TNO report 2003-BS-R0238
Resistance of Lantor Standard CondenStop® to fungal growth

Date 24 October 2003

Author(s) ir. M.M. Sanders

Copy number

Number of pages	15
Number of appendices	
Customer	Lantor B.V. Postbus 45 3900 AA Veenendaal
Project name	Condenstop
Project number	006/33115/01.06.01

Summary
Lantor BV has requested that *TNO Bouw* conduct a study of Standard CondenStop®'s ability to resist mould. The study is conducted in conformance with the Standard *TNO Bouw* method for determining the resistance of building and finishing materials to the growth of mould.

The experiments showed that under both stationary and dynamic conditions, no mould growth occurred on the Standard CondenStop® test samples. The majority of the reference samples became completely covered with mould, which showed that the test satisfied the requirements for a comparable test and the resulting quality evaluation.

Standard Condenstop®' resistance to mould can be qualified as class I `impervious to mould growth'.

Table of contents

1 Introduction

Lantor BV requested *TNO Bouw* to conduct a study of Standard CondenStop®'s resistance to the growth of mould. The study was conducted in conformance with the tender dated 9 May 2003, reference number 2003-BSB0450/SSM/hnwa.

The study consisted of determining Standard CondenStop®'s resistance to the growth of mould, in conformance with the Standard *TNO Bouw* method. This characteristic is expressed in conformance with the *TNO Bouw* quality characteristics developed for this purpose.

The customer delivered the Standard CondenStop® material in May 2003 in roll form. Mr. Spoelstra serves as the contact person during the study.

This report contains the results of the study.

2 Social relevance and background

Periodic inventory of the quality of Dutch residences (by the Ministry of Housing, Regional Development and the Environment) has shown that 15-20% of Dutch residences have problems with dampness and mould. Mould can cause health problems, in particular for patients with chronic obstructive respiratory disorder, but it has also been shown that they can also have a harmful effect on people who do not suffer from allergies. Problems with mould are not limited to existing housing; new and relatively dry residences are also subject to these problems sometimes.

In general, mould spores can be found in all residences. Depending on a number of physical, chemical and biotic factors from the environment, these spores can develop into many different types of mould. Moisture is one important condition. Moisture in residences is related to the production (for example showers), the thermal quality of the construction (thermal bridge), ventilation (affected by the resident's habits) and the how well any crevices are filled (how airtight the residence is).

Recent research (Adan et. al. 1999) has made it clear that the finishing materials used for walls and ceilings to an important extent determine the physical, chemical and hygric conditions of the micro-climate in which moulds develop. Finishing materials help determine the total relative humidity in the surface layer (absorbing, buffering and release of moisture from the air).

Finishing materials contain substances that promote mould growth; the addition of the proper substances can create a biostatic (growth inhibiting) or biocidal (mould destroying) effect. The hygric behaviour and the features of building and finishing materials that promote mould growth can collectively be expressed as the so-called susceptibility to mould.

A general method has been developed at *TNO Bouw* to determine the level of susceptibility to mould growth for building and finishing materials that are applied in the interior environment, specifically in homes. This is the Standard *TNO Bouw* method. Using this method one can obtain a realistic image of the behaviour to be expected in practice. In residences there are two characteristic problem environments: the `thermal bridge' situation and the `bathroom' situation. The materials to be tested were set up in the following test situations:

1. Constant relative humidity (97%) and environmental temperature (22°C);
Based on experience amassed from earlier research, optimum growth of mould can be expected to occur under these conditions. This stable climate is particularly important for determining differences in either growth inhibiting or growth stimulating properties of the finishing material.

2. Varying dry and humid air and an environmental temperature of 22°C and 30° C, respectively;
This mimics the so-called `bathroom' climate. Under these dynamic conditions the moisture resistant properties of the material can contribute considerably to the differences in mould growth.

In Dutch practice it has turned out that a specific type of mould prevails in each of these problem situations. These specific types of mould were used in these experiments.

Based on the Standard *TNO Bouw* method a quality label is assigned to the susceptibility to mould; this susceptibility label had been internationally recognised in the interim.

3 Approach

3.1 Material

• Standard CondenStop®

The Standard CondenStop® material is a specially developed material for inhibiting condensation on non-insulated metal building structures. It is a non-woven fibre material that can absorb more than 900 grams of moisture per m^2 of surface area. It has a layer of glue on one side with which the material can be affixed to the metal. The material has a thickness of approximately 1.2 mm. In this experiment Lantor Standard CondenStop®, article code S25I12740324, ID number 136848, produced by Lantor BV on 28 April 2003 was used.

• Mould

The following moulds were used in the experiments:

- Penicillium chrysogenum (CBS 401.92)

This mould is primarily present in the Dutch residences in both a stable climate and in a dramatically changing climate. The mould has a green-black colour.

- Cladosporium sphaerospermum (CBS 797.97)

This mould is very dominant on plastered and painted structures in Dutch bathrooms. The mould has an olive brown to black colour. The mould grows best under conditions with very high relative humidity near the saturation point.

The moulds are grown at the Central Bureau for Fungal Cultures (*Centraalbureau voor Schimmelcultures* or *CBS* in Utrecht. The CBS number identifies the stock in question as coming from the collection of the CBS. In the experiments cultures that were at optimum spore-producing stage were used. (At least seven or ten days old, respectively.)

• References

In order to be able to properly compare repeated experiments and control the conditions within an experiment, reference specimens are included in the experiments, which are tested simultaneous with and in the same manner as the materials being studied. The standard TNO plaster is used for the mould experiments. This plaster consists of three parts (by mass) of calcium sulphate hemihydrate ($CaSO_4.½H_20$) and two parts by mass of the so-called Czapek solution. The composition of this solution, made with demineralised water, is shown in table below.

Table I – Composition of the Czapek solution

Ingredient	name	quantity[q]
Saccharose	C12Hn011	30.0
Sodium nitrate	$NaNO_3$	3.0
Dipotassium hydrogen phosphate	K_2HPO_4	1.0
Potassium chloride	KCL	0.5
Maqnesium sulphate sept aq	$MgSO_4.7H_20$	0.5
Iron sulphate sept aq	$FeSO_4.7H_20$	0.01

3.2 Method

• Preparing the specimens
The specimens were prepared under aseptic conditions. All instruments and surfaces were rinsed with ethanol before use. Sterile gloves were worn during the procedure.

42 mm diameter circles were cut from the roll of Standard CondenStop® material delivered by the customer. These circles fit precisely in the moulds, where the plaster is generally made. The material was affixed to the bottom of the mould with tape. The material was placed in the moulds with either the non-woven side or with the glue side up. A total of forty specimens were created for the two experiments using this method; half were tested on the glue side; the other half on the non-woven side.

The reference specimens were created in square 3 mm thick plastic moulds that contain a round hole with a diameter of 42 mm. The plaster was made using the recipe described above and placed in the moulds. The plaster remained in the moulds during experiments.

The specimens were kept at controlled conditions (20 ± 2 °C, 50 ± 5% RV) for a period of at least ten days, to ensure that they all were subjected to the same initial situation.

• Creating the mould suspension
An aqueous suspension containing mould spores was used to inoculate (contaminate) the test specimens. Separate spore suspensions were needed for the two experiments. The two different suspensions were made from young mould cultures that were producing ample spores, which were seven and ten days old, respectively.

The procedure specified in British Standard – BS 3900 – was used to do this (British Standard Institution, 1989). Below is a description of the work method used.

All the requisite glass items, the utensils and the laminated ventilated hood were rinsed with ethanol before creating the suspensions. Sterile vinyl gloves were worn while creating the suspensions and during the inoculation process.

The suspensions are made of demineralised water, to which a 0.01% solution of Tween 80 (a compound that lowers the fluid surface tension) is added. About 2 ml of this solution is added to the mould culture, after which with a sterile hypodermic needle of spores is released. This suspension of spores is then poured in an Erlenmeyer flask, containing glass beads, after which the Erlenmeyer flask is shaken to separate the spores from one another. The solution is filtered using a sterile gauze filter to remove any residue of the substrate and any mycelium from the suspension.
The number of spores in the spore suspension is then determined using a counting chamber. If necessary, the preceding actions can be (partially) repeated with the suspension already obtained (too few spores) or the suspension can be thinned with demineralised water (too many spores). Then the suspension is ready for use.

The following concentrations of spores are used in the suspensions:

Mould	Number of spores
Penicillium chrysogenum	>= 4*10e6
Cladosporium sphaerospernum	>= 7*10e6

Until they were used, the suspensions were kept cool (6°C) and an hour before inoculation they were removed from the refrigerator so that they could warm to room temperature.

- Inoculation

The inoculation of the specimens and the reference specimens was conducted in a laminated ventilated hood cleaned with ethanol. During this procedure the lab employees wore disinfected gloves.

The specimens and the references were placed in groups of ten in a metal rack rinsed with ethanol. The suspension was distributed as uniformly as possible on the test and reference specimens using an atomizer. Earlier research has demonstrated that the amount of suspension used is approximately 0.3 ml per specimen.

- Incubation

The test specimens were incubated immediately after inoculation in the Standard *TNO Bouw* method configuration. This is a closed re-circulating system, in which conditioned air is circulated over a row of specimens arranged in series. Two types of conditions (stationary and dynamic) are possible, depending on the experiment. The configuration is constructed of ten separate channels or rows, over which air is circulated at a more or less constant flow rate (speed < 5 cm/s). Each row contains a space for ten test specimens. The specimens are placed in the rack diagonally, so that each position in row is occupied by the test specimen in question. This results in a balanced experiment during which the influence the position has on the result can be determined.

- Evaluation of the growth

In the Standard *TNO Bouw* method, the mould growth is evaluated visually. The evaluation is based on the time-dependent development of the coverage level of the specimen surface area. An evaluation scale from BS 3900 is used, which is based on the following (non-linear) criteria:

Table 2— Mould growth evaluation scale

Score	Percentage of the surface area covered G
0	G=0
1	G s 1
2	1<G<_10
3	10<Gs30
4	30<Gs70
5	G>70

The test specimens were evaluated one to several times per week.

• Duration of the experiments
In conformance with the Standard *TNO Bouw* method, the experiments lasted 3 months. The two experiments lasted a total of 88 days.

• Determining the susceptibility to mould growth
Earlier research (Adan et. al., 1999) has shown that mould growth on media with a finite quantity of nutrients normally develops along an S-shaped curved. Slow growth is followed by a period of rapid growth. This is subsequently followed by a period of slow growth, during which the maximum coverage level is reached.

When determining the susceptibility to mould growth, this time-dependent growth development is taken into account. The mould growth pattern is translated into a mathematically described curve, the so-called logistic model:
$y=\alpha/(1+e^{4\varepsilon(\delta-t)a})$

Legend:

y	score for the coverage level	[-]
t	Time	[days]

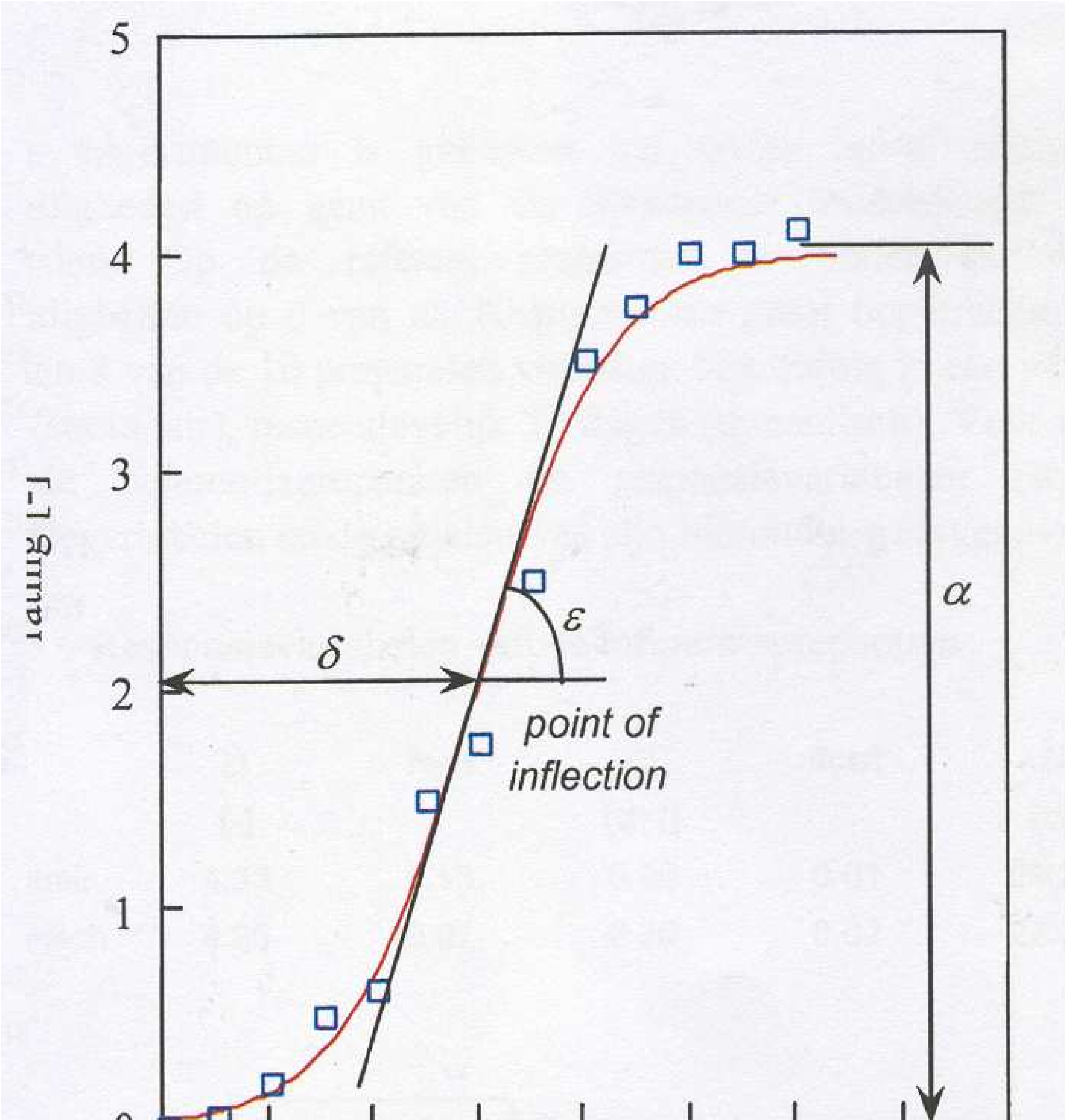
And the so-called susceptibility variables:

α	Asymptotic maximum score	[-]
ε	slope in the point of inflection	[days $^{-1}$]
δ	moment of the point of inflection	[days]

The α is the maximum coverage that is reached, the ε is a measurement of the maximum growth speed and the δ indicates the time at which the maximum growth speed occurs.

From the results of the evaluations, these three susceptibility variables are determined using curve fitting. The ε and δ are generally strongly correlated. The susceptibility variables are important when characterizing a material's susceptibility to mould. Initially we look at the α, after which the ε can be used for further nuancing. The figure below shows the significance of the susceptibility variables.

Figure 1 — Logistic model of the S-shaped growth pattern of micro-organisms in o-called batch cultures

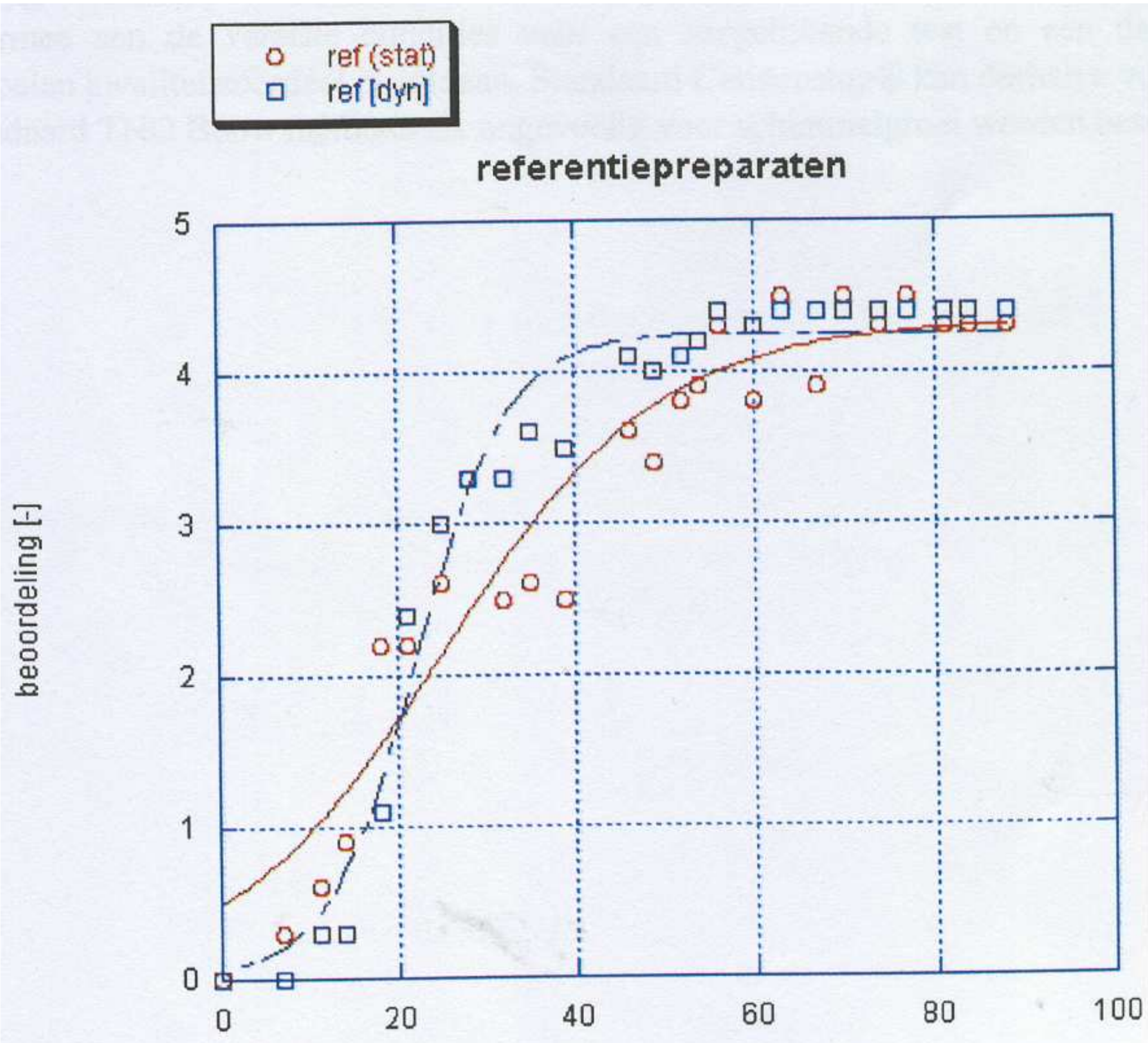


4 Results

The experiments show that there was no mould growth on any of the Standard CondenStop® test specimens under either stationary or dynamic circumstances. There was mould growth on 9 of the 10 reference specimens under stationary and dynamic circumstances. Under both conditions, 8 of the 10 specimens reached full growth in a period of an average of 37 days (stationary), and 33 days (dynamic) respectively. For both experiments the susceptibility variables (valuers) for the reference specimens were determined. The susceptibility variables and the growth curves are shown below.

Table 3 – Susceptibility variables of the reference specimens

	❑ [-]	Error	❑ [d-1]	Error	❑ [d]	Error
stationary	4.33	0.18	0.09	0.01	25.25	2.17
dynamic	4.25	0.07	0.20	0.02	22.22	0.70



time [d]

Figure 2 – growth curve for the reference specimens under stationary (ref stat) and dynamic (ref dyn) circumstances

5 Discussion
5.1 Test conditions

The growth of the reference specimens provides information about the circumstances during the experiments. The results from the experiments do not completely conform to the anticipated growth pattern based on previous research in terms of the period of fastest growth (δ). The circumstances (viability of the suspension, conditions in the configuration) were thus less optimal than desired. However, both experiments show complete growth on most of the reference specimens (a = 5) and also sufficient conformance between the replicas for both the references and the Standard Condenstop®.

5.2 Resistance to mould growth

The experiments show that no growth occurred on the Standard Condenstop® test specimens. The majority of the reference specimens showed complete growth, which satisfies the conditions required for a comparable test and a corresponding quality evaluation. Thus, based on the Standard *TNO Bouw* method Standard Condenstop® can be considered impervious to mould growth.

6 Conclusion

In characterizing a material's susceptibility to mould growth - given the differences in earlier research between the behaviour under stationary and dynamic circumstances – a distinction must be made between the two situations. The environment in which a material will be used is important in such a characterisation. The *TNO Bouw* quality system uses the susceptibility variable α from both experiments: α_{cond} for the dynamic situation, a_{stat} for the stationary situation.

The susceptibility to mould growth can be divided into the following quality classes:

Class	Description	Recommended application	Definition
I	Impervious to mould growth	all living areas in all types of structures; particularly appropriate for bathroom and kitchen or structures on which condensation frequently collects	$\alpha_{cond} <= 1.25^{*}$
II	reasonably susceptible to mould growth	all living areas other than the bathroom and kitchen	$\alpha_{cond} > 1.25^{*}$ $a_{stat} <= 2.5$
III	Susceptible to mould growth	Only for fully interior structures or structures that adjoin exterior surfaces in areas other than the bathroom and kitchen provided these structures are well insulated *not* appropriate for bathrooms or kitchens or structures subject to frequent condensation	$\alpha_{cond} > 1.25$` $a_{stat} > 1.25$`

Standard Condenstop®'s resistance to mould growth conforms to Class I `impervious to mould growth'.

Literature

Adan, O.C.G., et. al., De Schimmelgevoeligheid van finishing materials, Delft: TNO Bouw, 7 September 1999.

British Standard Institution, BS 3900 British Standard methods of test for paints, Part G6 Assessment or resistance to fungal growth, British Standard Institution, 1989.

www.lantor.nl