ALBERTA TRANSPORTATION

TECHNICAL STANDARDS BRANCH

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TEST PROCEDURE FOR MEASURING THE VAPOUR TRANSMISSION, WATERPROOFING AND HIDING POWER OF CONCRETE SEALERS.

SCOPE - This test procedure outlines the steps required to assess the vapour transmission, waterproofing and hiding power performance of Concrete Sealers.

1.0 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 in order to compare the results of the sealed cubes to those of the control cubes.

1.2 RELATED DOCUMENTS

- ASTM D5095, "Standard Test Method for Determination of Nonvolatile Content in Silanes, Siloxanes and Silane-Siloxane Blends Used in Masonry Water Repellent Treatments"
- B388, "Specification for the Supply of Concrete Sealers"
- BT002, "Test Procedure for Alkaline Resistance of Penetrating Sealers for Bridge Concrete"
- BT008, “Test Procedures for Sealers Using Infrared Spectroscopy and Gas Chromatographic Separation”
- BT010, "Test Procedure for Casting and Storing Concrete Test Specimens for use in Approval Testing of Sealers"

1.3 HAZARDOUS MATERIALS

This test procedure may involve hazardous materials, operations and equipment. This procedure does not propose to address all of 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% 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.

2.0 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. where 100% represents the moisture content when the cubes were removed from the moist room. A legend explaining all abbreviations used in this specification is appended.

2.3 AIR DRYING 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°C ± 1°C, aided by fans, to the relative moisture contents shown in Table I. Drying must be completed within the time limits shown in Table I. This applies to all sealer types except Type 1a. Type 1a cubes shall be placed in an oven maintained at 50° ± 2°C until RM specified in Table I is reached. These cubes shall then be transferred to the conditioning chamber maintained at 50 ± 4% RH and 23 ± 1°C to cool for a minimum period of 1 day.

Select three cubes that have dried closest to the target relative moisture in the same time period and designate as 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 I are described in Specification B388.

TABLE I

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

Cubes that do not meet these limits shall not be used for testing sealers.

3.0 TEST SPECIMENS

3.1 CASTING AND STORING OF CONCRETE TEST SPECIMENS

Cast, store and mark test cube specimens according to Bridge Test BT010 for these tests.

3.2 ORIENTATION OF TEST CUBE

Position the screeded face of the cube upward during all immersion in sealer or water.

3.3 LABELLING OF TEST CUBES

Label the test cubes with an approved felt pen such as Berol Liquid Tip Permanent Marker for identification purposes and re-label as required.

4.0 APPLICATION OF SEALERS

4.1 TYPE 1 PENETRATING SEALER

Apply Type 1 or penetrating sealers by totally immersing the set of three test cubes in a container of the sealer material. The supplier is to instruct the test lab as to the desired coverage rate and the number of immersions required to a maximum of three for Type 1 sealers and a maximum of two for all other sealers. Each

immersion is to be for a maximum of two minutes with a four-hour maximum drying time between immersions. Immerse the cubes with the screeded side up and at 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 two immersions (three immersions for Type 1) 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 or clear film forming sealers by uniform brushing to all sides of a set of three test cubes. The supplier is to instruct the test lab as to the desired coverage rate and the number of uniform brushings required to a maximum of two and a four-hour maximum drying time between brushings. If the supplier's stated coverage is not reached with two brushings, the tests will continue with the coverage as obtained or a new formulation of the product may be required.

Prior to applying Type 2a sealers to test cubes, agitate sufficiently to get solids into suspension. The two component Type 2b sealers require proper measuring and mixing. Apply these sealers at ambient lab temperature and ensure that the pot life is not exceeded.

4.3 TYPE 3 COLOURED FILM FORMING SEALERS

Apply Type 3 or coloured film forming sealers by uniform brushing to all sides of a set of three test cubes. The supplier is to instruct the test lab as to the desired coverage rate and the number of uniform brushings required to a maximum of two and a four-hour maximum drying time between brushings. If the supplier's stated coverage is not reached with two 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 of the sealer using the established coverage rate obtained during sealer application must be checked according to Method 14.1 of CGSB 1-GP-71 of the Canadian General Standards Board.

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.
TS_1	-	weight of test cube after first immersion or brushing when dripping has stopped.
TS_2	-	weight of test cube before second immersion or brushing.
TS_3	-	weight of test cube after second immersion or brushing when

dripping has stopped.

TS_4 - weight of test cube before third immersion (Type 1 only).

TS_5 - weight of test cube after third immersion (Type 1 only).

TD_1 - weight of test cube after 5 days of drying at 50 ± 4% RH in ambient temperature of 23 ± 2°C.

TD_2 - 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.

$$SF = (TS_1 - TM) + (TS_3 - TS_2) + (TS_5 - TS_4)$$

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/m^2.

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.

5.0 PROCEDURE FOR MEASURING VAPOUR TRANSMISSION PERFORMANCE

5.1 INTRODUCTION TO THE VAPOUR TRANSMISSION TEST

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.

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% RH and ambient temperature of 23°C. Vapour transmission performance shall be measured prior to waterproofing performance, based on the weight loss (VTL) recorded.

5.2 DETERMINATION OF VAPOUR TRANSMISSION

The final 10-day portion of the drying period yields TD_2 for test cubes and CD_2 for control cubes.

The water loss due to vapour transmission (VLT) is the difference between the average cube weight after the initial 5-day drying period (TD_1) and the average cube weight after 15 days of drying (TD_2).

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

$$VLT = TD_1 - TD_2$$

The control set of cubes is started at the same relative moisture as the test cubes and stored for the 15-day drying period.

Weights are determined for the control cubes using the average weights for the three test cubes.

CD_1 - weight of control cubes after the initial 5-day drying period.
CD_2 - weight of control cubes after 15 days of drying.

Calculate the water loss in control cubes due to vapour transmission as follows:

$$VLC = CD_1 - CD_2$$

Calculate the vapour transmission percentage as follows:

$$VT = \frac{VLT}{VLC} \times 100\%$$

6.0 PROCEDURE FOR MEASURING WATERPROOFING PERFORMANCE

6.1 SEALED AND CONTROL CUBES

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. This will require oven drying the sealed cubes at 60^{o}C for a period of time that will adjust them to the same relative moisture content as the control cubes.

Weighing before and after drying will be required for this adjustment.

The weight added by the hardened sealer adhering to the test cubes at the end of the 15-day drying period shall be determined as based on the following assumptions:

a) All sealer evaporation takes place during the initial 5-day drying period.

b) The concurrent water loss in the test cubes is equal to the water loss in the control cubes during the same 5-day drying period, multiplied by the vapour transmission ratio (VT).

c) It follows that the balance of test cube losses during the initial 5-day drying period is made up of sealer loss due to evaporation (SL).

d) It also follows that the weight of sealer adhering to sealed cubes at the end of

the total 15-day drying period is equal to the total sealer weight applied to the cube, minus evaporated sealer.

$$SD = (TS_1 - TM) + (TS_3 - TS_2) + (TS_5 - TS_4) - SL$$

Test cubes shall be adjusted to the moisture content of control cubes at the end of the 15-day drying period, making due allowance for the weight of dry sealer (SD) adhering to them.

6.2 DETERMINATION OF WATERPROOFING PERFORMANCE

Weigh both the sealed and control cubes immediately before water immersion and record the weight. The cubes are then totally immersed in tap water at 23 ± 2^oC 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 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 to be calculated as follows:

$$= (\frac{CGTG1}{CG})x100\%$$

Initial Waterproofing Performance

CG - average weight gain per cube of the control set

TG_1 - average weight gain per cube of the sealed set

6.3 DETERMINATION OF WATERPROOFING PERFORMANCE AFTER SURFACE ABRASION ON TYPE 1 SEALERS

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

Once the drying is complete, sandblast the entire surface of the three 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^o angle to the cube face being blasted. Sandblasting leaves a rough surface making it difficult to measure the amount of surface removed. In order to improve the measurement of surface loss per cube side, weigh the material removed from each face. Remove mass from each of the six faces as follows:

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

Weigh the sealed cubes after abrasion and record the weight. Immerse the cubes as in Section 6.2 above to determine the effect of surface abrasion on the waterproofing performance of the sealer.

Calculate the waterproofing performance after abrasion as follows:

$$\text{Waterproofing Performance} = \left(\frac{CGTG2}{CG}\right) x100\%$$

CG - average weight gain per cube of the control set as obtained in paragraph 6.2.

TG2 - average weight gain per cube of sealed set after abrasion.

7.0 PROCEDURE FOR MEASURING SOLIDS CONTENT

7.1 NON-VOLATILE CONTENT

Non-volatile content is used for calculating the increase in weight of sealed cubes due to the sealer after the volatile content has evaporated.

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 nonvolatile 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^oC. Weights are determined at the beginning and end of the 14 day vapour transmission period and the weight loss is the water or liquid content of the sealer and the material retained is the non volatile content.

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

The non-volatile content of type 2a, 2b and 3 sealers is Ns%, as determined in Section 5.2 above.

7.2 NON-VOLATILE CONTENT, ACCELERATED TEST PROCEDURE FOR TYPE 2 & 3 SEALERS

For purposes of finger printing and approval of products, the non-volatile content test shall be repeated as per Section 7.1 except that the sample shall be dried to a constant weight in a ventilated oven maintained at $110 \pm 5^{o}C$. The result shall be reported as the Solids Content, SC by the formula listed below.

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.

$$SC\% = \frac{\text{Weight of retained material x 100}}{\text{initial weight of sealer}}$$

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

8.0 LAB DATA ACQUISITION FORMS FOR CONCRETE SEALER TESTS

8.1 SECTION 1. GENERAL

Lab:_____ Lab Project # _____

Client:_____

Lab Series # _____ Date Sealer Received: _____

Sealer Manufacturer & Address: _____

_____

Alberta Distributor & Address: _____

_____

Sealer Type:_____ Name:_____

Generic Description:_____

Classification:_____

Viscosity:_____ Texture:_____

Specific Gravity, Component "A":_____ "B":_____

Combined or single: _____ = Gs

Requested Application Rate: _____ mL/m^2

Proposed Application Rate, 1st Appl: _____ mL/m^2

2nd Appl: _____ mL/m^2 Comb: _____mL/m^2

3rd Appl: _____ mL/m^2 (Type 1c only)

Comb: _____ mL/m

Time Type 1b cubes needed to dry to 70 $\pm$ 2% RM: _____ days

Time Type 1c cubes needed to dry to 80 $\pm$ 2% RM: _____ days

Time Allowed between Applications: _____ min.

Legend

CC	Control Cubes
CD_1	Weight of Control Cubes after initial 5 days of Drying
CD_2	Weight of Control Cubes after initial 5 days of Drying
CG	Weight Gain of Control Cubes, 1st Water Immersion
CM	Weight of Control Cubes after moist conditioning
Gs	Specific Gravity
L1, L2 ...	Line number
L1av, L2av ...	Average of that line
Ns	Nonvolatile Content
RH	Relative Humidity
RM	Relative Moisture Content
SC	Solids content of sealers, accelerated method
SD	Weight of dried sealer adhering to treated cubes
SF	Weight of Fresh Sealer applied to treated cubes
SL	Weight of sealer portion that evaporated during drying period
SSD	Saturated surface-dry
SW	Weight of Fresh Sealer
TC	Test Cubes
TD_1	Weight of Test Cubes after initial 5 days of Drying
TD_2	Weight of Test Cubes after 10 days of Drying
TG1	Weight Gain of Test Cubes, 1st Water Immersion
TG2	Weight Gain of Test Cubes, 2nd Water Immersion
TM	Weight of Test Cubes after moist conditioning
TS_1	Weight of Sealed Cubes, 1st application
TS_2	Weight of Sealed Cubes, before 2nd application
TS_3	Weight of Sealed Cubes, after 2nd application
TS_4	Weight of Sealed Cubes, before 3rd application
TS_5	Weight of Sealed Cubes, after 3rd application
VLC	Water Loss due to Vapour Transmission in Control Cubes
VLT	Water Loss due to Vapour Transmission in Test Cubes
VT	Vapour Transmission, %, of Test Cubes
W/C	Water-Cement Ratio