Laboratory Report T32800.08.10-R1

Static Wind Uplift Testing

of

Tufdek Waterproofing Systems

in accordance with

ICC-ES AC39

Prepared for: **Tuff Industries Inc.**
9570 Bottom Wood Lake Road
Lake Country, BC V4V 1S7
Canada
c/o: Bryan Hughes

Test Lab: **TRINITY|ERD**
10 Mauney Court, Columbia, SC 29201

Date of Issuance: August 10, 2010

Revision 1: **February 6, 2017**

CLIENT INFORMATION: **Tuff Industries Inc.**
9570 Bottom Wood Lake Road
Lake Country, BC V4V 1S7
c/o: Bryan Hughes

TRINITY|ERD PROJECT: 2010.T32800SC

SAMPLES:

Membranes:	**By:**
Tufdek	Tuff Industries

Adhesives / Compounds:	**By:**
Tuff Trowel On	Tuff Industries
Tuff Low VOC Contact Adhesive	
Tuff Roll-On	
Tuff-Deck Patch	

SAMPLE DELIVERY: TRINITY|ERD randomly sampled roll goods and adhesives representative of production at the Lake Country, BC distribution facility on 03/29/2010 in accordance with ICC-ES AC85 requirements. The named client arranged for shipment of said materials to TRINITY|ERD's South Carolina lab for testing, received 04/20/2010.

TEST DATE(S): 05/13/2010 – 07/26/2010

M-D NOTIFICATION: ERD07108

TECHNICIANS: C. Phillips, A. Holtkamp, H. Dixon, W. Narciso (sampling)

TESTS:

PROPERTIES	STANDARDS	EQUIPMENT
Impact Resistance	AC39, Sec. 4.15, FM 4470	ERD Foot Traffic apparatus
Peel Adhesion	ASTM D903	Satec T-5000
Bonded pull – 2 x 2 ft	AC39, Sec. 4.13.4, ANSI/FM 4474(B), TAS 114(D)	ERD Bonded Pull
Wind uplift - 12 x 24 ft	AC39, Sec. 4.13.4, ANSI/FM 4474(D), TAS 114(J)	ERD 12x24 Test apparatus

STANDARDS: ICC-ES AC39, Approved April 2011 – *Acceptance Criteria for Walking Decks*, ©ICC-ES.
FM Standard 4470, *Approval Standard for Single-Ply, Polymer-Modified Bitumen Sheet, Built-Up Roof (BUR) and Liquid Applied Roof Assemblies for use in Class 1 and Noncombustible Roof Deck Construction,* ©FM Approvals, LLC.
ASTM D903-98 (Reapproved 2004) – *Standard Test Method for Peel or Stripping Strength of Adhesive Bonds*, ©ASTM.
ANSI/FM 4474 – American National Standard for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures, ©FM Approvals, LLC.
Testing Application Standard (TAS) 114-11, Appendix D – *Test Procedure for Simulated Uplift Pressure Resistance of Adhered Roof System Assemblies,* ©ICC.
Testing Application Standard (TAS) 114-11, Appendix J – Test Procedure for 12' x 24' Simulated Uplift Pressure Resistance of Roof System Assemblies, ©ICC.

1. IMPACT RESISTANCE PER "RESISTANCE TO FOOT TRAFFIC TEST": (ICC-ES AC39, SEC. 4.15; FM 4470, SEC. 5.5)

1.1 Specimen Preparation:
A 12-inch square section of the membrane is loose-laid horizontally over the selected substrate.

1.2 Procedure:
A 3 in. (76 mm) square steel plate with rounded corners is be centered on the specimen centerline and positioned along the butt-edge and side-joint of the substrate. A 200 lb load is imposed on the steel plate. The superimposed load shall be reduced to zero and the sample cover reloaded a minimum of four additional times, with penetration and residual readings taken each time without removing the plate. The specimen shall be inspected after the test and the condition of the cover noted at the steel plate interface.

Tearing or cracking of the protective coating causing exposure of the plastic, glass fibers, foam or other compressible core material is unacceptable.

1.3 Results:

TABLE 1: IMPACT RESISTANCE

Specimen	Substrate	Result	Pass/Fail
Tufdek	Plywood	No penetration, no damage	**Pass**
	Concrete	No penetration, no damage	**Pass**

2. COMPARATIVE PEEL RESISTANCE: (ASTM D903)

2.1 Scope:
Comparative adhesion testing was conducted on the Tufdek membrane applied to plywood and concrete substrates using three adhesives to select the critical adhesive for each substrate. The critical adhesive was then used to construct the full scale wind uplift specimens.

2.2 Specimen Preparation:
Five specimens measuring 1 x 12 inches (1 x 6 inches bonded) were constructed by bonding the membrane to plywood and concrete substrates using the referenced adhesives.

- Tuff Trowel On: Substrate only at 130 ft^2/gallon.
- Tuff Roll-On: Substrate only at 160 ft^2/gallon.
- Tuff Low VOC Contact Adhesive: Contact-application at 100 ft^2/gallon/surface.

Specimens were constructed and conditioned at 73°F and 50% relative humidity for 28 days prior to testing.

2.3 Procedure:
The unbonded section of the specimen is secured in the lower grip, and the substrate is secured in the upper grip of the universal testing machine (See Figure 2 from D903 standard). Load is applied at a modified rate of 2 inches/minute, and average peel adhesion load is recorded.

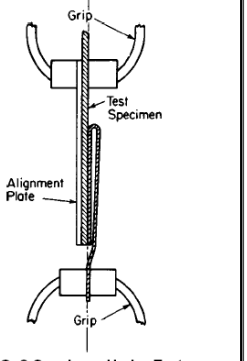
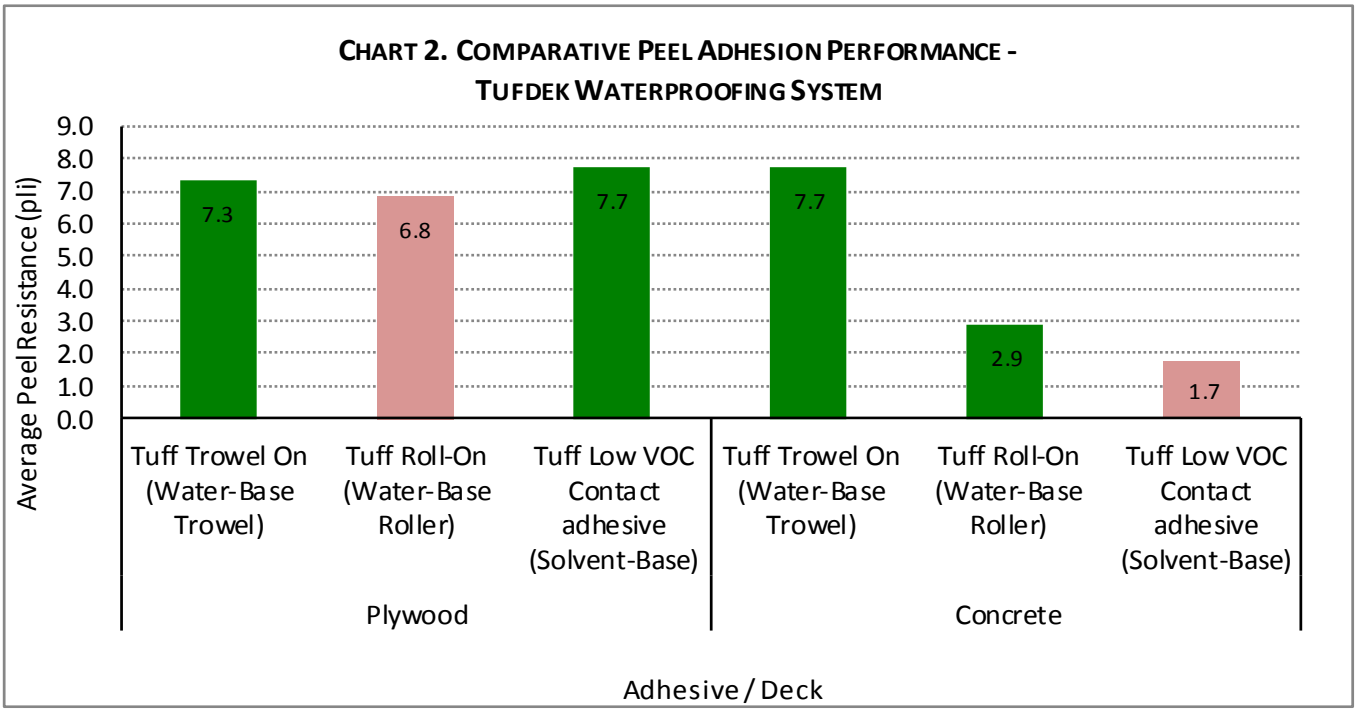


FIG. 2 Specimen Under Test

2.4 Results:

TABLE 2: COMPARATIVE PEEL ADHESION

Substrate	Adhesive	Test Data (pli)					Results	
		1	2	3	4	5	Average	SD
Plywood	Tuff Trowel On	8.7	6.8	6.8	8.7	5.6	**7.3**	1.4
	Tuff Roll-On	7.2	6.5	6.0	6.9	7.6	**6.8**	0.6
	Tuff Low VOC Contact Adhesive	6.7	5.7	8.2	10.8	7.0	**7.7**	2.0
Concrete	Tuff Trowel On	9.2	7.0	7.9	7.3	7.2	**7.7**	0.9
	Tuff Roll-On	2.5	2.9	2.7	2.7	3.6	**2.9**	0.4
	Tuff Low VOC Contact Adhesive	1.5	1.6	1.8	1.9	1.8	**1.7**	0.2



2.5 Observations:

The critical adhesive for plywood substrate applications is Tuff Roll-On. **Tuff Roll-On** adhesive was utilized for the 12 x 24 ft simulated uplift testing over plywood deck.

The critical adhesive for concrete substrate applications is Tuff Low VOC Contact Adhesive. **Tuff Low VOC Contact Adhesive** was utilized for the 2 x 2 ft bonded pull testing over concrete deck.

3. BONDED PULL – 2 X 2: (ICC-ES AC39, SEC. 4.13.4, FM 4474)

3.1 Specimen Preparation:

Three panels measuring 2 x 2 ft are constructed for each assembly, using the specifications provided by the client. The specimen is held at ambient conditions for 28 days prior to testing.

TABLE 3A: 2X2 FT SPECIMEN ASSEMBLY

Sample ID	Deck	Waterproofing Application	
		Membrane	Attach
1	Concrete	Tufdek	Tuff Low VOC Contact Adhesive, applied @ 100 sq. ft. /gal.

3.2 Procedure:

A 0.75 in thick piece of plywood is adhered to the top of the specimen as a load transfer device. A 2 x 2 ft. steel plate is mechanically attached to the plywood facer. A load cell is installed in-line with the center-point of the steel plate and the apex of a steel frame, which sits over the specimen with its supporting members at deck-level.

A hydraulic pump is used to increase pressure to the test panel, and load is recorded through the load-cell. A net pressure of 30 psf is applied to the test sample and maintained for 1 min. The pressure is increased in increments of 15 psf and held for 1 min. until failure occurs.

3.3 Results:

TABLE 3B: TEST RESULTS, BONDED PULL, 2 X 2, PANEL 1

Sample ID:	1
Deck:	Concrete
Waterproofing Membrane:	Tufdek
Waterproofing Membrane Attach:	Tuff Low VOC Contact Adhesive, applied @ 100 sq. ft. /gal.

Specimen #	Failing Pressure (psf)	Mode of Failure	Passing Pressure (psf)
1	None	Exceeds equipment capacity	1260
2	None		1260
3	None		1260
		Average:	**1260**
		Standard Deviation:	0
		Allowable Maximum Design Pressure (psf):	**-630**

4. WIND UPLIFT RESISTANCE – 12 X 24 FT: (ICC-ES AC39, SEC. 4.13.4, FM 4474)

4.1 Sample Preparation:

One specimen measuring 13 x 27 ft is constructed for each assembly.

Decking consists of nominal 5/8-inch thick T&G plywood mechanically attached 6-inch o.c. with #8 wood screws and LePage Bulldog Grip PL 400 Heavy-Duty Sub-Floor Adhesive, to wood structural supports spaced 16" o.c.

Deck joints are filled & leveled with Tuff-Deck Patch leveling compound.

TABLE 4A: SUMMARY OF 12 X 24 FT SPECIMEN CONSTRUCTION

Sample ID	Deck	Waterproofing Application	
		Membrane	Attach
2	See 4.1	Tufdek	Tuff Roll-On, applied @ 160 sq. ft. /gal.

View of Adhesive / Membrane Application

4.2 Procedure:

The simulated wind uplift pressure tests utilize a 24 ft (7.3 m) long by 12 ft (3.7 m) wide steel vacuum pressure vessel arranged to apply vacuum air pressure at pre-established standard rates to the topside of the test panel, which forms the bottom of the pressure vessel.

A net pressure of 30 psf (1.4 kPa) is applied to the test sample and maintained for 1 minute. The pressure is increased in increments of 15 psf (0.7 kPa) and held for 1 min until failure occurs.

4.3 Results:

TABLE 4B: TEST RESULTS, WIND UPLIFT, 12 x 24, SAMPLE 2			
Sample ID:	2		
Deck:	5/8-inch thick T&G plywood, attached with #8 wood screws and LePage Bulldog Grip PL 400 Heavy-Duty Sub-Floor Adhesive, to wood structural supports spaced 16" o.c. Deck joints are filled & leveled with Tuff-Deck Patch leveling compound.		
Waterproofing Membrane:	Tufdek		
Waterproofing Membrane Attach:	Tuff Roll-On, applied @ 160 sq. ft. /gal.		
Failing Pressure (psf)	**Failure Time (sec)**	**Mode of Failure**	**Passing Pressure (psf)**
None	N/A	Exceeds equipment capacity	**345**
		Average:	**345**
		Allowable Maximum Design Pressure (psf):	**-172.5**

5. CONCLUSIONS:

5.1 Impact Resistance:

TRINITY|ERD has tested Tufdek waterproofing systems for impact resistance in accordance with the requirements set forth in Section 4.15 of ICC-ES AC39 over plywood and concrete substrates.

Review of results indicates compliance with the criteria set forth in the test method.

5.2 Wind Uplift Performance:

5.2.1 **Panel 1: Pass 1260 psf ⇨ Allowable Design Pressure = -630 psf:**

Deck:	Concrete
Waterproofing Membrane:	Tufdek applied in Tuff Trowel-On, Tuff Roll-On or Tuff Low VOC Contact Adhesive in accordance with Tuff Industries published installation instructions.

5.2.2 **Panel 2: Pass 345 psf ⇨ Allowable Design Pressure = -172.5 psf:**

Deck:	5/8-inch thick T&G plywood at max. 16-inch o.c. spans, attached to wood structural supports with #8 wood screws and LePage Bulldog Grip PL 400 Heavy-Duty Sub-Floor Adhesive, or attached to meet project design loads to the satisfaction of the Authority Having Jurisdiction.
Deck Joint Treatment:	Deck joints are filled & leveled with Tuff-Deck Patch leveling compound.
Waterproofing Membrane:	Tufdek applied in Tuff Trowel-On, Tuff Roll-On or Tuff Low VOC Contact Adhesive in accordance with Tuff Industries published installation instructions.

5.3 The simulated uplift test protocols references herein are identical to those found TAS 114, Appendix D and J. Therefore, testing herein is also applicable for use in the HVHZ jurisdictions of the Florida Building Code.

Please contact our offices with any questions.

Sincerely,
TRINITY|ERD

Signed: _____
Charles Phillips
Section Lead, Large Scale Testing

Signed: _____
Robert Nieminen, P.E.
Vice-President
Florida Reg. No. 59166

REPORT HISTORY:

Date	Event	Notes	Authorized By:
08/04/2010	Draft report issued	For client review	RN
08/10/2010	Final report issued	After client review	RN
02/03/2017	Draft Revision 1 issued	For client review; update product trade names per client declaration	RN
02/06/2017	Revision 1 issued	After client review; update product trade names per client declaration	RN