Bridge Test Procedure – BT001
Measuring the Vapour Transmission and Waterproofing Performance of Concrete Sealers

Transportation and Economic Corridors – Technical Standards Branch

BT001 – August 29, 2023

Scope: This test procedure outlines the steps required to assess the vapour transmission, waterproofing, and hiding power performance of concrete sealers.

1. General

1.1. Introduction

This test procedure requires all test cubes, including the control set, to be of the same dryness and age. This is of prime importance since the following tests rely on these requirements to compare the results of the sealed cubes to those of the control cubes.

1.2. Related Documents

The following documents are to be used in conjunction and are related with this bridge test procedure.

B388	Material Testing Specification for Concrete Sealers
BT002	Test Procedure for Alkaline Resistance of Penetrating Sealers for Bridge Concrete
BT008	Test Procedure for Finger Printing Sealers Using Infrared Spectroscopy and Gas Chromatographic Separation
BT010	Test Procedure for Casting and Storing of Concrete Test Specimens for Use in Approval Testing of Sealers

The following published procedure is available from The American Society for Testing and Materials (ASTM):

ASTM D5095	Standard Test Method for Determination of Nonvolatile Content in Silanes, Siloxanes and Silane-Siloxane Blends Used in Masonry Water Repellent Treatments

1.3. Hazardous Materials

This test procedure may involve hazardous materials, operations, and equipment. This procedure does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.

1.4. Testing Laboratory and Equipment

Test results shall only be accepted from a test facility approved by both Alberta Transportation and the Canadian Standards Association under CSA Standard A283, Category II.

An electronic weigh scale having a capacity not less than 4000 grams and a sensitivity of 0.1 grams and a conditioning chamber capable of maintaining 50 ± 4% relative humidity (RH) at 23 ± 1°C are required. The cubes for the abrasion test are to be sandblasted after the waterproofing test and a steel plate shield with a 100 mm square opening is required during sandblasting to allow each cube face to be blasted separately. All time intervals given in days shall be measured ± 60 minutes. A thermostatically controlled oven, that is accurate within ± 2°C, shall be provided for concrete cube drying. When oven drying is called for, the oven shall be cooled to lab temperature before cubes are placed in it. Oven temperature shall then be increased to the specified drying temperature at the rate of 20°C/hr.

2. Moisture Content

2.1. Total Moisture Content

Prior to applying sealers to test cubes, the relative moisture content must be adjusted by the following procedure. First, determine the total moisture content of the cubes as follows. Remove a set of three cubes from the moist curing room, weigh each cube and record to the nearest 0.1 grams, then oven dry at 95°C for 7 days and reweigh. Total moisture content is measured in grams and is defined as the difference between the original and dried weights. This total represents the weight of moisture in a test cube stored at 100% RH. These three cubes shall not be re-used for further testing.

2.2. Definition of Relative Moisture Content

The relative moisture content (RM) of test cubes will be expressed as a percentage of the total moisture content (i.e. 100% represents the moisture content when the cubes were immediately removed from the moist room). A legend explaining all abbreviations used in this specification is included in the Laboratory Data Acquisition Form included in Material Testing Specification B388.

2.3. Air and Oven Drying of Test Cubes

Prior to applying sealers to test cubes, remove eight cubes from the moist curing room and allow to dry by natural evaporation in 50 ± 4% relative humidity and 23 ± 1°C, aided by fans, to the relative moisture contents shown in Table 1 below. Drying must be completed within the time limits shown in Table 1. This applies to all sealer types except Type 1a. Type 1a cubes shall be placed in an oven maintained at 50 ± 2°C until the RM specified in Table 1 is reached. These cubes shall then be transferred to the conditioning chamber and maintained at 50 ± 4% RH and 23 ± 1°C to cool for a minimum period of 24 hours.

Select three cubes that have dried closest to the target RM in the same time and designate these as the test cubes to receive the sealer. The sealer must be applied at this time. Do not attempt to store test cubes in the adjusted RM for later sealing. Select another three cubes for non-sealed controls. The remaining two cubes will be submerged in a water bath for 48 hours prior to being returned to the curing room for future use.

This drying process results in the surface being drier than the interior of the cubes and will simulate normal field conditions when the sealers are applied. Weigh the cubes just after removal from the moist room at 100% RH and again after drying.

Cubes that are accidentally over-dried by more than 2% shall not be used unless returned to 100% RM and then allowed to re-dry naturally prior to applying sealer. The sealer types shown in Table 1 are described in Material Testing Specification B388.

The table below shows the minimum requirements for Vapor Transmission (VT) performance for each type of sealer.

TABLE 1: AIR AND OVEN DRYING OF TEST CUBES

Sealer Type	Age of Cubes after Casting (days)	Relative Moisture Content of Cubes (RM)	Time Limits to Complete Drying of Cubes (days)
Type 1a	Min. 60	55 ± 2%	n/a
Type 1b	Min. 60	70 ± 2%	14 to 21
Type 1c	8 to 183	80 ± 2%	6 to 8
Type 2a	Min. 60	70 ± 2%	14 to 21
Type 2b	Min. 60	70 ± 2%	14 to 21
Type 3	Min. 60	70 ± 2%	14 to 21

Cubes that do not meet the limits shown in Table 1 shall not be used for testing sealers.

3. Test Specimens

3.1. Casting and Storing of Concrete Test Specimens

Cast, store, and mark all test cube specimens in accordance with Bridge Test Procedure BT010.

3.2. Orientation of Test Cubes

Position the screeded face of the cubes upwards during all immersions in sealer and water.

3.3. Labelling of Test Cubes

Label the test cubes with an approved felt pen such as a Berol liquid tip permanent marker for identification purposes and re-label as required.

4. Application of Sealers

4.1. Type 1 Penetrating Sealer

Apply Type 1 penetrating sealers by totally immersing the set of three test cubes in a container of the sealer material. The supplier shall instruct the test lab as to the desired coverage rate and the number of immersions required (to a maximum of 3). Each immersion is to be for a maximum of 2 minutes with a 4-hour maximum drying time between immersions. Immerse the cubes with the screeded side up to a depth of 10 mm from the surface of the sealer to provide uniform conditions of pressure. If the supplier's stated coverage is not reached with three immersions, the test will continue with the coverage as obtained or a new formulation of the product may be required.

4.2. Type 2 Clear Film Forming Sealers

Apply Type 2 clear film forming sealers by uniform brushing to all sides of a set of three test cubes. The supplier shall instruct the test lab as to the desired coverage rate and the number of uniform brushings required to a maximum of 2 coats and a 4-hour maximum drying time between brushings. If the supplier's stated coverage is not reached with 2 brushings, the tests will continue with the coverage as obtained or a new formulation of the product may be required.

Prior to applying any product, ensure the material is agitated, proportioned, and mixed sufficiently. Apply these sealers at ambient lab temperature and ensure that the pot life is not exceeded.

4.3. Type 3 Pigmented Film Forming Sealers

Apply Type 3 pigmented film forming sealers by uniform brushing to all sides of a set of three test cubes. The supplier shall instruct the test lab as to the desired coverage rate and the number of uniform brushings required to a maximum of 2 coats and a 4-hour maximum drying time between brushings. If the supplier's stated coverage is not reached with 2 brushings, the tests will continue with the coverage as obtained or a new formulation of the product may be required.

Before proceeding with the vapour transmission test, the hiding power and gloss of the sealer using the established coverage rate obtained during sealer application must be tested in accordance with Material Testing Specification B388.

4.4. Determination of Rate of Sealer Application

Apply each sealer to a set of three cubes.

The total sealer uptake is determined immediately upon completion of each immersion or brushing application for each test cube. Weighing is also required just before each immersion or brushing after the drying period.

Weights are recorded as indicated below.

TM = weight of test cube before first immersion or brushing
TS1 = weight of test cube after first immersion or brushing when dripping has stopped
TS2 = weight of test cube before second immersion or brushing
TS3 = weight of test cube after second immersion or brushing when dripping has stopped
TS4 = weight of test cube before third immersion (Type 1 only)
TS5 = weight of test cube after third immersion (Type 1 only)
TD1 = weight of test cube after 5 days of drying at 50 ± 4% RH in ambient temperature of 23 ± 2°C
TD2 = weight of test cube after 15 days of drying at 50 ± 4% RH in ambient temperature of 23 ± 2°C

Calculate fresh sealer weight (SF) using the average weights for the three test cubes.

SF = (TS1 - TM) + (TS3 - TS2) + (TS5 - TS4)

The fresh sealer weight is converted into sealer volume by way of the specific gravity and divided by the total surface area of the cube to indicate the application rate expressed in mL/m2.

Record the number of immersions or brushings, the drying time between and the coverage rate.

Weigh the freshly sealed cubes and place on a tray equipped with blunted nails pointing up that do not damage the coating or affect its waterproofing performance.

5. Procedure for Measuring Vapour Transmission Performance

5.1. Introduction to the Vapour Transmission Test

The following procedure has been set up to measure the weight loss attributable to water alone. The cube treated with sealer will initially loose both water and sealer since most sealers contain volatile constituents. Allow the sealed cubes and control cubes to dry for 15 days after sealer application in a humidity-controlled chamber at 50 ± 4% RH and ambient temperature of 23 ± 2°C. Vapour transmission performance shall be measured prior to waterproofing performance, based on the weight losses recorded.

The vapour transmission value represents a ratio comparing the drying performance of the sealer treated cubes to that of untreated control cubes over a period of 10 days (this period is the final portion of the 15-day drying period). Both sealed and control set of cubes are started at the same relative moisture for the 15-day drying period.

5.2. Determination of Vapour Transmission Performance

The water loss due to vapour transmission of the test cubes (VLT) is the difference between the average sealed cube weight after the initial 5-day drying period (TD1) and the average sealed cube weight after 15 days of drying (TD2).

The water loss in treated cubes due to vapour transmission is calculated as follows:

$$VLT = TD1 - TD2$$

The water loss due to vapour transmission of the control cubes (VLC) is the difference between the average control cube weight after the initial 5-day drying period (CD1) and the average control cube weight after 15 days of drying (CD2).

The water loss in control cubes due to vapour transmission is calculated as follows:

$$VLC = CD1 - CD2$$

The vapour transmission performance percentage is calculated as follows:

$$VT = \left(\frac{VLT}{VLC}\right) x\ 100\%$$

6. Procedure for Measuring Waterproofing Performance

6.1. Introduction to the Waterproofing Test

The cubes used for measuring waterproofing performance are the same as those used in the vapour transmission testing. It is important that both sets of cubes, sealed and control, are brought to the same moisture content before testing. This will require oven drying the sealed cubes at 60°C until they have the same relative moisture content as the control cubes. Weighing before and after drying, as well as adjustments for the weight of dry sealer on the test cubes will be required for this calibration.

The weight added by the dry sealer (SD) adhering to the test cubes shall be determined based on the following:

(a) The total weight difference of the sealed test cubes during the initial 5-day drying period is due to:
    i. fresh sealer loss (SL) due to the evaporation of volatile constituents; and
    ii. concurrent water loss due to vapour transmission
(b) The concurrent water loss due to vapour transmission is equal to the water loss in the control cubes during the initial 5-day drying period multiplied by the vapour transmission ratio (VT).
(c) The remaining weight difference during the initial 5-day drying period is therefore due to fresh sealer loss (SL)
(d) The weight added by the hardened sealer (SD) is the difference between the previously measured fresh sealer weight (SF) and now acquired sealer loss (SL):

SD = SF – SL

The sealed test cubes shall be adjusted to the same relative moisture content as the control cubes at the end of the 15-day drying period immediately after the Vapour Transmission testing is completed and before proceeding with waterproofing performance testing, making do allowance for the weight of dry sealer (SD) adhering to them.

6.2. Determination of Waterproofing Performance

Weigh both sets of test and control cubes immediately before water immersion and record the weights and relative moisture contents (note that both sets of cubes should have equal relative moisture contents despite the test cubes being slightly heavier due to the hardened sealer).

The cubes are then totally immersed in tap water at 23 ± 2°C with the screeded face upwards and 25 mm below the water level while immersed. Support the cubes such that all surfaces are freely exposed to water. Remove the cubes from the water tank after 120 hours. Surface-dry the cubes to produce a saturated surface dry (SSD) condition and then re-weigh within 60 seconds from time of removal from the bath. Light toweling may be used to aid in surface drying. Report the average weight gained by each set of cubes during immersion.

Waterproofing performance of the sealed cube as a percentage of the control cube is calculated as follows:

Waterproofing Performance (before abrasion) = $\left(\frac{CG-TG1}{CG}\right) x\ 100\%$

CG = average weight gain per cube of the control set after 120 hours of immersion

TG1 = average weight gain per cube of the sealed set after 120 hours of immersion

6.3. Determination of Waterproofing Performance after Surface Abrasion (Type 1 Sealers Only)

This test applies to sealers being approved as Type 1 sealers used on bridge decks when exposed to abrasion. After performing the tests in Section 6.2, the same set of sealed test cubes shall be oven dried at 60 ± 2°C until the moisture gained during the immersion in Section 6.2 is removed to within ± 1 gram. Weighing before and after drying is required for this adjustment.

Once the drying is complete, sandblast the entire surface of the three test cubes to evenly remove an average amount of cement paste from all sides of the treated cubes. Only one cube face will be exposed to sandblasting at any time. Mechanically shield the other faces from the sandblast spray. Maintain the nozzle at 90° angle to the cube face being blasted. Sandblasting leaves a rough surface making it difficult to measure the amount of surface removed. Therefore, the cubes shall be weighed before and after each round of removal to ensure the weight removed per face and cumulative weight loss per cube are in accordance with the requirements in Table 2 below:

TABLE 2: SURFACE REMOVAL REQUIREMENTS FOR TYPE 1 SEALER WATERPROOFING PERFORMANCE

Sealer Type	Weight Removed per Face (g)	Cumulative Weight Loss per Cube (g)
Type 1a	12.0 ± 1.0	72.0 ± 2.0
Type 1b	12.0 ± 1.0	72.0 ± 2.0
Type 1c	24.0 ± 1.0	144.0 ± 2.0

Upon adequate surface removal, the sealed test cubes shall then be re-tested in accordance with Section 6.2 to determine the effect of surface abrasion on the waterproofing performance of the sealer.

Waterproofing performance of the sealed cube as a percentage of the control cube after abrasion is calculated as follows:

Waterproofing Performance (after abrasion) = $\left(\frac{CG-TG2}{CG}\right) x\ 100\%$

CG = average weight gain per cube of the control set after 120 hours of immersion (same as Section 6.2)

TG2 = average weight gain per cube of the sealed set after 120 hours of immersion (after abrasion)

7. Procedure for Measuring Non-Volatile/Solids Content

7.1. Non-Volatile Content (Types 1, 2, and 3 Sealers)

Non-volatile content is used for calculating the increase in weight of sealed cubes due to the sealer after the volatile content has evaporated and is used for product identification purposes. This value can also be used as comparison to verify the dry sealer weight calculated from Section 6.1.

Determine non-volatile content (Ns) as follows:

(a) **Type 1 Sealers** - use the results from ASTM D5095, "Standard Test Method for Determination of Nonvolatile Content in Silanes, Siloxanes and Silane-Siloxane Blends Used in Masonry Water Repellent Treatments," to obtain non-volatile content (Ns) expressed as a percent of sealer weight.

(b) **Type 2 and 3 Sealers** - a quantity of sealer equivalent to the known sealer uptake for one cube is placed in a flat open aluminum pan with a surface area equal to a test cube (i.e. 600 cm^2) and stored in a conditioning chamber at 50 ± 4% RH and 23 ± 1°C. Weights are recorded at the beginning and end of a 15-day drying period (to align with the duration of the vapor transmission test). The weight loss is the volatile content of the sealer and the material retained is the non-volatile content.

$$Ns\ (\%\ of\ mass)\ =\ \frac{weight\ of\ retained\ material}{initial\ weight\ of\ sealer}\ x\ 100\%$$

7.2. Solids Content (Types 2 and 3 Sealers)

For purposes of finger printing and approval of products, the non-volatile content test completed in Section 7.1 shall be repeated except that the sample shall be dried to a constant weight in a ventilated oven maintained at 110 ± 5°C. Constant weight shall be established after cooling of the sample in a desiccator and noting a weight difference of less than 2% of the total weight loss in two successive weighings separated by a minimum of 3 hours of drying.

The result shall be reported as the Solids Content, SC by the formula listed below:

$$SC\ (\%\ of\ mass)\ =\ \frac{weight\ of\ retained\ material}{initial\ weight\ of\ sealer}\ x\ 100\%$$

This procedure is similar to the determination of Ns in all other aspects.