movements. Principle figure

the extent will depend upon the manufacturer and the one ordering. The most important point is that the deviations must be kept under control, that the acceptable deviations are specified, i.e. that manufacturing tolerances are given. The influence on the joint width will appear from Fig. 9.

When mounting the panels, it is correspondingly necessary to take into account certain deviations in the assembly and to specify assembling tolerances. These will be superimposed the manufacturing tolerances. Finally the movements in the joints due to change of temperature and moisture content, wind, settlements etc. have to be added. The combined influence of manufacturing tolerances, assembly tolerances and movements will result in a joint width varying from a minimum width W_{min} to a maximum width W_{max} as shown in Fig. 9.

The basic joint width shown on the drawings will then be the following:

$$W_{basic} = W_{min} + T_m + T_a + M$$

In this case it is assumed that the tolerances are symmetrical, manufacturing tolerances $\pm T_m$, assembling tolerances $\pm T_a$, and symmetrical movements $\pm$ M from an intermediate stage. The maximum joint width will follow accordingly as:

$$W_{max} = W_{min} + 2\,T_m + 2\,T_a + 2\,M$$

For this the difference between W_{max} and W_{min} will follow as:

$$W_{max} - W_{min} = 2\,T_m + 2\,T_a + 2\,M$$

This is the difference which can be calculated, and also has to be calculated to make it possible to select building gaskets on a technical basis. Every single type of gasket has its own strictly limited functional range where the gasket is able to fulfill its functions as a seal. The upper limit corresponds to a point on the compression or deformation characteristics where the gasket is sufficiently tight, normally against air penetration. The lower limit is found from one out of two criteria, either the requirement that the deformation force shall be within an acceptable limit or that the gasket shall not be deformed so much that it is partially destroyed. For closed-cell sponge, the pressure in the cells may for instance increase to a level where the cells will burst. For rectangular sections, this will usually occur at a compression to a height less than 70% of the initial height for material densities in the range 0,25 - 0,35. A similar situation may also easily occur with gaskets made from solid (non-porous) qualities of rubber or plastic if the shapes of the sections are not properly made.

The functional range of building gaskets has to be found separately for every single gasket from proper testing. The shape of the gasket has a significant influence on the result. For this reason, it is difficult to give general figures for the different groups of products. Some figures are, however, presented in **Table 12.** It should be pointed out that the data presented in this table should not be considered as exact limits but figures for information only.

Table 12
Approximate data on the functional range for different groups of building gaskets

Product group		Functional range in % of the basic height of the gasket
61	Metal gaskets	30 to 70
62	Fibrous gaskets	30 to 70
63	Gaskets of open-cell sponge	15 to 40
64	Gaskets of closed-cell sponge	50 to 95
65	Resilient gaskets of solid rubber, plastics etc.	35 to 85

The first thing to do when selecting type of gasket is to calculate the joint movements. The movements will depend on the details of the construction, and have to be calculated separately in every single case. Factors that have to be taken into account are the size of the panels etc., their colour and method of fixing, the kind of material, the location of the gasket, the orientation etc. Usually the most important movements derive from changes in temperature and moisture content. In light constructions, wind loads can also result in significant movements. In more special cases initial shrinkage and settlements have to be taken into account.

The maximum and minimum temperatures occuring in the outer shell of a building can of course differ much from one country to another. In Norway the temperature fluctuations are approximately 75 °C in a light coloured and 100 °C in a dark coloured building. These figures can also be used in various other countries. When the gaskets are placed internally, the temperature changes are usually smaller.

The moisture movements must be calculated and added to the thermal movements. Thermal and moisture movements may counteract, but if this is not definitely certain, they should be added, at least statistically.

When the joint movements have been calculated, the tolerances have to be fixed. It is of vital importance that the expected deviations are stipulated in a realistic way, and that tolerances, i.e. acceptable deviations, are fixed on this basis. In this way, the maximum joint width difference, correspondig to $W_{max} - W_{min}$, can be calculated and used as the basis for selection of the right type of gasket.

In Fig. 9, the variations in joint width are shown very great. This is not only an overdoing to better illustrate the proportions. Practical experiences have shown that the variations in joint width are very often surprisingly great. This will appear very clearly from an English report (18). Here the author draws rather discouraging conclusions with regard to the possibilities of obtaining accuracy when building with large size concrete panels. The actual studies do, however, only cover buildings which were completed when the survey was made. In cases where tolerances have been fixed and a certain control has been agreed in advance, the results are much better. It is quite clear that the right thing to do is to form a sound estimate of the deviations which can be expected, and lay down sensible requirements to tolerances in production as well as in assembly. In any case it should be remembered that tolerance problems are not solved by simply neglecting them. A possible way out of difficulties like this is to control measure the joints on the building site, and to select suitable gaskets based on the results obtained.

Significant and calculable movements are also found in windows. If the sash and frame is considered as parts fixed relative to each other, the resulting movements are found to be moderate. In practice, however, the sitation is completely different. This is due to the fact that the different parts of windows and doors are not always straight and plane. When there is a temperature difference between inside and outside air, one side of for instance a sash member will be longer than the other. The result will be a crooked sash. A similar situation will occur under moisture differences. Consequently the joint between sash and frame will change as sash and/or frame is curving or straightening out again. Similar movements may also occur under heavy wind loads, as sash and frame will only be fixed at the locking points and free to be deformed between them, see **Fig. 10.**

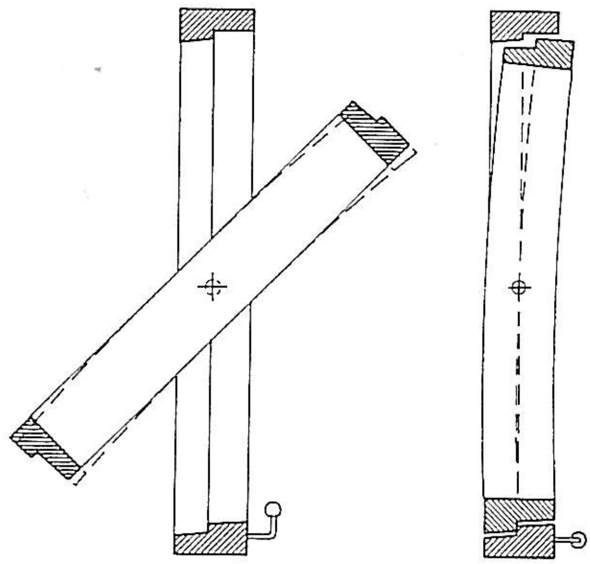

Fig.10. Deformation of the sash on a horizontally pivoting window

When the difference in joint width, $W_{max} - W_{min}$, has been found, the nominal height of the gasket is adjusted until the functional range of the gasket is corresponding to the difference $W_{max} - W_{min}$.

Example No. 1. Joints between wall panels. Calculated $W_{max} - W_{min} = 7$ mm. A tubular gasket section is wanted with a functional range from 50% to 85% of the nominal height. The latter is calculated from 0,85 h - 0,50 h = 7 mm. This gives a nominal height h = 20 mm.

Example No. 2 Joints between sash and frame in an openable window. Calculated $W_{max} = 5$ mm and $W_{min} = 3$ mm, giving $W_{max} - W_{min} = 2$ mm. Wanted is a tubular gasket with a functional range from 50% to 85% of the nominal height. This is calculated from 0,85 h - 0,50 h = 2 mm, giving h = 5,7 mm, or 6 mm rounded off. Control calculations will give a height of 50% of the nominal height in the minimum joint and 83% in the maximum joint. Both figures are withing the functional range and consequently acceptable.

Difficulties in selecting a gasket may occur when the difference $W_{max} - W_{min}$ is great, and the joint widths W_{max} as well as W_{basic} and W_{min} at the same time fixed. This corresponds to the case when the building is there already, and the joints have to be sealed. The system as such is in fact over-determined. The result may be that the joints can not be sealed with one single type and size of gasket, and that two or more sizes may be necessary. The previously mentioned example No. 2 is such an overdetermined system, but here the problem could be solved with one single gasket, fortunately enough. The following example will illustrate the problem in a better way.

Example No. 3 Joints between wall panels. Fixed $W_{basic} = 15$ mm, calculated $W_{max} = 25$ mm and $W_{min} = 5$ mm. A tubular gasket is wanted with a functional range from 50% to 85% of the nominal height. If the height is calculated from 0,85 h - 0,50 h = 25 - 5 mm, the result will be a gasket with a nominel height of 57 mm and joint widths from 28,5 mm to 48,5 mm. When the basic joint width at the same time is set at 15 mm, the problem can only be solved by using gaskets of two or more sizes; one size in the smallest joints, another in the somewhat wider joints, and possible a third etc. In the actual case, the problem can be solved by using three different tubular gaskets, as follows:

Gasket No. 1, nominal height 10 mm, joints 5 mm to 8,5 mm

Gasket No. 2, nominal height 17 mm, joints 8,5 mm to 14,5 mm

Gasket No. 3, nominal height 29 mm, joints 14,5 mm to 25 mm

More detailed examples on calculation of joint sizes and selection of jointing materials is given in an architectural data sheet (19).

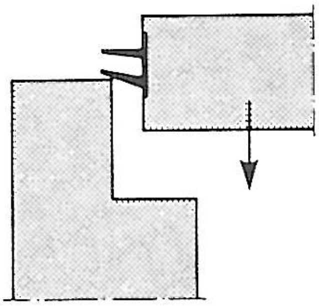

Fig.11. Sliding gasket mounted on a window sash

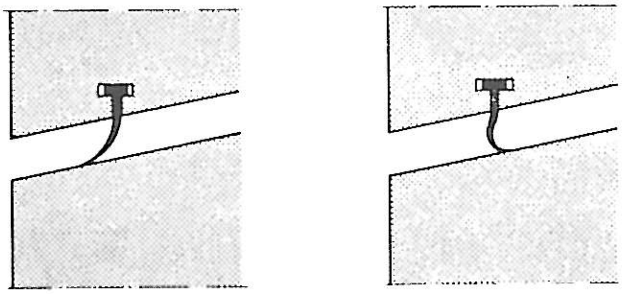

Fig.12. Sliding gaskets are turned when a window or door is opened again

The previous considerations are first of all valid for gaskets that are squeezed between two flat surfaces, i.e. the compression gaskets, but can also to a large extent be used for the so-called sliding gaskets, see Fig. 1, type 652. Such gaskets base their sealing function on one or more lips sliding on the other joint surface as shown in **Fig. 11.** Sliding gaskets were more widely used some years ago than they are now. The reason for the reduced use is first of all found in the fact that the lips of a sliding gasket has to be turned when a window or door is opened, see **Fig. 12.** A high force is needed to do this, and this again put high stresses on the hinges etc. A sliding gasket is also depending on a fairly correct joint size, and does in practice not accept any wide tolerances or deviations. Increased deviations may either result in leaking windows, or alternatively, that the force needed to open a window may be so high that the window can not be opened at all, or that the gasket is torn or weared if the opening is successfull. The wearing and abrasion problems are particularly consentrated to the corner joints.

To the practical details in the use of building gaskets in general belong the application of the principle of two-stage seals. An example is shown in **Fig. 13** for an outwards opening window. Usually there is a small air leak around the gasked used as weather stripping. If the driving rain is permitted to reach and wet the air seal, the result may be a driving rain penetration. A building gasket should not be used as a combined air and water barrier. In correctly designed joints in windows and doors, the gasket is only an inner air seal while the correct constructional details make up the outer rain barrier (20), (21).

In windows with more than one rebate or possible gasket position, the gaskets are usually mounted on the inner one, and in such a way that the joint between the sash and the inner frame is made air tight. This is very important in reducing the risks of condensation between the glasses in coupled window sashes, see **Fig. 14.**

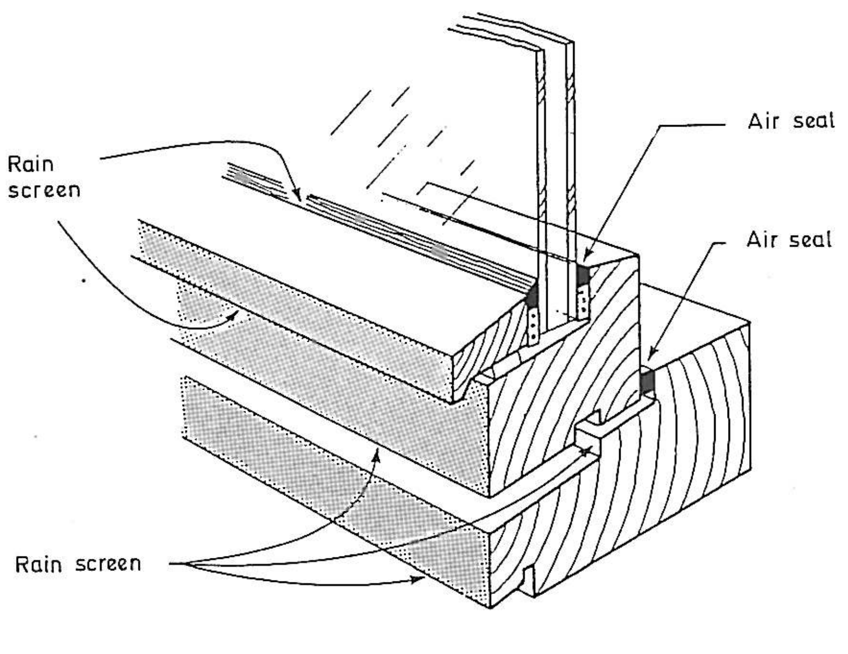

Fig.13. The principle of two-stage seals applied on windows, between sash and frame, frame and wall as well as for the glazing details

In windows, the gaskets are frequently mounted in special grooves, as shown in **Fig. 15.** The grooves are made in the machining of the window members, but the connection between them in the corners has to be made by hand. The parts of the grooves going out straight through the frame corners have to be sealed, otherwise an acceptable tightness in the corners can not be reached.

In windows, the gaskets also have to be mounted in different ways, depending on the hanging of the window sash. In side-hung windows and doors, the gaskets are usually mounted in the rebate as shown on **Fig. 16 a.** With this mounting, they may easily be damaged on the hinged side. For this reason, it is recommended to put the gasket on the side of the frame at this point, as shown in **Fig. 16 b.**

A few more factors are worth taking into account when designing joints sealed with building gaskets.

One is to find the right gasket material quality, depending on the stresses the gaskets are subjected

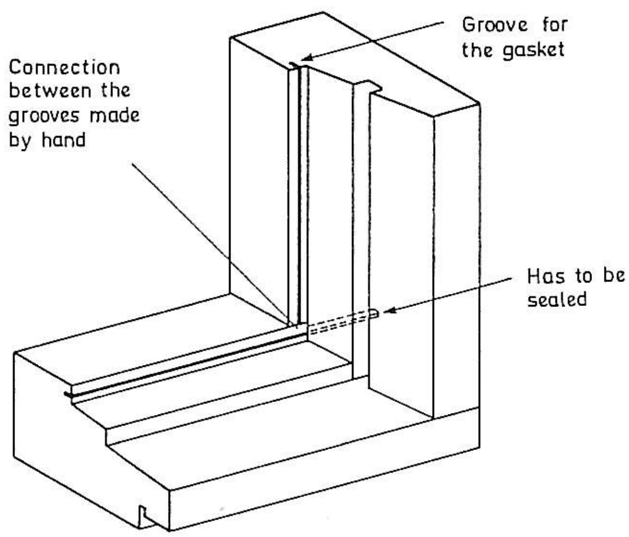

Fig.15. Corner connection of wooden window frame, with grooves for the gaskets

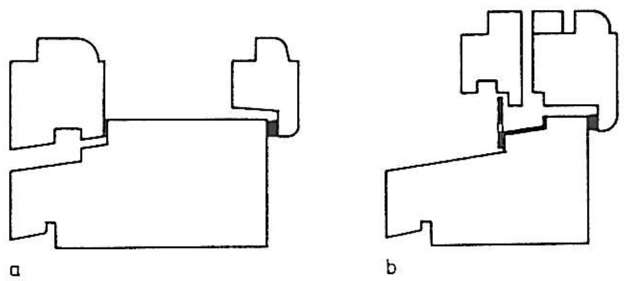

Fig.14. Gaskets should always be mounted in the inner position in windows.

a) Separate sashes moving inwards and outwards

b) Coupled sashes moving inwards together

to and the requirements for functional suitability and durability. Only realistic aging tests can indicate how long a gasket can be expected to serve all right under natural exposure conditions.

A second point is the jointing of the different lengths of gasket, especially in the corners and crosses. It is important that the gaskets are cut and jointed together in the right way in all kinds of meeting points. Some information about recommended jointing details is found in the chapter on workmanship.

A third point is that all the surfaces the gaskets are forced against, have to be smooth enough to avoid leaks under the gasket. This should in fact be a very obvious point, and further comments should not be necessary. Anyhow, failures like this

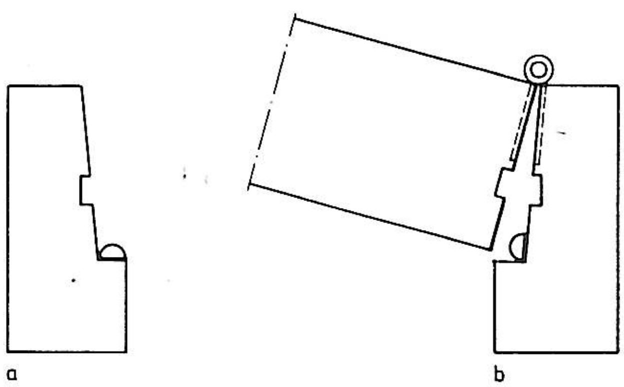

Fig.16. Position of the gasket in a side-hung window.

a) On three sides

b) On the hinged side

still occur. Uneven surfaces have to be made smooth enough by mortar, top screed, paint or any other suitable means.

From time to time, gaskets are used in places where they are subjected to quite unusual stresses. They may for instance be put in extremely humid atmospheric conditions for a long period of time, or even be used under water. So far there has been no gasketing system available that can ensure a lasting seal under those conditions. Over time, water will always penetrate. It is then important to have the joints designed to drain out the water again.

Joints in floors and other traffic areas are also subjected to special stresses like wearing, intrusion of grit etc. If the joints are also subjected to chemical stresses, the situation will be really particular and ask for special measures.

4 Workmanship

Building gaskets are always supplied as products ready for use. They have a certain size and shape, and all which is needed to do with the gasket itself, is to cut the individual lengths the right way. But of course all steps like pretreatment of surfaces, fixing of gaskets, jointing etc. have to be made the right way to ensure a good result.

4.1 Pretreatment of joint surfaces

Sufficiently smooth joint surfaces is one of the basic requirements in the use of building gaskets for joint sealing purposes. Uneven surfaces rarely result in acceptable tightness. Surfaces like that have to be given a better smoothness by grinding, plastering, painting etc. Damaged joint surfaces have to be repaired.

Self-adhesive building gaskets put approximately the same requirements to the condition of the joint surfaces as building sealants do. The substrates have to be sufficiently clean and dry and free from contaminations like oil, fat, wax etc., otherwise the glue will not stick well to the substrate. For other types of gaskets, the requirements to clean and dry surfaces are not quite as critical as for the self-adhesive gaskets. Even here, however, it is recommended to remove dust, dirt, water, ice, wax etc. before the gaskets are mounted.

4.2 Fixing of gaskets

In all normal applications, the building gaskets have to be properly secured in the joints. If not, there is an impending risk of gasket displacement. In some cases, unsecured gaskets may even work themselves out of the joints, as a result of the forces they are subjected to when the joints are moving. To squeeze an unsecured gasket between two flat surfaces is only in exceptionel cases an acceptable solution.

For the present selection of building gaskets, a total of five different mounting and fixing methods can be used, as shown on the **Figs. 17 - 21.**

A. Gluing

In earlier days, it was not unusual that the gaskets were fixed by gluing with for instance a contact glue. Such a time consuming method is rarely used nowadays. Self-adhesive gaskets have on the other hand increased in popularity. The glue is usually applied as a double-coated pressure-sensitive tape with a stick-release agent. The protection is removed just before the gaskets are mounted. The glue has to be reinforced to avoid stretching of the gaskets during the mounting sequence. This reinforcement can be conveniently put in the backing of the glue.

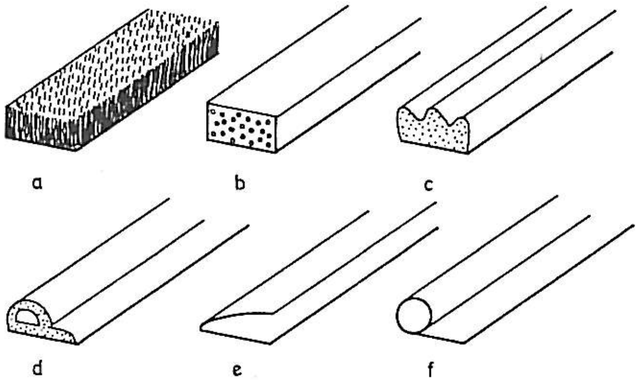

Fig.17. Self-adhesive gaskets. a) nylon pile gasket, b-d) gaskets of rubber or plastics sponge material, e-f) resilient gaskets of solid rubber or plastics

Self-adhesive gaskets are available in a number of different shapes and sizes, Fig. 17, made of solid as well as porous (expanded) plastics or rubbers, and also as pile. They can only be used on fairly smooth surfaces. In many cases, it is also recommended to secure the self-adhesive gaskets by staples or similar.

B. Fixing by staples or tacks

Many types of building gaskets are fastened to the substrate by staples, tacks or similar. A basic requirement for this way of fixing is that the substrate is sufficiently smooth. The gaskets must also be shaped with a lip or nib which can be used in the fixing process. Further, the substrate must be able to take staples, tacks or similar. When these three conditions are fulfilled, however, a high number of gaskets can be fastened in this way, Fig. 18. The distance between the individual fixing points should be short enough to keep the gaskets well in place, particularly in the corners. Staples and tacks must of course not be put straigt through the tubular or wing-shaped parts of the gaskets

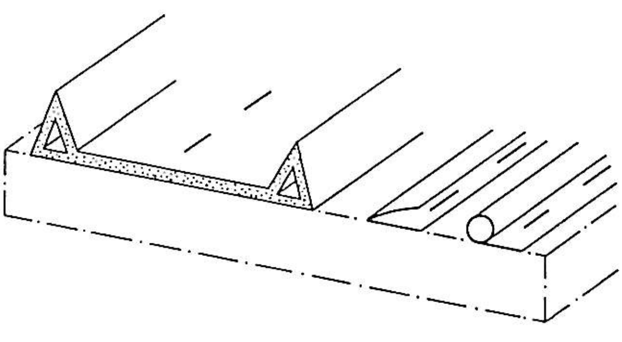

Fig.18. Gaskets fixed by staples or tacks

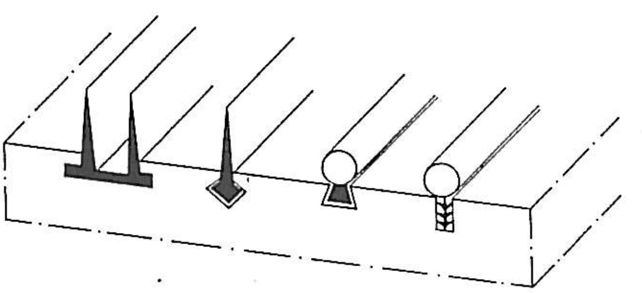

Fig.19. Gaskets mounted in grooves

which perform the primary sealing function. All fixing points have to be in the parts of the gaskets intended for this purpose.

C. Mounting in grooves

Some of the available types of gaskets are specially shaped for mounting in grooves, for instance in some window or wall systems. The gaskets are then equipped with a special foot part, Fig. 19. They are either mounted by forcing the foot part into the groove or by drawing then into the grooves from the ends. In both cases the gaskets have to be shaped with nibs or hooks, to keep them in place in the grooves.

Great care has to be exercised in the mounting of building gaskets in grooves. It is important to avoid stretching the gaskets, otherwise they may contract again over time with resulting openings in the corner joints. One way to avoid this problem is by cutting the gaskets with an over-length and mount them with a slight compression longitudinally in the grooves. A better and safer way of avoiding point leaks in the corners is by fixing the individual gasket lengths in the ends by staples, tacks or similar. In some cases it is also possible to solve this problem by welding or gluing the corner connections.

D. Mounting in joints

Some types of building gaskets are mounted into the joints in building constructions, for instance between wall panels, after the constructions have been erected, Fig. 20. The gaskets are then kept in place in the joints by the pressure the gaskets exert on the joint surfaces. In practice, the gaskets have to be specially shaped with nibs, hooks or similar. Otherwise the gaskets will have a tendency to work themselves out of the joints. The alternative is to give the joint surfaces a proper shape to avoid gasket displacement.

The gasket products mounted this way are partially specially shaped to be forced into the joints with special tools. A special group of products is made up by tubular gaskets which are evacuated to collapse before they are introduced in the joints. They recover when air is let into them again. Another special group is the precompressed impregnated open-cell sponge gaskets, which are left to expand in the joints.

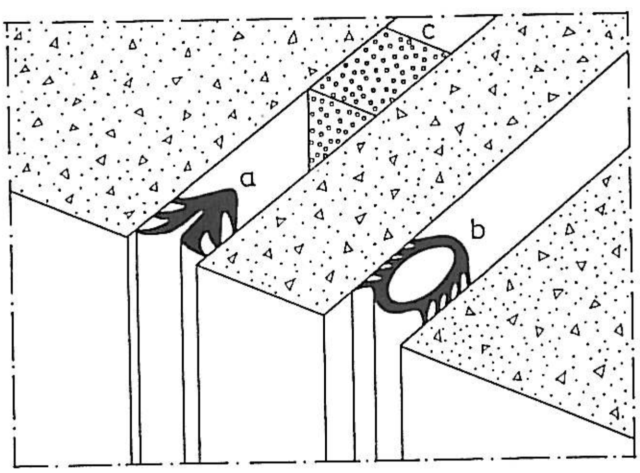

Fig.20. Gaskets mounted into joints. a) gasket forced into the joint, b) vacuum tube, c) gasket of precompressed open-cell sponge

E. Mounting on building elements

Gaskets can also be made with a shape which permit them to be clamped on building elements and components before they are mounted. These types are in fact double gaskets, made up of two single gaskets which are extruded and kept together as a unit.

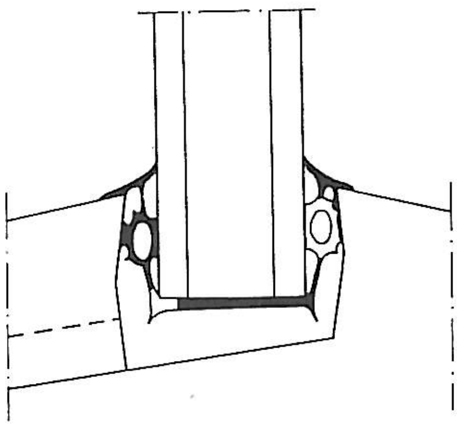

Fig.21. U-shaped gasket mounted on a sealed glazing unit

This type of gasket has to some extent been used for glazing purposes and for mounting lightweight panels. Usually, special precautions are necessary to avoid water penetration. With the glazing gasket as shown on Fig. 21, it is for instance necessary to cut holes for drainage and pressure-equalization as indicated by the white parts of the gasket cross-section. Great care should always be shown in using gaskets like this.

4.3 Jointing the gaskets together

One of the main problems involved in sealing joints with building gaskets is to make all connections between the different lengths of gasket sufficiently tight. This is specially due for the corner connections and crosses. The other two main problems are, as mentioned before, to choose the right material quality, dependent on the location of the gasket in the building, and to cope with the tolerance problems.

The requirements to the finish of the connections between the individual gasket lengths will depend upon the intended function of the gaskets in the building construction. For gaskets used as a rain barrier, for instance in joints in an external wall, the requirement to rain tightness will be of prime interest while the requirement to air tightness often is a secondary one. When the gaskets are used as an air seal in the joints, the requirement to air tightness will on the other hand be a primary one. This is for instance the case with gaskets used as weatherstrips for air seal between sash and frame in openable windows and between door and frame in doors. Inproperly finished gasket connections, especially in the corners, may reduce the air tightness drastically, even with the best types of gaskets available.

The main point in making joints sealed with gaskets properly air tight is to mount the gaskets as continuous as possible. In windows and doors the gaskets should either be lead uncut around the corners or made with closed corner joints. The gaskets also have to be lead in a suitable way past or through the hinges. They have to be in the same plane in the window, otherwise there will be holes in the air seal when the gaskets jump from one position to another.

The corner connections of gaskets used as weather-strips in windows can be made in several different ways.

- by leading the gasket uncut around the corners
- by mitering
- by overlapping
- with straight cut gaskets
- with special corner pieces

For the different types of gaskets, one or more of these possible solutions may be used, depending upon the type and section of the gasket as well as the construction and material in the window or door.

Mounting of a gasket **uncut around a corner** is only possible when the width of the gasket is small. A 90° bend is usually not possible without detrimental deformation of the tightening parts. One possible solution is to cut notches in the foot

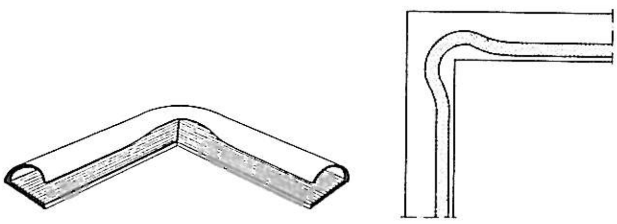

Fig.22. V-shaped gasket bent uncut around a corner thanks to a V-shaped notch in the foot part

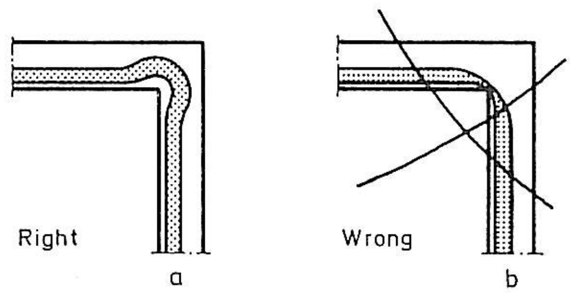

Fig.23. Gaskets mounted uncut around the corners.

a) Correct details. The gasket mounted with overlength, as this will prevent openings in the corner if the gasket shrinks.

b) Wrong details. When the gasket shrinks, an opening in the corner will result

part of the gasket, as this will frequently enable the tightening parts to be bent with only acceptable deformation, see **Fig. 22.** The bent gasket should preferably be mounted with overlength, to avoid corner leaks in case of gasket shrinkage, see **Fig. 23.**

Mitred corners are particularly interesting for gaskets mounted in grooves, but may also be used in other cases. It should in this connection be remembered that gaskets frequently shrink on aging, sometimes rather much. The gaskets will then have a tendency to contract lengthwise. This contraction has to be avoided, either by fixing the individual lengths in their original and correct position by means of staples, tacks or glue, **Fig. 24,** alternatively by welding or vulcanizing the mitred joints. A carefully mounted mitred joint, secured in a suitable way, should, however, result in a fully acceptable seal.

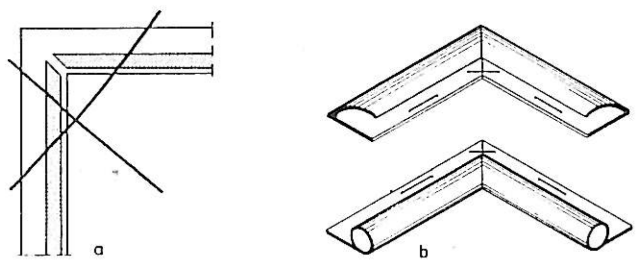

Fig.24. Gaskets with mitred joints.

a) Unsecured gaskets may shrink and open up in the corner joints.

b) Gaskets secured by staples, tacks etc. remain in place

Overlapping the gaskets in the corners is a somewhat safer solution. One important point is, however, that the material thickness in the various parts of the sections is not too great. Otherwise there may be difficulties in obtaining an even compression of the gasket over the length. An advantage of this type of corner connection is that it is only to a minor degree influenced by possible shrinkage of the gasket material.

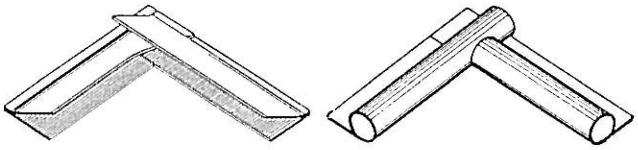

Fig.25. Typical good overlapping corner joints

Overlapped joints are most conveniently made by splitting up the ends of the gaskets and cutting away the parts not needed to make a good overlapping, see **Fig. 25.**

Corners with **straight cut gaskets** put together in simple butt joints are those most easily made. This is also the most widely used corner solution. It is, however, very important to have the gaskets assembled very carefully, and the gasket lengths secured at the ends by means of staples, tacks or similar, see **Fig. 26.** This type of corner joint will still have a certain apparent draw-back. A lot of the presently available types of gaskets do quite simply not give sufficiently tight corner joints when they are put together with butt joints, even when the details are most carefully made. Most suitable are gaskets made of closed-cell sponge material in rectangular cross-sections and some types of tubular gaskets. Less suitable are the V-shaped sections as well as all types of sliding gaskets.

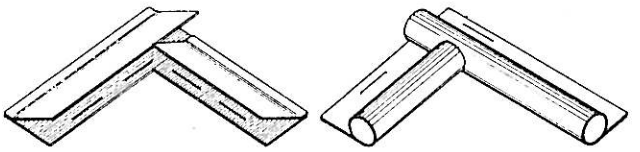

Fig.26. Typical butt joints

Special corner pieces with welded or vulcanized miterings are not widely used, but they are in progress. The corner pieces have basically the same profile as the corresponding gasket, and when they are used, the problems with the corner joints themselves are eliminated. On the other hand, they introduce a higher number of ordinary gasket joints. In a traditional window, the result will be eight horizontal or vertical joints instead of four corner joints. Such joints have to be glued or vulcanized, **Fig. 27.** Alternatively the ends of the corner pieces may be put into the gasket ends, and everything secured by staples, **Fig. 28.**

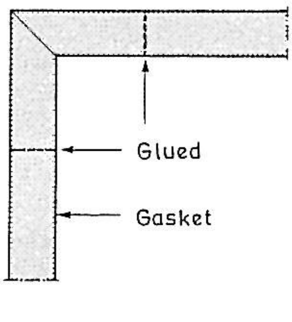

Fig.27. Special corner piece, glued to the gaskets

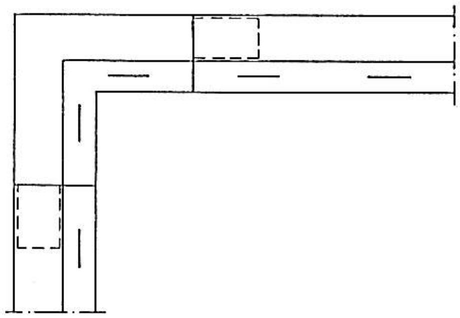

Fig.28. Gaskets with inserted corner piece, secured by staples

For gaskets used as air seal in joints between wall panels, the possible methods for jointing the lengths are not as many as for gaskets in windows and doors. In panel constructions, the straight cut corners and crossings are dominating, but systems with special corner pieces do exist. In difficult cases, a building sealant is frequently used to make up an additional seal. A slightly different situation exists for gaskets used as rain barrier in the outer parts of the joints. Here a separate air barrier is present in the inner parts of the construction. In cases like this, a reduced air tightness in the rain barrier is usually accepted. In many cases, the space behind the rain barrier is properly ventilated and drained. It is then sufficient to let the gaskets cross and overlap each other in a suitable way, as for instance shown in **Fig. 29.**

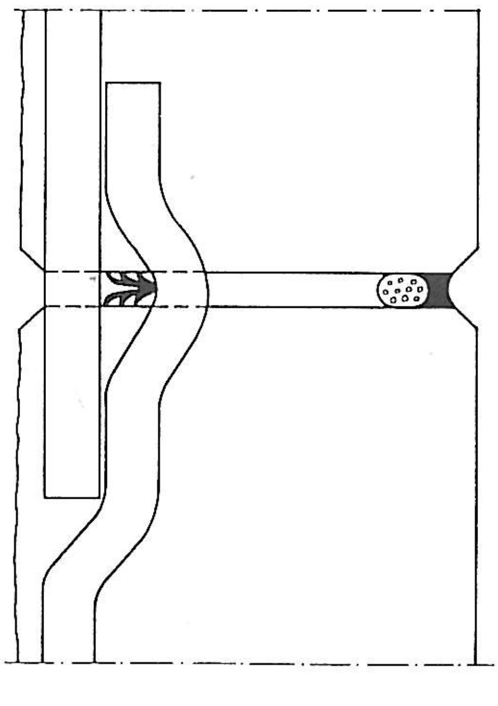

Fig.29. Vertical cross-section through a joint crossing. Overlapping of two vertical and one horizontal gaskets serving as rain barrier

5 Development of suitable test programmes

5.1 Different product applications

Building gaskets frequently constitute an alternative to building sealants. Just as there are many possible applications for building sealants, there will be a number of different applications for gaskets. It is at least so from a theoretical point of view, but in practice the gaskets will not have as many possible applications as the sealants. As a starting point in an evaluation of the possible applications, it can be convenient to take a comprehensive systematical survey for sealants made by the Expandite Ltd. Company in London. A total of eleven different main applications are described in detail in their Technical Handbook (22). The main applications are further subdivided into a number of more specific application areas.

The eleven main application areas and examples are as follows:

1. Joints in water retaining structures

   Irrigation canals, culverts, dams, reservoirs, sea walls, sewage works, swimming pools, water treatment and storage.

2. Joints in traffic surfaces

   Airfields, bridges, car parks, elevated roads, petrol service station forecourts, vehicle workshops and service areas, pedestrian areas.

3. Joints in building substructures and other water excluding structures

   Basements, retaining walls, site slabs, subways.

4. Joints in roofs and roof finishes

   Bitumen felt roofing, corrugated sheet roofing, mastic asphalt roofing, sheet metal roof finishes, tiled roofs, concrete roofs.

5. Joints in external walling and cladding

   Brickwork, blockwork walling, insitu concrete walling, precast concrete cladding panels, composite wall panels, light-weight cladding panels, wall tiles, mosaics, brick slips.

6. Joints in glazing, infill panels, frames and window walling

   Metal frames, timber frames, glazing without frames, curtain walling, double glazing, concrete store frames, plastic frames, roof lights.

7. Joints in internal finishes: floors

   Mastic asphalt floors, screeded floors, tiled floors, wood block floors.

8. Joints in internal finishes: walls and partitions

   Dry linings and acoustic tiles, fairfaced bricks, blockwork, plasterwork, polished stone as marble, wall tiling, internal glazing.

9. Joints in internal finishes: ceilings

   Ceiling boards and tiles, fairfaced concrete, plasterwork.

10. Joints in building services

    Air ducting, pipe work, laboratory fume extract ducting, refuse chutes, guttering, service ducts in floors, manholes, laboratory drainage ducting, services entry into building.

11. Joints in building fixtures

    Baths, handbasins, sinks, urinals, W.C.s, worktops.

For each of the main applications listed, attention is paid to different types of joints, different material surfaces to be jointed, application conditions as well as possible stresses on the jointing material.

The system with eleven main application areas as given in the previous sections, has been developed for **sealants.** Attempts to convert this to building gaskets have rapidly revealed certain limitations. The main application areas Nos. 1, 2 and 3 are first of all typical for sealants. The same is partly due for the application areas Nos. 4, 7 and 11. Gaskets are not recommended used as a permanent seal against water pressure. Still they are used for these purposes from time to time. It is then important to be aware of the risks involved. A building gasket used to seal against water pressure is sufficiently tight only in the exceptional cases. When an acceptable tightness is obtained, this is also usually limited in time. In such cases, a certain leak has to be accepted, and the leaking water drained away or removed in other suitable ways.

Typical recommended applications for building gaskets are found in the application areas Nos. 5, 6, 8, 9 and 10, partly also in the areas Nos. 4 (sheet roofing), 7 and 11.

A closer and more detailed study of the available types of building gaskets and their possible applications has shown that it is possible to make up a more simplified list of typical application areas. This list is considerably shorter than the one for sealants. For gaskets, the following four main applications areas will do:

I **Air barrier in windows and doors** and other types of components or constructions made to be opened and closed periodically. In the actual cases, the gaskets only seal against air penetration and not against driving rain. They are mounted in a position where they are protected from climatic stresses. The gaskets even serve as sound insulation promotors.

II **Air barrier in joints in large panel wall systems etc.** The gaskets have to seal against air penetration, but not against water. They are used in joints between building panels and parts permanenty fixed to a loadbearing construction. Also gaskets like this are protected from climatic stresses.

III **Mounting strips for glazing.** Such gaskets do not only seal against air but also have to make up an acceptable seal against driving rain. The gaskets are exposed to internal as well as external environments.

IV **Rain screen in joints with a two-stage seal.** The purpose of this type of gaskets is first of all to shed rain water, and tightness against air penetration is not a primary requirement, only a secondary. The rain screen is the outer seal in joints with a two-stage seal, and its resistance to climatic stresses has to be correspondingly high.

From a theoretical point of view, a fifth group can, as mentioned before, be added to the four main groups given above, covering gaskets used to seal against water pressure. The application of gaskets for this purpose is, however, connected with so many uncertainties that it is not considered as meaningful to list them under a separate heading.

5.2 Suitable applications of different types of gaskets.

The basis for the classification of building gaskets according to **Table 1** is the functional properties of the products and the way they are applied in the joints. The classification is a fairly rough one. On the market, a wide range of different products is available. A more distinct subdivision and listing of the different types of products is obtained when functional requirements are put to every product group, combined with requirements to testing and documentation of the results obtained.

When the different groups of gaskets as listed in Table 1 are related to the four earlier mentioned main application areas, the following brief survey can be made:

Type 611. Metallic strips.

These products now only find a very limited use within the application area No. I, gaskets for use as air barrier in windows and doors, and partly also within area No. IV, rain screens in joints with two-stage seal.

Type 612. Metallic strips combined with fibre or sponge material.

This type of product also has a much restricted application within area I, air barriers in windows and doors.

Types 621 - 623. Fibrous gaskets.

Such products were earlier fairly well represented on the market. Now they are rarely found. Those available are used as air barriers in windows and doors (area No. I), but only when the requirements to air tightness are moderate. Other types of gaskets have in general much lower and better air penetration rates.

Types 631, 632 and 633. Gaskets of open-cell sponge.

These products now find a very limited application. Gaskets of open-cell material have a high rate of air penetration under normal conditions, and have to be given an unusual high degree of compression to fulfill the requirements to air tightness normally put to building gaskets. They are used partly as air barrier in windows and doors (area No. I) and partly as air barrier in joints in walls (area No. II). They are also used as a barrier to dust penetration, for instance between the sashes in dual windows.

Types 641 and 642. Gaskets of closed-cell sponge.

This is now a very comprehensive group, covering a number of new materials, shapes and cross-sections. They are used partly as air barrier in windows and doors (area No. I), partly as air barrier in joints in walls (area No. II), and partly also for glazing purposes (area No. III). So far they have not been used as rain screen in two-stage joints (area No. IV), but it is probably only a question of time before suitable products will appear on the market.

Type 651. Compression gaskets of solid rubber, plastics etc.

This group is for the time being the most comprehensive group of building gaskets on the market. This is true for quantity as well as quality. These products are used within all application areas. They are found as air barriers in windows and doors (area No. I), as air barriers in joints in large-panel walls etc. (area No. II), as mounting strips for glazing (area No. III) and as rain screen in joints with a two-stage seal (area No. IV). The products sometimes used as water seal are also found in this group.

Type 652. Sliding gaskets of solid rubber, plastics etc.

This group only covers a limited number of products. They are only used in a few very special window and door designs, usually as air barrier, but sometimes also as rain screen.

Table 13. Relevant properties for different types of gaskets.
Main application area No. I. Air barriers in windows and doors.

Properties/Useful gaskets		611	612	621	622	623	631	641	651	652
2.01	Shape	xx	xx	xx	xx	xx	xx	xx	xx	xx
2.02	Volume									
2.03	Weight							(x)	(x)	
2.04	Colour									
2.05	Smell, toxicity									
2.06	Deformation resistance	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.07	Closing force for windows and doors	x	x	x	x	x	x	x	x	x
2.08	Stretch resistance				xx	xx	xx	xx		
2.09	Tear resistance								(x)	
2.10	Hardness								x	x
2.11	Abrasion resistance									xx
2.12	Compression set	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.13	Shrinkage, creep									
2.14	Fatigue									
2.15	Combustibility		xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.16	Air penetration	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.17	Water vapour penetration							(x)	(x)	
2.18	Ozone resistance		xx	xx	xx	xx	xx	xx	xx	xx
2.19	Water absorption							xxx		
2.20	Rain penetration									
2.21	Water penetration under static pressure									
2.22	Resistance to solvents, salt spray, cleaning agents and other chemicals	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.23	Contact and migration stain	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.24	Influence of high and low temperatures			xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.25	Sound penetration									
2.26	Durability	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.27	Paintability	xx	xx	xx	xx	xx	xx	xx	xx	xx
2.28	Serviceability	xx	xx	xx	xx	xx	xx	xx	xx	xx

Table 14. Relevant properties for different types of gaskets.
Main application area No. II. Air barriers in large panel wall systems etc.

Properties/Useful gaskets		631	632	633	641	642	651
2.01	Shape	xx	xx	xx	xx	xx	xx
2.02	Volume						
2.03	Weight			xx	xx	xx	xx
2.04	Colour						
2.05	Smell, toxicity						
2.06	Deformation resistance	xxx	xxx	xxx	xxx	xxx	xxx
2.07	Closing force for windows and doors						
2.08	Stretch resistance	x	x	x	x	x	
2.09	Tear resistance						
2.10	Hardness						x
2.11	Abrasion resistance						
2.12	Compression set	xxx	xxx	xxx	xxx	xxx	xxx
2.13	Shrinkage, creep						
2.14	Fatigue						
2.15	Combustibility	xxx	xxx	xxx	xxx	xxx	xxx
2.16	Air penetration	xxx	xxx	xxx	xxx	xxx	xxx
2.17	Water vapour penetration				(x)	(x)	(x)
2.18	Ozone resistance	xx	xx	xx	xx	xx	xx
2.19	Water absorption						
2.20	Rain penetration						
2.21	Water penetration under static pressure						
2.22	Resistance to solvents, salt spray, cleaning agents and other chemicals	xxx	xxx	xxx	xxx	xxx	xxx
2.23	Contact and migration stain						
2.24	Influence of high and low temperatures	xxx	xxx	xxx	xxx	xxx	xxx
2.25	Sound penetration						
2.26	Durability	xxx	xxx	xxx	xxx	xxx	xxx
2.27	Paintability						
2.28	Serviceability	xx	xx	xx	xx	xx	xx

Table 15. Relevant properties for different types of gaskets.
Main application area No. III. Mounting strips for glazing.

Properties/Useful gaskets	641	651
2.01 Shape	xx	xx
2.02 Volume		
2.03 Weight		
2.04 Colour		
2.05 Smell, toxicity		
2.06 Deformation resistance	xxx	xxx
2.07 Closing force for windows and doors		
2.08 Stretch resistance	xxx	(x)
2.09 Tear resistance		x
2.10 Hardness		x
2.11 Abrasion resistance		
2.12 Compression set	xxx	xxx
2.13 Shrinkage, creep		
2.14 Fatigue		
2.15 Combustibility	xxx	xxx
2.16 Air penetration	xxx	xxx
2.17 Water vapour penetration		
2.18 Ozone resistance	xx	xx
2.19 Water absorption	xxx	xx
2.20 Rain penetration	xxx	xxx
2.21 Water penetration under static pressure		
2.22 Resistance to solvents, salt spray, cleaning agents and other chemicals	xxx	xxx
2.23 Contact and migration stain	x	x
2.24 Influence of high and low temperatures	xxx	xxx
2.25 Sound penetration		
2.26 Durability	xxx	xxx
2.27 Paintability	xx	xx
2.28 Serviceability	xx	xx

Table 16. Relevant properties for different types of gaskets.
Main application area No. IV. Rain screen in joints with a two-stage seal.

Properties/Useful gaskets	611	641	642	651
2.01 Shape	xx	xx	xx	xx
2.02 Volume				
2.03 Weight	xx	xx	xx	xx
2.04 Colour				
2.05 Smell, toxicity				
2.06 Deformation resistance	xxx	xxx	xxx	xxx
2.07 Closing force for windows and doors				
2.08 Stretch resistance		x	x	
2.09 Tear resistance				
2.10 Hardness				x
2.11 Abrasion resistance				
2.12 Compression set	xxx	xxx	xxx	xxx
2.13 Shrinkage, creep				
2.14 Fatigue				
2.15 Combustibility		xxx	xxx	xxx
2.16 Air penetration	(x)	(x)	(x)	(x)
2.17 Water vapour penetration				
2.18 Ozone resistance	xx	xx	xx	xx
2.19 Water absorption		xxx	xxx	xx
2.20 Rain penetration	xxx	xxx	xxx	xxx
2.21 Water penetration under static pressure		(x)	(x)	(x)
2.22 Resistance to solvents, salt spray, cleaning agents and other chemicals	xxx	xxx	xxx	xxx
2.23 Contact and migration stain				
2.24 Influence of high and low temperatures		xxx	xxx	xxx
2.25 Sound penetration				
2.26 Durability	xxx	xxx	xxx	xxx
2.27 Paintability	xx	xx	xx	xx
2.28 Serviceability	xx	xx	xx	xx

5.3 Test programmes for different types of gaskets for different applications

Based on the earlier considerations, detailed test programmes can be worked out for different types of gaskets and a number of applications. The programmes will not be shown in details here, as they would fill too many pages. For the purpose of this report, it has been found more convenient to show a total of four tables, one for each of the main application areas as listed under point 5.1.

A total of twelve different types of gaskets are covering the four main application areas, as given in the **Tables 13 - 16.** Each table is showing the types of gaskets useful for this main application area. The interesting types differ in number. For each combination of type of gasket and application area, the relevant properties are listed.

For practical reasons, it is not possible to give detailed information on the considerations laying behind the selection of relevant properties for every combination of type of gasket with main application area. In the Tables 13 - 16 the following marks have been used:

xxx relevant property to be documented with test results

xx relevant property where information shall be given, but where documentation by test results is not compulsory

x relevant property

(x) relevant property only in special cases

No marking means not relevant property in the actual case.

A test programme can easily be written out in detail in every relevant case, based on the Tables 13 - 16 and the information given in section 2.

5.4 Quality assurance and quality certification

The quality of any built space is no better than the quality of the materials and components used in the construction. Quality assurance on all points is consequently a vital aspect.

A simple straigthforward prototype testing of a building product like a gasket is one step towards a quality assurance. A final and reliable result can, however, only be reached when internal and external control measures are added. A quality certification programme on these lines for building materials and components has been developed by the Norwegian Building Research Institute. It is a volontary control, testing, licensing and certification system, covering the following five points:

1. Prototype testing of the materials and components used in the manufacturing.

2. Prototype testing of the finished products.

3. External control as unannounced inspections of the manufacturing sites.

4. Checking of randomly selected samples taken from the running production or on the open market.

5. Control of the manufacturers own internal quality control.

In addition to these five points, the manufacturers must also present appropriate instructions or directives on the application of their products.

The NBI quality certification programme is open to manufacturers in Norway as well as abroad.

The NBI quality assurance and certification programme has been successfully used for more than ten years. The first group of products to be covered by the programme was the sealed glazing units, starting in 1978. The system worked out by NBI was that year adopted by the organisation of manufacturers of sealed glazing units in Norway, as compulsory for its members. The quality of the Norwegian sealed glazing units has later on increased considerably and the callbacks have been drastically reduced. The sealed glazing units manufactured in Norway are now among the best in the world.

Another product group where the quality certification system has been successfully used is the gaskets. For these, more than 100 individual products are now covered by the NBI quality certification, most of them made by manufacturers residing outside of Norway. The NBI quality certification has consequently already gained international recognition.

More details about the NBI quality assurance and quality certification system are given in a recent publication (23).

6 Prototype testing of selected gaskets

A presentation of test methods and test programmes very often leads to questions about test results. To meet this situation, the Norwegian Building Research Institute has selected a total of 14 different commercially available gaskets on the open market, and subjected them to complete prototype testing according to the NBI test programmes.

6.1 The products

The 14 gaskets shall not be given by brand names here, but by the following more general descriptions:

Gasket 1 is made of a yellowish open-cell polyurethane sponge material, has a square section of 9 mm x 6 mm and is self-adhesive with glue on one side, group 631

Gasket 2 is a similar gasket made of PVC sponge material with mainly open cells, 9 mm x 4 mm, self-adhesive, group 631

Gasket 3 is also made of open-cell sponge, but impregnated with asphalt. Group 633, cross-section 25 mm x 30 mm

Gasket 4 is made of closed-cell EPDM sponge in black colour, self-adhesive, cross-section 10 mm x 5 mm, ribbed on one side, group 641

Gasket 5 is made of closed-cell black butyl rubber sponge, self-adhesive, spuare section 8 mm x 6 mm, group 641

Gasket 6 is made of white closed-cell EPDM sponge, self-adhesive, P-shaped cross-section 9 mm x 5,5 mm, group 641

Gasket 7 is a P-shaped silicone rubber product in grey colour, 6,5 mm high with a foot part for stapling etc., group 651

Gasket 8 is a V-shaped white silicone rubber product, height 8 mm, foot part for stapling, group 651

Gasket 9 is a black P-shaped EPDM rubber product, 9,5 mm x 5,5 mm, foot part for stapling, group 651

Gasket 10 is also in black EPDM rubber, V-shaped with foot part for stapling, cross-section 9 mm x 6,5 mm, group 651

Gasket 11 is made of black chloroprene rubber, P-shaped cross-section 6 mm high with foot part for stapling, group 651

Gasket 12 is also in black chloroprene rubber, V-shaped with foot part for stapling, height 7,5 mm, group 651

Gasket 13 has a P-shaped cross-section, is made of grey soft PVC, 8 mm high with a foot part for mounting in grooves, group 651

Gasket 14 is a double-extrusion in soft and hard PVC, V-shaped with a height of 7 mm and foot part for stapling, group 651.

Eleven of the gaskets were products intended to be used as air barrier in windows and doors, main application area No. I. This applies to the gaskets Nos. 1, 2, 6, 7, 8, 9, 10, 11, 12, 13 and 14. One single gasket, No. 3, was a typical product for use as air barrier in large panel wall systems etc. in application area No. II, while the remaining gaskets Nos. 4 and 5 were mounting strips for glazing, main application area No. III. No product for main application area No. IV, rain screen in joints with a two-stage seal, was included.

The 14 gaskets were all tested according to the relevant test programmes as given in the **Tables 13-16**, and the results evaluated according to the limits set for the individual properties in chapter 2.

6.2 Test results

The results from the prototype testing of the 14 gaskets have been summarized in the three **Tables 17-19**. For practical reasons, the presentation of results has to be limited to what can be concentrated into these three tables. They will however, give a sufficiently clear picture of the capacity of the individual gaskets.

6.3 Evaluation of the test results

Gasket No. 1

The open-cell sponge material in this 6 mm high gasket has to be given a high degree of compression, to about 25 % of the original height, to get an acceptably low air penetration. The forces needed to reach this compression is at an acceptable level, giving the gasket a deformation resistance rating of "good". The air penetration at the same compression is, however, as high as 2,7 m^3/mh, which is above the acceptable limit. After aging, a higher air penetration is accepted, giving the 6 mm high gasket a functional range from 1,1 mm to 1,4 mm. The gasket can consequently only be used in narrow and fairly stable joints.

The compression set of the same gasket is good to acceptable, the combustibility acceptable, the

Table 17
Test results for deformation resistance, stretch resistance, compression set and combustibility

Gasket number	Deformation resistance			Stretch resistance		Compression set				Combustibility		
	N 23 °C	N 5 °C	Lower functional limit, mm	% at 20 N	% at 40 N	70 °C 1 h	70 °C 24 h	23 °C 1 h	23 °C 24 h	Time s	Part mm	Speed mm/s
1	90	100	1,1			41	28	45	22	88	83	
2	80	120	2,8			67	62	23	11			4
3	330	580	9,0			7	0	15	1			0,4
4	310	400	4,0	0,35	0,7	32	19	16	8			0,5
5	330	370	3,2	0,5	0,9	68	39	51	10			2,4
6	41	56	2,7			12	8	23	15			1,0
7	43	49	2,9			14	11	9	5	77	14	
8	47	55	4,3			6	4	13	9	129	4	
9	39	40	2,5			37	26	16	5			0,4
10	16	19	3,2			15	10	15	10			0,4
11	115	128	3,2			29	16	13	9	45	15	
12	39	47	3,9			50	19	22	12	76	14	
13	70	75	4,8			69	68	18	8	108	31	
14	72	200	5,4			75	69	28	16			0,4

resistance to mineral spirit and alcohol acceptable, the staining risk low, the low temperature flexibility acceptable and the weather resistance acceptable. Altogether a gasket with limited applications, but an acceptable possibility for these limited applications.

Gasket No. 2

This 4 mm high gasket of mainly open-cell sponge is not easy to compress, but the deformation resistance is still on an acceptable level at 75 % of the original height. A deformation to 25 % of original height is not reached by acceptable forces. The compression set is above the acceptable level, the burning speed much to high, the air penetration low, the resistance to mineral spirit and alcohol not acceptable, the staining risk low, the low temperature flexibility acceptable, and the weather resistance acceptable. The functional range is calculated to be from 2,8 mm to 3,8 mm, but the results from other properties condemn this gasket as an unsuitable product.

Gasket No. 3

This asphalt impregnated open-cell sponge gasket is difficult to compress. The forces needed to reach the anticipated 25 % of the original height is above the acceptable level when the temperature is low. The weather resistance is not acceptable, and the air penetration after aging so high that the gasket will not have any calculable functional range at all. The other properties of the gasket are for this reason not interesting to evaluate.

Gasket No. 4

The closed-cell rubber material of this 5 mm high mounting strip for glazing is hard to compress to 75 % of the original height, but the deformation resistance of the gasket is just on the acceptable level. The stretch resistance is acceptable, the compression set good, the burning speed acceptable, the airtightness excellent, the water absorption acceptable, the rain penetration resistance in a drained glazing system excellent, the resistance to chemicals like mineral spirit acceptable, the low temperature flexibility acceptable, and the weather resistance good. Altogether a good gasket for strip glazing, with a functional range from 4,0 mm to 4,8 mm.

Gasket No. 5

The closed-cell rubber material of this 6 mm high mounting strip for glazing is also hard to compress to 75 % of the original height, but the deformation resistance is anyhow on an acceptable level. The stretch resistance is also acceptable, the compression set, however, too high, the burning speed too high, the air penetration very low, the water absorption acceptable, the rain penetration resistance in a drained glazing excellent, the resistance to mineral spirit acceptable, the low temperature flexibility acceptable and the weather

Table 18
Test results for air penetration, water absorption, rain penetration and resistance to chemical agents

Gasket number	Air penetration m^3/m h at normal compression	Water absorption % 24 h	7 d	28 d	Rain penetration	Resistance to solvents, salt spray, cleaning agents etc.
1	2,7 1)					Significant swelling in mineral spirit and alcohol 3)
2	0,8					Significant shrinkage in mineral spirit and alcohol
3	1,5					Asphalt impregnation dissolved in mineral spirit, partly also in alcohol and alcaline cleaning agent
4	0,2	5	7	12	No penetration only with a two-stage seal 2)	Significant swelling in mineral spirit, followed by a slight shrinkage on drying
5	0,2	7	17	22	No penetration only with a two-stage seal 2)	Noticeable swelling in mineral spirit
6	0,4	4	9	15		Noticeable swelling in mineral spirit, followed by shrinkage
7	0,3					Significant swelling in mineral spirit, reversible. Weight loss 3%
8	1,5					Significant swelling in mineral spirit, reversible. Weight loss 2%
9	0,3					Significant swelling in mineral spirit, followed by shrinkage. Weight loss 15%
10	2,4					Significant swelling in mineral spirit, followed by shrinkage. Weight loss 12%
11	0,3					Unsignificant swelling in mineral spirit, but marked shrinkage on drying. Weight loss 4%
12	2,0					Marked swelling in mineral spirit, and noticeable shrinkage on drying. Weight loss 3%
13	0,5					Only minor changes in mineral spirit
14	2,2					No significant changes in mineral spirit

Comments to Tables 18 and 19:

1) The air penetration diagrams are not shown, for practical reasons. The air penetration figures at normal compression have been taken from the diagrams for the different gaskets, prior to aging. The upper limit in the functional range from the diagrams after aging.

2) The rain penetration tests were carried out on two windows, size 1,2 m x 1,2 m. One was of the oldfashioned type with horizontal rebate without drainage, the other one with sloped bottom rebate and drainage under the bottom bead. The sealed glazing units were installed with the gasket to be tested, on both sides of the unit, and compressed about 20%. The corner joints were first made as tight as possible, later on with about 3 mm openings.

   I Non-drained rebate, perfectly tight corners: No leakage.

   II Drained rebate, perfectly tight corners: No leakage.

   III Non-drained rebate, about 3 mm openings in the bottom corner joints inside as well as outside: Water penetration in the corners after 2 minutes.

   IV Drained rebate, about 3 mm openings in the bottom corner joints inside as well as outside: A few droplets were following the air stream after one hour, but no real water penetration.

   The results show quite clearly that it is possible to have the gaskets jointed and compressed in such a way that the installation is impervious to driving rain immediately after the work has been finished. When openings in the corner joints do occur, however, due to imperfections or shrinkage on aging, it is only the properly drained rebates that will give an acceptable result.

3) Comments on resistance to chemicals are restricted to the tests where there were any noticeable changes.

Table 19
Test results for contact and migration stain, low temperature flexibility and weather resistance

Gasket number	Discolouration figure				Low temperature flexibility	Weather resistance		Upper functional limit, mm
	Contact stain		Migration stain			Free shrinkage %	Visible changes	
	Alkyd	PUR	Alkyd	PUR				
1	1	1	0	0	Test passed	2,6	Shrinkage 0,7%	1,4 1)
2	1	0	0	0	Test passed	2,4	Shrinkage 0,1%	3,8
3					Test passed	3,4	Shrinkage 1,4%	7,5
4					Test passed	0,6	Insignificant	4,8
5					Test passed	2,4	Shrinkage 0,3%	5,5
6	2	2	0	0	Test passed	2,0	Insignificant	5,0
7	1	1	0	0	Test passed	0,4	Insignificant	6.0
8	0	0	0	0	Test passed	0,4	Insignificant	6,5
9	2	2	1	1	Test passed	1,6	Insignificant	5,0
10	2	2	1	1	Test passed	1,3	Insignificant	5,5
11	2	1	1	1	Test passed	1.0	Insignificant	5,5
12	1	1	0	0	Test passed	1,2	Insignificant	6,5
13	1	1	0	0	Test passed	2,4	Shrinkage 0,4%. Gasket not stapled	4,5
14	1	1	0	0	Test passed	1,4	Insignificant	6,0

resistance acceptable. This product fulfilled the requirements in earlier test programmes, but is now coming out as not acceptable any longer, first of all due to more strict requirements to compression set.

Gasket No. 6

This tubular gasket of closed-cell sponge rubber is very easy to compress, giving a deformation resistance on the level excellent. The compression set is from excellent to good, the burning speed just acceptable, the airtightness excellent, the water absorption acceptable, the resistance to chemicals like mineral spirit acceptable, the staining risks acceptable, the low temperature flexibility acceptable and the weather resistance good. With a calculated functional range from 2,7 mm to 5,0 mm, this 5,5 mm high gasket turns out as a good one.

Gasket No. 7

This tubular gasket of silicone rubber is very easy to compress, giving a deformation resistance on the level excellent. The compression set is also on the level excellent, the combustibility acceptable, the airtightness excellent, the resistance to chemicals like mineral spirit acceptable, the staining risks on the level good, the low temperature flexibility acceptable and the weather resistance excellent. With a calculated functional range from 2,9 mm to 6,0 mm, this 6,5 mm high tubular gasket is definitely an excellent one.

Gasket No. 8

This V-shaped silicone rubber gasket is also easy to deform, giving a deformation resistance rating of excellent, the compression set is also on the level excellent, the combustibility acceptable, the air tightness acceptable, the resistance to chemicals like mineral spirit acceptable, the staining risks on the level excellent, the low temperature flexibility acceptable and the weather resistance excellent. The functional range of this 8 mm high gasket is from 4,3 mm to 6,5 mm, and the gasket obviously an excellent one.

Gasket No. 9

This tubular EPDM-rubber gasket is easy to compress, with a deformation resistance on the level excellent. The compression set is on the level good, the burning speed acceptable, the air tightness excellent, the resistance to mineral spirit not acceptable, the staining risks on the levels acceptable to good, the low temperature flexibility acceptable and the weather resistance good. The functional range of this 5,5 mm high gasket is calculated to be from 2,5 mm to 5,0 mm, but the use of this gasket should be restricted to applications where the gasket is not subjected to aggressive chemicals like mineral spirit.

Gasket No. 10

The V-shaped EPDM gasket is also easy to deform, giving a deformation resistance on the level excellent. The compression set for this gasket is excellent and the burning speed acceptable. The air penetration is, however, above the acceptable limit, due to concentrated leaks in the corner joints. The resistance to mineral spirit is also not acceptable, while the staining risks are acceptable to good, the low temperature flexibility acceptable and the weather resistance good. A higher air penetration is accepted for the gasket in aged condition, giving a calculated functional range from 3,2 mm to 5,5 mm. The application of this gasket should, however, be restricted to cases where it is not subjected to aggressive chemicals like mineral spirit.

Gasket No. 11

This tubular chloroprene rubber gasket is more difficult to compress than the alternative EPDM rubber gasket No. 9, due to higher material thickness in the tubular part. Anyhow, the deformation resistance is on an acceptable level. The compression set is on the level excellent, the combustibility acceptable, the airtightness excellent, the resistance to mineral spirit good, the staining risks acceptable to good, the low temperature flexibility acceptable and the weather resistance good. This 6 mm high gasket has a functional range from 3,2 mm to 5,5 mm, and is a good one.

Gasket No. 12

The alternative V-shaped chloroprene rubber gasket is more easy to deform, with a deformation resistance on the level excellent. The compression set is on the level acceptable to good, the combustibility acceptable, the air penetration just on the acceptable limit, the resistance to mineral spirit good, the staining risks on a level from good to excellent, the low temperature flexibility acceptable and the weather resistance good. The 7,5 mm high V-shaped gasket has a functional range from 3,9 mm to 6,5 mm, and is also a good alternative.

Gasket No. 13

This 8,5 mm high PVC gasket for mounting in grooves is fairly easy to deform, with a deformation resistance on the level good. The compression set at higher temperatures is, however, above the acceptable limit. The combustibility is acceptable, the airtightness excellent in the initial state, the resistance to chemicals like mineral spirit good, the staining risks very low, the low temperature flexibility acceptable, but the weather resistance not acceptable. The shrinkage of the gasket in the grooves leaves the gasket with no functional range at all. This, in combination with the high compression set mentioned, makes this gasket an unacceptable one.

Gasket No. 14

The V-shaped PVC double-extrusion is also hard to deform, but the deformation resistance is just acceptable at the lower temperature test level. The compression set is, however, also for this gasket above the acceptable level at the higher test temperature. The burning speed is acceptable and the air penetration just above the acceptable level in the initial state. The resistance to chemicals like mineral spirit is good, the staining risks very low, the low temperature flexibility acceptable and the weather resistance good. The functional range of this 7 mm high gasket can be calculated to be from 5,4 mm to 6,0 mm, but the high compression set at the high temperature level makes also this gasket unacceptable.

6.4 Concluding remarks to the prototype testing of selected gaskets

A closer study of the results from the prototype testing of the 14 different types of selected gaskets will reveal that the gaskets come out of the tests with different results. For some of them the results are good, for others moderate or even poor.

The samples were all collected on the open market in 1983, and represent only commercially available products. Some of them have later been replaced by modified new and improved versions. Anyhow, the products tested should be representative also for the gaskets available on the Norwegian market in 1988. The test programmes have prooved that they are able to differentiate between the different types and qualities of building gaskets, and the results also seem to be in good agreement with the available practical experiences.

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8 Appendix

Norwegian Building Research Institute Test Methods for Building Gaskets

1 SCOPE

This test method is used to find out if a building gasket has a sufficiently low resistance to deformation when it is installed or during actual use. Building gaskets always have a certain size and shape in unmounted condition; they have a closely defined cross section. The sealing function is based on its ability to take certain elastic deformations. For this reason, the gasket must be able to be compressed or deformed to the right degree with reasonably heavy loads.

2 FIELD OF APPLICATION

The method can be used for all types of building gaskets, particularly those intended to be used as air seal between sash and frame in windows and doors. For gaskets with particularly complicated cross sections, modifications in the test method may be necessary.

3 REFERENCES

Margrete Dalaker: Building Gaskets. Norwegian Building Research Institute, Report No. 40, 1964 (In Norwegian).

Tore Gjelsvik: Building Gaskets. AB Svensk Byggtjänst, Report No. 11, 1983 (In Swedish).

This test method was first developed by the Norwegian Building Research Institute in 1959. It has been modified and improved several times over the years. It was adopted as NORDTEST method NT BUILD 108 in September 1979.

4 DEFINITIONS

None

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 Principle

The gasket is compressed or deformed, and the deformation recorded as a function of the deformation force.

6.2 Apparatus and Materials

Flat square base plate 0,25 m x 0,25 m.

Measuring device, dial gage or similar, mounted in the centre of the base plate.

Four mounting supports, 125 mm long each.

Flat square acrylic plastics plate, 0,15 m x 0,15 m, weight approx. 0,05 kg (50 g).

Flat square metal plates, 0,2 m x 0,2 m, five of 1 kg each, five of 2 kg each and two of 5 kg each.

Closed cabinet conditioned at 278 K (5 °C).

6.3 Preparation and Conditioning of Test Specimens

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

Four pieces of gasket, 125 mm long each, are cut for each test temperature to be used.

6.4 Procedure

The test apparatus and the 125 mm long pieces of gasket are reconditioned at 296 K (23 °C) and 50% RH.

Four of the test pieces are mounted on the four mounting supports, and these are subsequently placed on the flat base plate. The assembly is made to form a square, and assymetrical gaskets are placed with the same side towards the centre of the plate.

The measuring device is calibrated to read the height of the gasket from the top of the mounting supports.

The gasket assembly is loaded with the 0,05 kg plastics plate and the measuring device read after 60 seconds.

The assembly is subsequently loaded with the metal plates, one at a time, and a new reading taken every time after 60 seconds. The loading is interrupted when the deformation has reached a sufficiently high level.

The same procedure is repeated with four new pieces of gasket at a temperature of 278 K (5 °C).

The same procedure may also be repeated with another four new pieces of gasket at another temperature, if agreed.

6.5 Expression of Results

The deformation read is expressed as a function of the deformation force exerted on the gasket. This is shown by means of a diagram with one curve for each temperature the gasket was tested. From this diagram the following information is taken out:

- The deformation force needed to deform one meter of the gasket to a certain point. Normally this point is at 25% deformation. The deformation force is given for 296 K (23 °C) as well as 278 K (5 °C) and other possible test temperatures
- The lower limit in the functional range, dependent upon the maximum force acceptable for various applications.

6.6 Accuracy

The difficult point is to establish the starting point of the deformation curve at the beginning of the test. The height or thickness of a gasket is not always uniform, and may vary over the length. The initial loading with the 0,05 kg plastics sheet will level out most of the minor variations without exerting any major deformation force. In spite of this, it is usually adviceable to extend the deformation diagram to zero load.

The rest of the loading test is more easily carried out. Care should be taken, however, to centre all loads, as this is necessary to obtain the same deformation throughout the full length of gasket.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

BYGGFORSK

Building Gaskets
Compression Set

NBI-72
1988

1 SCOPE

This test method has been developed to make it possible to study the degree of permanent deformation a gasket will get when it is kept compressed or deformed over time. Building gaskets base their function on an elastic deformation, and must consequently have a high degree of elasticity. If the permanent deformation is too large, that is to say if the degree of plasticity is too high compared with the elasticity, the gaskets may not be able to follow the changes in joint width. In special cases, they may even fall out of the joints.

2 FIELD OF APPLICATION

The method can be used for all types of building gaskets, particularly those intended to be used as air seal between sash and frame in windows and doors. For gaskets with particularly complicated cross sections, modifications in the test method may be necessary.

3 REFERENCES

Margrete Dalaker: Building Gaskets. Norwegian Building Research Institute, Report No. 40, 1964 (In Norwegian).

Tore Gjelsvik: Building Gaskets. AB Svensk Byggtjänst, Report No. 11, 1983 (In Swedish).

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This test method is based on the fundamental studies of building gaskets at the Norwegian Building Research Institute in the years 1959-63. It has been modified and improved several times over the years. It was adopted as NORDTEST method NT BUILD 109 in September 1979.

4 DEFINITIONS

None.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 **Principle**

The gasket is kept compressed or deformed under closely controlled conditions for a specified time. The height is measured before the test, during the deformation as well as at certain points of time after unloading. Figures for compression set are calculated from the measurements.

6.2 **Apparatus and Materials**

At least four flat rectangular stiff plates 0,1 m x 0,1 m, made of a suitable material as for instance metal or plywood.

A wide selection of metal distance pieces in different thicknesses.

Optical measuring device for gasket height measurements, measuring accuracy 0,01 mm or better.

Metal clips or weights of different sizes.

Ventilated heating cabinet.

6.3 **Preparation and Conditioning of Test Specimens**

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

Two pieces of gasket, 100 mm long each, are cut for each test temperature to be used.

6.4 **Procedure**

The test apparatus and the 100 mm long pieces of gasket are reconditioned at 296 K (23 °C) and 50% RH.

Two of the test pieces are mounted on one of the flat stiff plates in a way specified or approved by the manufacturer. The height or thichness of the gasket in the unloaded state is measured with the optical device at three points on each piece of gasket, six points altogether. The measuring points should be located at least 20 mm from the ends of the 100 mm long pieces, and also at least 20 mm from each other.

The gaskets are compressed to the desired thickness by means of another flat plate, the distance pieces and the clips or weights. The compressed height of the gaskets should be as follows:

- approx. 25% of the original height for gaskets of open-cell sponge, group 63
- approx. 75% of the original height for gaskets of closed-cell sponge, group 64
- approx. 75% of the original height for gaskets of solid rubber, plastics etc., group 65.

The height of the compressed gaskets is checked at the same six measuring points used to measure the height in the unloaded state.

The test assembly with the compressed gaskets is stored for 24 hours at 343 K (70 °C). At the end of this period, the test assembly is removed from the heating cabinet, the loads removed and the gaskets permitted to cool off at a temperature of 296 K (23 °C). The height of the gaskets is remeasured one hour and 24 hours after unloading.

A second test assembly with two new pieces of gasket is prepared in the same way as indicated in the previous sections. This test assembly is stored for 168 hours at a temperature of 296 K (23 °C). The load is removed at this temperature and the sample maintained at the same conditions. The height is remeasured one hour and 24 hours after the load has been removed.

Additional tests may be carried out with new test assemblies prepared in the same way, and other test conditions. Suggested alternative test temperatures are 233 K (-40 °C), 248 K (-25 °C), 263 K (-10°C), 273 K (0°C) and 328 K (55 °C). Suggested relaxation temperature 296 K (23 °C).

6.5 Expression of Results

Mean values of the measurements are worked out for the original height of the samples (h_1), the compressed height (h_2) and the height one hour after the load has been removed (h_3), alternatively 24 hours. All figures are given in mm with at least two decimals. The compression set is calculated as

$$100 \frac{h_1 - h_3}{h_1 - h_2} \%$$

The result is given as whole numbers at 343/296 K (70/23 °C) and one hour and 24 hours, respectively at 296 K (23 °C) and one and 24 hours. Thus a total of four figures is given.

The results of possible additional measurements at other conditions than those specified are given the same way, clearly indicating the temperatures and times used.

6.6 Accuracy

In earlier days, when a slide rule or similar simple device was used to measure the height of the gaskets, the measuring accuracy was not always as good as it should be. With the optical measuring device, the accuracy is exellent.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

BYGGFORSK

Building Gaskets Combustibility

NBI-73
1988

1 SCOPE

This test method is intended to give a comparative evaluation of the combustibility of building gaskets.

2 FIELD OF APPLICATION

The test can be used for all types of gasket.

3 REFERENCES

Test method NBI-51, 1987: Building Sealants. Combustibility.

This test method was developed by the Norwegian Building Research Institute in the early 1970's. It was adopted as NORDTEST method NT BUILD 105 in March 1979.

4 DEFINITIONS

Observations are made to study if a material is ignited, and if so, in which way it is burning. The materials are judged in the following way:

- Non-combustible according to the method, if they do not burn after two ignition attempts of 30 seconds each
- Self-extinguishing according to the method, if the specimen is extinguished before the flame has reached a mark 125 mm from the end. The burnt part is measured as 125 mm minus the unburnt length, measured along the lower edge of the specimen. The time from removal of the flame until the specimen is extinguished is noted as the burning time
- Combustible according to the method, if the specimen burns to the 125 mm mark. The burning speed is calculated from the time the flame front is using from a first to a second mark, observed at the lower edge of the specimen.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 Principle

The gaskets are exposed to the heat from the open flame of a propane burner. The non-combustibility, the possible self-extinguishing characteristics or a clear combustibility as defined in point 4, is noted.

6.2 Apparatus and Materials

Ventilated test cabinet, suitable to provide for draft-free conditions during the testing.

Adjustable stand for horizontal positioning of a metal net with a mesh size of about 10 mm.

Propane burner, 10 mm Ø.

6.3 Preparation and Conditioning of Test Specimens

The building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

Three test pieces should be cut to lengths of 150 mm each.

6.4 Procedure

The test apparatus and the 150 mm long pieces of gasket are reconditioned at 296 K (23 °C) and 50% RH.

Each one of the test pieces is marked 25 mm from either end. One piece at a time is placed on the metal net with one end flush with the edge of the net.

The gasket is ignited with a 25 mm blue flame of the propane burner, as decribed in test method NBI-51.

6.5 Expression of Results

State whether the material has been found non-combustible, self-extinguishing or combustible, and if relevant, also the observed burning time, burnt part or burning speed. Mean values are used, if the specimens do not behave so differently that they belong to different classes. In such a case the results are given separately for each specimen.

6.6 Accuracy

The method is sensible to drafts, which should be avoided.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

1 SCOPE

This test method is used to measure the air penetration through a building gasket when it is squeezed between two flat surfaces.

2 FIELD OF APPLICATION

The method can be used for all types of building gaskets, but is specially suitable for those intended to be used as air seal between sash and frame in windows and doors. For gaskets used as a rain barrier, the air tightness of the gasket is less critical, but even here it is favourable with a gasket with an air penetration on a low level.

For gaskets with particularly complicated cross sections, modifications in the test method may be necessary.

3 REFERENCES

Margrete Dalaker: Building Gaskets. Norwegian Building Research Institute, Report No. 40, 1964 (In Norwegian).

Tore Gjelsvik: Building Gaskets. AB Svensk Byggtjänst, Report No. 11, 1983 (In Swedish).

This test method was first developed by the Norwegian Building Reseach Institute in 1959. It has been modified and improved several times over the years. It was adopted as NORDTEST method NT BUILD 110 in September 1979.

4 DEFINITIONS

None

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 **Principle**

A special test assembly is prepared, and the air penetration of this assembly measured at different degrees of deformation of the gasket and at specified air pressure differences.

6.2 **Apparatus and Materials**

Flat stiff rectangular plates approx. 0,12 m x 0,45 m each, made from a suitable material, for instance aluminium or float glass.

Apparatus for measuring the rate of air penetration at superpressures up to 700 Pa.

Flat metal plates 0,12m x 0,45 m, ten of 5 kg each.

Metal distance pieces of different sizes.

Optical measuring device for gasket height measurements.

6.3 **Preparation and Conditioning of Test Specimens**

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

For the air penetration test, a test piece of the gasket is cut to a length of 1,00 m.

6.4 **Procedure**

The test apparatus and the 1,00 m long gasket are reconditioned at 296 K (23 °C). The gasket is shaped into a closed loop with external dimensions approximately 75 mm x 425 mm, and fastened and jointed as recommended by the manufacturer. Usually the test assembly will have four normal corner joints. The height of the gasket is measured with the optical measuring device.

The test assembly is mounted in the special apparatus for air penetration measurement. The gasket is compressed or deformed to the desired thickness by using the weights and the distance pieces. The air flow is measured in m^3/h at a superpressure of 700 Pa and different degrees of deformation of the gasket. The actual degree of deformation is determined individually in every single case, but the gaskets should normally be compressed at least to:

- 25% of the original height for gaskets made of open-cell material, group 63
- 75% of the original height for gaskets made of closed-cell material, group 64

- 75% of the original height for gaskets made of solid rubber etc, group 65.

The number of measuring points should not be less than three, and in any case high enough to ensure a reliable test result.

Spot leaks are localized, for instance with a smoke gun.

The procedure described in the previous sections is repeated on the same test assembly with the corner joints sealed with putty or similar material. This is done to separate the corner leaks from the leaks through the gasket itself.

The testing can also be carried out at other superpressures than 700 Pa, for instance 50, 300 and 500 Pa, but testing at the lower superpressures is not compulsory.

6.5 Expression of Results

The measurements are giving results for air penetration at a specific superpressure and different degrees of deformation of the gasket, with four normal corner joints as well as with sealed corner joints. Based on the measurements, the air penetration is recalculated to express the average air flow in m^3/mh through four meters of gasket and four corner joints. The air flow figure does then represent one meter of gasket with one normal joint.

The results are presented in a diagram showing the air penetration as a function of the deformation of the gasket. If more than one superpressure is used, there will be one curve for each superpressure. Any marked spot leaks and any other observations of importance should be given separately. The way the corner joints were made has to be clearly specified.

6.6 Accuracy

The greatest problem is to make up the test assembly in such a way that it represents a reliable model, that is to say, to shape the gasket as described under point 6.4. If only this matter is solved in a reasonable way, the actual testing described under the same point should present no difficulties, and should be possible to carry out with great accuracy.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

Building Gaskets
Resistance to Solvents, Salt Spray, Cleaning Agents and Other Chemicals

BYGGFORSK

NBI-75
1988

1 SCOPE

This test method is used to check if gaskets are sufficiently resistant to solvents, salt spray, cleaning agents etc. Gaskets may come into contact with chemicals like this, at least periodically. The method is **not** intended for studying the chemical resistance of gaskets on long time exposure, for instance to organic acids.

2 FIELD OF APPLICATION

The method can be used for all types of gasket which are subjected to the influence of solvents, salt spray, cleaning agents or other chemicals periodically during normal use.

3 REFERENCES

NBI-53, 1987, Building Sealants. Resistance to Solvents, Salt Spray, Cleaning Agents and Other Chemicals.

This test method was developed by the Norwegian Building Research Institute in the early 1970's. It was adopted as NORDTEST method NT BUILD 111 in September 1979.

4 DEFINITIONS

Acceptable resistance to the influence of agents as indicated in point 1 is present if no significant change in the condition of the gasket can be observed at the end of the test.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 Principle

The gaskets are subjected to the influence of solvents and chemical agents under controlled conditions. Any visual changes are recorded. The specimens may also be weighed and the dimensions measured, as agreed.

6.2 Apparatus and Materials

Hooks or similar devices for the suspension of the test pieces.

Glass beakers, Ø > 60 mm.

Slide rule or similar measuring device, readable to 0,1 mm.

Balance, measuring accuracy 10^{-6} kg (1 mg).

6.3 Preparation and Conditioning of Test Specimens

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

One piece of gasket, 100 mm long, is cut for each of the chemical agents to be used in the testing.

6.4 Procedure

The test apparatus and the 100 mm long pieces of gasket are reconditioned at 296 K (23 °) and 50% RH.

Each piece of gasket is attached to a hook or similar device. The different solvents etc are poured into the glass beakers, one for each of them, to a depth of about 50 mm. A specimen is put into each beaker so that the lower half is immersed. After about 300 s (5 min) the samples are taken up again and stored almost horizontally with the dipped end in the lower position. The immersion is carried out four times a day with intervals of 2 hours during a total of 5 days. Normally, the gaskets are tested in 4% salt water, mineral spirit mixture of 70% isooctane and 30% toluene, 96% ketone alcohol and an alcaline cleaning agent. Other types of chemicals may be used if desired.

The specimens are inspected at regular intervals and any visble changes noted. The specimens are weighed and the dimensions measured as agreed, and possible changes given.

6.5 Expression of Results

Any visible changes are given. Changes in weight and dimensions are given as agreed.

6.6 Accuracy

The method is simple and reliable. Of cource there may be some problems with the visual inspection, but experienced observers seem to have no problems. Measurements of weight and dimensions are usually more difficult to carry out, and are for this reason not compulsory.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

1 SCOPE

This test method may be used to obtain information about the possible changes in the functional properties of a building gasket when it is subjected to weathering.

A building gasket has to be able to seal properly, even in aged condition. It must not shrink too much, otherwise the result may be openings in the corner joints etc. Possible exudation of plasticizer and a sticky surface are also unwanted results. The gasket itself must of course maintain its properties to seal against air penetration over a long period of time.

For practical reasons, the weather resistance is tested by accelerated weathering in the laboratory.

2 FIELD OF APPLICATION

The method can be used for all types of building gaskets. For gaskets with particularly complicated cross sections, modifications in the test method may be necessary.

3 REFERENCES

Test method NBI-74, 1988: Building Gaskets. Air Penetration.

Test method NBI-83, 1988: Building Materials and Components for Exterior Walls etc. Weather Resistance, Cyclic Short Time Test.

4 DEFINITIONS

None.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 **Principle**

The method is based on measurements of air penetration and dimensions, as well as visual observations, on a specially made test assembly before and after accelerated weathering. Measurements and observations are also made on an additional length of gasket hanging free in the accelerated weathering apparatus.

6.2 **Apparatus and Materials**

Equipment for air penetration testing of building gaskets according to test method NBI-74, 1988.

Equipment for accelerated weathering of building materials and components according to test method NBI-83, 1988.

6.3 **Preparation and Conditioning of Test Specimens**

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

For the air penetration test, a test piece of the gasket is cut to a length of 1,00 m. A second piece, 0,5 m long, is used for the free exposure.

6.4 **Procedure**

A test assembly for air penetration measurements is produced as described in test method NBI-74, 1988. In practice, the same test assembly is used. The air penetration measurements are carried out, and the gasket dimensions measured as far as possible.

The test assembly is then mounted in the special test equipment for accelerated weathering of building materials and components at the Norwegian Building Research Institute.

The 0,5 m long additional sample of gasket is weighed and measured, and mounted freely in the same equipment.

Both samples are exposed for the agreed period of time. Usually this is 112 days for gaskets exposed to the outdoor climate in practical use and 56 days for gaskets used in more sheltered locations. Other testing times may be agreed.

At the end of the accelerated weathering, the test pieces are taken out and inspected and measured again. This may also be done at other points of time, if agreed.

6.5 Expression of Results

All possible visible changes occuring during the accelerated weathering are given as a result. The same applies to possible changes in weight and dimensions, as well as in air penetration of the specially made test assembly.

6.6 Accuracy

The accuracy of this test is very good.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

Building Materials and Components for Exterior Walls etc. Weather Resistance, Cyclic Short Time Test

BYGGFORSK

NBI-83
1988

1 SCOPE

This test method has been specially designed to study the influence of outdoor climate on the performance of materials and components used in exterior walls etc. For practical reasons, the weather resistance is studied by accelerated testing in a special apparatus in the laboratory.

2 FIELD OF APPLICATION

The test method can basically be used for all types of materials and components in the exterior envelope of a building, first of all in exterior walls, but also, to some extent, in roofs etc. The test apparatus and the test cycle used is always the same, but the duration of the exposure and the details in the test procedure have to be considered separately in every single case.

3 REFERENCES

Tore Gjelsvik: Large Scale Test Facilities for Durability Studies in Scandinavia. Norwegian Building Research Institute, Report No. 97, 1985.

4 DEFINITIONS

The weather resistance of building materials and components has to be described in different ways according to the types of materials and components and their intended functions in the exterior envelope. Usually it is described as the changes occuring during the exposure or lack of changes. The possible changes can be fissures, cracks or other types of visual damage, loss of gloss or colour changes, changes in weight and dimensions, changes in the mechanical properties etc.

5 SAMPLING

Unless otherwise agreed, the manufacturer of the materials or components to be tested, has to supply the quantities necessary for the test, together with a sufficiently detailed description of the products and their intended use. The samples shall be sufficiently large to be representative of the products.

6 TEST METHOD

6.1 **Principle**

The samples to be tested are mounted in a special apparatus for accelerated weather resistance testing and exposed to an artificial weathering cycle for an agreed period of time. The weather resistance is found from the detectable changes in the visual characteristics and measurable properties.

6.2 **Apparatus and Materials**

A special apparatus for accelerated weather resistance testing of building materials and components according to the Norwegian Building Research Institute. The basic features are shown on **Fig. 1.**

The apparatus consists of a circular chamber (E) and three fixed boxes for the climatic strains (A, B and C). The central chamber (E) has four test frames of at least one by one meter each. On Fig.1 these are marked 1, 2, 3 and 4. Usually the test frames are shaped as niches with a closed bottom insulated behind with 50 mm mineral wool. In the test frames or openings the materials and components to be tested are mounted on brackets with hooks, clips, pins or similar. The central chamber is most of the time fixed in a resting position, but is with certain intervals of time moved a quarter turn (90°). The test openings and the samples are in that way subjected to the following test cycle:

A Radiation from sun lights lamps of the type Osram Ultra Vitalux GUR 53 300 W or similar and simultaneous heating to an elevated temperature. Radiation intensity 1900 W/m^2 (input).

B Wetting with a spray of demineralized water, 15 ± 2 liters per square meter and hour at a temperature of 291 ± 5 K (18 ± 5 °C).

C Cooling and freezing to a temperature of 253 ± 5 K (-20 ± 5 °C).

D Thawing at room temperature 296 ± 2 K (23 ± 2 °C) and 40 ± 10% RH, with possibilites for inspecting and changing the samples without stopping the test apparatus.

Usually the resting time in each position is set at one hour. This gives a maximum black panel temperature of 348 ± 5 K (75 ± 5 °C) in

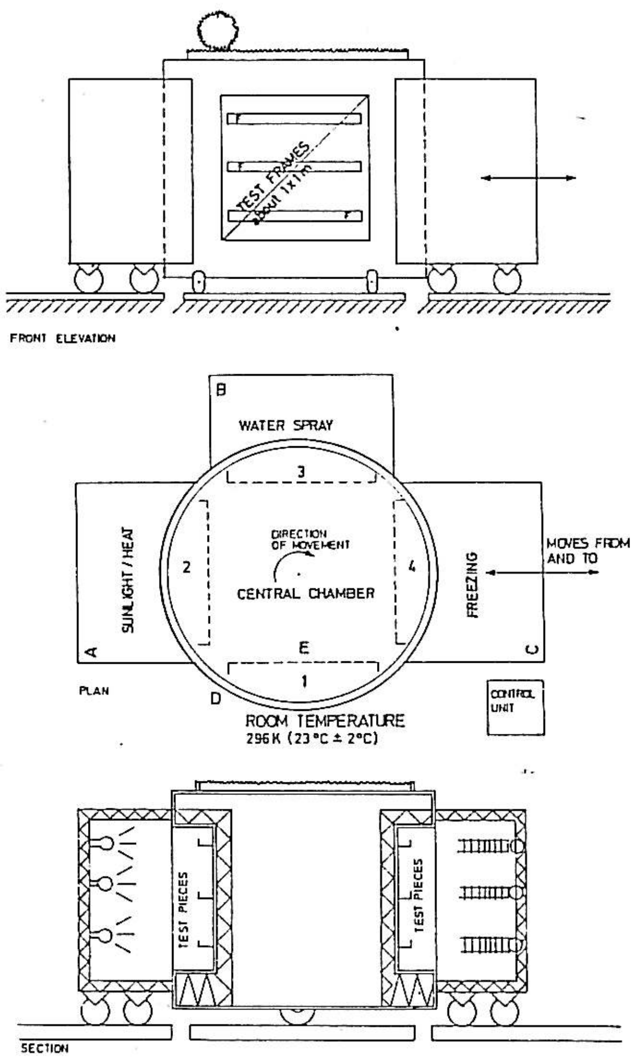

Fig. 1. Drawing of a typical aging apparatus according to this test method.

position A, and a total time of four hours for each full cycle. The apparatus is operating continuously.

The times given can be changed, as the resting time in each position can be adjusted from ten minutes to six hours, but this is usually not done.

The size of the test specimens can be selected freely within a maximum size permitted by the test apparatus. For the time being (1988), apparatus is available to accomodate samples up to 0,9 m x 0,9 m and 1,5 m x 2,5 m respectively.

In addition to the special apparatus for accelerated weathering, it is necessary to have other types of equipment to check the interesting properties of the materials and components to be tested, depending upon what is under test and which properties are interesting.

6.3 Preparation and Conditioning of Test Specimens

The test specimens are prepared as specified and agreed. The details of the preparation has to be considered separately in every single case.

6.4 Procedure

The test specimens are mounted in the apparatus as prescribed. The exposure time will depend upon the type of material or component to be tested. Testing periods of 56 and 112 days are normal, but the testing time can also be as short as 10 days or as long as 336 days or more.

The test specimens are inspected at regular intervals and observations and measurements carried out according to the programme.

6.5 Expression of Results

As a result of the test, any visual or measureable changes are given. The changes can be visual observations, loss of gloss, colour changes, sweating, sagging, changes in weight and dimensions, changes in mechanical properties a.s.o.

6.6 Accuracy

All kinds of accelerated aging tests involve a certain degree of uncertainty, and the results have to be considered with care. The test method and apparatus described have, however, been used for more than 20 years, and the results seem promising.

The interesting point is of course the acceleration factor, the figure to be used for calculating from accelerated testing to natural aging. This factor will depend upon what kind of material or component which is tested and the actual type of outdoor climate to compare with. Usually the acceleration factor is from 12 to 15 times when the normal cycle as described is used. In any case, the information provided by this test method is considered to give valuable indications.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

BYGGFORSK

Building Gaskets
Water Absorption

NBI-102
1988

1 SCOPE

This test method has been developed to check the water absorption of building gaskets. Some gasket materials may absorb water if they come into contact with driving rain or condensation. In such cases it is interesting to know the degree and rate of absorption, as well as possible changes in dimensions, hardness etc.

2 FIELD OF APPLICATION

The method can be used for all types of building gaskets, but is first of all interesting for gaskets made of closed-cell materials.

3 REFERENCES

DIN53495. Testing of Plastics. Determination of Water Absorption by Storage in Cold Water, Procedure C and CL (In German).

This test method is based on DIN 53495. It was adopted at NORDTEST method NT BUILD 106 in March 1979.

4 DEFINITIONS

None.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 Principle

A piece of gasket is submerged in water at room temperature for a given time under closely controlled conditions. Any changes in weight, dimensions, colour or other visual characteristics are noted.

6.2 Apparatus and Materials

Three glass beakers, Ø > 60 mm.

Slide rule or similar measuring device, readable to 0,1 mm.

Balance, measuring accuracy 10^{-6} kg (1 mg).

Metal net or similar.

6.3 Preparation and Conditioning of Test Specimens

Building gaskets are supplied as products ready to use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

Three pieces should be cut to a length of 50 mm each.

6.4 Procedure

The test apparatus and the 50 mm long pieces of gasket are reconditioned at 296 K (23 °C) and 50% RH.

The three pieces of gasket are visually inspected, weighed and measured. The three beakers are filled with distilled or deionized water with a temperature of 296 K (23 °C) to a level about 75 mm. One piece of gasket is entirely submerged in each beaker. Gaskets with a tendency to float up are kept down by means of the metal net or similar device.

After periods of 24 hours, 7 days and 28 days, the test pieces are removed from the beakers and carefully dried with blotting paper or similar. They are then visually inspected again, weighed and measured. The water in the beakers is inspected for any discolouration, smell or other noticeable changes.

6.5 Expression of Results

The weight change is expressed as per cent of the starting weight of the gasket. Any changes in dimensions are expressed in a similar way. All visible changes as change in colour, bubbles or cracks in the surface of the gaskets as well as changes in the water in the beakers, are decribed as far as possible.

6.6 Accuracy

The method is simple and reliable.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

Building Gaskets
Rain Penetration

1 SCOPE

This test method is used to study the ability of a building gasket to seal against driving rain in a joint.

2 FIELD OF APPLICATION

The method may be used for all types of building gasket intended to be used as rain barriers in joints in buildings. The ability of a gasket to seal against driving rain is, however, dependent on a number of details in the construction where the gasket is used. A driving rain test can consequently only be carried out when a sufficiently detailed joint design is available.

3 REFERENCES

Test method NBI-93, 1983: Exterior Walls (Windows, Doors, Facades etc.). Driving Rain Testing with Pulsating Air Pressure (In Norwegian.)

NORDTEST method NT BUILD 116, Water Resistance Test with Pulsating Air Pressure Against Windows, Windowdoors, Facades etc.

This test method is based on long time experience at the Norwegian Building Research Institute. It was adopted as NORDTEST method NT BUILD 107 i March 1979.

4 DEFINITIONS

None

5 SAMPLING

Unless otherwise agreed, the materials to be tested is supplied by the sponsor of the test. The samples shall be sufficiently large to be representative of the gaskets to be tested.

6 METHOD OF TEST

6.1 Principle

It is almost impossible to give a detailed general description of a rain penetration test on a building gasket. The general test method referred to should be used as a basis, and modifications introduced to adapt the method to the types of gasket to be tested. The actual test method is a functional test where the gaskets are used in a specific construction.

6.2 Apparatus and Materials

Driving rain test apparatus as described in test method NBI-93, equal to NORDTEST method NT BUILD 116.

6.3 Preparation and Conditioning of Test Specimens

The test pieces and test assembly are prepared according to the principles described in point 6.1.

6.4 Procedure

The testing is carried out as described in test method NBI-93, with the modifications that might be necessary for the specific types of gasket to be used.

6.5 Expression of Results

The results are given as stated in test method NBI-93, 1983.

6.6 Accuracy

No comments.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

BYGGFORSK

Building Gaskets
Contact and Migration Stain

NBI-104
1988

1 SCOPE

This test method is used to study the risks of staining involved in contact between a building gasket and painted or varnished surfaces, plastic coatings or similar. In openable windows, for instance, discolouration of the paint or varnish is usually considered as unwanted. Physical and/or chemical reactions may also occur, resulting in exudations and sticky surfaces.

2 FIELD OF APPLICATION

The method can be used for all types of building gaskets, particularly those intended to be used as air seal between sash and frame in windows and doors.

3 REFERENCES

ISO 3865. Rubber, Vulcanized - Methods of Test for Staining in Contact with Organic Material. First Edition 1977.01.15.

This test method is based on ISO 3865, method A. It was adopted as NORDTEST method NT BUILD 112 in September 1979.

4 DEFINITIONS

Contact stain is a staining occuring in the contact area when a gasket is pressed against a substrate at an elevated temperature.

Migration stain is a staining occuring outside the contact area, in some cases visible only after ultraviolet radiation.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 METHOD OF TEST

6.1 Principle

A sample of the gasket is kept in contact with a specified substrate under closely controlled conditions, and the possible unwanted reactions studied and recorded.

6.2 Apparatus and Materials

Stiff flat plates 75 mm x 100 mm.

Ventilated heating cabinet.

Loads to exert pressure on the test pieces.

Light box with inside dimensions 750 mm x 750 mm x at least 460 mm, painted white inside.

A thermocouple and equipment for temperature measurements.

Sun light lamps of the type Osram Ultra Vitalux GUR 53 300 W or similar, with radiation in the range 0,28 µ - 5,0 µ.

6.3 Preparation and Conditioning of Test Specimens

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

For the staining tests, two 60 mm long pieces of gasket are cut for each type of paint or varnish to be tested.

6.4 Procedure

Each type of paint or varnish to be tested is applied to two flat plates of the type described in point 6.2. The plates should be made from a material which does not react with the paint or varnish to be used. The surface coatings are applied to the plates according to the instructions given by the manufacturers.

Usually a semi-glossy white alkyd paint and a glossy white polyurethane paint are used, but other types of paint may be used as agreed.

The apparatus and materials are conditioned at 296 K (23 °C) and 50% RH.

One test assembly is prepared for each type of paint or varnish to be tested. Two 60 mm long pieces of gasket are placed on one of the painted surfaces, spaced about 40 mm and with the ends about 20 mm from the edges of the plate. The second painted or varnished surface is then put on top of the first one and the assembly loaded with a weight sufficient to produce a pressure of 100 N per metre gasket. The whole assembly is placed in the heating cabinet at at temperature of 343 ± 2 K (70 ± 2 °C). It is important to secure that there is no foreign matter in the heating cabinet which can produce vapours that may influence the possibility of discolouration.

After 24 hours, the samples are removed from the cabinet and cooled to a temperature of 296 K (+23 °C).

One plate is then washed with mild soapwater. Those parts of the painted plate which have been in direct contact with the gasket are inspected for contact stain and the neighbouring areas for migration stain.

Any discolouration is evaluated according to the following scale:

0 = no discolouration

1 = faint discolouration

2 = moderate discolouration

3 = heavy discolouration

Any other noticeable changes are recorded, e.g. if the gasket has adhered to the paint or varnish.

The other plate, the one without the gaskets, is placed with the painted or varnished side up and radially in the light box within two concentric circles of 90 and 300 mm diameters. The centre point of the two circles should be directly on the centre point of the bottom and the sun light lamp directly over this point.

The distance between the lamp and the samples is adjusted so that the temperature measured with the thermocouple is 333 ± 15 K (60 ± 15 °C).

For self-adhesive gaskets, both plates are tested.

The samples are exposed to radiation for 8 hours. During this period the temperature in the cabinet should be 333 ± 15 K (60 ± 15 °C) as measured with the thermocouple. After cooling to room temperature, the painted surface is washed with mild soapwater and inspected for any signs of discolouration. This is recorded and evaluated in the usual way.

6.5 Expression of Results

The degree of discoluration is given, as well as any other visual changes.

6.6 Accuracy

No comments.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

1 SCOPE

This test method is used to study a possible unwanted stretching of reinforced self-adhesive gaskets during mounting. The method may also be used for other types of reinforced gaskets.

2 FIELD OF APPLICATION

The test method may be used for all kinds of reinforced gaskets.

3 REFERENCES

SS 81 81 34 (In Swedish).

4 DEFINITIONS

None.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 TEST METHOD

6.1 Principle

A piece of the gasket is stretched, and the elongation measured at different force levels up to a maximum force of 40 N.

6.2 Apparatus and Materials

Universal tensile testing machine or similar device, able to produce loads of 5 N, 20 N and 40 N respectively.

Equipment for measuring the elongation of a 500 mm long piece of gasket with an accuracy of 0,1 mm.

6.3 Preparation and Conditioning of Test Specimens

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

For the stretch resistance test, three test pieces of gasket are cut to a length of at least 0,7 m each.

6.4 Procedure

The test apparatus and the three pieces of gasket are reconditioned at 296 K (23 °C) and 50% RH.

The 0,7 m or larger pieces of gasket are mounted, one at a time, in the universal tensile testing machine or alternative device. Care must be taken to ensure that the gaskets will not break at the grips. The test piece is preloaded with a load of 5 N. A 500 mm long measuring distance is marked on the gasket. The load is then increased to 20 N, and the elongation of the 500 mm long measuring distance read after 30 seconds. The load is afterwards increased to 40 N, and the elongation read again after another 30 seconds.

The same procedure is repeated with the two other pieces of gasket.

6.5 Expression of Results

The elongation at 20 N and 40 N respectively are given as average values for the three tests. The elongation is given as per cent of the original length.

6.6 Accuracy

Difficulties may arise with gaskets breaking at the grips in the testing machine. Correct details at these points are important. Otherwise the accuracy of the test itself is good.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.

1 SCOPE

This test method has been specially developed to study the risk of tear propagation in gaskets fastened to a wooden substrate with staples or similar.

2 FIELD OF APPLICATION

The method may be used for all types of gasket which are intended to be fastened to the substrate by means of staples, tacks, etc. It is specially useful for gaskets of solid rubber or plastics for use as air seal in windows and doors.

3 REFERENCES

Swedish National Testing Institute, test method SP 42 20 03 - 1981.

4 DEFINITIONS

None.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 TEST METHOD

6.1 **Principle**

A piece of gasket is fastened by staples or similar to a wooden substrate, and the tear resistance found by pulling.

6.2 **Apparatus and Materials**

Pieces of planed knotless spruce or fir, size approximately 20 mm x 20 mm x 10 mm.

Universal tensile testing machine with a testing speed of 8 ± 2 mm/s (480 ± 120 mm/min).

Staples, tacks or similar, as specified by the gasket manufacturer, together with equipment for mounting these fastening devices.

6.3 **Preparation and Conditioning of Test Specimens**

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

Three pieces of gasket are cut to a length of 150 mm each.

6.4 **Procedure**

The test equipment and the 150 mm long pieces of gasket are reconditioned at 296 K (23 °C) and 50% RH.

Each piece of gasket is fixed to one of the planed wooden substrates by means of a staple, tack or similar, and as specified by the gasket manufacturer.

One test assembly at a time is mounted in the universal tensile testing machine, and the gasket pulled in its longitudinal direction and parallell to the planed surface. The testing speed should be 8 ± 2 mm/s (480 ± 120 mm/min). The tensile strength at break is recorded, as well as any visual observations on the type of failure. For fibre reinforced gaskets, the maximum force is read.

6.5 **Expression of Results**

The tear resistance is given as the average figure for the three measurements. Any visible observations or possible comments should also be given.

6.6 **Accuracy**

No comments.

6.7 **Test Report**

Use NBI-G01, point 6.7, and include the points applicable to this test method.

BYGGFORSK

Building Gaskets
Low Temperature Flexibility

NBI-160
1988

1 SCOPE

The purpose of this test method is to have a simple and rapid check of the flexibility of a gasket at low temperatures.

2 FIELD OF APPLICATION

The method may be used for all types of building gaskets without any kind of stiff reinforcement.

3 REFERENCES

None.

4 DEFINITIONS

None.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 TEST METHOD

6.1 **Principle**

A piece of the gasket is conditioned at 253 K (-20 °C), and twisted and flexed by hand at this low temperature. The behaviour of the gasket is observed visually.

6.2 **Apparatus and Materials**

Test chamber with a temperature of 253 K (-20 °C).

Well insulating gloves.

6.3 **Preparation and Conditioning of Test Specimens**

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Otherwise the gaskets are tested as received.

Three pieces of gasket are cut to a length of 150 mm each.

6.4 **Procedure**

The three pieces of gasket are conditioned at 253 K (-20 °C). They are then flexed and twisted by hand at this temperature, one at a time, and continuously observed for any unacceptable stiffness, cracking or any other unwanted low temperature effects. During the handling, the operator should wear well insulating gloves.

6.5 **Expression of Results**

The result of the low temperature flexibility test is given as passed/not passed. Any special observations are described by words.

6.6 **Accuracy**

No comments.

6.7 **Test Report**

Use NBI-G01, point 6.7, and include the points applicable to this test method.

1 SCOPE

This test method is used to study if a specific type of building gasket will take paint, and if so, whether any unwanted reactions will occur or not.

2 FIELD OF APPLICATION

The method may be used for any type of building gasket, but is first of all intended for gaskets to be used as air seal between sash and frame in openable windows.

3 REFERENCES

Kristin Breder and Tore Gjelsvik: Paintability of Gaskets. Innredningsindustriens Forskningsgruppe, Publication No. 8, Blindern/Oslo 1979 (In Norwegian).

4 DEFINITIONS

None.

5 SAMPLING

Unless otherwise agreed, the material to be tested is supplied by the sponsor of the test. The sample shall be sufficiently large to be representative of the gasket to be tested.

6 TEST METHOD

6.1 **Principle**

Short pieces of gasket are overpainted with selected types of paint and varnish. The specimens are observed visually, to check if they will take paint/varnish and that the paint/varnish will dry out properly, as well as to note any possible unwanted reactions between the coating and the gasket material.

6.2 **Apparatus and Materials**

Planed pieces of knotless spruce or fir, size 100 mm x 70 mm x 10 mm.

Selected samples of paint and varnish. Under normal conditions, the following five should be used:

- a slow-drying alkyd based teak oil for outdoor use
- an alkyd based white paint for outdoor use
- an acryl based white dipersion paint for outdoor use
- a two-component clear polyurethane varnish
- a two-component clear acid curing varnish.

Other types may be used as agreed.

6.3 **Preparation and Conditioning of Test Specimens**

Building gaskets are supplied as products ready for use. They should be reconditioned at least one week at 296 K (23 °C) and 50% RH, preferably as straight lengths free on a flat surface. Moderately deformed gaskets may be given an additional reconditioning for 10 minutes in hot water at 323 K (50 °C). Heavily deformed gaskets should not be used. Otherwise the gaskets are tested as received.

Two 100 mm long pieces of gasket are cut for each of the paints and varnishes to be tested. The five types of coatings listed under point 6.2 will thus require a total of ten pieces of gasket. In addition, two more pieces are cut for a blind test.

6.4 **Procedure**

Two pieces of gasket are fixed to one of the planed wooden substrates by means of staples, tacks, glue or in any other suitable way. For each paint or varnish to be tested, one test specimen like this is produced.

The gasket samples on the test specimens are overpainted with the interesting types of paint and varnish, one for each specimen, and left to dry or cure at 296 K (23 °C) and 50% RH for the specified period of time.

One of the pieces of gasket on each specimen is also given a second coat of paint or varnish, which is also permitted to cure in the right way.

A reference sample is prepared with the remaining two pieces of gasket. This is left uncoated, as a blind test.

The prepared samples are stored at 296 K (23 °C) and 50% RH for four weeks. They are observed at regular intervals, and any possible visible changes noted.

The results are evaluated according to the following scale:

0 = no really unfavourable reactions, but possible secondary reactions as flaking of the paint without damage to the gasket are accepted

1 = undesirable reactions as for instance retarded paint drying

2 = unfavourable reactions as paint remaining sticky and possibly discoloured

3 = very unfavourable reactions as paint remaining very sticky and discoloured.

6.5 Expression of Results

The results are expressed as a figure from 0 to 3 as indicated in point 6.4. The visual observations are also described in proper wording as far as possible.

6.6 Accuracy

No comments.

6.7 Test Report

Use NBI-G01, point 6.7, and include the points applicable to this test method.