RESEARCH REPORT

TESTING THE ADHESION OF AIR BARRIER MEMBRANES IN WALL ASSEMBLIES

Canada

CMHC SCHL
HOME TO CANADIANS

CMHC—HOME TO CANADIANS

Canada Mortgage and Housing Corporation (CMHC) is Canada's national housing agency. We contribute to improving the living conditions and the well-being of Canadians.

Our housing finance activities centre around giving Canadians access to affordable financing solutions. The main tool to achieve this goal is our mortgage loan insurance program.

We help lower-income households — seniors, people with disabilities, Aboriginals, women and children fleeing family violence, youth at risk, and individuals who are homeless or at risk of homelessness — to gain access to safe, affordable housing.

Through our research, we encourage innovation in housing design and technology, community planning, housing choice and finance. We offer a wide variety of information products to consumers and the housing industry to help them make informed purchasing and business decisions.

We also work with our government partners and industry to promote Canadian products and expertise in foreign markets, thereby creating jobs for Canadians here at home.

In everything that we do, we are committed to helping Canadians access a wide choice of quality, affordable homes, and making vibrant and sustainable communities a reality across the country. CMHC is home to Canadians.

Visit us at www.cmhc.ca

You can also reach us by phone at 1 800 668-2642
(outside Canada call 613 748-2003)
By fax at 1 800 245-9274
(outside Canada 613 748-2016)

Canada Mortgage and Housing Corporation supports the Government of Canada policy on access to information for people with disabilities. If you wish to obtain this publication in alternative formats, call 1 800 668-2642.

TESTING THE ADHESION OF AIR BARRIER MEMBRANES

IN WALL ASSEMBLIES

Prepared For: Mr. Luis de Miguel
Senior Researcher
Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Prepared By: Retro-Specs Consultants Ltd.
446-B Brooklyn Street
Winnipeg, Manitoba
R3J 1M7

Tel: (204) 885-2670
Fax: (204) 832-4381
Email: retrspec@mts.net

Report Date: October 2004

RESEARCH HIGHLIGHT

March 2005

Technical Series 05-105

TESTING THE ADHESION OF AIR-BARRIER MEMBRANES IN WALL ASSEMBLIES

INTRODUCTION

Structural integrity of the air barrier is one of the requirements identified in the *1995 National Building Code of Canada* (NBCC). This means that an air-barrier system in a structure that is exposed to wind load should transfer the load to the structure. Further, the air-barrier system should be designed and built to resist specified wind loads.

One of the critical performance characteristics of air-barrier materials is long-term adhesion. An air-barrier system must be able to resist peak wind-loads, stack-pressure effects and sustained pressurization loads over the long-term without showing signs of detachment, rupturing, deflection or creep-load failure.

Currently, there is limited information about adhering air-barrier materials to an underlying surface, or how adhesion changes both over time and through exposure to different environmental conditions.

RESEARCH PROJECT

Retro-Specs Consultants Ltd., Winnipeg, conducted this research for Canada Mortgage and Housing Corporation (CMHC).

Objectives

- Evaluate and compare the adhesion performance between membranes and substrates of different air-barrier membrane materials and to determine whether time, environmental conditions or the type of primer used together with the membrane affect adhesion.
- Provide a benchmark for membrane–substrate adhesion that could provide both a reference point for comparison with other test results and quantifiable performance requirements that could be applied in the field.

Figure 1: The hand-operated digital fastener tester used for tensile adhesion.

Scope of work

1. Establish benchmarks for the adhesion strength between an air-barrier membrane and substrate.
2. Establish adhesion strength between an air-barrier membrane and substrate after exposure to different environmental conditions and to identify changes in adhesion performance compared to project benchmarks. This phase consisted of three mutually exclusive sections:

Canada

CMHC SCHL
HOME TO CANADIANS

- Exposure to low temperature.
- Exposure to high temperature and high humidity.
- Water saturation.

3. Establish adhesion strength between an air-barrier membrane and substrate after predetermined time intervals and determine whether adhesion performance increased, decreased or remained constant.

Environmental variables

To determine the effect of environmental conditions—cold temperatures, high temperature-high RH and wetting of substrate—on the performance of membrane–substrate adhesion strength of air-barrier systems. To make this determination, samples were either:

Exposed to a temperature of -20°C (-4°F) for 48 hours

or

Exposed to a temperature of 25°C (77°F) at 95 per cent RH for 60 days

or

Saturated with water for eight days, after which the substrate was allowed to dry. Following each exposure condition, the researchers measured adhesion strength between the air-barrier material and substrate at room temperature.

Figure 2: Fast peel test

Sampling

A total of 375 specimens were constructed. Each of the 32 membrane-substrate combinations was considered a "system."

Construction of samples

Eight different membrane systems were considered:

- five self-adhesive sheet membrane systems
- one torch-applied sheet membrane system
- two liquid-membrane systems.

Each membrane system was tested on four substrates:

- exterior drywall
- glass-faced gypsum board
- poured-in-place concrete
- concrete block

The eight membrane systems and four substrates made a total test sample of 32 different air-barrier systems.

All specimens were constructed and membranes installed in strict accordance with manufacturers' recommendations under controlled laboratory conditions. Self-adhesive sheet membranes and torch-applied sheet membranes were installed over the complete surface of one side of the substrate, with a 3.8-cm (1.5-in.), folded, salvage-edge at the top of the sample to facilitate peel-adhesion testing. The specimens were allowed to cure for a minimum of 24 hours before conditioning or testing.

To prepare the liquid-membrane specimens, a skim coat of liquid-membrane material was applied over the complete surface of one side of the substrate. Liquid membranes were allowed to cure for a minimum of seven days before conditioning or testing.

Membrane adhesion to the substrate was tested three ways

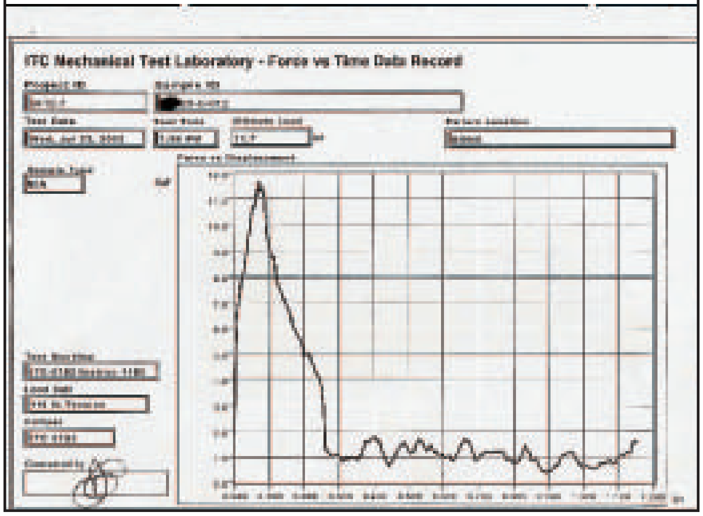
1. strength of tensile adhesion to the substrate
2. slow-peel resistance
3. fast-peel resistance.

Tensile adhesion testing was conducted in general accordance with ASTM D 4541, using a hand-operated, digital-fastener tester that applied a tensile load to the specimen.

Slow-peel resistance testing

Test specimens were mounted vertically on the wall and a 100-g (3.5-oz.) load was clamped onto the salvage edge on a strip of the membrane, placing a 180-degree peel-load against the salvage edge. The length of the portion of the strip that detached and peeled from the substrate was measured and recorded daily.

Figure 3: Example of tensile resistance graph showing failure load.



Fast-peel resistance testing

The rigid substrate of the test specimen was clamped to a vertical alignment plate mounted on the base of a universal testing machine equipped with a tension-load cell. The salvage edge on a strip of the membrane was folded back 180 degrees and firmly gripped with a specially fabricated clamp attached to the load-cell through a tension rod. The loading-cell was zeroed and the test machine was started to peel the strip from the rigid substrate. The force required to peel the strip from the substrate was recorded on graphs.

No sample was exposed to more than one of the conditioning variables. In other words, a specimen that was "frozen" was not then saturated—a different specimen was built and saturated.

SIGNIFICANT FINDINGS

- When installed under controlled laboratory conditions and without exposure to any of the control variables, the torch-applied sheet membrane, liquid membranes and self-adhesive sheet membranes–solvent-based primers consistently withstood tensile loads in excess of 172 kPa (25.0 psi) without detaching from the substrate.
- Some specimens of torch-applied sheet membranes, liquid membranes and self-adhesive sheet membranes-solent-based primers, remained adhered at tensile loads as high as 370 kPa (53.8 psi), 450 kPa (65.2 psi) and 278 kPa (40.4 psi).
- Self-adhesive sheet membranes–water-based primers consistently withstood tensile loads up to 103 kPa (15.0 psi) without detaching from the substrate, although the range between the high 220 kPa (32.0 psi) and low 50 kPa (7.2 psi) test results was significantly larger than those of the other membranes.
- Under controlled laboratory conditions and without exposure to any control variables, and with a sustained 100-g load clamped onto the membrane's salvage edge, adhesion of self-adhesive sheet membranes was affected by the load in the short-term, as the membrane either peeled from the substrate or the polyethylene carrier-sheet separated from the bitumen (which remained adhered to the substrate) within the 28-day, slow-peel resistance test period.
- The torch-applied sheet membrane and liquid membranes exhibited good short-term resistance to the sustained load, as there was little to no detachment of these membranes during the 28-day test period.
- When installed under controlled laboratory conditions and without exposure to any of the control variables, a peak-peel load greater than 1.93 kN/m (11.0 lbf/in.) was generally required to peel the torch-applied sheet membrane, asphalt-based liquid membrane and self-adhesive sheet membranes–solvent-based primers from the substrate during fast-peel resistance testing, with some specimens remaining adhered at loads in excess of 6.13 kN/m (35.0 lbf/in.).
- During fast-peel resistance testing, self-adhesive sheet membranes–water-based primers and the rubber-based liquid membrane consistently peeled from the substrate at peak-peel loads less than 1.93 kN/m (11.0 lbf/in.) and as low as 0.75 kN/m (4.3 lbf/in.) and 0.19 kN/m (1.1 lbf/in.).
- A membrane's tensile-adhesion test results did not necessarily correlate with its peel-resistance test results.
- Adhesion characteristics of self-adhesive sheet membranes under controlled laboratory conditions and without exposure to any of the control variables depended on the primer or primer–substrate combination used. Self-adhesive sheet membranes consistently withstood higher tensile and peel loads without detaching from the substrate when a solvent-based primer was used compared with a water-based primer in the short-term.
- Fast-peel resistance of self-adhesive sheet membranes/solvent-based primers *decreased* over a 60-day time period, by as much as

Figure 4: Adhesive failure in the field

19% on one product and 63% on another. Fast-peel resistance of self-adhesive sheet membranes/water-based primers *increased* over a 60-day time period, by as much as 14% on one, 25% on another and 97% on a product using a specially-formulated primer.

- It did not appear that exposure to a given control variable had a similar effect on all mem-branes or all membranes within a particular membrane class (self-adhesive, torch-applied, etc.), or even an individual membrane. The effect of each of the three conditioning cycles—low-temperature, high-temperature–high-humidity and saturation—on tensile adhesion and peel-resistance was generally specific to the combination of membrane, primer, and substrate.
- For most membranes, the tensile strength of adhesion between the membrane and substrate when installed on either drywall or glass-faced gypsum board was greater than the tensile strength of the drywall and glass-faced gypsum board material.

CMHC Project Manager: Luis de Miguel, ldemigue@cmhc.ca
Research conducted by Retro-Specs Consultants Ltd. Winnipeg

Kevin D. Knight (project manager)

Bryan J. Boyle, B. Comm. (assistant project manager/author)

Graham A. Knight (construction and testing manager)

Jack Guerreiro and Roland Robertson (test specimen preparation and testing)

Additional testing by Industrial Technology Centre (ITC) in Winnipeg

Engineering services by Gary Proskiw, P.Eng. of Proskiw Engineering Ltd. and Bert Phillips, P.Eng. of UNIES Ltd

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more *Research Highlights* plus a wide variety of information products, visit our Web site at

www.cmhc.ca

or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1 800 668-2642
Fax: 1 800 245-9274

OUR WEB SITE ADDRESS: www.cmhc.ca

63876

L E POINT EN RECHERCHE

Mars 2005

Série technique 05-105

MISE À L'ESSAI DE L'ADHÉSION DES MEMBRANES PARE-AIR DANS LES MURS

INTRODUCTION

L'intégrité structurale du pare-air constitue l'une des exigences énoncées dans l'édition 1995 du *Code national du bâtiment du Canada* (CNBC). C'est donc dire que le pare-air d'un bâtiment exposé au vent doit transmettre la charge à l'ossature. De plus, le pare-air doit être conçu et constitué pour résister aux surcharges de vent spécifiées.

L'une des caractéristiques de performance fondamentales du pare-air réside dans son adhésion à long terme. En effet, le pare-air doit être en mesure de résister aux surcharges de pointe dues au vent, à l'effet de tirage et à des charges de pressurisation soutenues à longue échéance sans afficher de signes de décollement, de rupture, de fléchissement ou de défaillance sous l'action de charges de fluage.

À l'heure actuelle, il existe de l'information limitée concernant le mode d'adhésion du pare-air à la surface sous-jacente ou la façon dont l'adhésion change au fil du temps ou sous l'effet de différentes conditions environnementales.

RECHERCHE

Le cabinet Retro-Specs Consultants Ltd., de Winnipeg, a mené la présente recherche pour la Société canadienne d'hypothèques et de logement (SCHL).

Objectifs

- Évaluer et comparer l'adhésion de membranes pare-air et de supports différents, en plus de déterminer si le temps, les conditions environnementales ou le type d'apprêt employé avec la membrane influent sur l'adhésion.
- Fournir un repère pour l'adhésion de la membrane au support, qui pourrait offrir à la fois un point de référence à des fins de comparaison avec d'autres résultats d'essais et exigences quantifiables en matière de performance qui pourraient s'appliquer à pied d'œuvre.

Figure 1 : Appareil numérique à commande manuelle appliquant une charge de tension au spécimen.

Étendue des travaux

1. Établir des repères à l'égard de la force d'adhésion retenant le pare-air au support.
2. Établir la force d'adhésion du pare-air au support après avoir été exposé à différentes conditions environnementales, et indiquer les changements d'adhésion par rapport aux repères de la recherche. Cette phase comportait trois volets mutuellement exclusifs :

Canada

SCHL CMHC
AU CŒUR DE L'HABITATION

- l'exposition à une basse température;.
- l'exposition à une température élevée et à un taux d'humidité élevé;
- la saturation d'eau.

3. Établir la résistance d'adhésion du pare-air au support après des intervalles prédéterminés et établir si l'adhésion a augmenté, diminué, ou est demeurée constante.

Variables environnementales

Pour déterminer l'effet des conditions environnementales, en l'occurrence les températures froides, le degré élevé de température ou d'humidité relative (HR) ainsi que le mouillage du support, sur l'adhésion de la membrane au support, des échantillons ont été :

exposés à une température de -20 °C (-4 °F) pendant 48 heures

ou

exposés à une température de 25 °C (77 °F) à une HR de 95 % pendant 60 jours

ou

saturés d'eau pendant huit jours, puis on a laissé sécher le support. Suivant chaque condition d'exposition, les chercheurs ont mesuré la force d'adhésion retenant le pare-air au support à la température ambiante.

Figure 2 : Essai de résistance au décollement rapide

Échantillonnage

En tout, 375 spécimens ont été réalisés. Chacune des 32 combinaisons membrane-support a été considérée comme un « système ».

Confection des échantillons

Huit membranes différentes ont été étudiées :

- cinq membranes autoadhésives en feuille;
- une membrane en feuille appliquée au chalumeau;
- deux membranes liquides.

Chacune des membranes a été testée sur quatre supports :

- plaques de plâtre pour usage extérieur;
- plaques de plâtre revêtues de fibre de verre;
- béton coulé sur place;
- blocs de béton.

Les huit membranes et les quatre supports ont permis de constituer un échantillon total de 32 pare-air différents.

Tous les spécimens ont été réalisés et les membranes mises en œuvre en stricte conformité avec les instructions des fabricants dans des conditions contrôlées en laboratoire. Les membranes auto-adhésives en feuille et les membranes en feuille s'appliquant au chalumeau ont été mises en œuvre sur tout un côté du support, sauf sur une distance de 3,8 cm (1,5 po) où le bord supérieur non collé de l'échantillon a été replié pour faciliter l'essai d'adhésion et de décollement. On a laissé ensuite les spécimens mûrir pendant au moins 24 heures avant le conditionnement ou les essais.

Pour préparer les spécimens de membrane liquide, on a appliqué une couche de liaison de la membrane liquide sur tout un côté du support. On les a ensuite laissé mûrir pendant au moins sept jours avant le conditionnement ou les essais.

L'adhésion de la membrane au support a été testée de trois façons :

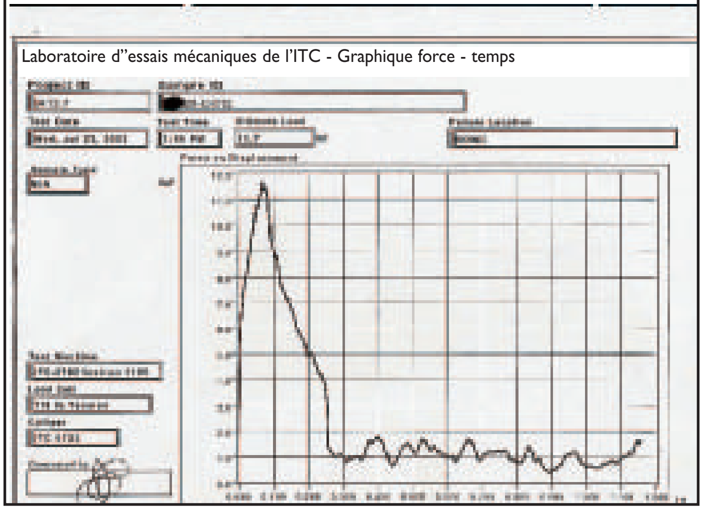
1. résistance à la traction de l'adhésion au support;
2. résistance au décollement lent;
3. résistance au décollement rapide.

Le test de résistance à la traction de l'adhésion a été mené en conformité générale avec la norme ASTM D 4541, au moyen d'un appareil numérique à commande manuelle, qui appliquait une charge de tension au spécimen.

Essai de résistance au décollement lent

Les spécimens d'essai ont été posés verticalement sur le mur et une charge de 100 g (3,5 oz) a été fixée au bord non collé de la bande de la membrane, en appliquant à 180° une charge d'arrachement contre le bord non collé. La longueur de la portion de la bande qui s'est détachée du support a été mesurée et consignée quotidiennement.

Figure 3 : Exemple de graphique de la résistance à la traction montrant la charge entraînant la défaillance



Essai de résistance au décollement rapide

Le support rigide du spécimen d'essai a été fixé à une plaque verticale d'alignement montée sur la base d'une machine d'essai universelle équipée d'une cellule de charge de tension. Le bord non collé de la bande de la membrane a été replié à 180° et fermement serré en place à l'aide d'une bride de fabrication spéciale fixée à la cellule de charge par une tige de tension. La cellule de chargement a été remise à zéro et la machine d'essai a ensuite commencé à arracher la bande du support rigide. La force requise pour arracher la bande du support a été consignée au moyen de graphiques.

Aucun échantillon n'a été exposé à plus d'une des variables de conditionnement. En d'autres mots, un spécimen qui était « gelé » n'était pas alors saturé; un spécimen différent était construit, puis amené au point de saturation.

RÉSULTATS SIGNIFICATIFS

- Lorsqu'elles ont été mises en œuvre dans des conditions contrôlées en laboratoire, sans toutefois être exposées à l'une des variables de contrôle, la membrane en feuille appliquée au chalumeau, les membranes liquides et les membranes autoadhésives en feuille posées à l'aide d'apprêts à base de solvant ont toujours résisté à des charges de traction supérieures à 172 kPa (25 lb/po^2) sans se détacher du support.
- Certains spécimens de membranes en feuille appliquées au chalumeau, de membranes liquides et de membranes autoadhésives posées à l'aide d'apprêts à base de solvant sont demeurés collés à des charges de traction atteignant 370 kPa (53,8 lb/po^2), 450 kPa (65,2 lb/po^2) et 278 kPa (40,4 lb/po^2).
- Les membranes autoadhésives en feuille posées à l'aide d'apprêts à base d'eau ont toujours résisté à des charges de traction atteignant 103 kPa (15 lb/po^2) sans se détacher du support, bien que la plage entre le maximum de 220 kPa (32 lb/po^2) et le minimum de 50 kPa (7,2 lb/po^2) ait été beaucoup plus importante que celle des autres membranes.
- Lorsqu'elles ont été mises en œuvre dans des conditions contrôlées en laboratoire, sans toutefois être exposées à l'une des variables de contrôle, mais assorties d'une charge soutenue de 100 g fixée au bord non collé de la membrane, les membranes autoadhésives en feuille ont vu leur adhésion être influencée par la charge à court terme, puisqu'elles se sont détachées du support ou que la feuille de polyéthylène s'est séparée du bitume (qui est demeuré collé au support) au cours de la période d'essai de résistance au décollement lent, d'une durée de 28 jours.
- La membrane en feuille appliquée au chalumeau et les membranes liquides ont affiché à court terme une bonne résistance à la charge soutenue, puisqu'elles se sont peu sinon pas du tout détachées au cours de la période d'essais de 28 jours.
- Lorsqu'elles ont été mises en œuvre dans des conditions contrôlées en laboratoire, sans toutefois être exposées à l'une des variables de contrôle, la membrane en feuille appliquée au chalumeau, la membrane liquide à base d'asphalte et les membranes en feuille autoadhésive posées à l'aide d'apprêt à base de solvant avaient généralement besoin d'une charge d'arrachement de pointe supérieure à 1,93 kN/m (11 lbf/po) pour se décoller du support au cours des essais de résistance à l'arrachement rapide, alors que certains spécimens sont restés collés à des charges supérieures à 6,13 kN/m (35 lbf/po).
- Lors de l'essai de résistance au décollement rapide, les membranes autoadhésives en feuille posées à l'aide d'un apprêt à base d'eau et la membrane liquide à base de caoutchouc se sont toujours détachées du support à des charges de pointe inférieures à 1,93 kN/m (11 lbf/po) et à des charges atteignant même 0,75 kN/m (4,3 lbf/po) et 0,19 kN/m (1,1 lbf/po).
- Les résultats des essais de résistance à la traction de l'adhésion de la membrane ne concordaient pas nécessairement avec les résultats des essais de résistance à l'arrachement.

Figure 4 : Défaillance d'adhésion de la membrane en service

- Les caractéristiques d'adhésion des membranes autoadhésives en feuille mises en œuvre dans des conditions contrôlées en laboratoire, sans toutefois être exposées à l'une des variables de contrôle, dépendaient de l'apprêt ou de la combinaison apprêt-support. Les membranes autoadhésives en feuille ont uniformément résisté à court terme à des charges de traction et d'arrachement plus élevées sans se détacher du support lorsqu'un apprêt à base de solvant avait été utilisé comparativement à un apprêt à base d'eau.
- La résistance au décollement rapide des membranes autoadhésives en feuille posées à l'aide d'un apprêt à base de solvant a diminué au cours d'une période de 60 jours, de 19 % pour un produit et de 63 % pour un autre. Par contre, la résistance au décollement rapide des membranes autoadhésives en feuille posées à l'aide d'un apprêt à base de'eau a augmenté au cours d'une période de 60 jours, de 14 % pour un produit, de 25 % pour un autre et de 97 % pour un produit posé à l'aide d'un apprêt de composition spéciale.
- Il n'a pas semblé que l'exposition à une variable de contrôle donnée ait eu un effet semblable sur toutes les membranes ou toutes les membranes à l'intérieur d'une catégorie particulière (autoadhésive, appliquée au chalumeau, etc.) ou même sur une membrane particulière. L'effet de chacun des trois cycles de conditionnement — température basse, température élevée, taux d'humidité élevé et saturation — sur la résistance à la traction de l'adhésion et la résistance à l'arrachement était généralement propre à la combinaison de membrane, d'apprêt et de support.
- Pour la plupart des membranes, la résistance à la traction de leur adhésion au support lorsqu'elles sont mises en œuvre sur des plaques de plâtre ordinaires ou des plaques de plâtre revêtues de fibre de verre était supérieure à la résistance à la traction des plaques de plâtre ordinaires et des plaques de plâtre revêtues de fibre de verre.

Directeur de projet : Luis de Miguel, ldemigue@cmhc.ca
Recherche menée par Retro-Specs Consultants Ltd. de Winnipeg

Kevin D. Knight (gestionnaire de projet)

Bryan J. Boyle, B. Comm. (gestion-naire de projet adjoint / auteur)

Graham A. Knight (gestionnaire de la construction et des essais)

Jack Guerreiro et Roland Robertson (préparation et mise à l'essai des spé-cimens)

Autres essais effectués par le Centre de technologie industrielle (ITC) de Winnipeg

Services de génie : Gary Proskiw, ing. du cabinet Proskiw Engineering Ltd. et Bert Phillips, ing. de UNIES Ltd.

Recherche sur le logement à la SCHL

Aux termes de la partie IX de la *Loi nationale sur l'habitation,* le gouvernement du Canada verse des fonds à la SCHL afin de lui permettre de faire de la recherche sur les aspects socio-économiques et techniques du logement et des domaines connexes, et d'en publier et d'en diffuser les résultats.

Le présent feuillet documentaire fait partie d'une série visant à vous informer sur la nature et la portée du programme de recherche de la SCHL.

Pour consulter d'autres feuillets *Le Point en recherche* et pour prendre connaissance d'un large éventail de produits d'information, visitez notre site Web à

www.schl.ca

ou communiquez avec la

Société canadienne d'hypothèques et de logement
700, chemin de Montréal
Ottawa (Ontario)
K1A 0P7

Téléphone : 1 800 668-2642
Télécopieur : 1 800 245-9274

NOTRE ADRESSE SUR LE WEB : www.schl.ca

63877

National Office
700 Montreal Road
Ottawa ON K1A 0P7
Telephone: (613) 748-2000

Bureau national
700 chemin de Montréal
Ottawa ON K1A 0P7
Téléphone : (613) 748-2000

Puisqu'on prévoit une demande restreinte pour ce document de recherche, seul le résumé a été traduit.

La SCHL fera traduire le document si la demande le justifie.

Pour nous aider à déterminer si la demande justifie que ce rapport soit traduit en français, veuillez remplir la partie ci-dessous et la retourner à l'adresse suivante :

Centre canadien de documentation sur l'habitation
Société canadienne d'hypothèques et de logement
700, chemin Montréal, bureau C1-200
Ottawa (Ontario)
K1A 0P7

Titre du rapport: ____

____

Je préférerais que ce rapport soit disponible en français.

NOM ____

ADRESSE____
rue App.

____
ville province Code postal

No de téléphone ( ) _______________

EXECUTIVE SUMMARY

One of the requirements for a successful air barrier system identified in the 1995 National Building Code of Canada is structural integrity; an air barrier system installed in an assembly subject to wind load, and other elements of the separator that will be subject to wind load, shall transfer that load to the structure, and it should be designed and constructed to resist specified wind loads. Long-term adhesion is a critical performance characteristic of air barrier materials; the air barrier system must be able to resist peak wind loads, stack pressure effects and sustained pressurization loads over the long-term without exhibiting signs of detachment, rupturing, deflection or creep load failure.

Currently there is limited industry reference as to how well air barrier materials should be adhered to substrates or how adhesion changes over time and/or when exposed to different environmental conditions. Canada Mortgage and Housing Corporation commissioned this project to quantify adhesion characteristics of air barrier membrane materials commonly used in multi-family and high-rise residential buildings. This study hopes to provide a benchmark for membrane-substrate adhesion that could provide both a reference point to which other test results could be compared, and quantifiable performance requirements that could be applied in the field.

The objective of the project was to evaluate and compare the membrane-substrate adhesion performance of different air barrier membrane materials, and to determine whether adhesion was affected by time, environmental conditions, or the type of primer. The scope of work consisted of three distinct and mutually exclusive experiments:

i. Establish benchmark performance standards for the strength of adhesion between the air barrier membrane and substrate.

ii. Establish the strength of adhesion between the air barrier membrane and substrate after exposure to environmental conditions and to identify changes in adhesion performance as compared to the project benchmarks. This phase consisted of three mutually exclusive sections:

- Exposure to low temperature.
- Exposure to high temperature and high humidity.
- Saturation.

iii. Establish the strength of adhesion between the air barrier membrane and substrate after predetermined time intervals, and to determine whether adhesion performance increased, decreased or remained constant over time.

Eight different membrane systems were considered in this project: five self-adhesive sheet membrane systems, one torch-applied sheet membrane system, and two liquid membrane systems. Each membrane system was tested on four substrates: exterior drywall, Dens-Glass Gold, poured-in-place concrete and concrete block, for a total of 32 different air barrier systems. All samples were constructed and membranes installed in

accordance with manufacturers' specifications and under controlled laboratory conditions.

Membrane adhesion to the substrate was tested three ways: strength of tensile adhesion to the substrate, slow-peel resistance and fast-peel resistance.

Tensile adhesion testing was conducted in general accordance with ASTM D 4541, using a hand-operated digital fastener tester that applied a tensile load to the specimen.

To conduct slow-peel resistance testing, test specimens were mounted vertically on the wall and a 100-gram load was clamped onto the salvage edge on a strip of the membrane, placing a 180-degree peel load against the salvage edge. The length of the portion of the strip that detached and peeled from the substrate was measured and recorded daily.

To conduct fast-peel resistance testing, the rigid substrate of the test specimen was clamped to a vertical alignment plate mounted on the base of a universal testing machine equipped with a tension load cell. The salvage edge on a strip of the membrane was folded back 180 degrees and firmly gripped with a specially fabricated clamp attached to the load cell through a tension rod. The loading cell was zeroed, and the test machine was started to peel the strip from the rigid substrate. The force required to peel the strip from the substrate was recorded on graphs.

Significant findings from the study were as follows:

- When installed under controlled laboratory conditions and without exposure to any of the control variables, the torch-applied sheet membrane, liquid membranes, and self-adhesive sheet membranes/solvent-based primers consistently withstood tensile loads in excess of 25.0 psi without detaching from the substrate, with some specimens of each remaining adhered at tensile loads as high as 53.8 psi, 65.2 psi and 40.4 psi respectively. Self-adhesive sheet membranes/water-based primers consistently withstood tensile loads up to 15.0 psi without detaching from the substrate, although the range between high (32.0 psi) and low (7.2 psi) test results was significantly larger than those of the other membranes.

- When installed under controlled laboratory conditions and without exposure to any of the control variables, and with a sustained 100-gram load clamped onto the membrane's salvage edge, adhesion of self-adhesive sheet membranes was effected by the load in the short-term, as the membrane either peeled from the substrate or the polyethylene carrier sheet separated from the bitumen (which remained adhered to the substrate) within the 28-day slow-peel resistance test period. The torch-applied sheet membrane and liquid membranes exhibited good short-term resistance to the sustained load as there was little to no detachment of these membranes during the 28-day test period.

- When installed under controlled laboratory conditions and without exposure to any of the control variables, a peak peel load greater than 11.0 lbf/in (1.93 kN/m) was generally required to peel the torch-applied sheet membrane, asphalt-based liquid membrane, and self-adhesive sheet membranes/solvent-based primers from the substrate during fast-peel resistance testing, with some specimens remaining adhered at loads in excess of 35.0 lbf/in (6.13 kN/m). Self-adhesive sheet membranes/water-based primers and the rubber-based liquid membrane consistently peeled from the substrate at peak peel loads less than 11.0 lbf/in (1.93 kN/m) and as low as 4.3 lbf/in (0.75 kN/m) and 1.1 lbf/in (0.19 kN/m) respectively.

- A membrane's tensile adhesion test results did not necessarily correlate with its peel-resistance test results.

- When installed under controlled laboratory conditions and without exposure to any of the control variables, the adhesion characteristics of self-adhesive sheet membranes depended on the primer or primer/substrate combination used with it. Self-adhesive sheet membranes consistently withstood higher tensile and peel loads without detaching from the substrate when a solvent-based primer was used than when a water-based primer was used, in the short-term.

- Fast-peel resistance of self-adhesive sheet membranes/solvent-based primers *decreased* over a 60-day time period, by as much as 19% on Product-A/SB and 63% on Product-C/SB. Fast-peel resistance of self-adhesive sheet membranes/water-based primers *increased* over a 60-day time period, by as much as 14% on Product-A/WB, 25% on Product-B/WB and 97% on Product-B/WBX.

- It did not appear that exposure to a given control variable had a similar effect on all membranes, or all membranes within a particular membrane class (self-adhesive, torch-applied, etc.), or even an individual membrane. The effect of each of the three conditioning cycles, low-temperature, high-temperature/high-humidity, and saturation, on tensile adhesion and peel-resistance was generally specific to the combination of membrane, primer, and substrate.

- For most membranes, the tensile strength of adhesion between the membrane and substrate when installed on either drywall or Dens-Glass Gold superseded the tensile strength of the drywall and Dens Glass Gold material.

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

1.1 Background

In 1995, major revisions to the National Building Code of Canada (NBCC) were introduced, defining mandatory requirements for air barrier systems in multi-family and high-rise residential buildings. Although building designers now had to ensure that specified air barrier materials met NBCC requirements, and installers now faced mandatory requirements for their installations, problems in the field continued. Many air barrier systems performed adequately, but there were also many instances of delaminating of air barrier materials.

One of the requirements for a successful air barrier system as identified in the NBCC is structural integrity, specifically "an air barrier system installed in an assembly subject to wind load, and other elements of the separator that will be subject to wind load, shall transfer that load to the structure." It should be "designed and constructed to resist 100% of the specified wind load as determined in Subsection 4.1.8." Long-term adhesion is therefore a critical performance characteristic of air barrier materials, as the air barrier system must be able to resist peak wind loads, stack pressure effects and sustained pressurization loads over the long-term without exhibiting signs of detachment, rupturing, deflection or creep load failure.

While Canada Mortgage and Housing Corporation (CMHC) has undertaken several studies to quantify the air permeability of commonly used construction materials, there is little published information on other aspects of air barrier material performance. Air barrier material manufacturers often provide the air permeance characteristics of their materials, but there is limited industry reference as to how well these materials should be adhered to substrates or how adhesion changes over time and/or when exposed to different environmental conditions.

CMHC commissioned this project to quantify adhesion characteristics of air barrier membrane materials commonly used in multi-family and high-rise residential buildings. Although the original scope of the study was to test various construction *details*, it was determined that the results would not be meaningful due to lack of information about the materials themselves. What was required, and what this study hoped to provide, was a 'benchmark' for membrane-substrate adhesion that could provide both a reference point to which other test results could be compared, and quantifiable performance requirements that could be applied in the field.

1.2 Project Team

Retro-Specs Consultants' (RSC) project team consisted of:

- Kevin D. Knight (Project Manager)
- Bryan J. Boyle, B. Comm. (Assistant Project Manager/Author)

- Graham A. Knight (Construction and Testing Manager)
- Jack Guerreiro (Test Specimen Preparation and Testing)
- Roland Robertson (Test Specimen Preparation and Testing)

Some of the specimen conditioning and testing was conducted by Industrial Technology Centre (ITC) in Winnipeg, Manitoba. The ITC project team consisted of:

- Wolfgang Herwig, P.Eng. (Project Manager)
- Lincoln Oree, CET (Mechanical Test Technologist)
- Dale Kellington, B.Sc. (Engineering Projects Coordinator)

Engineering services were provided by Mr. Gary Proskiw, P.Eng. of Proskiw Engineering Ltd., and Mr. Bert Phillips, P.Eng. of UNIES Ltd.

2.0 OBJECTIVES AND SCOPE

2.1 Objectives

The objective of the project was to evaluate and compare membrane-substrate adhesion performance of different air barrier membrane materials, and to determine whether adhesion was affected by time, environmental conditions, or the type of primer used in conjunction with the membrane.

2.2 Scope

The scope of work consisted of three distinct and mutually exclusive experiments:

i. Establish benchmark performance standards for the strength of adhesion between the air barrier membrane and substrate.

ii. Establish the strength of adhesion between the air barrier membrane and substrate after exposure to environmental conditions and to identify changes in adhesion performance as compared to the project benchmarks. This phase consisted of three mutually exclusive sections:

- Exposure to low temperature.
- Exposure to high temperature and high humidity.
- Saturation.

iii. Establish the strength of adhesion between the air barrier membrane and substrate after predetermined time intervals, and to determine whether adhesion performance increased, decreased or remained constant over time.

2.3 Materials Selection[1]

Three self-adhesive sheet membranes were selected and designated as ‘Product-A’, ‘Product-B’ and ‘Product-C’. Specimens of Product-A were constructed using either a solvent-based primer, designated as Product-A/SB, or a water-based primer, designated as Product-A/WB. Specimens of Product-B were constructed using either a water-based primer, designated as Product-B/WB, or a specially-formulated primer designated as Product-B/WBX[2]. Specimens of Product-C were constructed using a solvent-based primer, designated Product-C/SB.

---

[1] Refer to Appendices A through H for a more detailed description of each material and primer.

[2] Primer WBX is described by the manufacturer as “a high solid, organic primer with additives to facilitate adhesion to damp substrates and green concrete.” It is not a ‘traditional’ solvent-based primer, but rather more of a hybrid. As its VOC (Volatile Organic Compound) level is lower than traditional solvent-based primers and many of its properties and characteristics (such as temperature limitations for installation) are more reminiscent of water-based primers, it has been considered a member of the water-based primer family for the purpose of this study.

One torch-applied sheet membrane was selected and designated as 'Product-D'. Two liquid membranes were selected: an asphalt-based membrane designated as 'Product-E', and a rubber-based membrane designated as 'Product-F'.

Therefore, there were a total of eight different membrane systems considered for this project, as follows:

i. Self-Adhesive Sheet Membranes

- Product-A/SB
- Product-A/WB
- Product-B/WB
- Product-B/WBX
- Product-C/SB

ii. Torch-Applied Sheet Membrane Systems

- Product-D

iii. Liquid Membrane Systems

- Product-E
- Product-F

Four different substrates were considered in the project: exterior drywall, Dens-Glass Gold, poured-in-place concrete and concrete block. Each of the eight air barrier membranes was used in conjunction with each of the substrates, for a total of 32 different air barrier 'systems'.

3.0 MATERIALS

An air barrier is a material that can be used to control the movement of air through the building envelope or between dissimilar environments within the building. The NBCC specifies that sheet and panel type materials intended to provide the principal resistance to air leakage shall have an air leakage characteristic not greater than 0.02 $L/(s/m^2)$ measured at an air pressure difference of 75 Pa. While there are many materials that satisfy this requirement, the most commonly used air barrier materials fall under one of five categories: self-adhesive sheet membranes, torch-applied sheet membranes, liquid membranes, spray-applied urethane foam, and rigid air barrier materials (spray-applied urethane foam and rigid air barrier materials were not in the scope of this study).

Most commonly specified air barrier membrane materials demonstrate similar air and vapour permeance characteristics (in reference to their scope of use on a building)[3]. However, other performance characteristics such as adhesion, elongation, puncture resistance and tensile strength may vary considerably and must be taken into consideration when specifying materials, especially when used around roof/wall junctions, wall/window junctions and control joints where movement is expected as the variance may be enough to compromise the ability of the system to function correctly.

3.1 Self-Adhesive Sheet Membranes

Self-adhesive sheet membranes are commonly composed of modified bitumen or SBS rubberized asphalt compound reinforced with high-density cross-laminated polyethylene, synthetic fibers or polyester. The 'tacky' nature of the membrane allows it to 'bond' to the substrate, although the actual method of application will often vary between the different manufacturers' products. These membranes are generally impermeable to air, water and water vapour, can be installed over a wide variety of temperature ranges and climactic conditions, and can be used on a variety of different prepared and unprepared substrates subject to manufacturers' instructions. Their elasticity allows them to be used on details where some movement between adjoining surfaces is expected, and they offer the benefit of limited self-sealing ability around fasteners and penetrations.

3.2 Torch-Applied Sheet Membranes

Torch-applied sheet membranes are SBS modified bitumen membranes, reinforced with non-woven fiberglass or polyester, which are fused to the substrate using a propane torch. The substrate may or may not require priming prior to installation. They offer many of the same benefits as self-adhesive membranes but can be applied in a greater range of temperatures.

[3] The effectiveness of liquid membranes is highly dependant on the installer's ability as air leakage rates can vary significantly depending on the thickness applied. This is not a concern with prefabricated sheet membranes.

3.3 Liquid Membranes

Liquid membranes are either elastomeric bitumen or cold vulcanized synthetic rubbers that are applied to the surface in liquid form either by trowel or spray, and cure to form a resilient, monolithic, fully-bonded elastomeric sheet. Liquid membranes offer excellent crack-bridging capabilities, take considerably less time to install when spray-applied than sheet membranes, and where the seams between overlapping sheets of membrane can be potential leak areas, this is obviously not a concern for the liquid membrane. The self-sealing properties of liquid membranes vary considerably between different products, and liquid membranes must be used in combination with other materials to properly tie-in with adjoining systems and assemblies.

4.0 METHODOLOGY

4.1 Sampling

A total of 375 specimens were constructed, as described below.

Each of the thirty-two membrane-substrate combinations was considered a 'system'. Twelve specimens of each of the systems that used Dens Glass Gold, poured-in-place concrete, or concrete block as the substrate were constructed: three specimens for benchmark testing, three specimens for cold temperature conditioning and testing, three specimens for high-temperature/high-humidity conditioning and testing, and three specimens for saturation conditioning. Nine specimens of each of the systems that used drywall as a substrate were constructed: three specimens for benchmark testing, three specimens for cold temperature conditioning and testing, and three specimens for high-temperature/high-humidity conditioning; saturation conditioning was not conducted on systems that used drywall as the substrate[4]. Three additional specimens of the five self-adhesive membrane/concrete block systems were constructed for longevity conditioning and testing.

4.2 Construction of Samples

All specimens were constructed and membranes installed in strict accordance with manufacturers' recommendations and under controlled laboratory conditions. Self-adhesive sheet membranes and torch-applied sheet membranes were installed over the complete surface of one side of the substrate, with a 1.5-inch folded salvage edge at the top of the sample to facilitate peel-adhesion testing, and allowed to cure for a minimum of 24 hours before undergoing any conditioning or testing.

To prepare the liquid membrane specimens, a skim coat of liquid membrane material was applied over the complete surface of one side of the substrate. A two-inch wide strip of Bakor Yellow Jacket mesh was embedded into the skim coat where a strip would be scored. A full coat of membrane was then applied over the surface of the substrate. The mesh provided the rigidity to the strip required for peel resistance testing. Liquid membranes were allowed to cure for a minimum of seven days before undergoing any conditioning or testing. All liquid membranes were applied at the manufacturers' recommended coverage rate.

Specimen sizes were as follows:

- On drywall - 610 mm by 610 mm.
- On Dens-Glass Gold - 610 mm by 610 mm.
- On poured-in-place concrete - 355 mm by 355 mm.
- On concrete block - 390 mm by 190 mm.

---

[4] Prior to conducting any conditioning or testing, drywall specimens 610 mm by 610 mm were put through the saturation conditioning process, during which the drywall became unstable. Therefore, it was concluded that saturation conditioning would not be conducted on any of the systems where drywall was used as a substrate.

4.3 Methodology

4.3.1 Benchmarking

Specimens were tested without undergoing any environmental conditioning prior to testing.

4.3.2 Environmental Conditioning

Low-Temperature. Specimens were conditioned for 48 hours in ITC's environmental chamber. Conditions in the environmental chamber were maintained at -20 degrees C for the conditioning period. Specimens were spaced in the chamber to allow air circulation around all the specimens. Testing commenced after the conditioning cycle ended and once the specimens had been exposed to 'normal' environmental conditions (approximately 68°C and 25 % R.H.) for 24 hours.

High-Temperature/High-Humidity. Specimens were conditioned for 60 days in ITC's environmental chamber. Conditions in the environmental chamber were maintained at 25 degrees C and 95% relative humidity for the entire conditioning period. Specimens were spaced in the chamber to allow air circulation around all the specimens. Testing commenced after the conditioning cycle ended and once the specimens had been exposed to 'normal' environmental conditions for 24 hours.

Saturation. Specimens were conditioned for eight days in RSC's water sprinkler system. Dens Glass Gold and poured-in-place concrete specimens were subjected to a continuous and constant flow of water at a rate of four fluid ounces per minute, and concrete block specimens were subjected to a continuous and constant flow of water at a rate of eight fluid ounces per minute. Once the eight-day cycle was complete, specimens were allowed to dry for seven days before testing commenced.

4.3.3 Longevity

Specimens were prepared with five two-inch wide peel strips across them. Every 15 days, one strip from each specimen underwent fast peel resistance testing until all strips had been tested.

4.4 Testing Protocols

4.4.1 Tensile Adhesion

Tensile strength of adhesion between the membrane and substrate was measured in general accordance with ASTM D 4541 "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers." To conduct the test, an 11.88-square inch test pad was applied perpendicular to the test surface using 3M Scotch-Weld Acrylic Structural Plastic Adhesive DP8005. Once the adhesive had cured, the area of the membrane covered by the test pad was scored, separating the test area from the rest of the membrane. A Com-Ten model 341KHD 1500 (wide frame) hand-operated digital fastener tester was then attached to the test pad and aligned to apply tension normal to the test surface. The load was increased until one of three conditions occurred: any portion of the membrane test area detached from the substrate, the test pad detached from the membrane, or the substrate within the test area became damaged.

Due to substrate size constraints, three ‘pulls’ were made on drywall and Dens-Glass Gold specimens, two pulls were made on poured-in-place concrete specimens, and one pull was made on the concrete block specimens. RSC conducted all tensile adhesion tests and recorded results. Results were recorded in pounds per square inch (psi).

4.4.2 Slow-Peel Resistance

To prepare each specimen, a two-inch wide strip was scored into the membrane, starting at the top edge and running down the membrane approximately eight inches in length. An additional ¼-inch strip of membrane was removed on either side of the strip to isolate it from the remainder of the specimen.

To conduct the slow peel resistance tests (used to simulate creep load), the test specimens were mounted vertically on the wall, and a 100-gram load was clamped onto the salvage edge of the strip, placing a 180-degree peel load against the salvage edge. The length of the portion of the strip that detached from the substrate was measured and recorded daily. A test was considered complete once a 150-mm length of the strip was detached, or after 28 days, whichever occurred first. Testing and recording of data was performed by RSC.

4.4.3 Fast-Peel Resistance

To prepare each specimen, a two-inch wide strip was scored into the membrane, starting at the top edge and running down the membrane approximately eight inches in length. An additional ¼-inch strip of membrane was removed on either side of the strip to isolate it from the remainder of the specimen.

Fast peel tests were performed in general accordance with ASTM D 903 “Standard Test Method for Peel or Stripping Strength of Adhesive Bonds,” with the following modifications:

- The strip that was peeled from the substrate panel was two inches wide rather than the one-inch width used in the standard test method.

- The rate of travel of the test machine grip was 200 mm per minute rather than the 305 mm per minute used in the standard test method, resulting in a peeling separation rate of 100 mm per minute.

- The test specimens were longer than shown in the ASTM standard.

Peel tests were performed on an Instron Model 1125 universal testing machine equipped with a tension load cell. The rigid substrate of the test specimen was clamped to a vertical alignment plate mounted on the base of the test machine. The salvage edge of the strip was folded back 180 degrees and firmly gripped with a specially fabricated clamp attached to the load cell through a tension rod.

The loading cell was zeroed, and the test machine was started to peel the strip from the rigid substrate. Crosshead speed was set at 200 mm per minute giving a bond line separation rate on 100 mm per minute.

The force required to peel the strip from the substrate was recorded on graphs. Results were measured in pounds of force per inch (lbf/in). Testing and recording of data was performed by ITC.

5.0 OBSERVATIONS AND DISCUSSION

5.1 Project Benchmark Results for Different Membrane Classes

5.1.1 Tensile Adhesion

Figure 1 shows the percentage of valid tensile adhesion tests for each membrane product (when installed under controlled laboratory conditions and without exposure to the control variables) where the membrane withstood the given tensile load without detaching from the substrate, and the 'high' and 'low' results for each product. For a tensile adhesion test to be considered 'valid', one of the following criteria was met: (1) the membrane detached from the substrate, or; (2) the substrate ruptured at a tensile load which fell within the specified range while the membrane remained adhered to the substrate, or; (3) the test pad detached from the membrane at a tensile load which fell within the specified range while the membrane remained adhered to the substrate.

Figure 1.
The percentage of valid tensile adhesion benchmark tests where the membrane remained attached to the substrate under a given tensile load.

PRODUCT	ADHESION TEST RESULTS WHERE MEMBRANE WITHSTOOD TENSILE LOAD WITHOUT DETACHING (%)						HIGH AND LOW TEST RESULTS (psi)	
	5 psi	10 psi	15 psi	20 psi	25 psi	30 psi	High	Low
SELF-ADHESIVE SHEET MEMBRANES WITH SOLVENT-BASED PRIMER								
Product-A/SB	100.0	100.0	100.0	100.0	100.0	75.0	40.4	25.3*
Product-C/SB	100.0	100.0	100.0	100.0	100.0	100.0	31.6**	N/A***
SELF-ADHESIVE SHEET MEMBRANES WITH WATER-BASED PRIMER								
Product-A/WB	100.0	100.0	89.5	40.0	25.0	9.1	31.9**	14.4
Product-B/WB	100.0	100.0	92.3	65.2	40.0	25.0	32.0**	14.2
Product-B/WBX	100.0	85.2	53.8	45.8	4.2	0.0	25.1	7.2
TORCH-APPLIED SHEET MEMBRANES								
Product-D	100.0	100.0	100.0	100.0	100.0	50.0	53.8	27.7
LIQUID MEMBRANES								
Product-E	100.0	100.0	100.0	100.0	100.0	100.0	65.2	49.2
Product-F	100.0	100.0	95.5	75.0	70.6	50.0	39.2	14.4

* The membrane detached from the substrate on only two tests.
** The peak load was achieved on a test where the membrane did not detach from the substrate. Therefore, the specimen might have been able to withstand an even higher tensile load.
*** The membrane did not detach from the substrate on any of the specimens.

Both self-adhesive sheet membrane/solvent-based primer products generally remained adhered to the substrate. In most cases, either the substrate ruptured or the test pad separated from the membrane before the membrane could detach; Product-A/SB only detached from the substrate on two of the twenty-seven tests (at 25.3 psi and 40.4 psi), and Product-C/SB did not detach from the substrate on any of the tests. On several of the tests, the tensile load reached before the test ended exceeded 30.0 psi.

The self-adhesive sheet membranes/water-based primers (Product-A/WB, Product-B/WB, and Product-B/WBX) generally remained adhered to the substrate up to a tensile load of 15.0 psi, although 51.6% detached from the substrate only once the tensile load applied reached 20.0 psi. Given that the highest test results occurred on specimens where the membrane did not detach from the substrate, self-adhesive sheet membranes/water-based primers appeared able to withstand similar tensile loads as self-adhesive membranes/solvent-based primers. However, the solvent-based primer specimens achieved higher results more consistently than the water-based primer specimens, and the lowest results for the water-based primer specimens were significantly lower than the lowest results for the solvent-based primer specimens.

The torch-applied sheet membrane (Product-D) withstood tensile loads up to 25.0 psi without detaching from the substrate. The membrane detached from the substrate on 50% of the valid tests where a tensile load greater than 25.0 psi was reached, although the membrane also withstood tensile loads as high as 53.8 psi without detaching. On all of the tests on drywall and Dens Glass Gold, the tensile strength of adhesion between the membrane and substrate exceeded the tensile strength of the substrate material.

The asphalt-based liquid membrane (Product-E) did not detach from the substrate at any tensile load lower than 49.2 psi, and remained adhered at tensile loads as high as 65.2 psi. On all of the tests on drywall and Dens Glass Gold, the tensile strength of adhesion between the membrane and substrate exceeded the tensile strength of the substrate material.

The rubber-based liquid membrane (Product-F) generally withstood tensile loads in excess of 25.0 psi, to a high of 39.2 psi, without detaching from the substrate. However, test results were significantly lower on Dens Glass Gold, where the membrane detached from the substrate on four of the nine tests, at tensile loads between 14.4 psi and 19.3 psi.

There are currently little to no published references as to what is the ‘acceptable’ strength of membrane-to-substrate adhesion. To provide some reference point for the results obtained in this study, it should be noted that one manufacturer (whose material was not included in this study) in its application guide for installation cited a minimum membrane-to-substrate adhesion rate of 16.0 psi for their self-adhesive membrane when installed on a plywood substrate on low-rise buildings when undergoing Canadian Construction Materials Centre Product Evaluation.

5.1.2 Slow-Peel Resistance

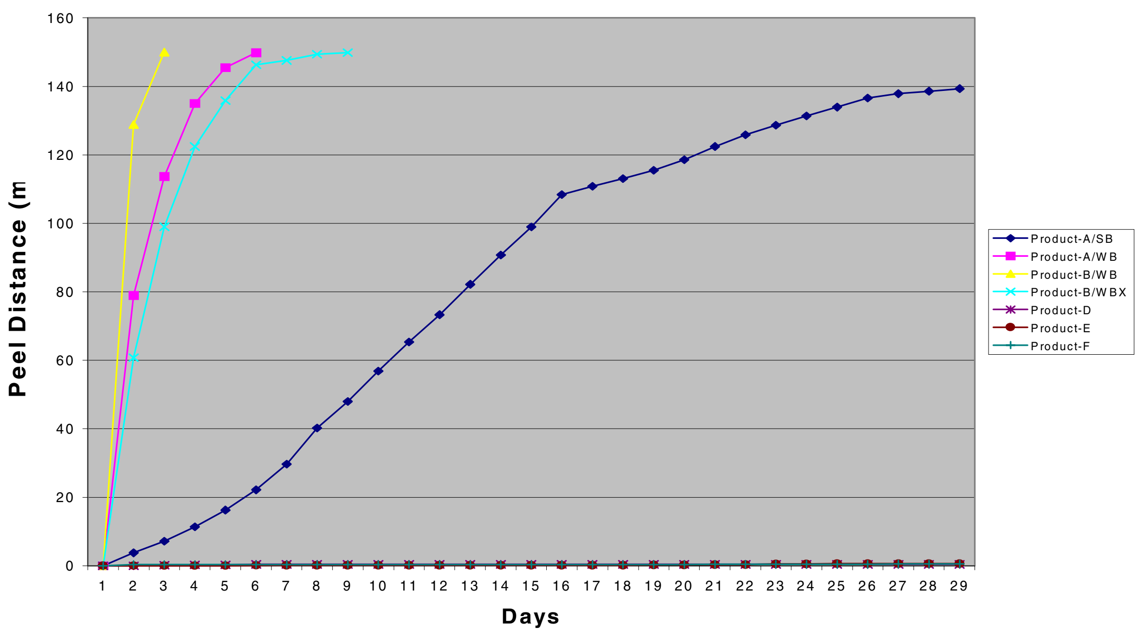
Slow-peel resistance of self-adhesive sheet membranes/solvent-based primers varied between products. Product-A/SB generally took between eleven and twenty-eight days to peel 150 mm. Product-C/SB did not detach from the substrate on any of the specimens. However, on all of the specimens, its polyethylene carrier sheet separated from the bitumen which remained adhered to the substrate. This separation began to occur between Day 5 and Day 16.

All of the specimens of self-adhesive sheet membrane/water-based primer (Product-A/WB, Product-B/WB and Product-B/WBX) peeled 150 mm within nine days from the start of the test; 52.8% of the specimens peeled 150 mm within 48 hours from the start of the test and 13.9% peeled 150 mm within 24 hours from the start of the test.

There was little to no detachment of the torch-applied sheet membrane (Product-D), the asphalt-based liquid membrane (Product-E) or the rubber-based liquid membrane (Product-F) over the 28-day testing period.

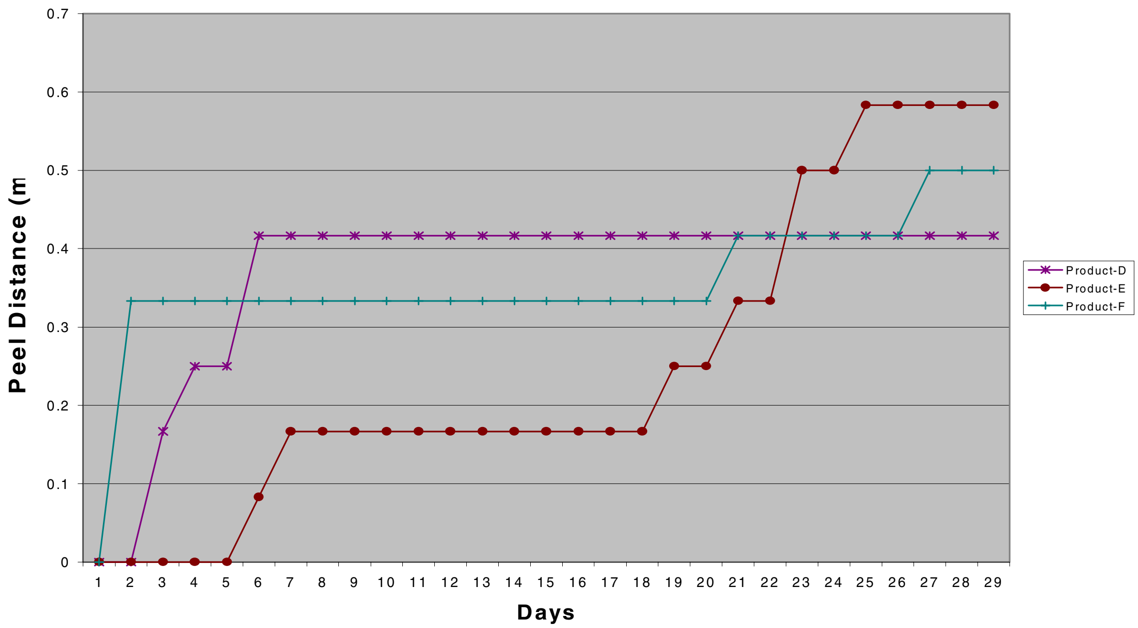
The difference in performance between the self-adhesive sheet membranes and the torch-applied sheet membrane and liquid membranes is evident on Figure 2, which shows the mean slow-peel resistance test results (the distance the membrane peeled each day during the 28-day test period) for each product when installed under controlled laboratory conditions and without exposure to the control variables. Note that the results for Product-C/SB were excluded from the graph as the membrane did not peel, but rather its polyethylene carrier sheet detached from the bitumen which remained adhered to the substrate.

Figure 2.
Mean slow-peel resistance benchmark test results for each membrane system.



As the distance that the torch-applied sheet membrane and liquid membranes peeled were comparitively much less than than the self-adhesive sheet membranes, it is difficult to determine their exact progress from the above graph. Figure 3 shows the results for the torch-applied and liquid membranes only. Note that the peel diatance scale in Figure 3 is only 1 mm, as opposed to 160 mm in Figure 2.

Figure 3.
Mean slow-peel resistance benchmark test results for torch-applied sheet membrane, asphalt-based liquid membrane and rubber-based liquid membrane.



5.1.3 Fast-Peel Resistance

Figure 4 shows the percentage of valid fast-peel resistance tests for each membrane product (when installed under controlled laboratory conditions and without exposure to the control variables) where the membrane required, at a minimum, the given peel load to detach and peel it from the substrate, and the 'high' and 'low' results for each product. For a fast-peel resistance test to be considered valid, one of the following criteria was met: (1) the membrane peeled from the substrate, or; (2) the substrate ruptured at a peak peel load which fell within the specified range while the membrane remained adhered to the substrate, or; (3) the membrane's polyethylene carrier sheet separated from the bitumen (which remained adhered to the substrate) at a peak peel load which fell within the specified range, or; (4) the was separation within the body of the material at a peak peel load which fell within the specified range.

To provide some reference point for the results, it should be noted that Canadian Construction Materials Centre Technical Guide for Air Barrier Systems for Exterior Walls of Low-Rise Buildings requires the adhesive peel strength of a modified bituminous membrane on an approved substrate to be ≥ 2.0 kN/m (11.4 lbf/in) when tested in accordance with CAN/CGSB-19.0-M77 (Method 14.6). ASTM D 903 is the test method currently used by most air barrier membrane manufacturers when conducting peel resistance testing, and was the test method selected for the purpose of this study.

Figure 4.
The percentage of fast-peel resistance benchmark tests where the peak peel load required to peel the membrane form the substrate fell within the given range.

PRODUCT	FAST-PEEL RESISTANCE TESTS THAT REQUIRED MINIMUM PEEL LOAD (%)				HIGH AND LOW TEST RESULTS (lbf/in)	
	≥ 11 lbf/in	≥ 15 lbf/in	≥ 20 lbf/in	≥ 25 lbf/in	High	Low
SELF-ADHESIVE SHEET MEMBRANES WITH SOLVENT-BASED PRIMER						
Product-A/SB	100.0	100.0	100.0	25.0	35.1*	21.2
Product-C/SB	100.0	81.8	72.7	50.0	29.0*	12.5
SELF-ADHESIVE SHEET MEMBRANES WITH WATER-BASED PRIMER						
Product-A/WB	58.3	18.2	18.2	10.0	26.4	6.4
Product-B/WB	50.0	0.0	0.0	0.0	12.6	10.0
Product-B/WBX	0.0	0.0	0.0	0.0	10.9	4.3
TORCH-APPLIED SHEET MEMBRANES						
Product-D	100.0	100.0	90.0	77.8	35.2*	16.7
LIQUID MEMBRANES						
Product-E	100.0	100.0	50.0**	0.0**	21.0*	18.1
Product-F	20.0	0.0	0.0	0.0	14.9*	1.1

* The peak load was achieved on a test where the membrane did not detach; the substrate ruptured, or there was separation between the layers of material itself. Therefore, the specimen might have been able to withstand an even higher tensile load.
** The membrane only peeled from the substrate on one test.

Both self-adhesive sheet membrane/solvent-based primers products generally remained adhered to the substrate during fast-peel resistance testing. The three specimens each of Product-A/SB and Product-C/SB that were installed on Dens Glass Gold all peeled from the substrate, requiring peak peel loads between 21.2 lbf/in (3.71 kN/m) and 22.5 lbf/in (3.94 kN/m), and 12.5 lbf/in (2.19 kN/m) and 18.4 lbf/in (3.22 kN/m) respectively. On drywall, poured-in-place concrete and concrete block, the polyethylene separated from the bitumen which remained adhered to the substrate, requiring peak peel loads in excess of 20.0 lbf/in (3.50 kN/m) to a high of 35.0 lbf/in (6.13 kN/m). As the highest results occurred on tests where the membrane did not peel, it appeared that each product could withstand even higher peel loads without detaching.

Fast-peel resistance of self-adhesive sheet membranes/water-based-primers varied by product, although generally the results for all products were significantly lower than on the solvent-based primer specimens. On Product-A/WB, 58% of the tests required a minimum peak peel load of 11.0 lfb/in (1.93 kN/m) to peel the membrane, yet the range of peak peel loads measured varied considerably as there was a difference of 20.0 lbf/in (3.50 kN/m) between the high and low results. On Product-B/WB, 50% of the tests required a minimum peak peel load of 11.0 lfb/in (1.93 kN/m) to peel the membrane, yet all of the results were between 10.0 lbf/in (1.75 kN/m) and 12.6 lbf/in (2.21 kN/m). All of the specimens of Product-B/WBX peeled at peak peel loads less than 11.0 lbf/in (1.93 kN/m), and at peak peel loads as low as 4.3 lbf/in (0.75kN/m).

The torch-applied sheet membrane (Product-D) generally required a minimum peak peel load in excess of 25.0 lbf/in (4.38 kN/m) to peel.

The asphalt-based liquid membrane only peeled from the substrate on one of the twleve tests, at a peak peel load of 18.1 lbf/in (3.17 kN/m). On nine of the other tests, there was separation in the body of the membrane material at the point of the mesh, with a layer of material remaining adhered to the substrate. This separation occurred at peak peel loads between 9.3 lbf/in (1.63 kN/m) and 21.0 lbf/in (3.68 kN/m).

The rubber-based liquid membrane generally peeled from drywall, poured-in-place concrete and concrete block at peak peel loads less than 11.0 lbf/in (1.93 kN/m). On Dens-Glass Gold, there was separation in the body of the membrane material at the point of the mesh, with a layer of material remaining adhered to the substrate. This separation occurred at peak peel loads between 9.1 lbf/in (1.59 kN/m) and 14.9 lbf/in (2.61 kN/m).

The focus of this research was the peak peel load required to peel the membrane from the substrate. Often, however, the minimum peel load required to peel the membrane differed between different ‘sections’ of the specimen. For example, while a peel load of 11.0 lbf/in (1.93 kN/m) may be required to detach and begin peeling the membrane, a lesser load may be required to continue peeling it once initial peeling has commenced. The ‘pattern’ or nature of peel depended on the material, the substrate upon which the material was installed, and the environmental conditions of which the specimen was exposed. The graphs in Appendices A through H show the different patterns for each material. A complete analysis of all of these patterns is beyond the scope of this paper.

5.2 Longevity Conditioning on Solvent-Based Primers and Water-Based Primers.

Fast-peel resistance of each self-adhesive sheet membrane/solvent-based primer product (Product-A/SB and Product-C/SB) decreased over the sixty-day time period. Figure 5 shows fast-peel resistance test results for a Product-C/SB specimen after Day 1, Day 30 and Day 60. After the first thirty days, the peak peel load required to peel the membrane dropped over 50% from 18.7 lbf/in (3.27 kN/m) to 9.0 lbf/in (1.58 kN/m). By Day 60, the peak peel load required to peel the membrane was 7.5 lbf/in (1.31 kN/m), a 60% decrease form Day 1.

Figure 6 shows fast-peel resistance test results for a Product-A/SB specimen after Day 1, Day 30 and Day 60. Although the decrease in fast-peel resistance does not appear as conclusive on this graph, it is more evident in the photograph of the specimen (Figure 7). The average decrease in fast peel resistance for this product over the 60-Day test period was 13%.

Figure 5.
Fast-peel resistance longevity test results for a Product-C/SB specimen.

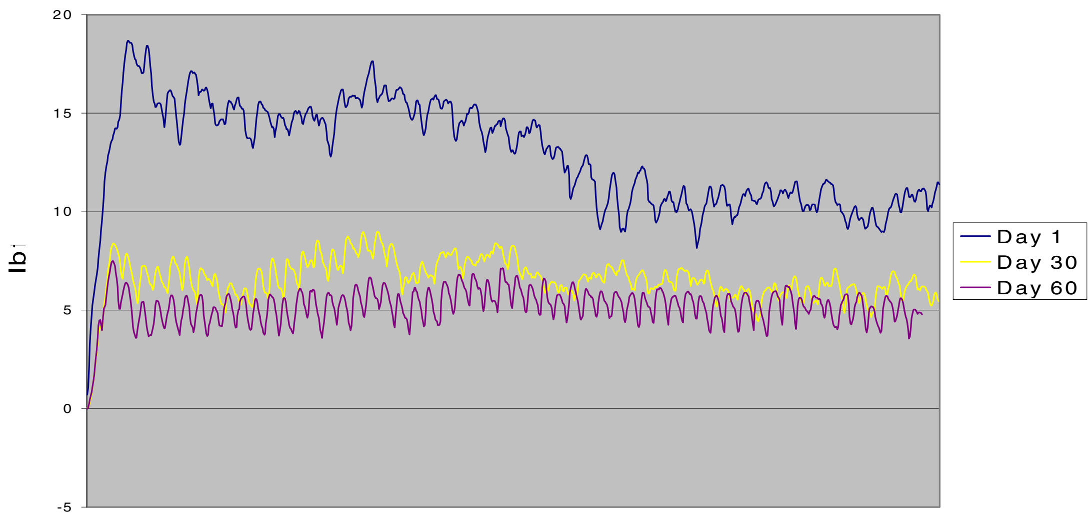


Figure 6.
Fast-peel resistance longevity test results for a Product-A/SB specimen.

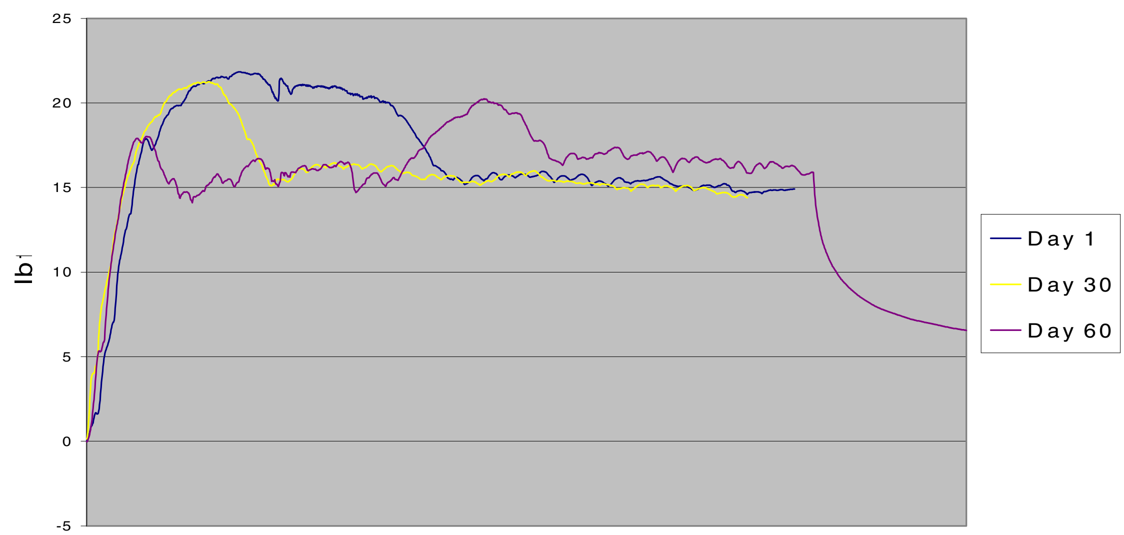


Figure 7.
Product-A/SB specimen after fast-peel resistance longevity testing.

Fast-peel resistance of each of the self-adhesive sheet membrane/water-based primer products (Product-A/WB, Product-B/WB and Product-B/WBX) *increased* over the sixty-day time period (Figures 8, 9 and 10). While the increase in fast-peel resistance as determined by peak peel load over the 60-day time period was generally between 6% and 25% for Product-A/WB and Product-B/WB, the *average* increase for the Product-B/WBX specimens was almost 60%.

Figure 8.
Fast-peel resistance longevity test results for a Product-A/WB specimen.

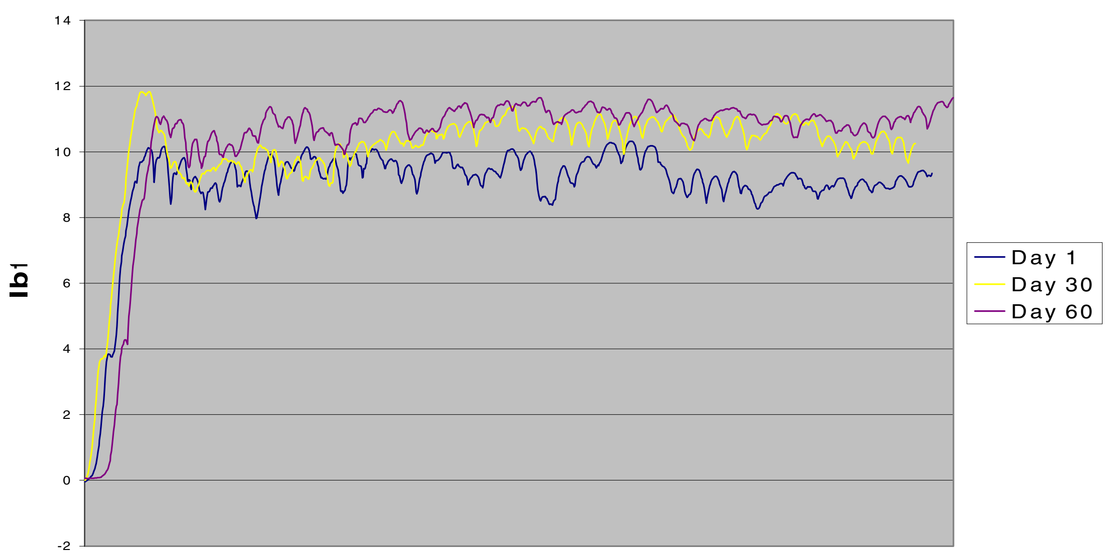


Figure 9.
Fast-peel resistance longevity test results for a Product-B/WB specimen.

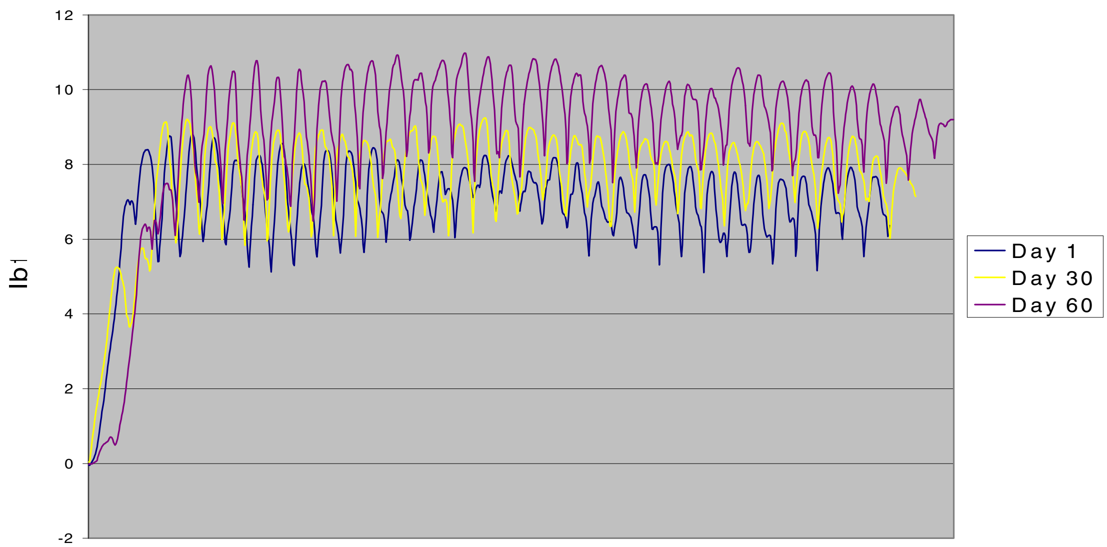
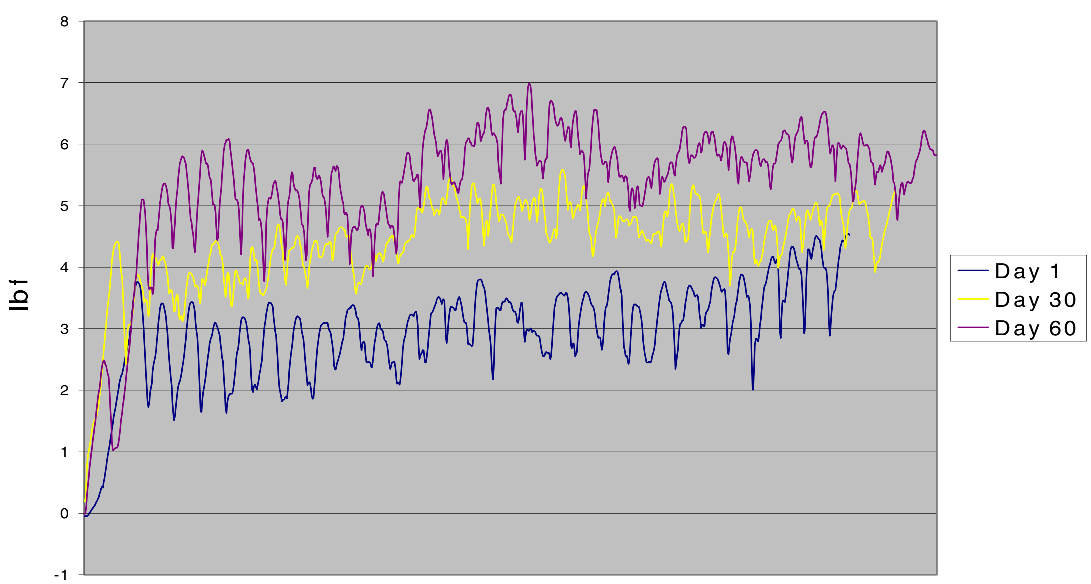


Figure 10.
Fast-peel resistance longevity test results for a Product-B/WBX specimen.



Photographs of Product-A/WB, Product-B/WB and Product-B/WBX specimens show an increased 'coverage' of the primer on the substrate, and the patterns on the back of the membrane strips indicate an increased 'wetting in' of the membrane into the block (Figures 11, 12, and 13).

Figure 10.
Product-A/SB specimen after fast-peel resistance longevity testing.

Figure 11.
Product-B/WB specimen after fast-peel resistance longevity testing.

Figure 12.
Product-B/WBX specimen after fast-peel resistance longevity testing.

As the fast-peel resistance of self-adhesive membranes changed over the 60-day time period, this should be considered when analyzing the fast-peel adhesion benchmark test results. This would likely have affected fast-peel resistance tests conducted after high-temperature/high-humidity conditioning, a 60-day conditioning cycle. Determining whether and how tensile adhesion or slow-peel resistance of self-adhesive sheet membranes, or any adhesion characteristics of torch-applied sheet membranes or liquid membranes, is effected by time is beyond the scope of this study.

Refer to Appendix I for complete longevity testing results.

5.3 Effect of Environmental Conditioning on Different Membranes

It did not appear that exposure to a given control variable had a similar effect on all membranes, or all membranes within a particular membrane class (self-adhesive, torch-applied, etc.), or even an individual membrane. The effect of each of the three conditioning cycles, low-temperature, high-temperature/high-humidity, and saturation, on tensile adhesion and peel-resistance was generally specific to the combination of membrane, primer, and substrate.

Refer to Appendices A through H for a description of each product and analysis of test results.

6.0 CONCLUSIONS

Significant findings from the study can be summarized as follows:

1. When installed under controlled laboratory conditions and without exposure to any of the control variables, the torch-applied sheet membrane, liquid membranes, and self-adhesive sheet membranes/solvent-based primers consistently withstood tensile loads in excess of 25.0 psi without detaching from the substrate, with some specimens of each remaining adhered at tensile loads as high as 53.8 psi, 65.2 psi and 40.4 psi respectively. Self-adhesive sheet membranes/water-based primers consistently withstood tensile loads up to 15.0 psi without detaching from the substrate, although the range between high (32.0 psi) and low (7.2 psi) test results was significantly larger than those of the other membranes.

2. When installed under controlled laboratory conditions and without exposure to any of the control variables, and with a sustained 100-gram load clamped onto the membrane's salvage edge, adhesion of self-adhesive sheet membranes was effected by the load in the short-term, as the membrane either peeled from the substrate or the polyethylene carrier sheet separated from the bitumen (which remained adhered to the substrate) within the 28-day slow-peel resistance test period. The torch-applied sheet membrane and liquid membranes exhibited good short-term resistance to the sustained load as there was little to no detachment of these membranes during the 28-day test period.

3. When installed under controlled laboratory conditions and without exposure to any of the control variables, a peak peel load greater than 11.0 lbf/in (1.93 kN/m) was generally required to peel the torch-applied sheet membrane, asphalt-based liquid membrane, and self-adhesive sheet membranes/solvent-based primers from the substrate during fast-peel resistance testing, with some specimens remaining adhered at peel loads in excess of 35.0 lbf/in (6.13 kN/m). Self-adhesive sheet membranes/water-based primers and the rubber-based liquid membrane consistently peeled from the substrate at peak peel loads less than 11.0 lbf/in (1.93 kN/m) and as low as 4.3 lbf/in (0.75 kN/m) and 1.1 lbf/in (0.19 kN/m) respectively.

4. A membrane's tensile adhesion test results did not necessarily correlate with its peel-resistance test results.

5. When installed under controlled laboratory conditions and without exposure to any of the control variables, the adhesion characteristics of self-adhesive sheet membranes depended on the primer or primer/substrate combination used with it. Self-adhesive sheet membranes consistently withstood higher tensile and peel loads without detaching from the substrate when a solvent-based primer was used than when a water-based primer was used, in the short-term.

6. Fast-peel resistance of self-adhesive sheet membranes/solvent-based primers *decreased* over a 60-day time period, by as much as 19% on Product-A/SB and 63% on Product-C/SB. Fast-peel resistance of self-adhesive sheet membranes/water-based primers *increased* over a 60-day time period, by as much as 14% on Product-A/WB, 25% on Product-B/WB and 97% on Product-B/WBX.

7. It did not appear that exposure to a given control variable had a similar effect on all membranes, or all membranes within a particular membrane class (self-adhesive, torch-applied, etc.), or even an individual membrane. The effect of each of the three conditioning cycles, low-temperature, high-temperature/high-humidity, and saturation, on tensile adhesion and peel-resistance was generally specific to the combination of membrane, primer, and substrate.

8. For most membranes, the tensile strength of adhesion between the membrane and substrate when installed on either drywall or Dens-Glass Gold superseded the tensile strength of the drywall and Dens Glass Gold material.

7.0 RECOMMENDATIONS FOR FUTURE WORK

This study has examined the tensile adhesion and peel resistance characteristics of commonly used air barrier membranes, how these adhesion characteristics change over time, and how they were affected by exposure to different environmental conditions over the short term. A study to determine how these adhesion characteristics change over the long term or with more prolonged exposure to different environmental conditions could provide a basis for future research that would be relevant given the life cycle expectations for air barriers as specified by designers. There are also several other air barrier membrane performance characteristics that could be considered, including durability under sustained and/or cyclic pressure conditions, structural durability of membranes spanning 'gaps', and adhesion on details not on flat planes and where the membrane has been stressed to fit the profile of the detail.

This study has examined five different air barrier membranes (eight different membrane-primer combinations) of three different membrane types (self-adhesive sheet membrane, torch-applied sheet membrane and liquid membrane), yet there are numerous other air barrier membranes currently on the market. There are also several other 'types' of air barriers, including spray-applied urethane foam and rigid air barrier materials. Subjecting any of these materials to the test protocols utilized in this study would be of great benefit to building designers.

While it has been shown that commonly used air barrier membrane materials considered in this study will 'stick' to most construction substrates, insufficient membrane-substrate adhesion continues to occur in the field. What might have even more relevance than individual material testing is a research study to determine the *field conditions* that might affect the ability of the material to function effectively and/or meet the National Building Code of Canada recommendations for an air barrier.

8.0 REFERENCES

Air-Ins Inc., Air Permeance of Building Materials: Summary Report, Canada Mortgage and Housing Corporation, Ottawa, ON, June 1998.

Boyle, B. J. and MeLampy, M. F., "Air Barrier Materials," *Journal of Protective Coatings and Linings*, Volume 20, Number 11, Society for Protective Coatings, November 2003.

Canadian Commission on Building and Fire Codes, National Building Code of Canada 1995, National Research Council Canada, Ottawa, ON, November 1999.

Canadian Construction Materials Centre, "Technical Guide for Air Barrier Materials," National Research Council Canada, Ottawa, ON, May 1997.

Canadian Construction Materials Centre, "Technical Guide for Air Barrier Systems for Exterior Walls of Low-Rise Buildings," National Research Council Canada, Ottawa, ON, May 1997.

Knight, K. D. and Boyle, B. J., "Guidelines for Delivering Effective Air Barrier Systems," Canada Mortgage and Housing Corporation, Ottawa, ON, 2002.

Knight, K. D., Boyle, B. J and Phillips, B. G., "A New Protocol for the Inspection and Testing of Building Envelope Air Barrier Systems," *Standard Technical Publication 1422*, American Society for Testing and Materials, West Conshohocken, PA, 2002.

Knight, K. D., Boyle, B. J and Phillips, B. G., "Quality Assurance for Building Envelope Air Barrier Systems," *Buildings VIII*, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta, GA, 2002.

Knight, K and Samuda, M., "Newly Developed Means of Testing Air Barriers During Construction: The Method and the Industry," *Fourth Energy-Efficient New Construction Conference*, Vancouver, BC, 1996.

Knight, K and Sharp, J., "Prescriptive Testing of Air Barrier System Performance," Energy Manager Conference, Toronto, ON, 1997.

Morrison Hershfield Ltd., Commissioning and Monitoring the Building Envelope for Air Leakage, Canada Mortgage and Housing Corporation, Ottawa, ON, March 1993.

Morrison Hershfield Limited, Testing of Air Barrier Construction Details, Canada Mortgage and Housing Corporation, Ottawa, ON, August 1991.

Persily, A. K., Envelope Design Guidelines for Federal Office Buildings: Thermal Integrity and Airtightness, United States Department of Commerce, Gaithersburg, MD, March 1993.

Quirouette, R. L., “A Study of the Construction Process,” *Building Practice Note No. 32*, National Research Council Canada, Ottawa, ON, 1982.

Quirouette, R. Marshall, S. and Rousseau, J., “Design Considerations for an Air Barrier System,” Canada Mortgage and Housing Corporation, Ottawa, ON, November 2000.

Sharp, J. F., Phillips, B. G. and Knight, K. D., Air Barrier and Building Envelope Environmental Impact Study, Manitoba Energy and Mines, Winnipeg, MB, April 1997.

<u>APPENDIX A</u>

Product-A/SB

Appendix A1 – Material Descriptions (from Manufacturer's Technical Literature)

The membrane is a self-adhered membrane consisting of an SBS rubberized asphalt compound which is integrally laminated to a blue cross-laminated film. The membrane is specifically designed to be self-adhered to a prepared substrate, and is designed for use as a self-adhered sheet air or vapour barrier. Its principal application is on walls of either masonry, concrete or drywall.

The primer is a rubber-based adhesive primer for self-adhesive membranes. It is used as a primer for self-adhesive membranes when applied to masonry, concrete, wood, drywall and metal surfaces.

Appendix A2 – Summary of Test Results

<u>Tensile Adhesion.</u>
Benchmark: Tensile adhesion was sufficiently high that the membrane only detached from the substrate on two of twenty-seven tests, at tensile loads of 25.3 psi and 40.4 psi. On the remaining tests, the substrate ruptured, the polyethylene carrier sheet separated form the bitumen which remained adhered to the substrate, or the test pad separated from the polyethylene carrier sheet.

Tensile adhesion did not *appear* significantly effected by any of the conditioning cycles, although this could not be conclusively determined as the number of tests where the membrane detached from the substrate was insufficient to draw a conclusion.

<u>Slow-Peel Resistance.</u>
Benchmark: On drywall and Dens Glass Gold, the membrane took between 11 and 15 days to peel 150 mm. By Day 28, specimens on poured-in-place concrete had peeled 150 mm, and specimens on concrete block had peeled at least 82 mm and were continuing to peel.

Slow-peel resistance appeared to decrease after each of the conditioning cycles. This decrease was most evident on poured-in-place concrete and concrete block, where the time required to peel 150 mm was half the benchmark time. The decrease on drywall and Dens Glass Gold specimens appeared insignificant.

<u>Fast-Peel Resistance.</u>
Benchmark: The membrane generally remained adhered to the substrate during fast peel resistance testing. The membrane did peel off Dens Glass Gold at peak peel loads between 21.2 lbf/in (3.71 kN/m) and 22.5 lbf/in (3.94 kN/m). On drywall, poured-in-place concrete and concrete block, the polyethylene carrier sheet separated from the bitumen, while the bitumen remained adhered to the substrate, requiring peak peel loads in excess of 20.0 lbf/in (3.50 kN/m) to a high of 35.0 lbf/in (6.13 kN/m).

Fast-peel resistance appeared to decrease slightly after each of the conditioning cycles. There were isolated instances where the membrane peeled from substrates where previously it had not, such as on poured-in-place concrete after high-temperature/high-humidity conditioning, but the peak peel load required was still in excess of 11.0 lbf/in (1.93 kN/m). There were also instances where the polyethylene separated from the bitumen under lower loads than previously recorded, but these loads were still in excess of 11.0 lbf/in (1.93 kN/m).

Blistering and separation of the polyethylene carrier sheet occurred during saturation conditioning.

Appendix A3 - Tensile Adhesion Test Results

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
DRYWALL		**DRYWALL**		**DRYWALL**			
LOAD (psi)	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**		
15.3	SUBSTRATE	21.0	SUBSTRATE	9.9	SUBSTRATE		
11.4	SUBSTRATE	21.6	SUBSTRATE	14.6	SUBSTRATE		
15.3	SUBSTRATE	22.0	SUBSTRATE	7.6	SUBSTRATE		
7.2	SUBSTRATE	16.6	SUBSTRATE	12.7	SUBSTRATE		
10.9	SUBSTRATE	10.7	SUBSTRATE	10.5	SUBSTRATE		
12.6	SUBSTRATE	12.7	SUBSTRATE	10.7	SUBSTRATE		
10.2	SUBSTRATE	18.3	SUBSTRATE	10.0	SUBSTRATE		
8.3	SUBSTRATE	16.4	SUBSTRATE	10.3	SUBSTRATE		
8.8	SUBSTRATE	10.9	SUBSTRATE	11.2	SUBSTRATE		

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
DENS-GLASS GOLD		**DENS-GLASS GOLD**		**DENS-GLASS GOLD**		**DENS-GLASS GOLD**	
LOAD (psi)	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**
21.1	TEST PAD	15.7	SUBSTRATE	14.3	SUBSTRATE	15.3	SUBSTRATE
12.1	TEST PAD	14.4	SUBSTRATE	15.4	SUBSTRATE	19.9	SUBSTRATE
15.4	TEST PAD	17.0	TEST PAD	20.9	SUBSTRATE	20.8	SUBSTRATE
21.6	TEST PAD	14.2	TEST PAD	18.6	SUBSTRATE	18.2	SUBSTRATE
19.2	TEST PAD	17.3	SUBSTRATE	24.6	SUBSTRATE	17.8	SUBSTRATE
14.7	TEST PAD	16.2	TEST PAD	23.3	SUBSTRATE	18.0	SUBSTRATE
16.0	TEST PAD	16.8	TEST PAD	14.4	SUBSTRATE	13.4	SUBSTRATE
13.8	TEST PAD	18.1	SUBSTRATE	24.1	SUBSTRATE	22.6	SUBSTRATE
12.4	SUBSTRATE	15.2	TEST PAD	18.0	SUBSTRATE	18.9	SUBSTRATE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
CONCRETE		**CONCRETE**		**CONCRETE**		**CONCRETE**	
LOAD (psi)	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**
20.7	POLY	17.7	TEST PAD	13.7	TEST PAD	13.7	TEST PAD
25.3	MEMBRANE	18.3	TEST PAD	19.7	TEST PAD	19.7	TEST PAD
27.8	POLY	14.9	TEST PAD	19.8	TEST PAD	19.8	TEST PAD
30.1	POLY	14.6	TEST PAD	18.3	TEST PAD	18.3	TEST PAD
27.2	POLY	14.0	TEST PAD	17.8	TEST PAD	17.8	TEST PAD
22.0	TEST PAD	16.5	TEST PAD	19.8	TEST PAD	19.8	TEST PAD

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
CONCRETE BLOCK		**CONCRETE BLOCK**		**CONCRETE BLOCK**		**CONCRETE BLOCK**	
LOAD (psi)	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**	**LOAD (psi)**	**SEPARATION OF**
27.1	TEST PAD	14.7	TEST PAD	24.0	MEMBRANE	24.2	POLY
31.8	TEST PAD	14.4	TEST PAD	22.1	TEST PAD	19.2	POLY
40.4	MEMBRANE	14.2	TEST PAD	21.0	TEST PAD	21.6	POLY

Appendix A4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	2	3	6	8	15	22	33	37	47	53	61	80	100	122	150													
mm	2	5	9	15	23	30	40	50	67	87	99	120	135	150														
mm	7	11	17	25	34	54	80	112	128	146	150																	

LOW-TEMPERATURE																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	43	104	150																									
mm	22	68	102	138	150																							
mm	4	15	31	38	58	88	110	121	145	150																		

HIGH TEMP/HIGH-HUMIDITY																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	9	23	43	65	92	120	144	150																				
mm	5	15	31	51	71	90	109	125	136	149	150																	
mm	5	15	26	47	66	85	98	110	126	136	143	150																

SATURATION																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	5	12	18	27	32	38	63	73	85	95	100	105	130	139	150													
mm	5	13	18	27	35	47	58	68	75	83	101	108	115	123	150													
mm	5	8	14	22	28	40	52	62	81	92	118	120	132	150														

LOW-TEMPERATURE																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	24	48	76	100	128	150																						
mm	33	64	92	127	150																							
mm	12	30	49	74	97	120	137	150																				

HIGH-TEMP/HIGH-HUMIDITY																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	3	12	21	35	51	65	76	85	91	98	107	117	126	130	141	150												
mm	1	4	8	18	27	38	47	55	58	65	70	75	83	87	95	102	115	131	141	150								
mm	2	7	12	25	36	48	59	66	72	76	81	86	92	93	98	101	114	125	136	143	150							

SATURATION																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	5	15	35	48	66	84	96	112	130	147	150																	
mm	10	25	48	76	96	113	130	143	150																			
mm	2	12	25	42	52	66	80	90	108	116	133	150																

Poured-In-Place Concrete

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	5	8	13	15	19	23	30	32	38	42	52	55	63	69	75	82	88	94	102	110	117	126	132	140	147	150		
mm	3	7	10	16	21	25	32	35	44	51	58	63	69	75	81	88	95	100	110	120	127	136	143	148	150			
mm	5	7	11	15	20	26	32	35	40	47	55	65	71	77	82	86	89	96	102	113	119	127	134	140	147	150		

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	50	115	150																									
mm	75	140	150																									
mm	62	132	150																									

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	15	30	40	85	62	70	75	85	88	100	110	121	130	140	150													
mm	5	13	22	33	52	60	66	76	86	98	110	125	132	150														
mm	15	25	45	58	74	84	90	103	117	133	145	150																

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	2	5	5	10	30	61	80	110	125	150												
mm	0	0	0	7	22	22	25	38	70	90	115	150																
mm	16	35	55	63	75	82	87	99	115	127	135	150																

Concrete Block

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	2	5	5	5	8	11	14	15	20	25	28	30	34	36	40	44	48	51	54	6	62	65	68	70	73	77	80	82
mm	4	7	12	15	20	25	30	33	39	42	48	54	58	65	71	75	79	85	91	98	115	115	120	127	135	137	140	142
mm	0	0	3	5	11	15	19	24	27	32	36	38	44	49	52	55	58	60	64	68	70	75	79	82	87	90	93	98

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	24	55	95	126	150																							
mm	5	20	38	51	68	92	105	120	138	148	150																	
mm	15	42	77	106	150																							

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	7	13	20	30	43	53	55	60	65	80	86	98	105	108	115	145	150											
mm	0	10	20	23	45	55	60	68	78	87	97	106	117	122	128	150												
mm	33	55	70	91	112	121	130	147	150																			

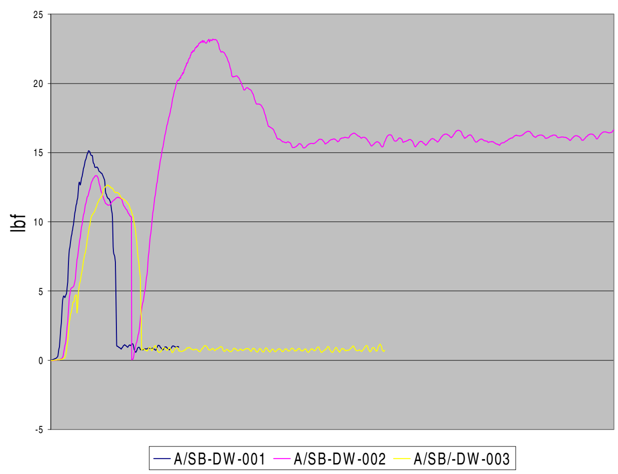
SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	3	20	43	62	105	143	150																				
mm	0	0	0	0	0	0	0	0	0	0	15	47	75	100	125	145	150											
mm	0	3	9	27	50	96	145	150																				

Appendix A5 – Fast-Peel Resistance Test Results

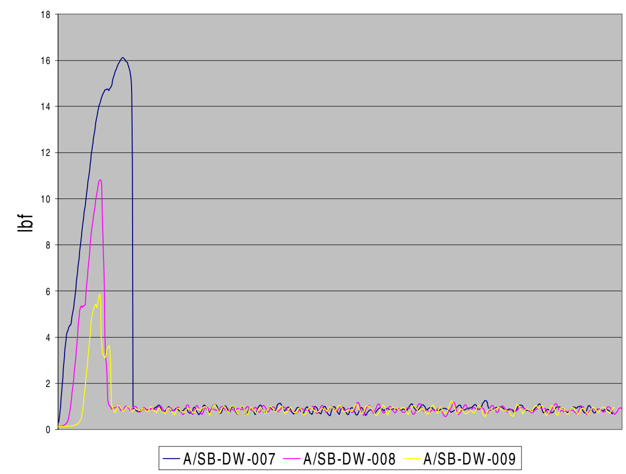
Drywall

Benchmark



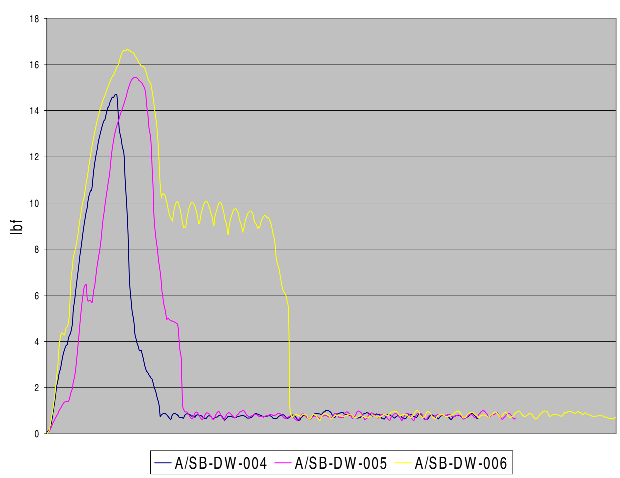
	SEPARATION	ULTIMATE LOAD (lbf/in)
A/SB-DW-001:	PAPER	15.2 (2.66 kN/m)
A/SB-DW-002:	POLYETHYLENE	23.2 (4.06 kN/m)
A/SB-DW-003:	PAPER	12.7 (2.22 kN/m)

Low-Temperature



	SEPARATION	ULTIMATE LOAD (lbf/in)
A/SB-DW-007:	PAPER	16.7 (2.92 kN/m)
A/SB-DW-008:	PAPER	10.8 (1.89 kN/m)
A/SB-DW-009:	PAPER	5.9 (1.03 kN/m)

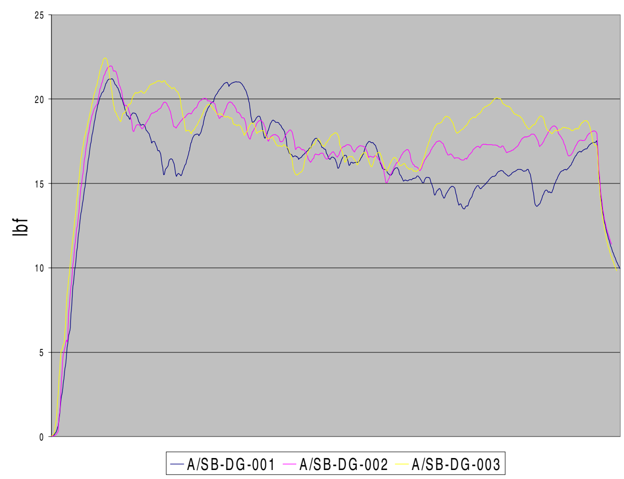
High-Temperature/High-Humidity



	SEPARATION	ULTIMATE LOAD (lbf/in)
A/SB-DW-004:	PAPER	14.7 (2.57 kN/m)
A/SB-DW-005:	PAPER	15.5 (2.71 kN/m)
A/SB-DW-006:	PAPER	16.7 (2.92 kN/m)

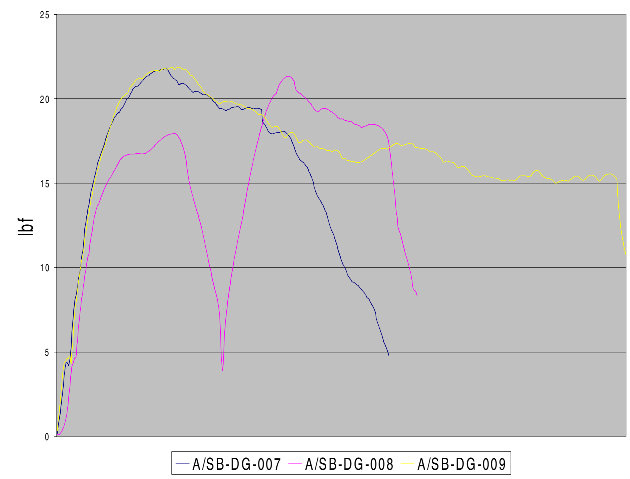
Dens-Glass Gold

Benchmark



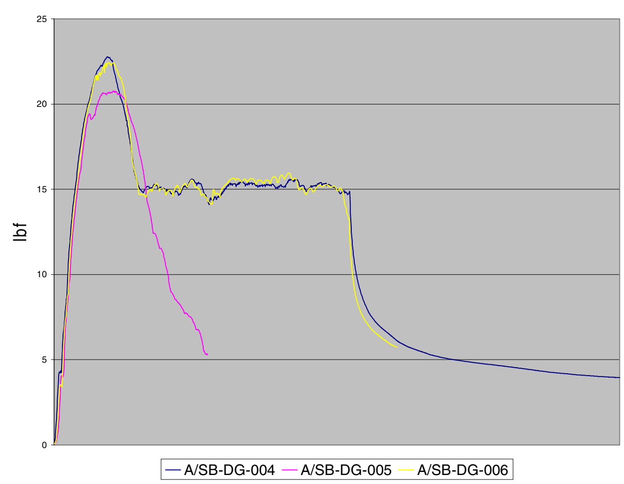
	SEPARATION,	ULTIMATE LOAD (lbf/in)
A/SB-DG-001:	MEMBRANE	21.2 (3.71 kN/m)
A/SB-DG-002:	MEMBRANE	22.0 (3.85 kN/m)
A/SB-DG-003:	MEMBRANE	22.5 (3.94 kN/m)

Low-Temperature



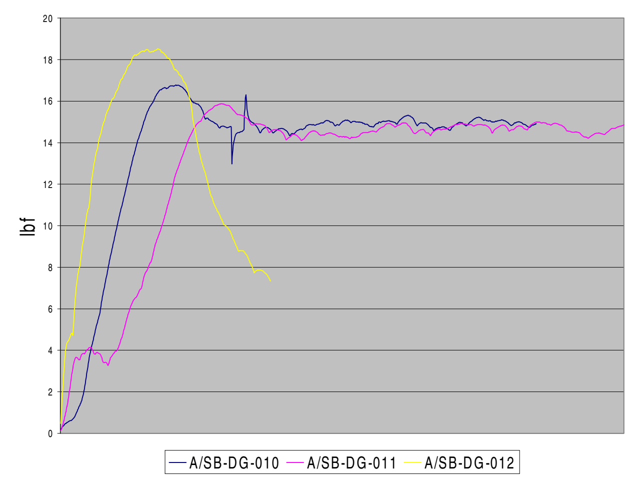
	SEPARATION,	ULTIMATE LOAD (lbf/in)
A/SB-DG-007:	MEMBRANE/POLY	21.8 (3.82 kN/m)
A/SB-DG-008:	MEMBRANE/POLY	21.4 (3.75 kN/m)
A/SB-DG-009:	POLYETHYLENE	21.9 (3.84 kN/m)

High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
A/SB-DG-004:	POLYETHYLENE	22.8 (3.99 kN/m)
A/SB-DG-005:	POLYETHYLENE	20.8 (3.64 kN/m)
A/SB-DG-006:	POLYETHYLENE	22.5 (3.94 kN/m)

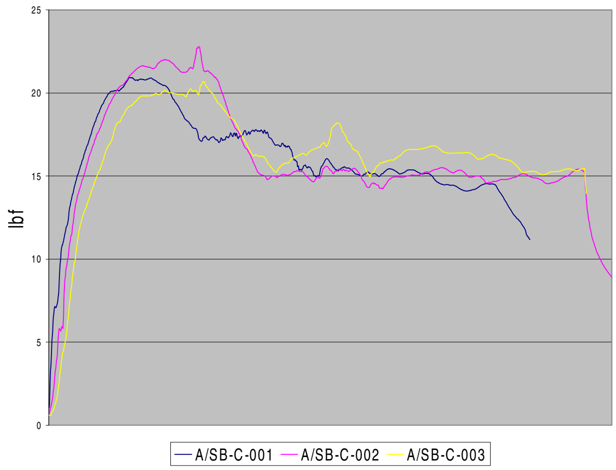
Saturation



	SEPARATION,	ULTIMATE LOAD (lbf/in)
A/SB-DG-010:	POLYETHYLENE	17.8 (3.12 kN/m)
A/SB-DG-011:	POLYETHYLENE	16.8 (2.94 kN/m)
A/SB-DG-012:	POLYETHYLENE	21.4 (3.75 kN/m)

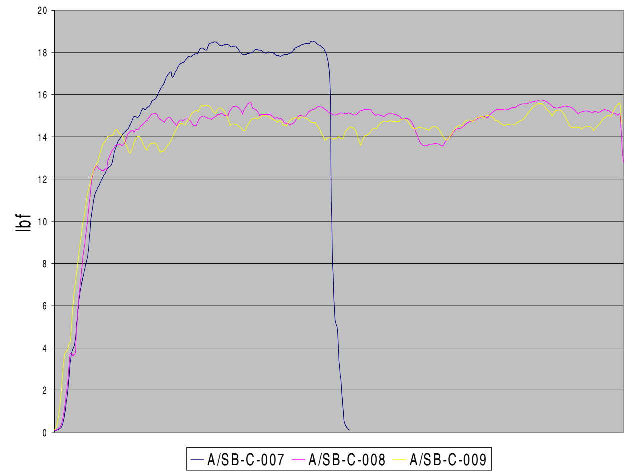
Poured-In-Place Concrete

Benchmark



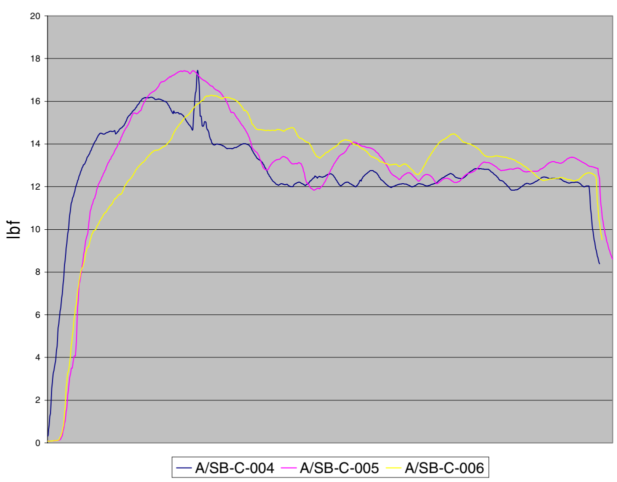
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-C-001:	POLYETHYLENE	21.0 (3.68 kN/m)
A/SB-C-002:	POLYETHYLENE	22.8 (3.99 kN/m)
A/SB-C-003:	POLYETHYLENE	20.7 (3.63 kN/m)

Low-Temperature



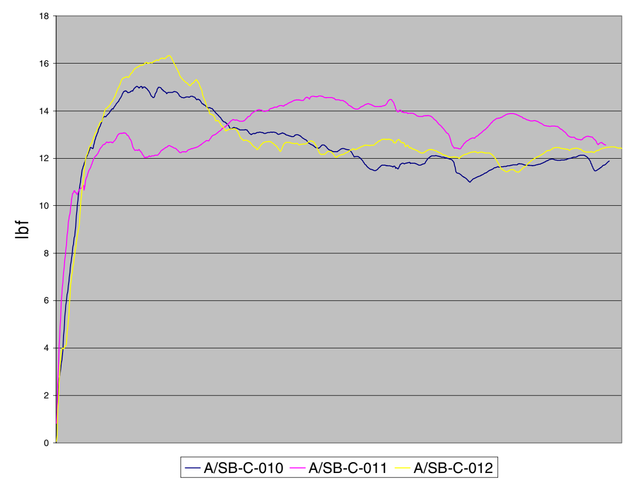
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-C-007:	MEMBRANE	18.6 (3.26 kN/m)
A/SB-C-008:	MEMBRANE	15.8 (2.77 kN/m)
A/SB-C-009:	MEMBRANE	15.6 (2.73 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-C-004:	POLYETHYLENE	17.5 (3.06 kN/m)
A/SB-C-005:	POLYETHYLENE	17.5 (3.06 kN/m)
A/SB-C-006:	POLYETHYLENE	16.3 (2.85 kN/m)

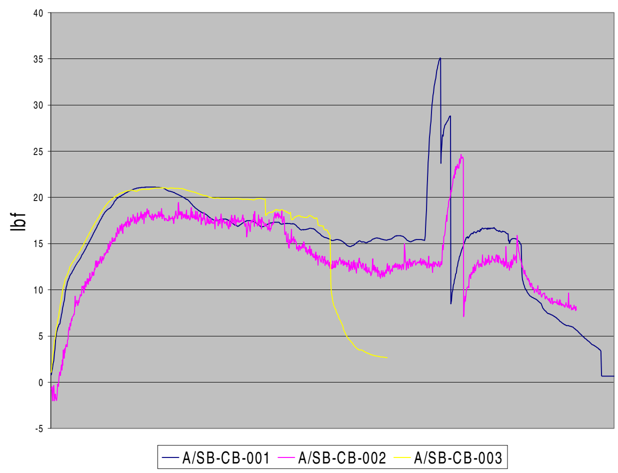
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-C-010:	POLYETHYLENE	15.1 (2.64 kN/m)
A/SB-C-011:	POLYETHYLENE	14.7 (2.57 kN/m)
A/SB-C-012:	POLYETHYLENE	16.4 (2.87 kN/m)

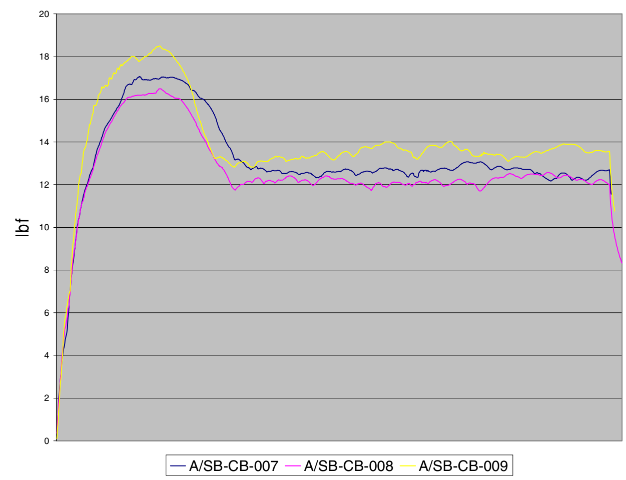
Concrete Block

Benchmark



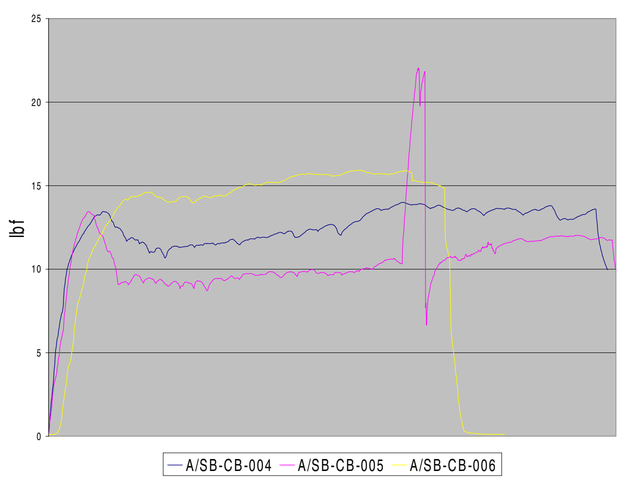
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-CB-001:	POLYETHYLENE	35.1 (6.15 kN/m)
A/SB-CB-002:	POLYETHYLENE	24.7 (4.33 kN/m)
A/SB-CB-003:	POLYETHYLENE	21.1 (3.70 kN/m)

Low-Temperature



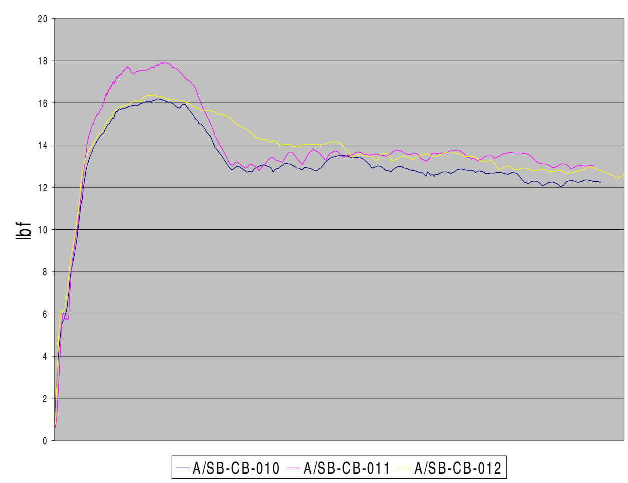
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-CB-007:	POLYETHYLENE	17.1 (2.99 kN/m)
A/SB-CB-008:	POLYETHYLENE	16.5 (2.89 kN/m)
A/SB-CB-009:	POLYETHYLENE	18.5 (3.24 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-CB-004:	MEMBRANE	14.0 (2.45 kN/m)
A/SB-CB-005:	MEMBRANE	22.1 (3.87 kN/m)
A/SB-CB-006:	MEMBRANE	16.0 (2.80 kN/m)

Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-CB-010:	POLYETHYLENE	16.2 (2.84 kN/m)
A/SB-CB-011:	POLYETHYLENE	17.9 (3.13 kN/m)
A/SB-CB-012:	POLYETHYLENE	16.4 (2.87 kN/m)

APPENDIX B

PRODUCT-A/WB

Appendix B1 – Material Descriptions (from Manufacturer's Technical Literature)

The membrane is a self-adhered membrane consisting of an SBS rubberized asphalt compound which is integrally laminated to a blue cross-laminated film. The membrane is specifically designed to be self-adhered to a prepared substrate, and is designed for use as a self-adhered sheet air or vapour barrier. Its principal application is on walls of either masonry, concrete or drywall.

The primer is a polymer emulsion based primer for self-adhesive membranes. It is used as a primer for self-adhesive membranes when applied to masonry, concrete, non-treated wood, and gypsum board.

Appendix B2 – Summary of Test Results

Tensile Adhesion.
Benchmark: The membrane generally remained adhered to the substrate up to a tensile load of 15.0 psi, although only 40% of valid test results exceeded 20.0 psi. Some specimens remained adhered to the substrate at tensile loads in excess of 30.0 psi.

Tensile adhesion appeared to decrease after low-temperature conditioning: on 67% of valid test results, the membrane detached at tensile loads less than 15.0 psi; on 30% of valid test results, the membrane detached at tensile loads less than 10.0 psi.

Tensile adhesion did not appear significantly effected by either high-temperature/high humidity conditioning or saturation conditioning.

Slow-Peel Resistance.
Benchmark: All specimens peeled 150 mm within six days from the start of the test.

Slow-peel resistance appeared to decrease after low-temperature conditioning, as all specimens peeled 150 mm within 48 hours from the start of the test, and 50% peeled 150 mm within 24 hours from the start of the test.

Slow-peel resistance did not appear significantly effected by high-temperature/high humidity conditioning or saturation conditioning.

Fast-Peel Resistance.
Benchmark: On 58% of valid tests, specimens required a peak peel load greater than 11.0 lbf/in (1.93 kN/m) to peel from the substrate, although the results varied by substrate. On drywall, a peak peel load of 26.4 lbf/in (4.62 kN/m) was required to peel the membrane. On Dens Glass Gold, the membrane peeled at peak peel loads between 6.4 lbf/in (1.12 kN/m) and 7.5 lbf/in (1.31 kN/m). On poured-in-place concrete and concrete block, the membrane peeled at peak peel loads between 8.5 lbf/in (1.49 kN/m) and 12.6 lbf/in (2.21 kN/m).

Fast-peel resistance appeared to decrease slightly after each of the conditioning cycles.

Appendix B3 - Tensile Adhesion Test Results

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
DRYWALL		DRYWALL		DRYWALL			
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF		
31.9	SUBSTRATE	15.7	SUBSTRATE	15.8	SUBSTRATE		
19.4	TEST PAD	16.0	TEST PAD	18.9	SUBSTRATE		
16.9	TEST PAD	18.7	SUBSTRATE	18.0	SUBSTRATE		
13.3	SUBSTRATE	21.4	SUBSTRATE	22.1	SUBSTRATE		
23.6	SUBSTRATE	16.5	SUBSTRATE	14.8	SUBSTRATE		
12.6	TEST PAD	21.5	SUBSTRATE	17.7	SUBSTRATE		
20.9	SUBSTRATE	14.7	SUBSTRATE	15.1	SUBSTRATE		
17.2	TEST PAD	13.4	SUBSTRATE	13.1	SUBSTRATE		
25.5	SUBSTRATE	12.9	SUBSTRATE	15.7	SUBSTRATE		

DENS-GLASS GOLD		DENS-GLASS GOLD		DENS-GLASS GOLD		DENS-GLASS GOLD	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
20.2	SUBSTRATE	8.5	MEMBRANE	15.2	TEST PAD	17.0	MEMBRANE
12.4	TEST PAD	10.2	MEMBRANE	19.7	SUBSTRATE	15.7	MEMBRANE
13.3	TEST PAD	9.9	MEMBRANE	19.3	SUBSTRATE	16.9	SUBSTRATE
14.2	TEST PAD	8.6	MEMBRANE	17.3	SUBSTRATE	13.0	MEMBRANE
14.9	MEMBRANE	8.2	MEMBRANE	19.4	SUBSTRATE	16.1	SUBSTRATE
10.9	TEST PAD	9.1	MEMBRANE	16.3	TEST PAD	13.0	MEMBRANE
19.4	TEST PAD	9.2	MEMBRANE	15.8	TEST PAD	15.5	MEMBRANE
15.9	TEST PAD	9.4	MEMBRANE	17.3	SUBSTRATE	16.5	SUBSTRATE
13.5	SUBSTRATE	6.1	MEMBRANE	16.4	SUBSTRATE	14.7	MEMBRANE

CONCRETE		CONCRETE		CONCRETE		CONCRETE	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
16.9	MEMBRANE	15.0	MEMBRANE	13.8	TEST PAD	29.5	POLY
19.7	MEMBRANE	14.9	MEMBRANE	17.3	MEMBRANE	21.5	POLY
14.8	MEMBRANE	14.0	MEMBRANE	11.5	TEST PAD	SPOILED SAMPLE	
19.1	MEMBRANE	13.8	MEMBRANE	14.5	TEST PAD		
18.9	MEMBRANE	15.1	MEMBRANE	8.8	TEST PAD	21.1	POLY
14.4	MEMBRANE	14.8	MEMBRANE	14.6	MEMBRANE	24.3	MEMBRANE

CONCRETE BLOCK		CONCRETE BLOCK		CONCRETE BLOCK		CONCRETE BLOCK	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
18.6	MEMBRANE	13.5	MEMBRANE	26.5	TEST PAD	17.3	MEMBRANE
27.5	MEMBRANE	14.4	MEMBRANE	22.7	MEMBRANE	14.4	MEMBRANE
19.6	MEMBRANE	13.6	MEMBRANE	25.0	TEST PAD	17.2	MEMBRANE

Appendix B4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	38	90	125	150																								
mm	108	150																										
mm	89	150																										

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	140	150																										
mm	120	150																										
mm	118	150																										

HIGH TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	68	150																										
mm	0	0	0	47	80	150																						
mm	0	75	150																									

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	130	150																										
mm	147	150																										

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	49	110	150																									
mm	56	128	150																									
mm	63	48	150																									

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

Poured-In-Place Concrete

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	66	115	150																									
mm	56	101	143	150																								
mm	62	107	150																									

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	145	150																										
mm	122	150																										
mm	85	150																										

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	N/A																											
mm	150																											

Concrete Block

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	34	74	117	150																								
mm	36	65	90	116	148	150																						
mm	31	62	95	130	150																							

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	72	150																										
mm	79	150																										
mm	79	150																										

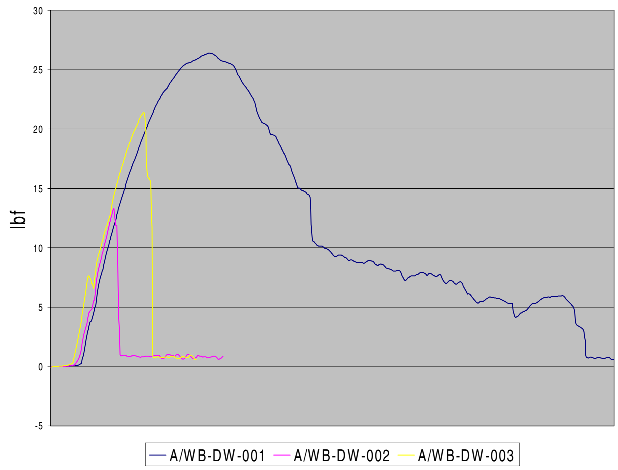
HIGH-TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	53	80	108	150																								
mm	135	150																										
mm	65	97	147	150																								

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	44	95	140	150																								
mm	47	100	125	150																								
mm	45	95	122	150																								

Appendix B5 – Fast Peel Resistance Test Results

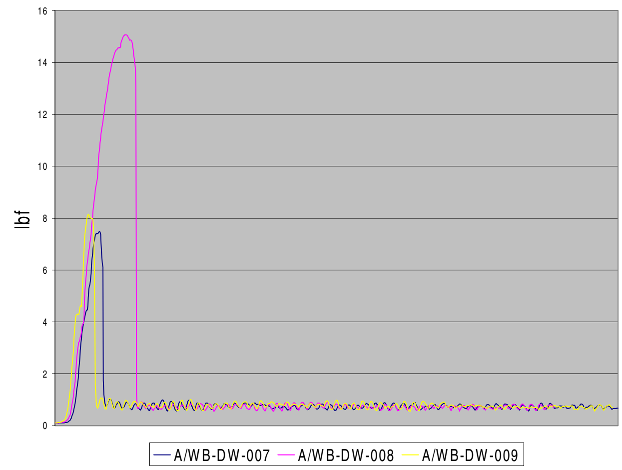
Drywall

Benchmark



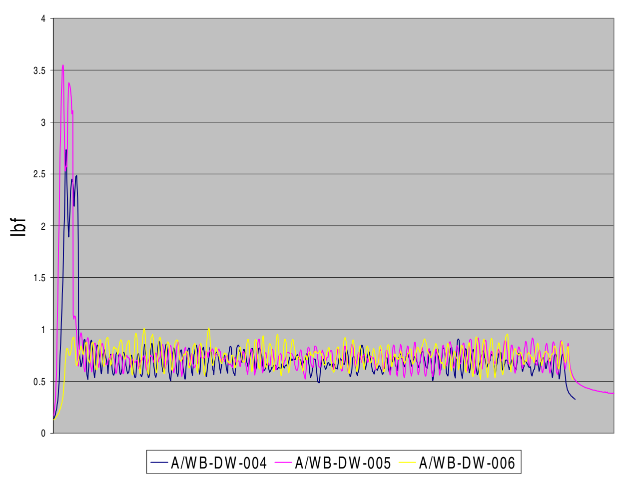
	SEPARATION,	ULTIMATE LOAD (lbf/in)
A/WB-DW-001:	MEMBRANE	26.4 (4.62 kN/m)
A/WB-DW-002:	PAPER	13.3 (2.33 kN/m)
A/WB-DW-003:	PAPER	21.4 (3.75 kN/m)

Low-Temperature



	SEPARATION,	ULTIMATE LOAD (lbf/in)
A/WB-DW-007:	PAPER	7.5 (1.31 kN/m)
A/WB-DW-008:	PAPER	15.1 (2.64 kN/m)
A/WB-DW-009:	PAPER	8.2 (1.44 kN/m)

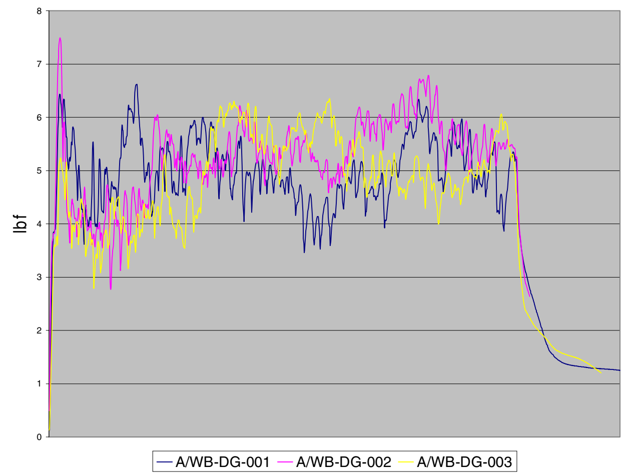
High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
A/WB-DW-004:	PAPER	5.8 (1.02 kN/m)
A/WB-DW-005:	PAPER	3.6 (0.63 kN/m)
A/WB-DW-006:	PAPER	1.0 (0.18 kN/m)

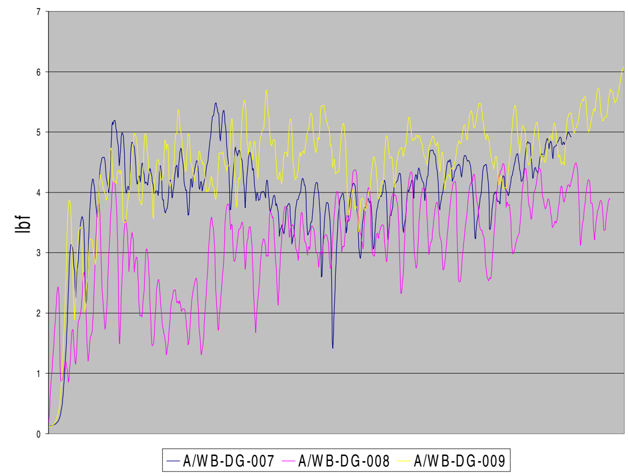
Dens-Glass Gold

Benchmark



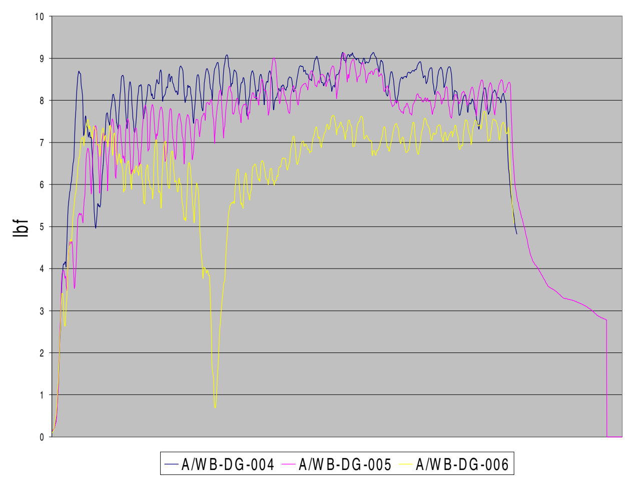
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-DG-001:	MEMBRANE	6.6 (1.16 kN/m)
A/WB-DG-002:	MEMBRANE	7.5 (1.31 kN/m)
A/WB-DG-003:	MEMBRANE	6.4 (1.12 kN/m)

Low-Temperature



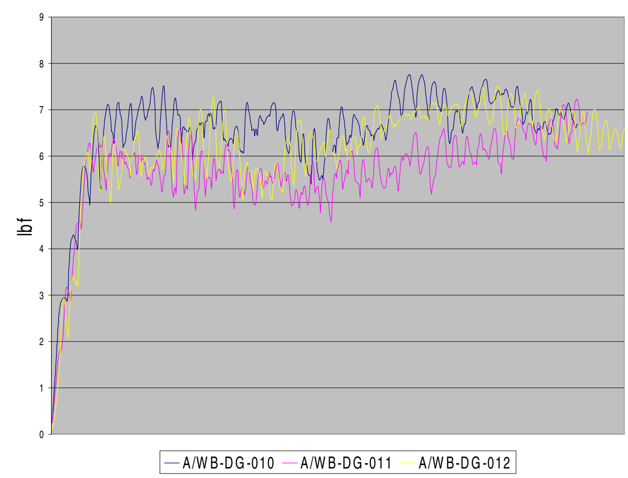
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-DG-007:	MEMBRANE	5.5 (0.96 kN/m)
A/WB-DG-008:	MEMBRANE	4.5 (0.79 kN/m)
A/WB-DG-009:	MEMBRANE	6.1 (1.07 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-DG-004:	MEMBRANE	9.2 (1.61 kN/m)
A/WB-DG-005:	MEMBRANE	9.1 (1.60 kN/m)
A/WB-DG-006:	MEMBRANE	7.8 (1.37 kN/m)

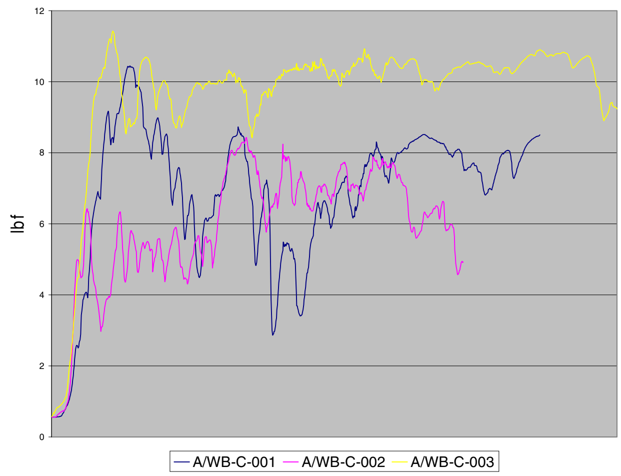
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-DG-010:	MEMBRANE	7.8 (1.37 kN/m)
A/WB-DG-011:	MEMBRANE	7.3 (1.28 kN/m)
A/WB-DG-012:	MEMBRANE	7.8 (1.37 kN/m)

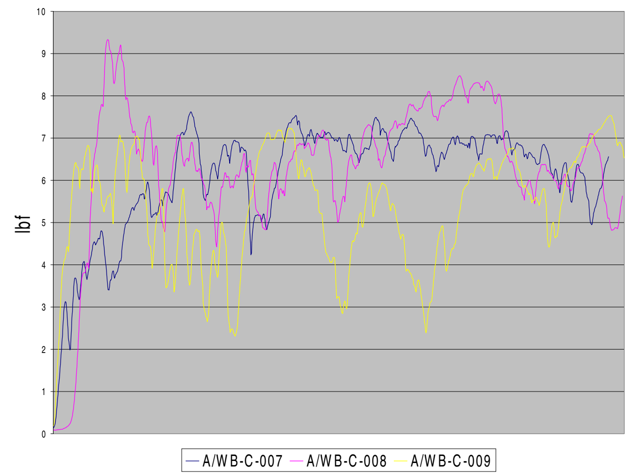
Poured-In-Place Concrete

Benchmark



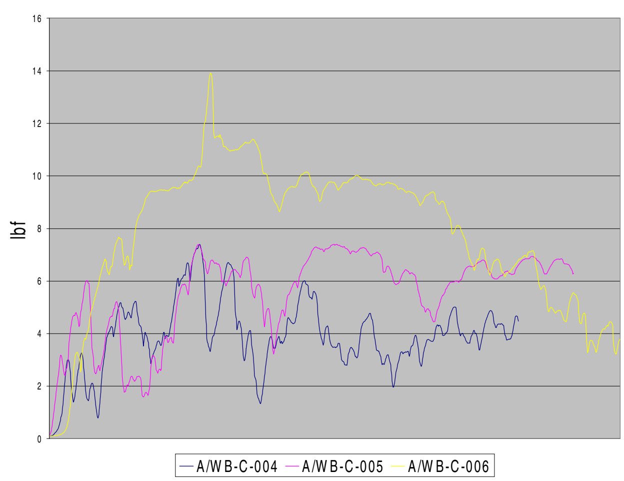
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-C-001:	MEMBRANE	10.5 (1.84 kN/m)
A/WB-C-002:	MEMBRANE	8.5 (1.49 kN/m)
A/WB-C-003:	MEMBRANE	11.5 (2.01 kN/m)

Low-Temperature



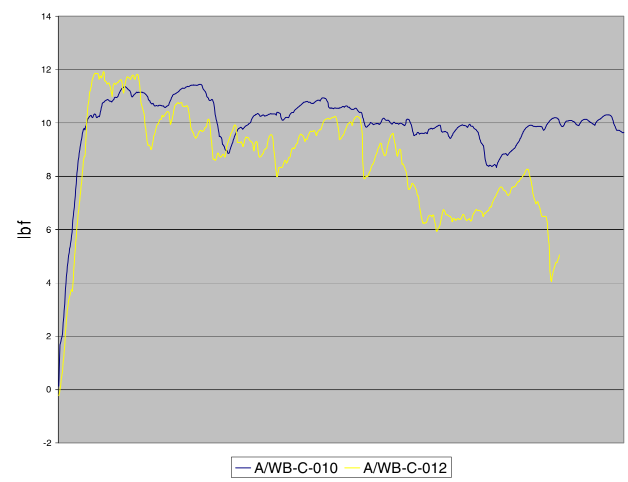
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-C-007:	MEMBRANE	7.6 (1.33 kN/m)
A/WB-C-008:	MEMBRANE	9.4 (1.65 kN/m)
A/WB-C-009:	MEMBRANE	7.6 (1.33 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-C-004:	MEMBRANE	7.4 (1.30 kN/m)
A/WB-C-005:	MEMBRANE	7.4 (1.30 kN/m)
A/WB-C-006:	MEMBRANE	13.9 (2.43 kN/m)

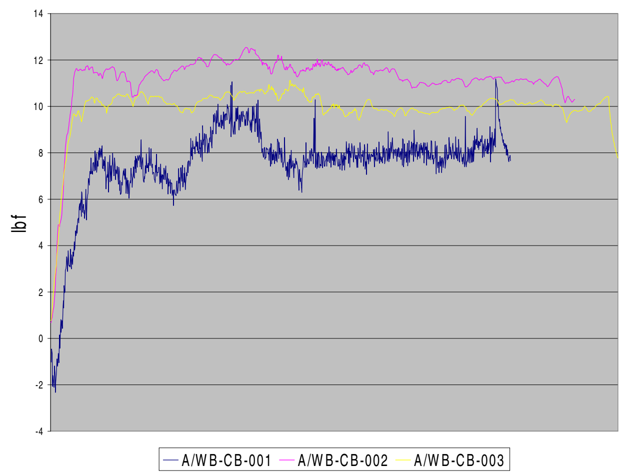
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-C-010:	MEMBRANE	11.5 (2.01 kN/m)
A/WB-C-011:	SPOILED SAMPLE	
A/WB-C-012:	MEMBRANE	12.0 (2.10 kN/m)

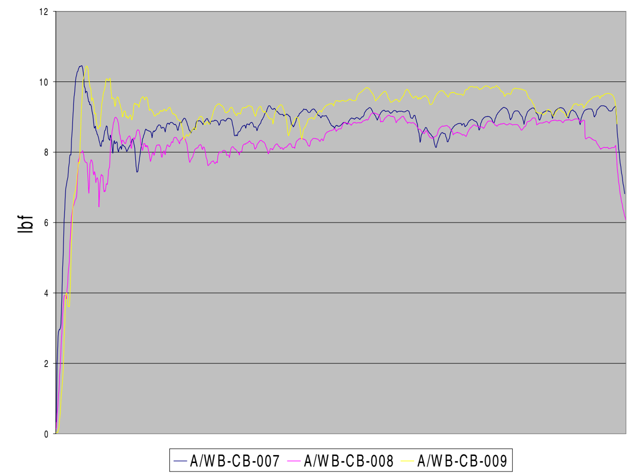
Concrete Block

Benchmark



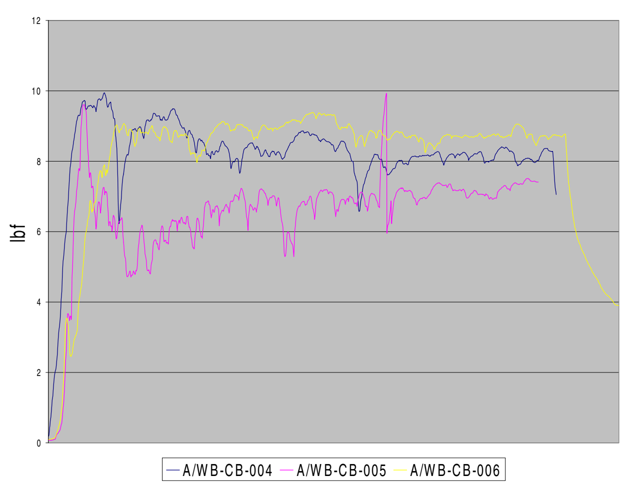
	SEPARATION	ULTIMATE LOAD (lbf/in)
A/WB-CB-001:	MEMBRANE	11.2 (1.96 kN/m)
A/WB-CB-002:	MEMBRANE	12.6 (2.21 kN/m)
A/WB-CB-003:	MEMBRANE	11.1 (1.94 kN/m)

Low-Temperature



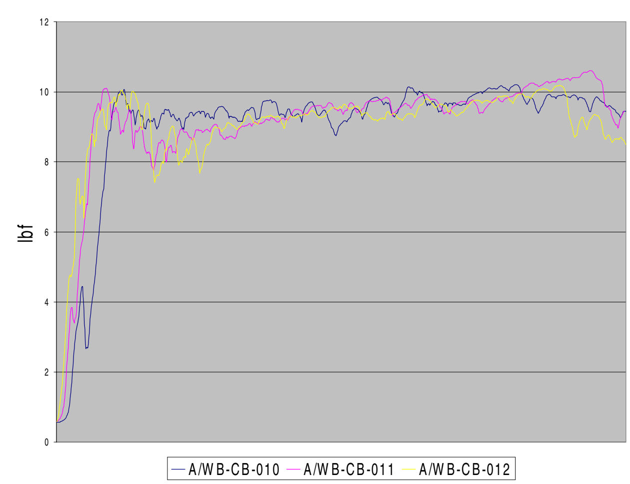
	SEPARATION	ULTIMATE LOAD (lbf/in)
A/WB-CB-007:	MEMBRANE	10.5 (1.84 kN/m)
A/WB-CB-008:	MEMBRANE	9.1 (1.59 kN/m)
A/WB-CB-009:	MEMBRANE	10.5 (1.84 kN/m)

High-Temperature/High-Humidity



	SEPARATION	ULTIMATE LOAD (lbf/in)
A/WB-CB-004:	MEMBRANE	10.0 (1.75 kN/m)
A/WB-CB-005:	MEMBRANE	10.0 (1.75 kN/m)
A/WB-CB-006:	MEMBRANE	9.4 (1.65 kN/m)

Saturation



	SEPARATION	ULTIMATE LOAD (lbf/in)
A/WB-CB-010:	MEMBRANE	10.2 (1.79 kN/m)
A/WB-CB-011:	MEMBRANE	10.6 (1.86 kN/m)
A/WB-CB-012:	MEMBRANE	10.2 (1.79 kN/m)

APPENDIX C

Product-B/WB

Appendix C1 – Material Descriptions (from Manufacturer's Technical Literature)

The membrane is a self-adhesive rubberized asphalt/polyethylene waterproofing membrane for air and vapor barrier applications, and can protect the building superstructure from the damaging effects of the elements.

The primer is a water-based primer which imparts an aggressive, high-tack finish on the treated substrate. It is specifically designed to facilitate tenacious adhesion of wall membranes to glass mat surfaced exterior gypsum boards such as Dens-Glass Gold.

Appendix C2 – Summary of Test Results

<u>Tensile Adhesion.</u>
Benchmark: The membrane generally withstood tensile loads up to 15.0 psi without detaching from the substrate. On over 65% of valid tests, the membrane withstood tensile loads in excess of 20.0 psi without detaching from the substrate; on 40% of valid tests, the membrane withstood tensile loads in excess of 25.0 psi without detaching from the substrate.

Tensile adhesion appeared to decrease after low-temperature conditioning, as 67% of valid test results were lower than 15.0 psi.

Tensile adhesion did not appear significantly effected by either high-temperature/high-humidity conditioning or saturation conditioning.

<u>Slow-Peel Resistance.</u>
Benchmark: All specimens peeled 150 mm within 48 hours from the start of the test. 25% of specimens peeled 150 mm within 24 hours from the start of the test.

Slow-peel resistance appeared to decrease after both low-temperature conditioning and saturation conditioning, as all specimens peeled 150 mm within 24 hours.

On Dens Glass Gold, slow-peel resistance appeared to *increase* after high-temperature/high humidity conditioning. By Day 28, the specimens had only peeled between 5 mm and 20 mm, and the rate of peel was at or less than 1 mm per day. On drywall, poured-in-place concrete and concrete block, slow-peel resistance did not appear significantly effected by high-temperature/high-humidity conditioning.

<u>Fast-Peel Resistance.</u>
Benchmark: On 50% of valid tests, the membrane peeled from the substrate at peak peel loads less than 11.0 lbf/in (1.93 kN/m), although all of the test results were between 10.0 lbf/in (1.75 kN/m) and 12.6 lbf/in (2.21 kN/m).

Fast-peel resistance appeared to decrease after each of the three conditioning cycles. After each conditioning cycle, the percentage of specimens that required a load greater than 11.0 lbf/in (1.93 kN/m) to peel decreased from the benchmark of 50%, to 10% after low-temperature conditioning, 33% after high-temperature/high-humidity conditioning, and 25% after saturation conditioning, with lows of 4.9 lbf/in (0.86 kN/m), 7.6 lbf/in (1.33 kN/m) and 6.8 lbf/in (1.19 kN/m) respectively.

On some specimens, the polyethylene carrier sheet blistered and there was separation of the membrane from the substrate during the saturation conditioning cycle.

Appendix C3 - Tensile Adhesion Test Results

DRYWALL

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
31.4	SUBSTRATE	17.3	SUBSTRATE	10.9	SUBSTRATE
32.0	SUBSTRATE	10.8	SUBSTRATE	10.6	SUBSTRATE
31.1	SUBSTRATE	14.1	SUBSTRATE	7.9	SUBSTRATE
21.7	SUBSTRATE	17.5	SUBSTRATE	14.5	SUBSTRATE
22.4	SUBSTRATE	10.9	SUBSTRATE	13.2	SUBSTRATE
29.1	SUBSTRATE	11.8	SUBSTRATE	13.1	SUBSTRATE
27.0	SUBSTRATE	18.9	SUBSTRATE	10.3	SUBSTRATE
22.4	SUBSTRATE	19.5	SUBSTRATE	10.5	SUBSTRATE
28.6	SUBSTRATE	21.3	SUBSTRATE	11.1	SUBSTRATE

DENS-GLASS GOLD

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
21.5	SUBSTRATE	7.7	TEST PAD	17.0	SUBSTRATE	13.3	SUBSTRATE
19.4	MEMBRANE	8.1	TEST PAD	15.7	SUBSTRATE	17.4	SUBSTRATE
19.2	SUBSTRATE	11.5	TEST PAD	17.3	SUBSTRATE	13.1	SUBSTRATE
23.4	SUBSTRATE	6.4	MEMBRANE	19.1	SUBSTRATE	18.7	SUBSTRATE
14.1	SUBSTRATE	8.0	TEST PAD	24.2	SUBSTRATE	19.5	SUBSTRATE
19.9	SUBSTRATE	5.2	TEST PAD	22.7	SUBSTRATE	21.0	SUBSTRATE
20.2	SUBSTRATE	8.1	MEMBRANE	16.3	SUBSTRATE	21.5	SUBSTRATE
23.1	SUBSTRATE	9.6	MEMBRANE	15.2	SUBSTRATE	19.9	SUBSTRATE
21.0	TEST PAD	7.7	TEST PAD	12.2	SUBSTRATE	13.6	SUBSTRATE

CONCRETE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
14.2	MEMBRANE	14.5	TEST PAD	16.4	TEST PAD	SPOILED SAMPLE	
15.2	MEMBRANE	14.7	TEST PAD	14.6	TEST PAD		
14.3	MEMBRANE	14.2	MEMBRANE	11.2	TEST PAD	11.5	MEMBRANE
19.7	MEMBRANE	14.1	MEMBRANE	15.6	TEST PAD	23.7	MEMBRANE
16.4	MEMBRANE	13.5	MEMBRANE	15.3	TEST PAD	19.4	MEMBRANE
19.3	MEMBRANE	13.8	MEMBRANE	15.5	TEST PAD	20.2	MEMBRANE

CONCRETE BLOCK

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
19.1	MEMBRANE	13.2	MEMBRANE	20.6	TEST PAD	16.3	MEMBRANE
16.7	TEST PAD	14.6	MEMBRANE	16.1	TEST PAD	17.3	MEMBRANE
20.2	MEMBRANE	13.7	MEMBRANE	17.9	TEST PAD	16.1	MEMBRANE

Appendix C4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	114	150																										
mm	98	150																										
mm	120	150																										

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	50	110	150																									
mm	44	95	147	150																								
mm	52	112	150																									

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	114	150																										
mm	136	150																										
mm	92	150																										

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	4	4	6	6	6	7	8	8	9	10	11	12	13	13	14	15
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	4	5	5	5	5	5
mm	0	0	0	2	3	4	5	5	5	5	5	7	7	7	8	8	10	12	15	15	15	15	15	16	16	17	18	19

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

Poured-In-Place Concrete

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	130	150																										
mm	150																											

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	SPOILED SAMPLE																											
mm	150																											
mm	150																											

Concrete Block

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	142	150																										
mm	150																											

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

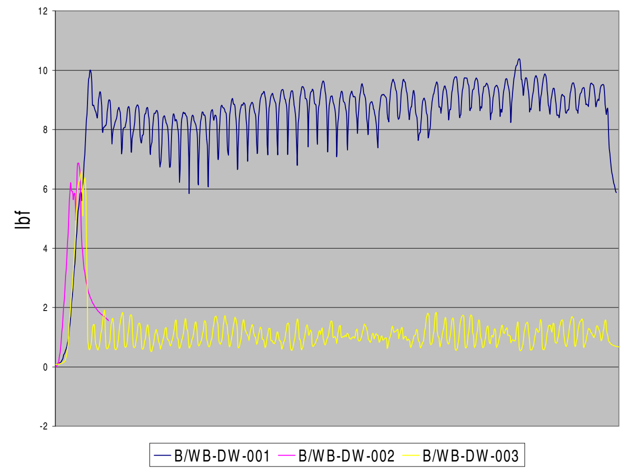
SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

Appendix C5 - Fast-Peel Resistance Test Results

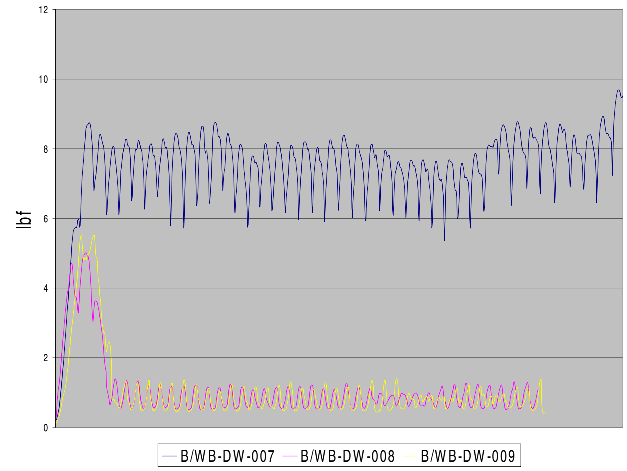
Drywall

Benchmark



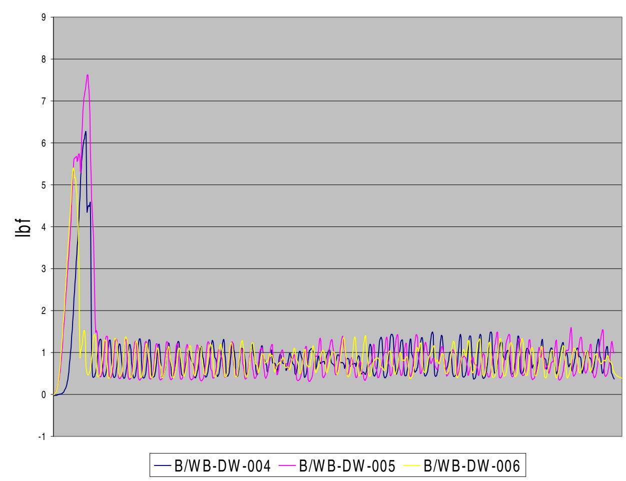
	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-DW-001:	MEMBRANE	10.4 (1.82 kN/m)
B/WB-DW-002:	PAPER	6.9 (1.21 kN/m)
B/WB-DW-003:	PAPER	6.6 (1.16 kN/m)

Low-Temperature



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-DW-007:	MEMBRANE	9.7 (1.70 kN/m)
B/WB-DW-008:	PAPER	5.0 (0.88 kN/m)
B/WB-DW-009:	PAPER	5.5 (0.96 kN/m)

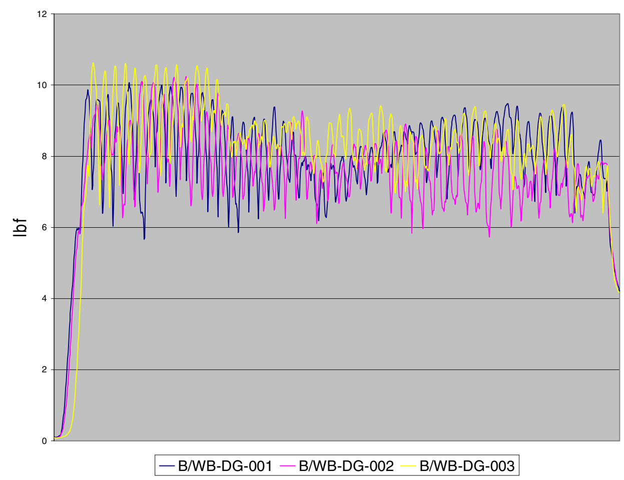
High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-DW-004:	PAPER	6.3 (1.10 kN/m)
B/WB-DW-005:	PAPER	7.7 (1.35 kN/m)
B/WB-DW-006	PAPER	5.4 (0.95 kN/m)

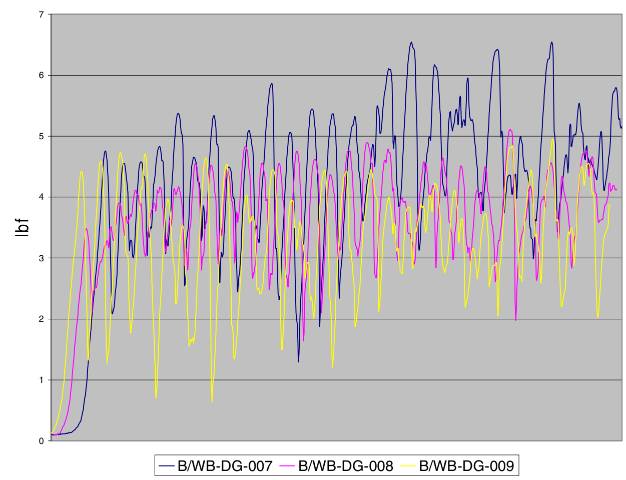
Dens-Glass Gold

Benchmark



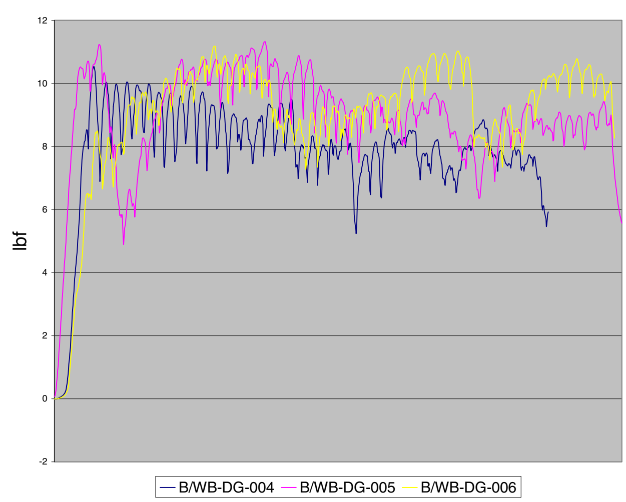
	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-DG-001:	MEMBRANE	10.1 (1.77 kN/m)
B/WB-DG-002:	MEMBRANE	10.3 (1.80 kN/m)
B/WB-DG-003:	MEMBRANE	10.6 (1.86 kN/m)

Low-Temperature



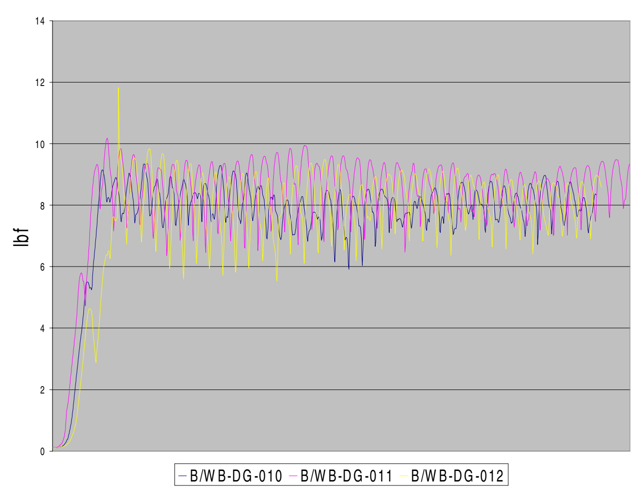
	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-DG-007:	MEMBRANE	6.6 (1.16 kN/m)
B/WB-DG-008:	MEMBRANE	5.1 (0.89 kN/m)
B/WB-DG-009:	MEMBRANE	4.9 (0.86 kN/m)

High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-DG-004:	MEMBRANE	10.6 (1.86 kN/m)
B/WB-DG-005:	MEMBRANE	11.4 (2.00 kN/m)
B/WB-DG-006:	MEMBRANE	11.2 (1.96 kN/m)

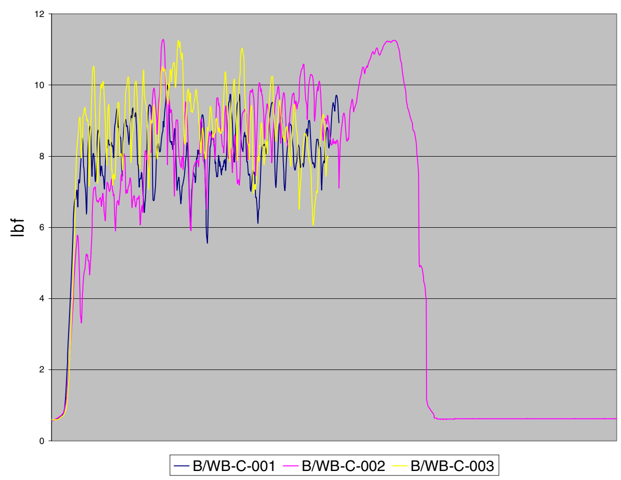
Saturation



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-DG-010:	MEMBRANE	9.4 (1.65 kN/m)
B/WB-DG-011:	MEMBRANE	10.2 (1.79 kN/m)
B/WB-DG-012:	MEMBRANE	11.8 (2.07 kN/m)

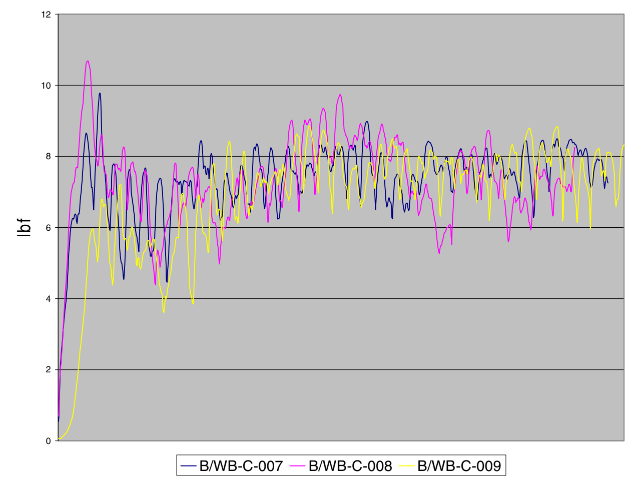
Poured-In-Place Concrete

Benchmark



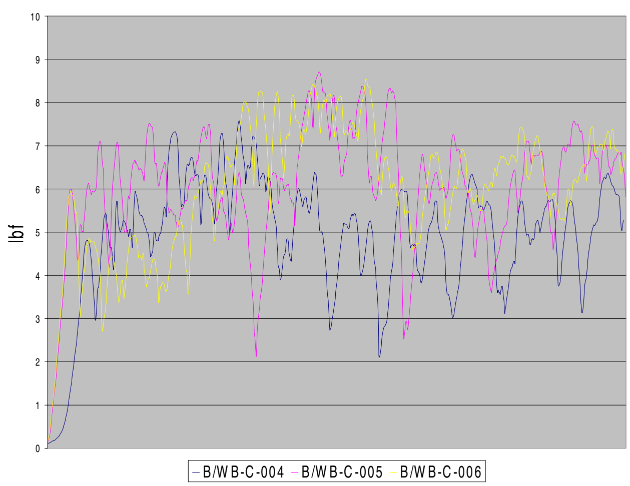
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WB-C-001:	MEMBRANE	10.0 (1.75 kN/m)
B/WB-C-002:	MEMBRANE	11.3 (1.98 kN/m)
B/WB-C-003:	MEMBRANE	11.3 (1.98 kN/m)

Low-Temperature



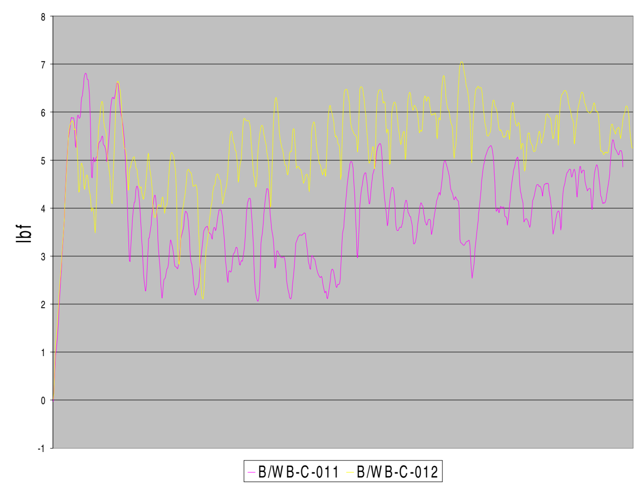
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WB-C-007:	MEMBRANE	9.8 (1.72 kN/m)
B/WB-C-008:	MEMBRANE	10.7 (1.87 kN/m)
B/WB-C-009:	MEMBRANE	8.9 (1.56 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WB-C-004:	MEMBRANE	7.6 (1.33 kN/m)
B/WB-C-005:	MEMBRANE	8.7 (1.52 kN/m)
B/WB-C-006:	MEMBRANE	8.1 (1.42 kN/m)

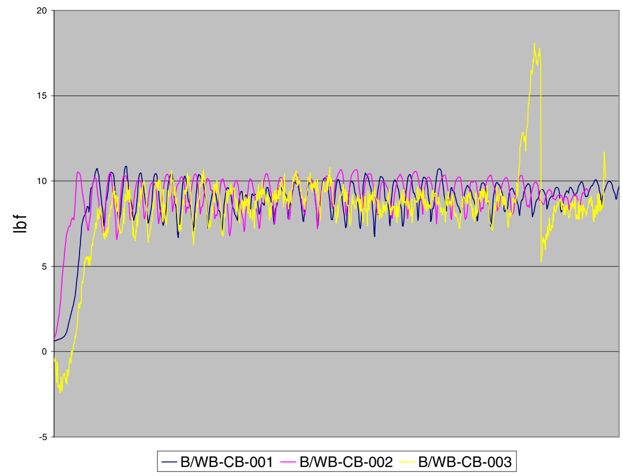
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WB-C-010:	SPOILED SAMPLE	
B/WB-C-011:	MEMBRANE	6.8 (1.19 kN/m)
B/WB-C-012:	MEMBRANE	7.1 (1.24 kN/m)

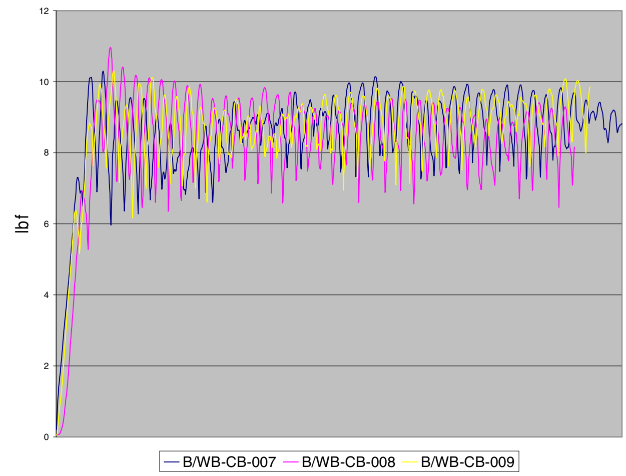
Concrete Block

Benchmark



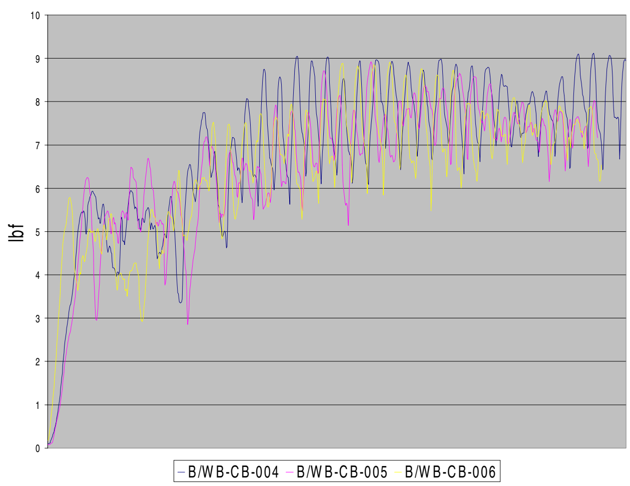
	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-CB-001:	MEMBRANE	11.2 (1.96 kN/m)
B/WB-CB-002:	MEMBRANE	12.6 (2.21 kN/m)
B/WB-CB-003:	MEMBRANE	11.1 (1.94 kN/m)

Low-Temperature



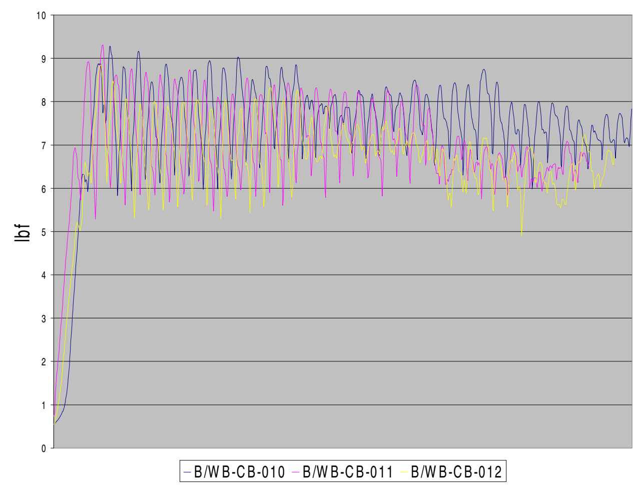
	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-CB-007:	MEMBRANE	10.3 (1.80 kN/m)
B/WB-CB-008:	MEMBRANE	11.0 (1.93 kN/m)
B/WB-CB-009:	MEMBRANE	10.4 (1.82 kN/m)

High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-CB-004:	MEMBRANE	9.1 (1.59 kN/m)
B/WB-CB-005:	MEMBRANE	8.9 (1.56 kN/m)
B/WB-CB-006:	MEMBRANE	8.9 (1.56 kN/m)

Saturation



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WB-CB-010:	MEMBRANE	9.3 (1.63 kN/m)
B/WB-CB-011:	MEMBRANE	9.3 (1.63 kN/m)
B/WB-CB-012:	MEMBRANE	8.9 (1.56 kN/m)

APPENDIX D

PRODUCT-B/WBX

Appendix D1 – Material Descriptions (from Manufacturer's Technical Literature)

The membrane is a self-adhesive rubberized asphalt/polyethylene waterproofing membrane for air and vapor barrier applications, and can protect the building superstructure from the damaging effects of the elements.

The primer is a specially formulated primer for use on 'green' concrete or damp surfaces. It is used to prime 'green' concrete, damp concrete, masonry or wood surfaces on which waterproofing membranes and underlayments will be applied.

Appendix D2 – Summary of Test Results

<u>Tensile Adhesion.</u>
Benchmark: The membrane detached from the substrate on twenty-four of twenty-seven tests, only 54% of which withstood tensile loads in excess of 15.0 psi. The lowest tensile load at which the membrane detached was 7.2 psi. Only 5% of valid test results exceeded 25.0 psi.

Tensile adhesion appeared to decrease after each of the three conditioning cycles, although the extent varied by both conditioning cycle and substrate.

- After low-temperature conditioning, only 37% of valid test results exceeded 10.0 psi, and only 28% exceeded 15.0 psi. The most significant decrease was on Dens Glass Gold where results were between 3.5 psi and 7.8 psi.

- After high-temperature/high-humidity conditioning, only 6% of valid test results exceeded 15.0 psi. The most significant decrease was on poured-in-place concrete where results were between 5.8 psi and 7.8 psi.

- After saturation conditioning, only 33% of valid test results exceeded 15.0 psi. The most significant decrease was on poured-in-place concrete where results were between 6.6 psi and 9.4 psi.

<u>Slow-Peel Resistance.</u>
Benchmark: Specimens took between 2 to 9 days to peel 150 mm.

Slow-peel resistance appeared to decrease after each of the three conditioning cycles. All specimens peeled 150 mm within 48 hours, and most within 24 hours. The only exception was on drywall after high-temperature/high-humidity conditioning where slow-peel resistance improved, although by Day 28 the specimens had still peeled at least 125 mm.

Fast-Peel Resistance.

Benchmark: All of the specimens peeled at peak peel loads less than 11.0 lbf/in (1.93 kN/m). The lowest results were recorded on Dens Glass Gold, where specimens peeled at peak peel loads between 4.3 lbf/in (0.75 kN/m) and 7.1 lbf/in (1.24 kN/m).

Fast-peel resistance appeared to decrease after each of the conditioning cycles, with one exception: on drywall specimens after high-temperature/high-humidity conditioning, fast-peel resistance increased by approximately 30%.

Blistering and creasing of the polyethylene carrier sheet occurred during saturation conditioning.

Appendix D3 - Tensile Adhesion Test Results

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY	
DRYWALL		DRYWALL		DRYWALL	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
22.6	MEMBRANE	14.4	TEST PAD	10.3	SUBSTRATE
19.4	TEST PAD	14.6	TEST PAD	10.4	SUBSTRATE
23.3	MEMBRANE	16.5	MEMBRANE	10.4	SUBSTRATE
25.1	MEMBRANE	17.3	SUBSTRATE	9.3	SUBSTRATE
23.1	MEMBRANE	15.7	TEST PAD	12.8	SUBSTRATE
22.1	MEMBRANE	16.8	SUBSTRATE	14.0	SUBSTRATE
11.0	SUBSTRATE	15.2	TEST PAD	9.3	SUBSTRATE
21.7	MEMBRANE	15.9	TEST PAD	11.7	SUBSTRATE
23.5	MEMBRANE	16.9	TEST PAD	12.5	SUBSTRATE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
DENS-GLASS GOLD		DENS-GLASS GOLD		DENS-GLASS GOLD		DENS-GLASS GOLD	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
14.4	MEMBRANE	3.8	MEMBRANE	8.8	MEMBRANE	7.7	MEMBRANE
10.4	MEMBRANE	5.1	MEMBRANE	9.8	MEMBRANE	7.8	MEMBRANE
8.8	MEMBRANE	2.7	MEMBRANE	11.3	MEMBRANE	8.0	MEMBRANE
12.5	MEMBRANE	4.0	MEMBRANE	12.8	MEMBRANE	8.7	MEMBRANE
8.8	MEMBRANE	3.5	MEMBRANE	9.8	MEMBRANE	8.5	MEMBRANE
10.8	MEMBRANE	4.5	MEMBRANE	11.5	MEMBRANE	9.7	MEMBRANE
12.9	MEMBRANE	4.3	MEMBRANE	9.2	MEMBRANE	7.4	MEMBRANE
8.0	MEMBRANE	3.8	MEMBRANE	10.7	MEMBRANE	8.0	MEMBRANE
7.2	MEMBRANE	4.3	MEMBRANE	9.8	MEMBRANE	9.9	MEMBRANE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
CONCRETE		CONCRETE		CONCRETE		CONCRETE	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
24.1	MEMBRANE	5.8	MEMBRANE	7.7	MEMBRANE	32.9	MEMBRANE
21.2	MEMBRANE	10.1	MEMBRANE	7.2	MEMBRANE	27.5	TEST PAD
22.8	MEMBRANE	6.5	MEMBRANE	6.7	MEMBRANE	30.4	MEMBRANE
15.2	TEST PAD	8.2	MEMBRANE	6.6	MEMBRANE	26.7	TEST PAD
23.7	MEMBRANE	4.1	MEMBRANE	7.8	MEMBRANE	19.9	MEMBRANE
19.4	MEMBRANE	6.9	MEMBRANE	5.8	MEMBRANE	22.0	MEMBRANE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
CONCRETE BLOCK		CONCRETE BLOCK		CONCRETE BLOCK		CONCRETE BLOCK	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
11.1	MEMBRANE	5.6	MEMBRANE	16.5	TEST PAD	7.7	MEMBRANE
12.5	MEMBRANE	5.6	MEMBRANE	12.4	MEMBRANE	6.6	MEMBRANE
12.5	MEMBRANE	7.8	MEMBRANE	14.1	MEMBRANE	9.4	MEMBRANE

Appendix D4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	32	60	80	115	145	150																						
mm	37	65	88	123	148	150																						
mm	32	63	90	119	148	150																						

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	3	7	12	19	22	26	31	36	43	44	45	48	53	57	59	62	68	76	85	90	92	95	101	110	116	122	128	134
mm	0	4	6	12	15	20	24	26	30	30	30	34	38	42	43	46	55	60	67	74	77	81	87	95	102	108	114	121
mm	1	5	11	20	28	38	41	46	50	52	55	60	67	75	81	88	101	112	123	133	136	142	150					

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	98	150																										
mm	27	42	60	100	130	133	150																					
mm	73	100	110	123	135	138	142	148	150																			

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

Poured-In-Place Concrete

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	60	108	150																									
Mm	61	118	150																									
mm	54	99	145	150																								

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	119	150																										
mm	150																											

Concrete Block

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	125	150																										
mm	70	110	146	150																								
mm	60	126	150																									

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	85	150																										
mm	85	150																										
mm	110	150																										

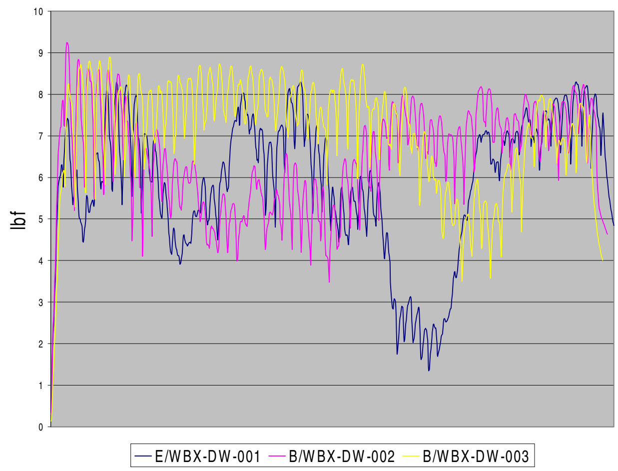
SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	150																											
mm	150																											
mm	150																											

Appendix D5 – Fast Peel Resistance Test Results

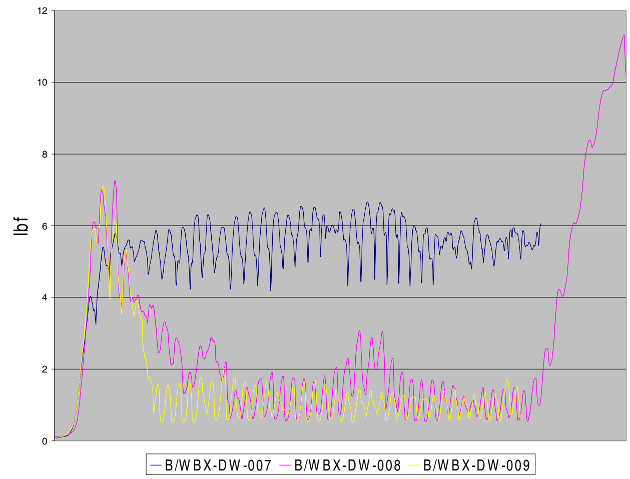
Drywall

Benchmark



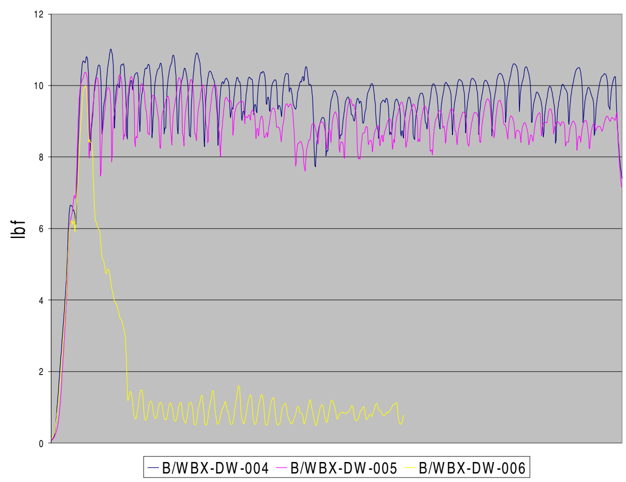
	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WBX-DW-001:	MEMBRANE/PAPER	8.3 (1.45 kN/m)
B/WBX-DW-002:	MEMBRANE/PAPER	9.3 (1.63 kN/m)
B/WBX-DW-003:	MEMBRANE/PAPER	8.9 (1.56 kN/m)

Low-Temperature



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WBX-DW-007:	MEMBRANE	6.7 (1.17 kN/m)
B/WBX-DW-008:	PAPER	7.3 (1.28 kN/m)
B/WBX-DW-009:	PAPER	7.1 (1.24 kN/m)

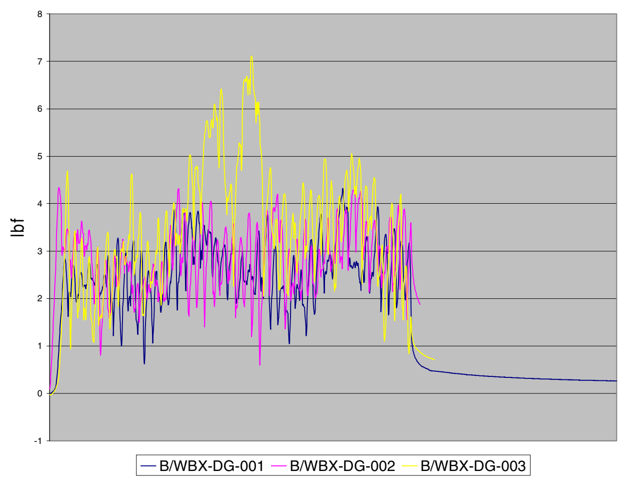
High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
B/WBX-DW-004:	MEMBRANE	11.0 (1.93 kN/m)
B/WBX-DW-005:	MEMBRANE/PAPER	10.4 (1.82 kN/m)
B/WBX-DW-006:	PAPER	10.0 (1.75 kN/m)

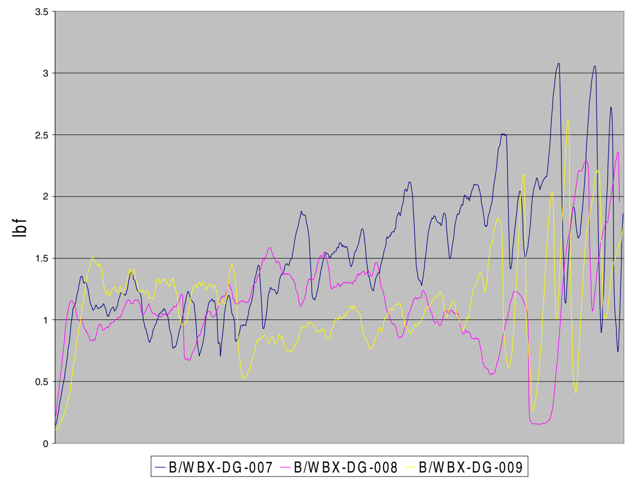
Dens-Glass Gold

Benchmark



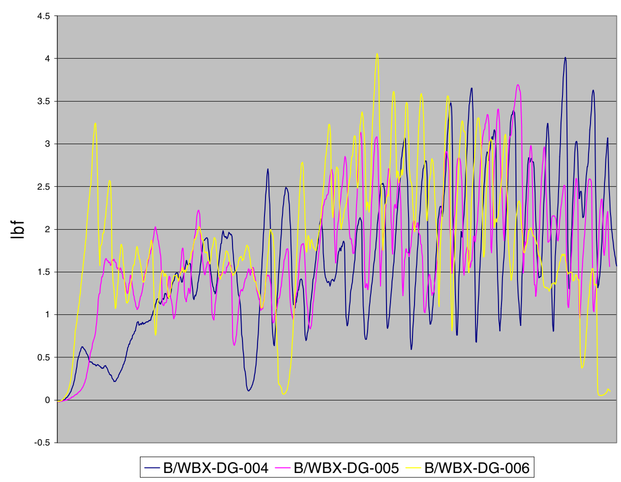
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-DG-001:	MEMBRANE	4.3 (0.75 kN/m)
B/WBX-DG-002:	MEMBRANE	4.4 (0.77 kN/m)
B/WBX-DG-003:	MEMBRANE	7.1 (1.24 kN/m)

Low-Temperature



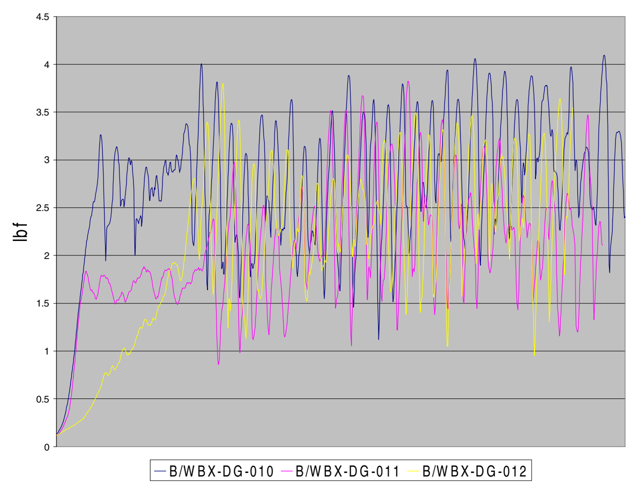
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-DG-007:	MEMBRANE	3.1 (0.54 kN/m)
B/WBX-DG-008:	MEMBRANE	2.4 (0.42 kN/m)
B/WBX-DG-009:	MEMBRANE	2.6 (0.46 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-DG-004:	MEMBRANE	4.0 (0.70 kN/m)
B/WBX-DG-005	MEMBRANE	3.7 (0.65 kN/m)
B/WBX-DG-006:	MEMBRANE	4.1 (0.72 kN/m)

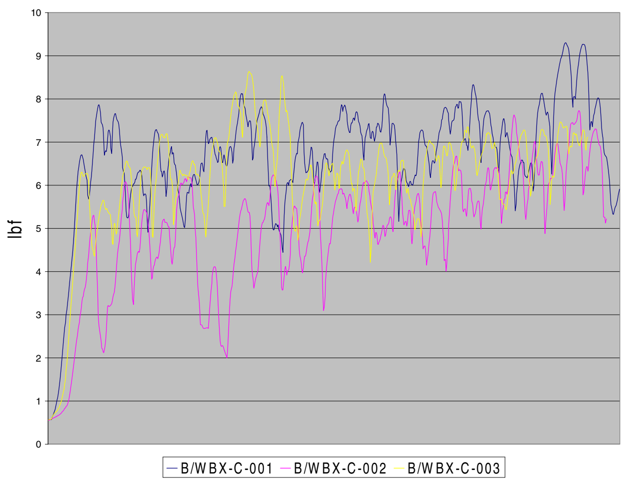
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-DG-010:	MEMBRANE	4.1 (0.72 kN/m)
B/WBX-DG-011:	MEMBRANE	3.8 (0.67 kN/m)
B/WBX-DG-012:	MEMBRANE	3.8 (0.67 kN/m)

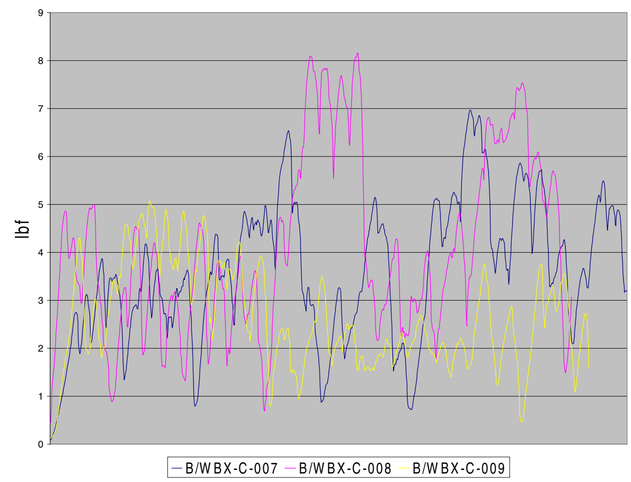
Poured-In-Place Concrete

Benchmark



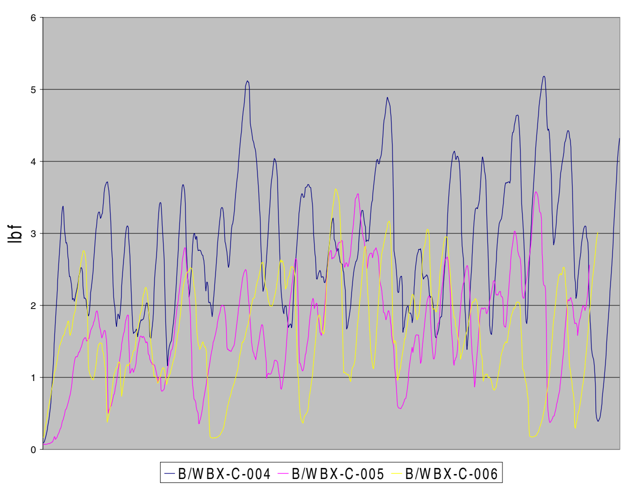
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-C-001:	MEMBRANE	9.3 (1.63 kN/m)
B/WBX-C-002:	MEMBRANE	7.8 (1.37 kN/m)
B/WBX-C-003:	MEMBRANE	8.7 (1.52 kN/m)

Low-Temperature



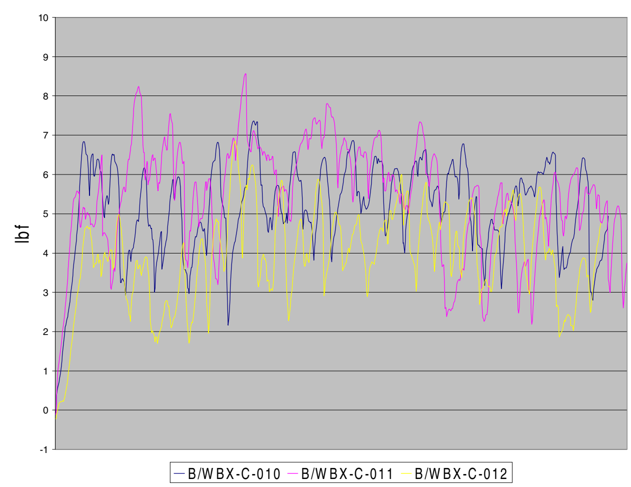
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-C-007:	MEMBRANE	7.0 (1.23 kN/m)
B/WBX-C-008:	MEMBRANE	8.2 (1.44 kN/m)
B-WBX-C-009:	MEMBRANE	5.1 (0.89 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-C-004:	MEMBRANE	5.2 (0.91 kN/m)
B/WBX-C-005:	MEMBRANE	3.6 (0.63 kN/m)
B/WBX-C-006:	MEMBRANE	3.6 (0.63 kN/m)

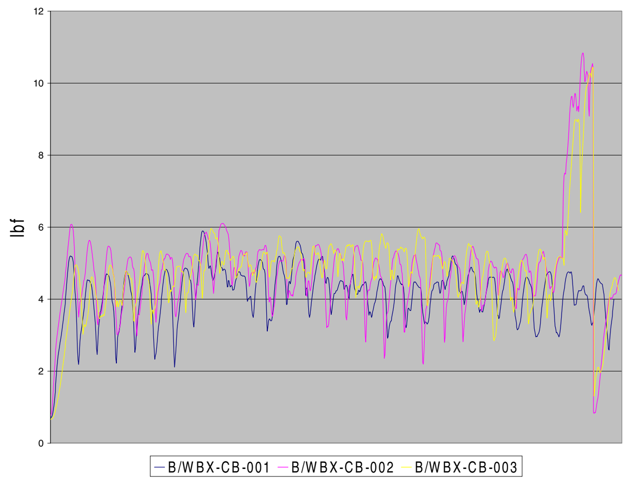
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-C-010:	MEMBRANE	7.4 (1.30 kN/m)
B/WBX-C-011:	MEMBRANE	8.6 (1.51 kN/m)
B/WBX-C-012:	MEMBRANE	6.9 (1.21 kN/m)

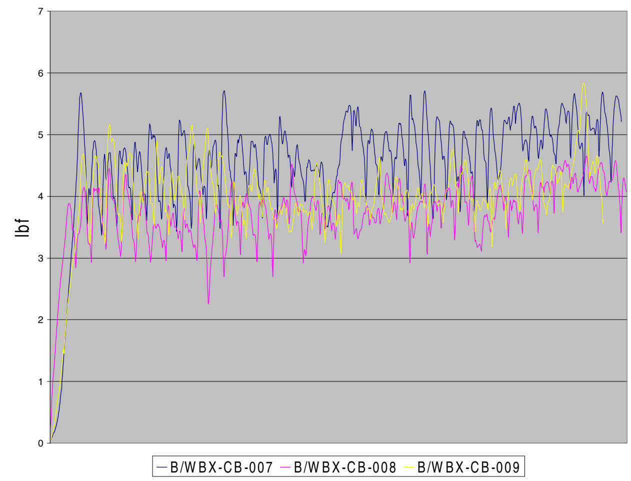
Concrete Block

Benchmark



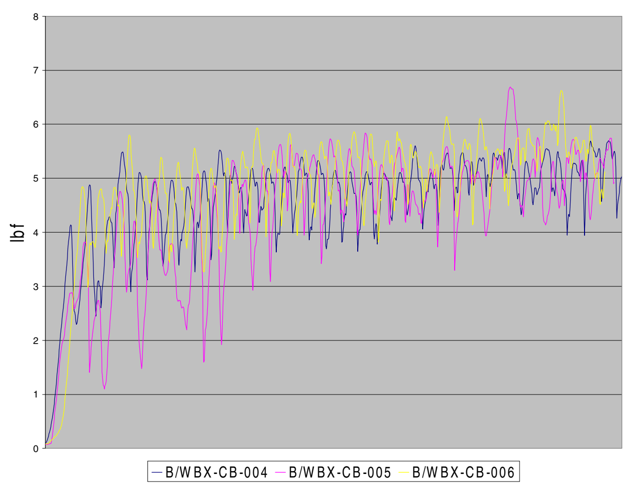
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-CB-001:	MEMBRANE	5.9 (1.03 kN/m)
B/WBX-CB-002:	MEMBRANE	10.9 (1.91 kN/m)
B/WBX-CB-003:	MEMBRANE	10.5 (1.84 kN/m)

Low-Temperature



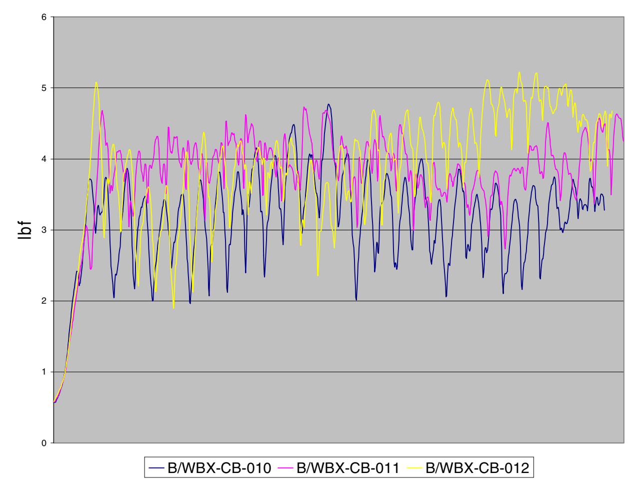
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-CB-007:	MEMBRANE	5.7 (1.00 kN/m)
B/WBX-CB-008:	MEMBRANE	4.7 (0.82 kN/m)
B/WBX-CB-009:	MEMBRANE	5.9 (1.03 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-CB-004:	MEMBRANE	5.7 (1.00 kN/m)
B/WBX-CB-005:	MEMBRANE	6.7 (1.17 kN/m)
B/WBX-CB-006:	MEMBRANE	6.7 (1.17 kN/m)

Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-CB-010:	MEMBRANE	4.8 (0.84 kN/m)
B/WBX-CB-011:	MEMBRANE	4.8 (0.84 kN/m)
B/WBX-CB-012:	MEMBRANE	5.2 (0.91 kN/m)

APPENDIX E

PRODUCT-C/SB

Appendix E1 – Material Descriptions (from Manufacturer's Technical Literature)

The membrane is a self-adhesive air/vapour barrier membrane composed of bitumen modified with thermoplastic polymers and high density polyethylene film. The self-adhesive underface is covered with a silicon release sheet.

The primer is a blend of synthetic rubber, volatile solvents and adhesive enhancing additives developed to improve adhesion of self-adhesive membranes onto most construction surfaces. It is recommended for lower temperature applications.

Appendix E2 – Summary of Test Results

<u>Tensile Adhesion.</u>
Benchmark: The membrane did not detach from the substrate on any of the tests; either the substrate ruptured or the test pad separated from the polyethylene carrier sheet. On several of the tests, tensile loads exceeding 30.0 psi had been applied to the specimen by the time the test ended.

The number of tests where the membrane detached from the substrate on either the benchmark testing or testing conducted after the conditioning cycles was insufficient to conclude whether tensile adhesion was affected by any of the conditioning cycles. The membrane did detach from the substrate on some tests conducted after saturation conditioning, requiring tensile loads in excess of 21.0 psi.

<u>Slow-Peel Resistance</u>.
Benchmark: The membrane exhibited good short-term resistance to sustained load. Although there was little to no detachment of the membrane during the 28-day test period, on all specimens the polyethylene carrier sheet separated from the bitumen which remained adhered to the substrate. This separation began to occur between Day 5 and Day 16.

There appeared to be some decrease in slow-peel resistance after both high-temperature/high-humidity conditioning and saturation conditioning, although the decrease was substrate-specific: on drywall and Dens Glass Gold after high-temperature/high-humidity conditioning, the membrane peeled 150 mm; on poured-in-place concrete after saturation conditioning, the membrane peeled 150 mm.

Slow-peel resistance did not appear to be significantly effected by low-temperature conditioning.

<u>Fast-Peel Resistance.</u>
Benchmark: The membrane generally remained adhered to the substrate during fast-peel resistance testing. The membrane did peel off Dens Glass Gold at peak peel loads between 12.5 lbf/in (2.19 kN/m) and 18.4 lbf/in (3.22 kN/m). On drywall, poured-in-place concrete and concrete block, the polyethylene carrier sheet separated from the

bitumen while the bitumen remained adhered to the substrate, generally requiring peak peel loads in excess of 20.0 lbf/in (3.50 kN/m).

Fast-peel resistance appeared to decrease after both high-temperature/high-humidity conditioning and saturation conditioning, as the membrane now peeled from the substrate on 70% of the tests, although a peak peel load greater than 11.0 lbf/in (1.93 kN/m) was required on 60% of those tests. The extent of the decrease was specific to the combination of substrate and conditioning cycle. The most significant decreases in fast peel resistance were on Dens Glass Gold after high-temperature/high-humidity conditioning and on poured-in-place concrete after saturation conditioning.

Fast-peel resistance did not appear significantly effected by low-temperature conditioning.

Appendix E3 - Tensile Adhesion Test Results

DRYWALL

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF
13.9	SUBSTRATE	19.1	SUBSTRATE	17.6	SUBSTRATE
16.8	SUBSTRATE	14.8	SUBSTRATE	13.3	SUBSTRATE
10.8	SUBSTRATE	14.1	SUBSTRATE	10.7	SUBSTRATE
8.6	SUBSTRATE	20.2	SUBSTRATE	14.5	SUBSTRATE
8.5	SUBSTRATE	20.0	SUBSTRATE	19.5	SUBSTRATE
9.7	SUBSTRATE	20.5	SUBSTRATE	12.9	SUBSTRATE
10.3	SUBSTRATE	12.6	SUBSTRATE	15.4	SUBSTRATE
10.4	SUBSTRATE	19.4	SUBSTRATE	16.2	SUBSTRATE
10.9	SUBSTRATE	20.7	SUBSTRATE	18.2	SUBSTRATE

DENS-GLASS GOLD

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF	SATURATION LOAD (psi)	SATURATION SEPARATION OF
16.0	SUBSTRATE	15.9	SUBSTRATE	26.5	SUBSTRATE	13.3	SUBSTRATE
22.7	SUBSTRATE	16.7	SUBSTRATE	26.9	SUBSTRATE	23.4	SUBSTRATE
12.3	SUBSTRATE	21.1	SUBSTRATE	21.8	SUBSTRATE	11.6	SUBSTRATE
23.9	SUBSTRATE	17.7	SUBSTRATE	16.6	SUBSTRATE	15.0	SUBSTRATE
19.4	SUBSTRATE	18.0	SUBSTRATE	23.2	SUBSTRATE	17.0	SUBSTRATE
13.0	SUBSTRATE	15.7	SUBSTRATE	22.5	SUBSTRATE	16.4	SUBSTRATE
20.4	SUBSTRATE	21.4	SUBSTRATE	22.4	SUBSTRATE	10.6	SUBSTRATE
20.7	SUBSTRATE	20.3	MEMBRANE	26.6	SUBSTRATE	21.4	SUBSTRATE
19.6	SUBSTRATE	18.0	MEMBRANE	26.0	SUBSTRATE	12.5	SUBSTRATE

CONCRETE

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF	SATURATION LOAD (psi)	SATURATION SEPARATION OF
31.6	TEST PAD	21.0	TEST PAD	37.7	MEMBRANE	22.1	MEMBRANE
31.6	TEST PAD	18.2	TEST PAD	25.4	TEST PAD	23.6	MEMBRANE
28.9	TEST PAD	23.0	TEST PAD	36.0	TEST PAD	21.9	MEMBRANE
22.0	TEST PAD	20.1	TEST PAD	37.8	TEST PAD	32.0	MEMBRANE
27.6	TEST PAD	21.0	TEST PAD	27.0	TEST PAD	23.0	MEMBRANE
2.9	TEST PAD	23.7	TEST PAD	31.1	MEMBRANE	27.4	MEMBRANE

CONCRETE BLOCK

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF	SATURATION LOAD (psi)	SATURATION SEPARATION OF
25.6	TEST PAD	26.0	TEST PAD	33.2	TEST PAD	29.0	TEST PAD
21.3	TEST PAD	24.8	TEST PAD	30.1	TEST PAD	26.9	TEST PAD
29.6	TEST PAD	22.9	TEST PAD	33.5	TEST PAD	21.6	MEMBRANE

Appendix E4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	1	1	1	1	1	2	20	POLY																				
mm	1	1	1	1	1	3	24	POLY																				
mm	2	2	2	2	2	2	2	POLY																				

LOW-TEMPERATURE																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	0	20	POLY																									
mm	0	22	POLY																									
mm	POLY																											

HIGH TEMP/HIGH-HUMIDITY																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	39	150																										
mm	45	125	150																									
mm	7	17	32	70	94	120	150																					

SATURATION																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	2	2	2	2	2	2	2	2	2	2	POLY																	
mm	6	6	6	6	POLY																							
mm	4	5	5	5	5	6	6	6	6	POLY																		

LOW-TEMPERATURE																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	0	0	POLY																									
mm	0	0	POLY																									
mm	0	0	POLY																									

HIGH-TEMP/HIGH-HUMIDITY																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	15	38	75	110	150																							
mm	2	4	10	35	59	82	91	110	110	115	122	135	138	146	150													
mm	9	25	57	90	139	150																						

SATURATION																												
DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
mm	0	0	0	POLY																								
mm	0	0	POLY																									
mm	0	0	0	POLY																								

Poured-In-Place Concrete

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	POLY																						
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	POLY														
mm	0	0	0	0	0	0	0	0	0	0	0	0	POLY															

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	POLY																										
mm	0	0	POLY																									
mm	0	0	POLY																									

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	30	55	110	150																								
mm	0	20	38	POLY																								
mm	38	50	75	83	POLY																							

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	102	150																										
mm	60	100	150																									
mm	86	150																										

Concrete Block

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	POLY														
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	POLY												
mm	0	0	0	0	0	0	0	0	0	0	0	POLY																

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	POLY																									
mm	0	0	0	POLY																								
mm	0	0	0	POLY																								

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	30	50	POLY																								
mm	18	25	POLY																									
mm	4	25	45	POLY																								

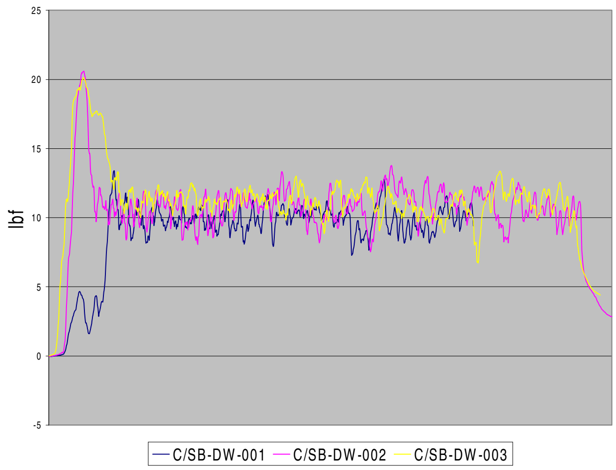
SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	3	15	22	POLY																								
mm	20	55	65	90	110	POLY																						
mm	20	55	67	80	120	POLY																						

Appendix E5 - Fast-Peel Resistance Test Results

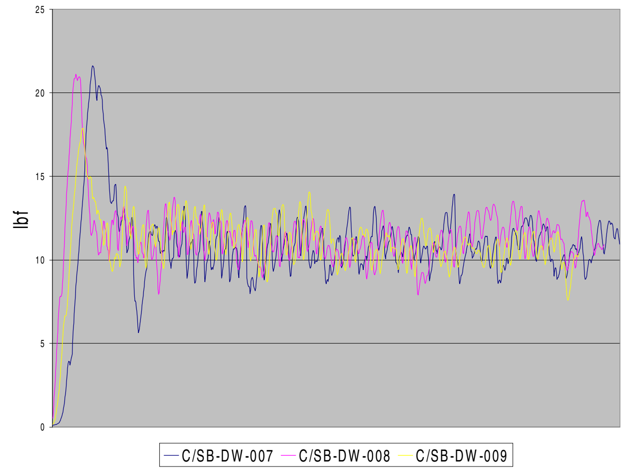
Drywall

Benchmark



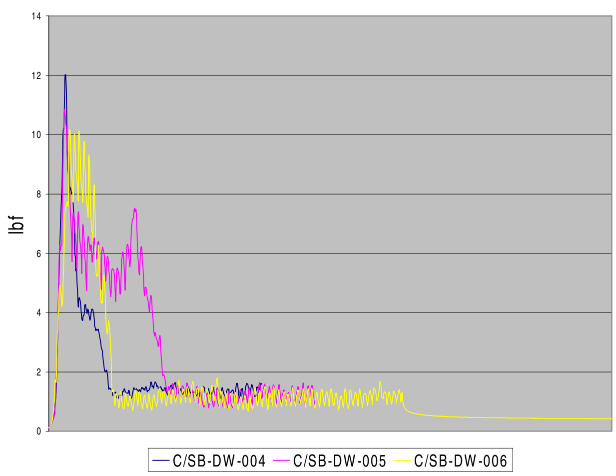
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-DW-001:	POLYETHYLENE	13.4 (2.35 kN/m)
C/SB-DW-002:	POLYETHYLENE	20.6 (3.61 kN/m)
C/SB-DW-003:	POLYETHYLENE	20.1 (3.52 kN/m)

Low-Temperature



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-DW-007:	POLYETHYLENE	21.6 (3.78 kN/m)
C/SB-DW-008:	POLYETHYLENE	21.1 (3.70 kN/m)
C/SB-DW-009:	POLYETHYLENE	17.9 (3.13 kN/m)

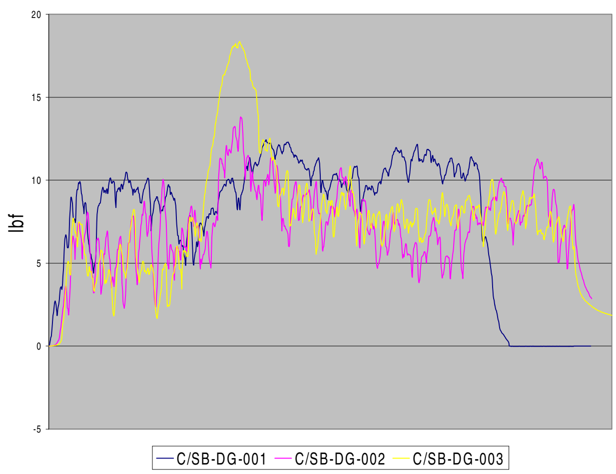
High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-DW-004:	PAPER	12.0 (2.10 kN/m)
C/SB-DW-005:	PAPER	10.9 (1.91 kN/m)
C/SB-DW-006:	PAPER	10.2 (1.79 kN/m)

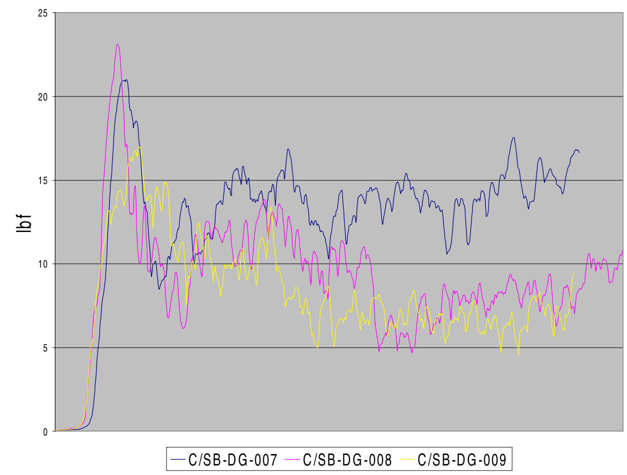
Dens-Glass Gold

Benchmark



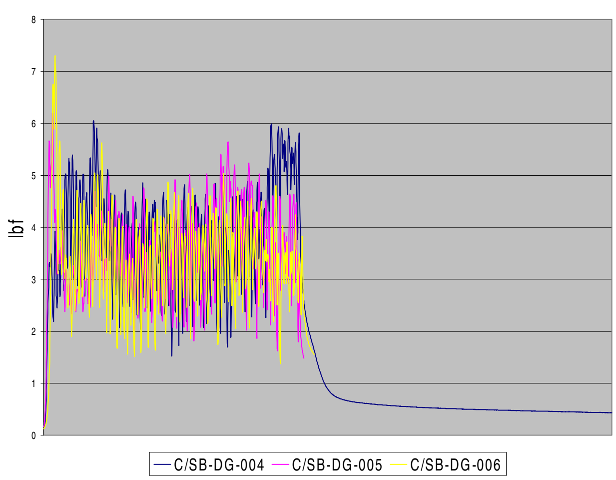
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-DG-001:	MEMBRANE/POLY	12.5 (2.19 kN/m)
C/SB-DG-002:	MEMBRANE	13.8 (2.42 kN/m)
C/SB-DG-003:	MEMBRANE/POLY	18.4 (3.22 kN/m)

Low-Temperature



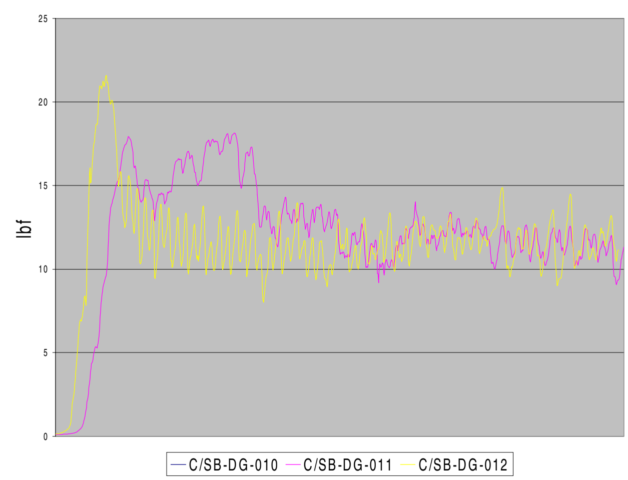
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-DG-007:	MEMBRANE/POLY	21.0 (3.68 kN/m)
C/SB-DG-008:	MEMBRANE/POLY	23.1 (4.05 kN/m)
C/SB-DG-009:	MEMBRANE/SUBS	17.0 (2.98 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-DG-004:	MEMBRANE	6.1 (1.07 kN/m)
C/SB-DG-005:	MEMBRANE	6.2 (1.09 kN/m)
C/SB-DG-006:	MEMBRANE	7.3 (1.28 kN/m)

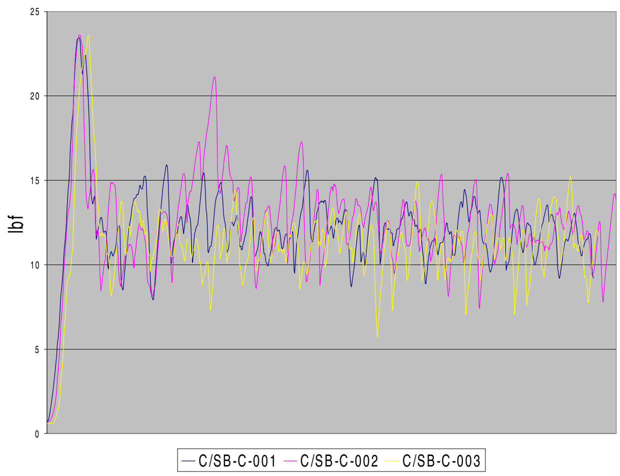
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-DG-010:	POLYETHYLENE	24.4 (4.27 kN/m)
C/SB-DG-011:	POLYETHYLENE	18.2 (3.19 kN/m)
C/SB-DG-012:	POLYETHYLENE	21.6 (3.78 kN/m)

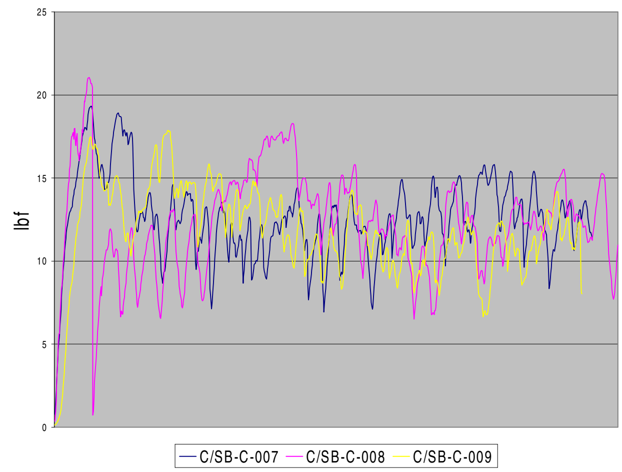
Poured-In-Place Concrete

Benchmark



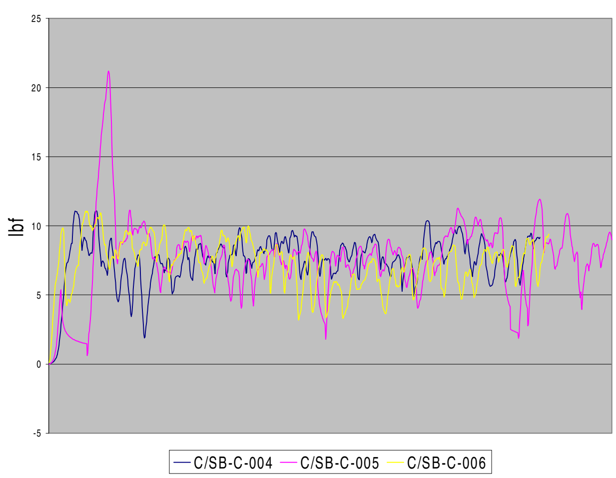
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-C-001:	POLYETHYLENE	23.5 (4.12 kN/m)
C/SB-C-002:	POLYETHYLENE	23.6 (4.13 kN/m)
C/SB-C-003:	POLYETHYLENE	23.6 (4.13 kN/m)

Low-Temperature



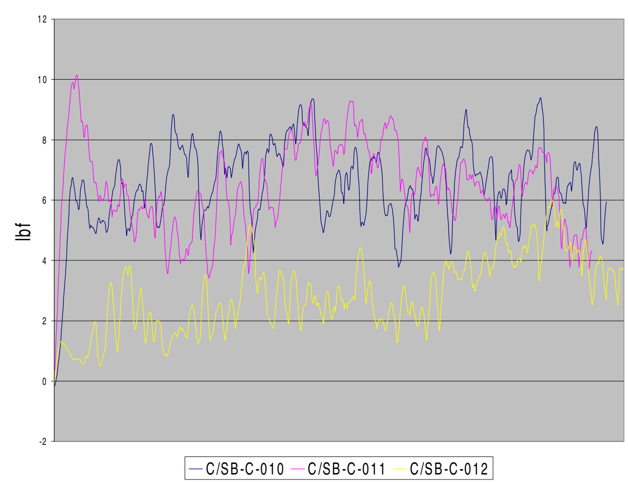
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-C-007:	POLYETHYLENE	19.3 (3.38 kN/m)
C/SB-C-008:	POLYETHYLENE	21.1 (3.70 kN/m)
C/SB-C-009:	POLYETHYLENE	17.9 (3.13 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-C-004:	MEMBRANE	11.1 (1.94 kN/m)
C/SB-C-005:	MEMBRANE	21.2 (3.71 kN/m)
C/SB-C-006:	MEMBRANE	11.1 (1.94 kN/m)

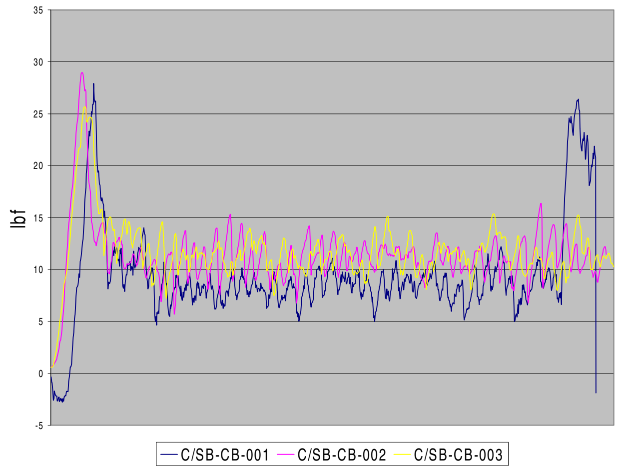
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-C-010:	MEMBRANE	9.9 (1.73 kN/m)
C/SB-C-011:	MEMBRANE	10.2 (1.79 kN/m)
C/SB-C-012:	MEMBRANE	6.0 (1.05 kN/m)

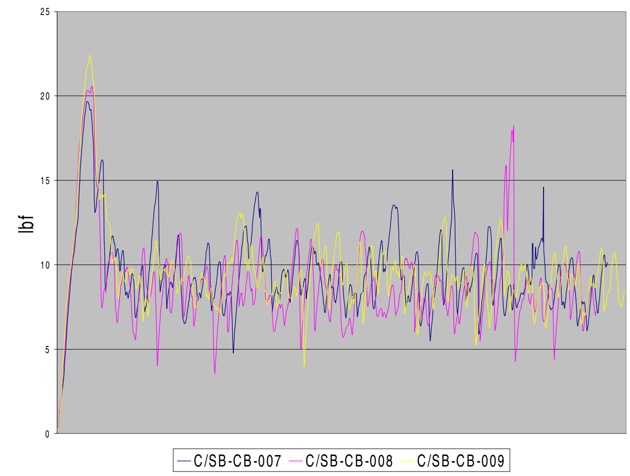
Concrete Block

Benchmark



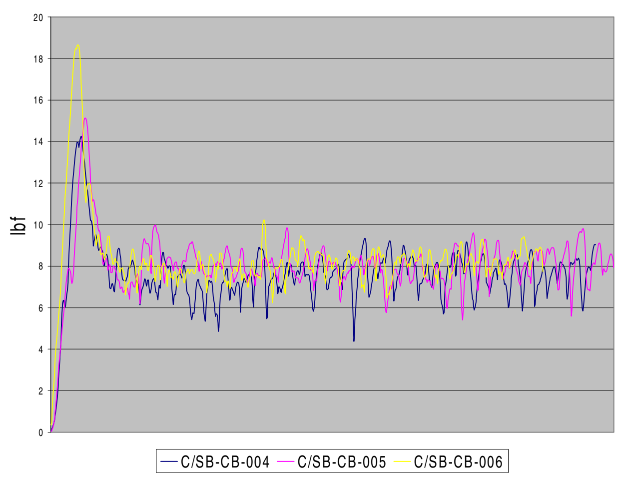
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-CB-001:	POLYETHYLENE	27.9 (4.89 kN/m)
C/SB-CB-002:	POLYETHYLENE	29.0 (5.08 kN/m)
C/SB-CB-003:	POLYETHYLENE	25.7 (4.50 kN/m)

Low-Temperature



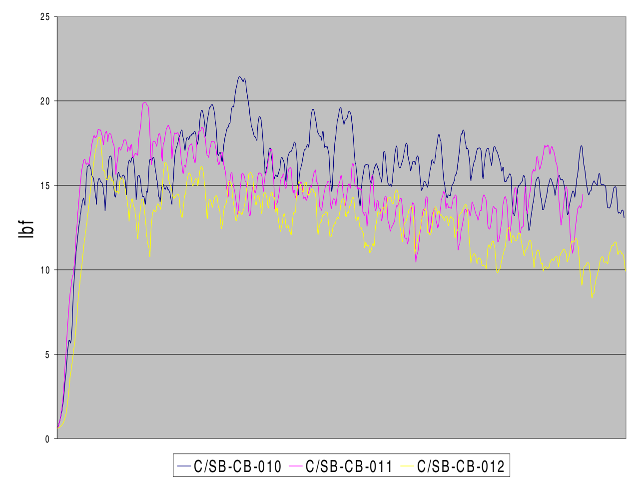
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-CB-007:	POLYETHYLENE	19.7 (3.45 kN/m)
C/SB-CB-008:	POLYETHYLENE	20.6 (3.61 kN/m)
C/SB-CB-009:	POLYETHYLENE	22.4 (3.92 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-CB-004:	MEMBRANE	14.3 (2.50 kN/m)
C/SB-CB-005:	MEMBRANE	15.2 (2.66 kN/m)
C/SB-CB-006:	MEMBRANE	18.7 (3.27 kN/m)

Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-CB-010:	MEMBRANE	21.5 (3.77 kN/m)
C/SB-CB-011:	MEMBRANE	19.9 (3.49 kN/m)
C/SB-CB-012:	MEMBRANE/POLY	17.9 (3.13 kN/m)

APPENDIX F

PRODUCT-D

Appendix F1 – Material Descriptions (from Manufacturer's Technical Literature)

The membrane is an SBS modified bitumen membrane reinforced with non-woven fiberglass. The membrane is specifically designed to be fused to the substrate by heating the lower surface with a propane torch. It has been designed for use as a thermofusible air barrier and is impermeable to air, moisture vapour and water. As an air barrier its principal application is on walls of masonry, concrete or drywall, and can also function as a waterproofing membrane on walls and decks.

The primer is a synthetic rubber-based primer designed for use with thermofused SBS modified bitumen membranes and hot-applied rubberized asphalt membranes when applied to concrete, masonry, wood, drywall and metal surfaces.

Appendix F2 – Summary of Test Results

Tensile Adhesion.
Benchmark: The membrane withstood tensile loads up to 25.0 psi without detaching from the substrate. The membrane detached from the substrate on 50% of the valid tests where a tensile load greater than 25.0 psi was reached, although the membrane also withstood tensile loads as high as 53.8 psi without detaching. On all of the tests on drywall and Dens Glass Gold, the tensile strength of adhesion between the membrane and substrate exceeded the tensile strength of the substrate material.

Tensile adhesion appeared to decrease after both low-temperature conditioning and saturation conditioning, although almost all valid test results still exceeded 15.0 psi, and over 60% exceeded 20.0 psi.

Tensile adhesion did not appear significantly effected by high-temperature/high-humidity conditioning.

Slow-Peel Resistance.
Benchmark: The membrane exhibited good short-term resistance to sustained load; there was little to no detachment of the membrane during the 28-day test period.

Slow-peel resistance appeared to be effected by each of the three-conditioning cycles, although the extent of the decrease could not conclusively be determined. On some of the specimens, there was separation of the membrane from the substrate during the early stages of the test, but by the end of the 28-day cycle, the membrane peel rate had slowed considerably or stopped altogether.

Fast-Peel Resistance.
Benchmark: A peak peel load in excess of 25.0 lbf/in (4.38 kN/m) was generally required to peel the membrane from the substrate.

Fast-peel resistance appeared to decrease after both low-temperature conditioning and saturation conditioning. The decrease was most evident on poured-in-place concrete and concrete block where fast-peel resistance decreased up to 50% from the benchmark.

Fast-peel resistance did not appear significantly effected by high-temperature/high-humidity conditioning.

Appendix F3 - Tensile Adhesion Test Results

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY	
DRYWALL		DRYWALL		DRYWALL	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
17.6	SUBSTRATE	10.8	SUBSTRATE	12.5	SUBSTRATE
15.5	SUBSTRATE	20.8	SUBSTRATE	11.5	SUBSTRATE
16.7	SUBSTRATE	14.1	SUBSTRATE	7.6	SUBSTRATE
13.5	SUBSTRATE	12.0	SUBSTRATE	12.6	SUBSTRATE
25.2	SUBSTRATE	24.0	SUBSTRATE	14.6	SUBSTRATE
20.7	SUBSTRATE	17.3	SUBSTRATE	12.3	SUBSTRATE
14.9	SUBSTRATE	17.7	MEMBRANE	12.7	SUBSTRATE
10.8	SUBSTRATE	15.7	MEMBRANE	12.3	SUBSTRATE
8.8	SUBSTRATE	15.6	SUBSTRATE	9.7	SUBSTRATE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
DENS-GLASS GOLD		DENS-GLASS GOLD		DENS-GLASS GOLD		DENS-GLASS GOLD	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
12.0	SUBSTRATE	17.4	SUBSTRATE	10.5	SUBSTRATE	14.4	SUBSTRATE
15.3	SUBSTRATE	18.2	SUBSTRATE	13.7	SUBSTRATE	4.5	MEMBRANE
23.2	SUBSTRATE	16.4	SUBSTRATE	17.9	SUBSTRATE	3.8	MEMBRANE
18.2	SUBSTRATE	17.3	SUBSTRATE	18.6	SUBSTRATE	20.8	SUBSTRATE
15.3	SUBSTRATE	19.6	SUBSTRATE	17.1	SUBSTRATE	22.4	SUBSTRATE
13.3	SUBSTRATE	15.7	SUBSTRATE	19.8	SUBSTRATE	18.0	MEMBRANE
11.3	SUBSTRATE	9.2	SUBSTRATE	14.4	SUBSTRATE	10.2	SUBSTRATE
16.7	SUBSTRATE	21.8	SUBSTRATE	13.1	SUBSTRATE	15.5	MEMBRANE
16.6	SUBSTRATE	19.3	SUBSTRATE	12.5	SUBSTRATE	15.2	MEMBRANE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
CONCRETE		CONCRETE		CONCRETE		CONCRETE	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
SPOILED SAMPLE		8.8	MEMBRANE	32.6	MEMBRANE	16.1	MEMBRANE
		22.6	MEMBRANE	29.1	MEMBRANE	22.8	MEMBRANE
33.4	MEMBRANE	16.9	MEMBRANE	27.1	MEMBRANE	25.1	MEMBRANE
28.0	MEMBRANE	18.2	MEMBRANE	34.1	MEMBRANE	24.8	MEMBRANE
27.7	MEMBRANE	21.6	MEMBRANE	34.3	MEMBRANE	15.5	MEMBRANE
28.2	MEMBRANE	19.8	MEMBRANE	36.1	MEMBRANE	27.6	MEMBRANE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/ HIGH HUMIDITY		SATURATION	
CONCRETE BLOCK		CONCRETE BLOCK		CONCRETE BLOCK		CONCRETE BLOCK	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
53.8	MEMBRANE	26.2	MEMBRANE	53.7	TEST PAD	18.6	MEMBRANE
39.7	MEMBRANE	23.3	MEMBRANE	53.1	MEMBRANE	21.7	MEMBRANE
SPOILED SAMPLE		19.8	MEMBRANE	57.3	TEST PAD	12.5	MEMBRANE

Appendix F4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	5	5	5	5	5	5	5	5	5	5

HIGH TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	15	15	15	20	20	20	20	20	20	20	20	20	20	20	20	21	21	21	21	21	21	21	21	21	21	21	21	21
mm	8	8	8	10	10	10	10	10	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HIGH-TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

Poured-In-Place Concrete

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	15	15	15	15	15	15	15	15	15	15	15	15	15	16	16	16	16	16	16	16	16	16	16	16	16	16	16
mm	0	0	5	5	25	25	25	25	25	25	25	32	32	32	32	34	35	35	35	35	45	48	48	48	48	48	48	48
mm	5	20	25	35	60	65	65	71	71	71	71	71	71	71	71	71	76	76	76	76	76	80	86	90	90	90	90	97

HIGH-TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	12	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	20	22	22	22	22	22	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	37	37	43	43

Concrete Block

BENCHMARK																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

LOW-TEMPERATURE																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	10	10	10	11	15	15	15	15	15	20	20	22
mm	0	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	7	7	7	7	7	7	7	9	10	10	11	11
mm	0	5	10	10	10	10	10	10	10	10	10	10	10	10	12	14	15	15	15	15	15	15	15	16	16	16	16	18

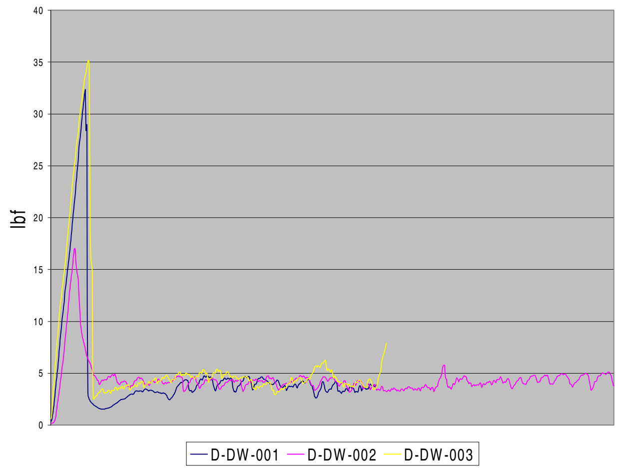
HIGH-TEMP/HIGH-HUMIDITY																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION																												
DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	55	55	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Appendix F5 – Fast-Peel Resistance Test Results

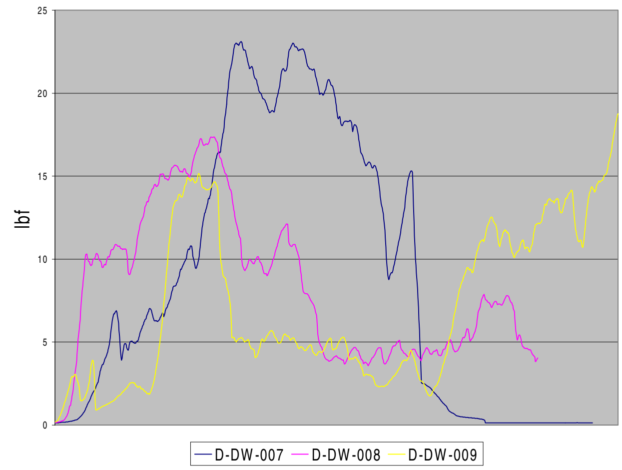
Drywall

Benchmark



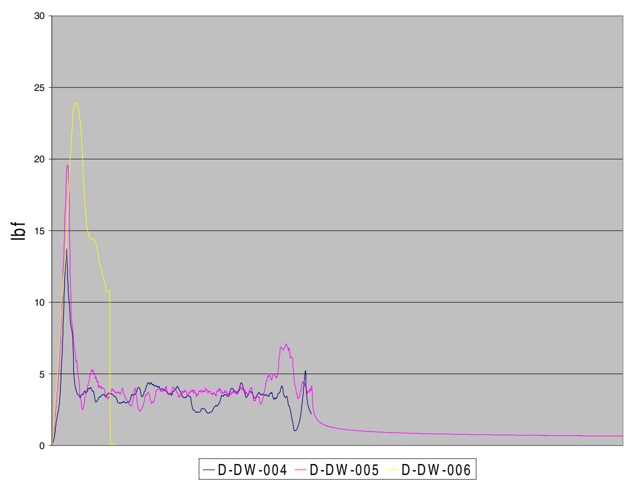
	SEPARATION,	ULTIMATE LOAD (lbf/in)
D-DW-001:	PAPER	32.0 (5.60 kN/m)
D-DW-002:	PAPER	17.0 (2.98 kN/m)
D-DW-003:	PAPER	35.2 (6.16 kN/m)

Low-Temperature Conditioning



	SEPARATION,	ULTIMATE LOAD (lbf/in)
D-DW-007:	POLYETHYLENE	23.1 (4.05 kN/m)
D-DW-008:	POLY/PAPER	17.9 (3.13 kN/m)
D-DW-009:	MEMBRANE/PAPER	18.8 (3.29 kN/m)

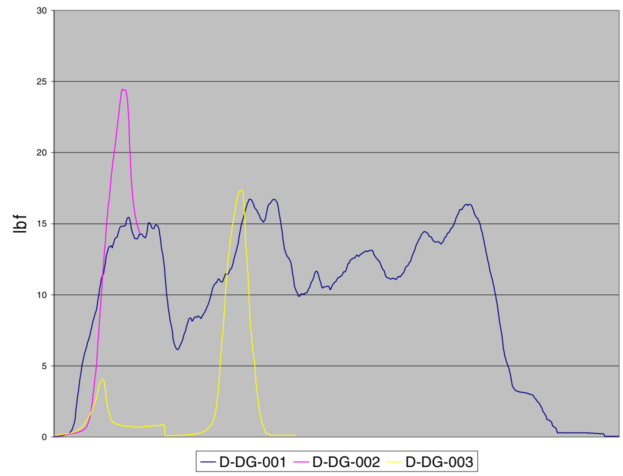
High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
D-DW-004:	PAPER	13.7 (2.40 kN/m)
D-DW-005:	PAPER	19.6 (3.43 kN/m)
D-DW-006:	MATERIAL	24.0 (4.20 kN/m)

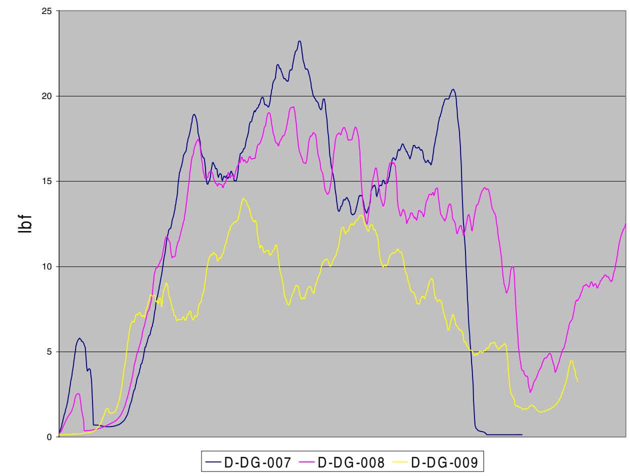
Dens-Glass Gold

Benchmark



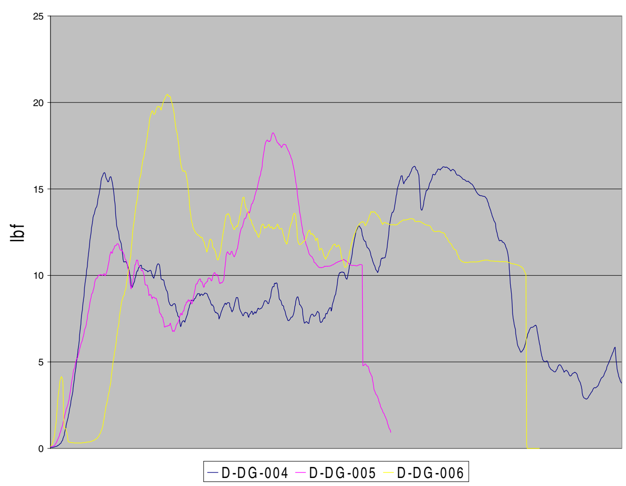
	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-DG-001:	MEMBRANE	16.7 (2.92 kN/m)
D-DG-002:	SUBSTRATE	24.5 (4.29 kN/m)
D-DG-003:	SUBSTRATE	17.4 (3.05 kN/m)

Low-Temperature



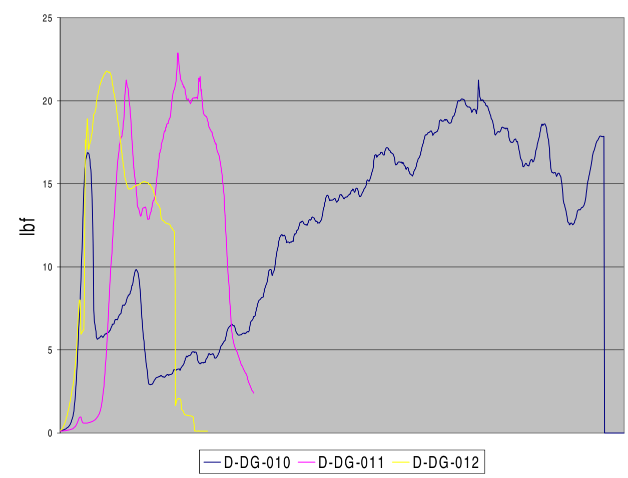
	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-DG-007:	MEMBRANE	23.3 (4.08 kN/m)
D-DG-008:	MEMBRANE	19.9 (3.49 kN/m)
D-DG-009:	MEMBRANE	14.0 (2.45 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-DG-004:	MEMBRANE	20.5 (3.59 kN/m)
D-DG-005:	MEMBRANE	18.3 (3.20 kN/m)
D-DG-006:	MEMBRANE	16.3 (2.85 kN/m)

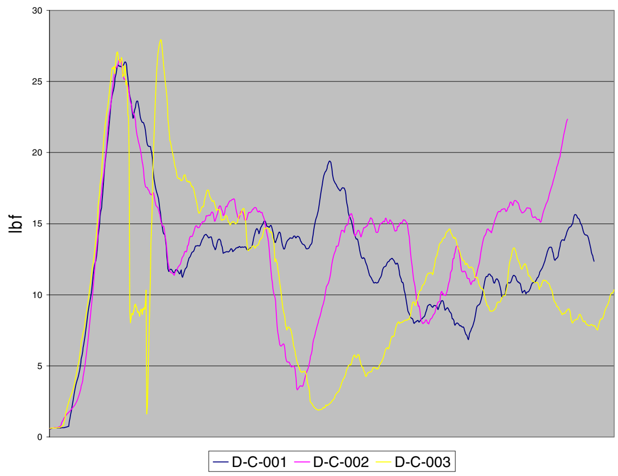
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-DG-010:	SUBSTRATE	21.3 (3.73 kN/m)
D-DG-011:	MEMBRANE	22.9 (4.01 kN/m)
D-DG-012:	MEMBRANE	21.8 (3.82 kN/m)

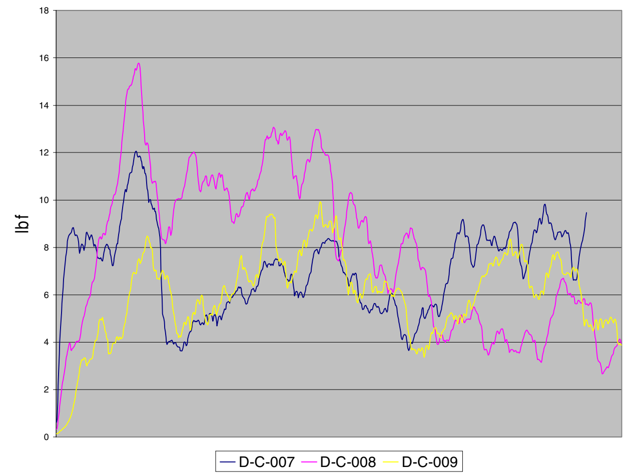
Poured-In-Place Concrete

Benchmark



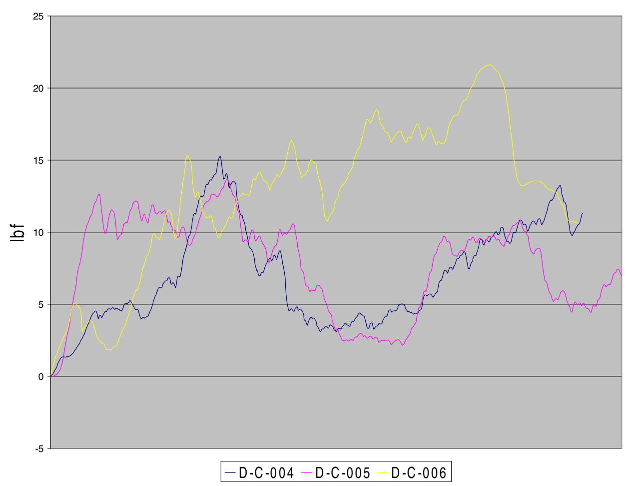
	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-C-001:	MEMBRANE	26.4 (4.62 kN/m)
D-C-002:	MEMBRANE	26.6 (4.66 kN/m)
D-C-003:	MEMBRANE	28.0 (4.90 kN/m)

Low-Temperature



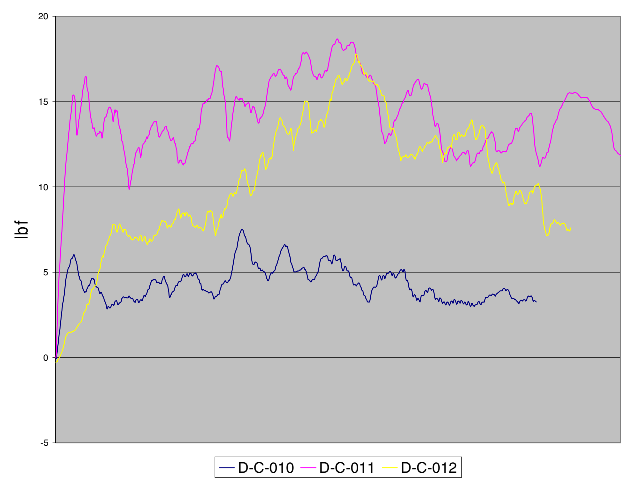
	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-C-007:	MEMBRANE	12.1 (2.12 kN/m)
D-C-008:	MEMBRANE	15.8 (2.77 kN/m)
D-C-009:	MEMBRANE	10.0 (1.75 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-C-004:	MEMBRANE	15.3 (2.68 kN/m)
D-C-005:	MEMBRANE	13.7 (2.40 kN/m)
D-C-006:	MEMBRANE	21.6 (3.78 kN/m)

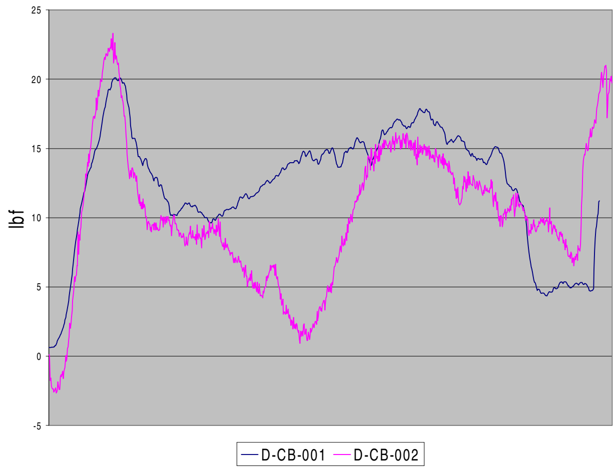
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-C-010:	MEMBRANE	7.5 (1.31 kN/m)
D-C-011:	MEMBRANE	18.7 (3.27 kN/m)
D-C-012:	MEMBRANE	17.8 (3.12 kN/m)

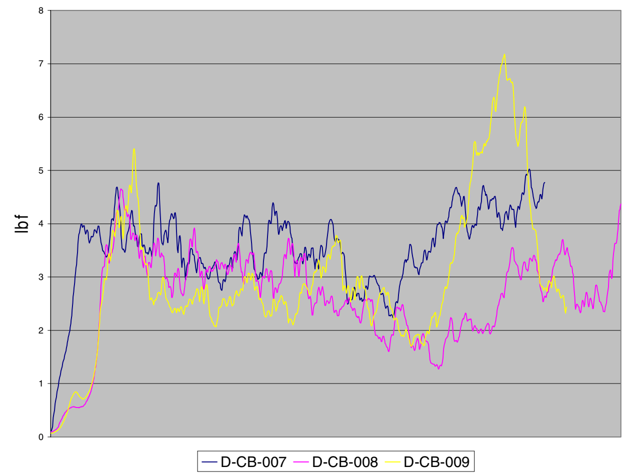
Concrete Block

Benchmark



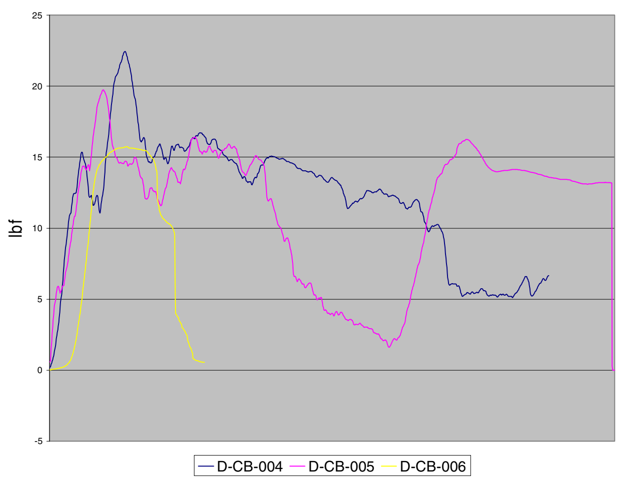
	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-CB-001:	MEMBRANE	20.1 (3.52 kN/m)
D-CB-002:	MEMBRANE	26.0 (4.55 kN/m)
D-CB-003:	SPOILED SAMPLE	

Low-Temperature



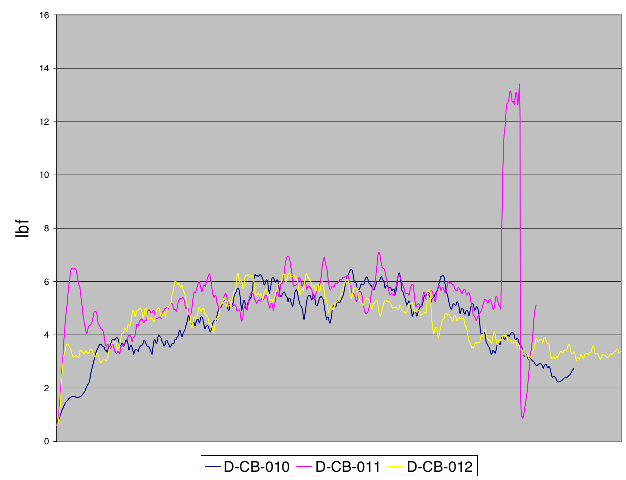
	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-CB-007:	MEMBRANE	5.0 (0.88 kN/m)
D-CB-008:	MEMBRANE	4.6 (0.86 kN/m)
D-CB-009:	MEMBRANE	7.2 (1.26 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-CB-004:	MEMBRANE	22.5 (3.94 kN/m)
D-CB-005:	MEMBRANE	19.8 (3.47 kN/m)
D-CB-006:	MEMBRANE	15.8 (2.77 kN/m)

Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
D-CB-010:	MEMBRANE	6.5 (1.14 kN/m)
D-CB-011:	MEMBRANE	7.2 (1.26 kN/m)
D-CB-012:	MEMBRANE	6.3 (1.10 kN/m)

<u>APPENDIX G</u>

PRODUCT-E

Appendix G1 – Material Description (from Manufacturer's Technical Literature)

The membrane is a one-component elastomeric bitumen liquid membrane designed to provide an air barrier when applied to construction surfaces. It cures to provide a tough monolithic, rubberlike membrane which resists air leakage. It can be used to provide an air and vapour barrier on construction surfaces such as masonry, concrete and drywall.

Appendix G2 – Summary of Test Results

<u>Tensile Adhesion.</u>
Benchmark: The membrane did not detach from the substrate at any tensile load lower than 49.2 psi, and remained adhered at tensile loads as high as 65.2 psi. On all of the tests on drywall and Dens Glass Gold, the tensile strength of adhesion between the membrane and substrate exceeded the tensile strength of the substrate material.

Despite the high benchmark test results, tensile adhesion improved after high-temperature/high-humidity conditioning as the membrane only detached on two of twenty-seven tests, at 108.8 psi and 112.0 psi. On the remaining tests, either the substrate ruptured or the test pad separated from the membrane before the membrane could detach from the substrate.

There appeared to be a slight decrease in tensile adhesion after low-temperature conditioning. The average tensile load at which the membrane detached from the substrate dropped by 19%, although the lowest tensile load at which the membrane detached was still 38.3 psi.

Tensile adhesion did not appear significantly effected by saturation conditioning.

<u>Slow-Peel Resistance.</u>
Benchmark: The membrane exhibited good short-term resistance to sustained load; there was little to no detachment of the membrane during the 28-day test period.

When installed on drywall, there was a decrease in the membrane's slow-peel resistance after both low-temperature conditioning and high-temperature/high-humidity conditioning. After low-temperature conditioning, the membrane peeled 150 mm in less than eight days. The decrease was not as severe after high-temperature/high humidity conditioning, as the three specimens had peeled 2 mm, 4 mm and 46 mm by Day 28. When installed on Dens Glass Gold, poured-in-place concrete or concrete block, there was no decrease in the slow-peel resistance of the membrane after low-temperature conditioning or high-temperature/high-humidity conditioning.

Slow-peel resistance did not appear significantly effected by saturation conditioning.

<u>Fast-Peel Resistance.</u>
Benchmark: The membrane only peeled from the substrate on one of the twleve tests, at a peak peel load of 18.1 lbf/in (3.17 kN/m). On nine of the other tests, there was separation

in the body of the membrane material at the point of the mesh, with a layer of material remaining adhered to the substrate. This separation occurred at peak peel loads between 9.3 lbf/in (1.63 kN/m) and 21.0 lbf/in (3.68 kN/m).

Fast-peel resistance appeared to decrease after low-temperature conditioning. The membrane peeled from the substrate on seven of the twelve tests, five of which were at peak peel loads less than 11.0 lbf/in (1.93 kN/m). On four of the remaining tests, there was separation in the body of the membrane material at the point of the mesh, with a layer of material remaining adhered to the substrate. This separation occurred at peak peel loads between 5.3 lbf/in (0.93 kN/m) and 9.3 lbf/in (1.63 kN/m), significantly lower than the benchmark results.

Fast-peel resistance did not appear significantly effected by either high-temperature/high-humidity conditioning or saturation conditioning.

Appendix G3 - Tensile Adhesion Test Results

DRYWALL

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/HIGH HUMIDITY	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
16.2	SUBSTRATE	12.5	SUBSTRATE	12.8	SUBSTRATE
11.3	SUBSTRATE	10.3	SUBSTRATE	13.5	SUBSTRATE
17.5	SUBSTRATE	18.4	SUBSTRATE	9.8	SUBSTRATE
12.5	SUBSTRATE	12.5	SUBSTRATE	7.7	SUBSTRATE
23.7	SUBSTRATE	12.1	SUBSTRATE	10.0	SUBSTRATE
12.4	SUBSTRATE	11.7	SUBSTRATE	10.7	SUBSTRATE
9.8	SUBSTRATE	11.8	SUBSTRATE	15.0	TEST PAD
13.1	SUBSTRATE	9.8	SUBSTRATE	11.2	SUBSTRATE
11.1	SUBSTRATE	20.3	SUBSTRATE	9.2	SUBSTRATE

DENS-GLASS GOLD

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/HIGH HUMIDITY		SATURATION	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
16.6	SUBSTRATE	14.6	SUBSTRATE	14.2	SUBSTRATE	14.9	SUBSTRATE
19.1	SUBSTRATE	12.2	SUBSTRATE	13.0	SUBSTRATE	20.6	SUBSTRATE
20.5	SUBSTRATE	15.8	SUBSTRATE	12.4	SUBSTRATE	13.6	SUBSTRATE
20.2	SUBSTRATE	16.0	SUBSTRATE	10.7	SUBSTRATE	13.1	SUBSTRATE
168	SUBSTRATE	21.5	SUBSTRATE	10.4	SUBSTRATE	14.9	SUBSTRATE
15.9	SUBSTRATE	12.8	MEMBRANE	9.8	SUBSTRATE	15.7	SUBSTRATE
17.9	SUBSTRATE	15.1	SUBSTRATE	13.8	SUBSTRATE	10.3	SUBSTRATE
16.4	SUBSTRATE	15.7	SUBSTRATE	13.8	SUBSTRATE	10.9	SUBSTRATE
14.6	SUBSTRATE	10.8	SUBSTRATE	14.6	SUBSTRATE	10.8	SUBSTRATE

CONCRETE

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/HIGH HUMIDITY		SATURATION	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
65.2	MEMBRANE	40.8	MEMBRANE	77.0	TEST PAD	53.6	MEMBRANE
63.4	MEMBRANE	58.8	MEMBRANE	78.2	TEST PAD	52.6	MEMBRANE
58.0	MEMBRANE	42.9	MEMBRANE	92.6	TEST PAD	68.3	MEMBRANE
50.8	MEMBRANE	46.0	MEMBRANE	80.6	TEST PAD	70.7	MEMBRANE
49.2	MEMBRANE	49.9	TEST PAD	108.0	TEST PAD	40.2	MEMBRANE
54.2	MEMBRANE	38.3	MEMBRANE	67.2	TEST PAD	43.6	MEMBRANE

CONCRETE BLOCK

BENCHMARK		LOW-TEMPERATURE		HIGH TEMP/HIGH HUMIDITY		SATURATION	
LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF	LOAD (psi)	SEPARATION OF
63.9	MEMBRANE	47.1	MEMBRANE	112.0	MEMBRANE	60.7	MEMBRANE
56.8	MEMBRANE	49.5	MEMBRANE	94.4	TEST PAD	63.7	MEMBRANE
63.2	MEMBRANE	54.0	MEMBRANE	108.8	MEMBRANE	56.3	MEMBRANE

Appendix G4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	4	4	4	4	4
mm	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3	3

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	3	5	31	110	150																				
mm	0	82	136	150																								
mm	0	6	9	132	150																							

HIGH TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
mm	0	0	0	0	0	1	1	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
mm	0	0	0	0	2	2	3	4	4	4	4	5	5	6	6	8	13	17	19	21	24	24	26	27	29	32	40	46

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Poured-In-Place Concrete

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	7	7	7	7
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Concrete Block

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	4	5	5	5	5	5	5	5
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	4	4	4	5	5	5	5

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

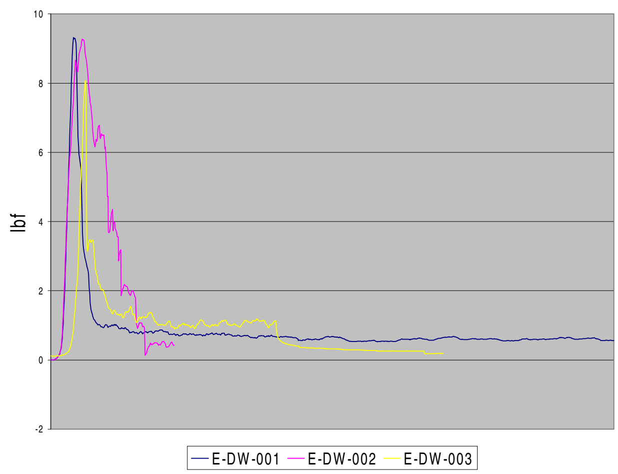
SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4

Appendix G5 – Fast-Peel Resistance Test Results

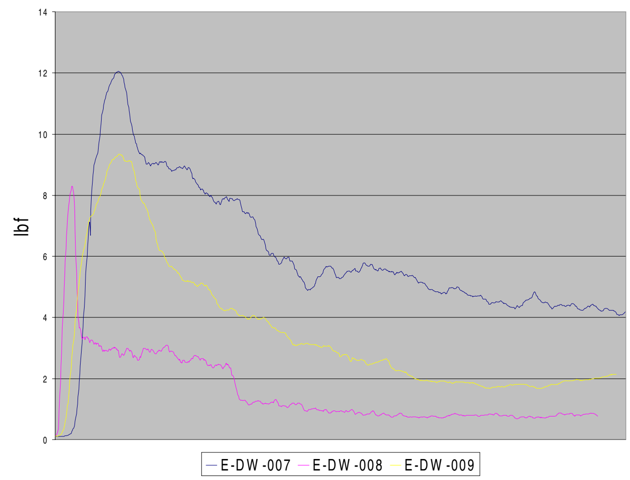
Drywall

Benchmark



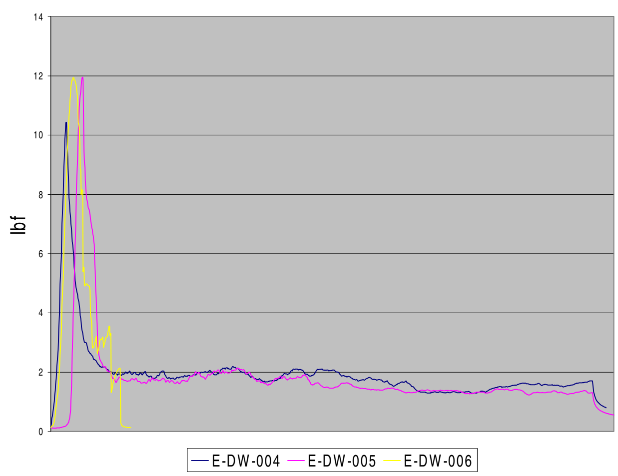
	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-DW-001:	PAPER	9.3 (1.63 kN/m)
E-DW-002:	MESH	9.3 (1.63 kN/m)
E-DW-003:	PAPER	8.1 (1.42 kN/m)

Low-Temperature



	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-DW-007:	MEMBRANE	12.1 (2.12 kN/m)
E-DW-008:	PAPER	8.3 (1.45 kN/m)
E-DW-009:	MESH	9.3 (1.63 kN/m)

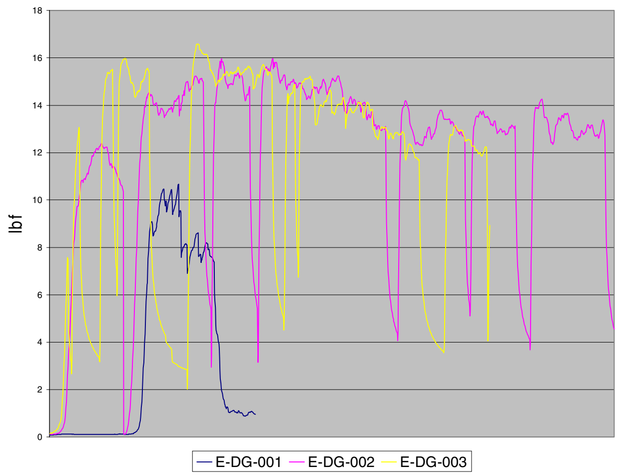
High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-DW-004:	PAPER	10.5 (1.84 kN/m)
E-DW-005:	PAPER	12.0 (2.10 kN/m)
E-DW-006:	MESH	12.0 (2.10 kN/m)

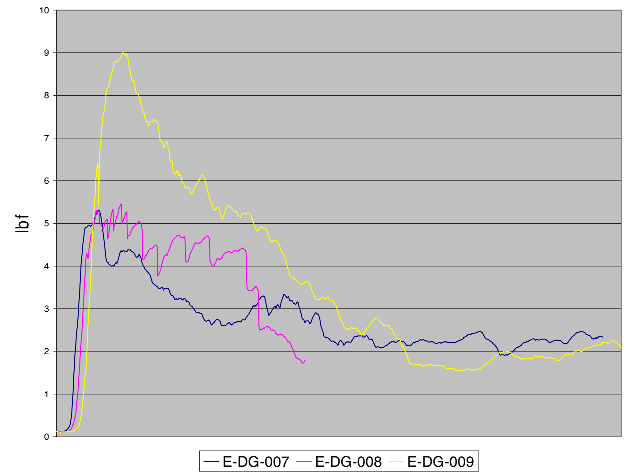
Dens-Glass Gold

Benchmark



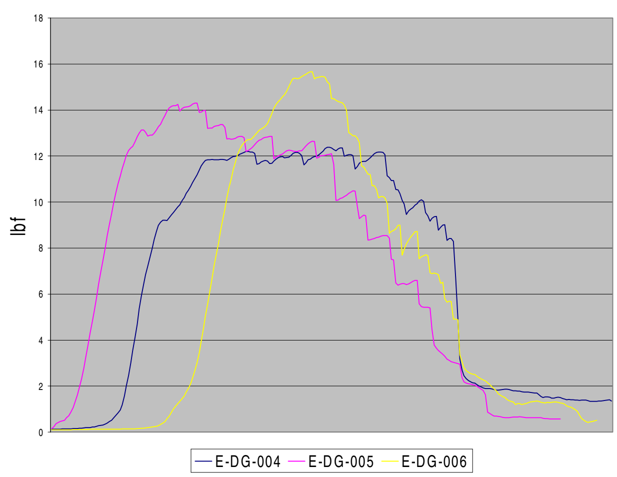
	SEPARATION	ULTIMATE LOAD (lbf/in)
E-DG-001:	MESH	10.7 (1.87 kN/m)
E-DG-002:	MESH	16.0 (2.80 kN/m)
E-DG-003:	MESH	16.6 (2.91 kN/m)

Low-Temperature



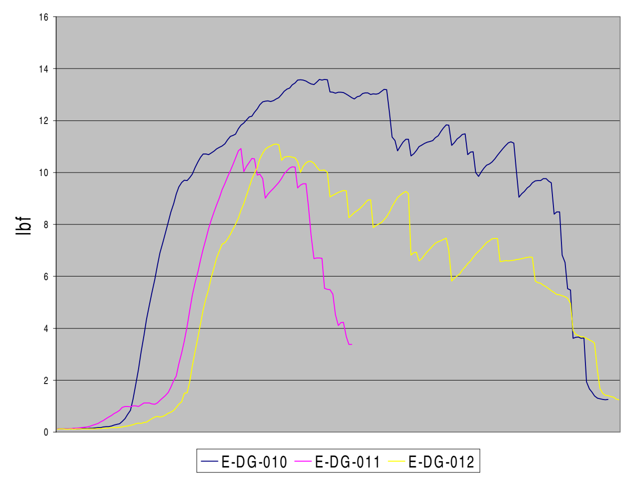
	SEPARATION	ULTIMATE LOAD (lbf/in)
E-DG-007:	MESH	5.3 (0.93 kN/m)
E-DG-008:	MESH	5.5 (0.96 kN/m)
E-DG-009:	MESH	9.0 (1.58 kN/m)

High-Temperature/High-Humidity



	SEPARATION	ULTIMATE LOAD (lbf/in)
E-DG-004:	MESH	12.4 (2.17 kN/m)
E-DG-005:	MESH	14.3 (2.50 kN/m)
E-DG-006:	MESH	15.7 (2.75 kN/m)

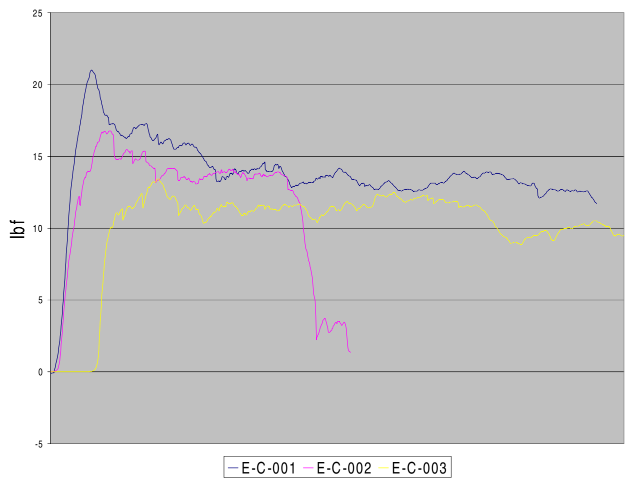
Saturation



	SEPARATION	ULTIMATE LOAD (lbf/in)
E-DG-010:	MESH	13.6 (2.38 kN/m)
E-DG-011:	MESH	10.9 (1.91 kN/m)
E-DG-012:	MESH	11.1 (1.94 kN/m)

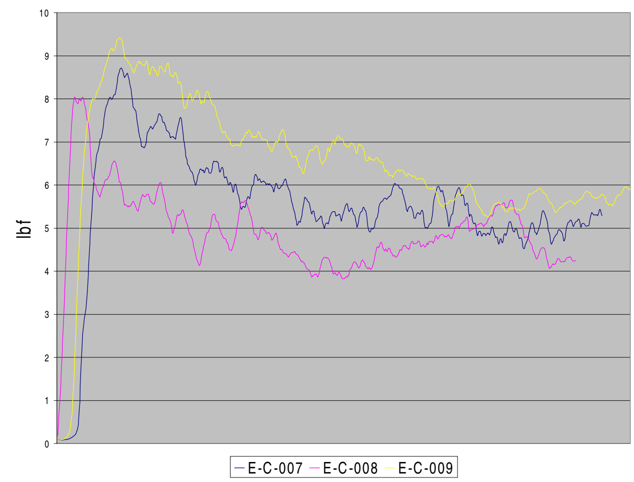
Poured-In-Place Concrete

Benchmark



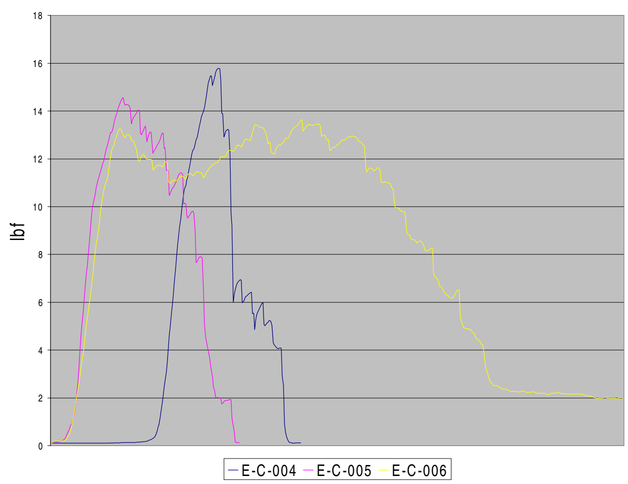
	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-C-001:	MESH	21.0 (3.68 kN/m)
E-C-002:	MESH	16.8 (3.94 kN/m)
E-C-003:	MESH	13.5 (2.36 kN/m)

Low-Temperature



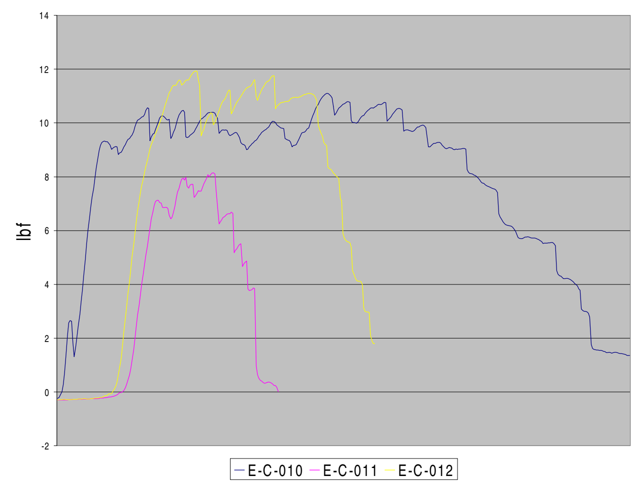
	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-C-007:	MEMBRANE/RESIDUE	8.7 (1.52 kN/m)
E-C-008:	MEMBRANE/RESIDUE	8.1 (1.42 kN/m)
E-C-009:	MEMBRANE/RESIDUE	9.4 (1.65 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-C-004:	MESH	15.8 (2.77 kN/m)
E-C-005:	MESH	14.6 (2.56 kN/m)
E-C-006:	MESH	13.7 (2.40 kN/m)

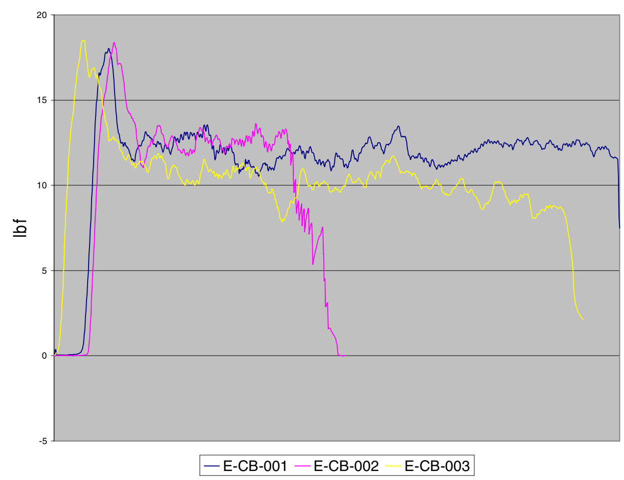
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-C-010:	MESH	11.1 (1.94 kN/m)
E-C-011:	MESH	8.2 (1.44 kN/m)
E-C-012:	MESH	12.0 (2.10 kN/m)

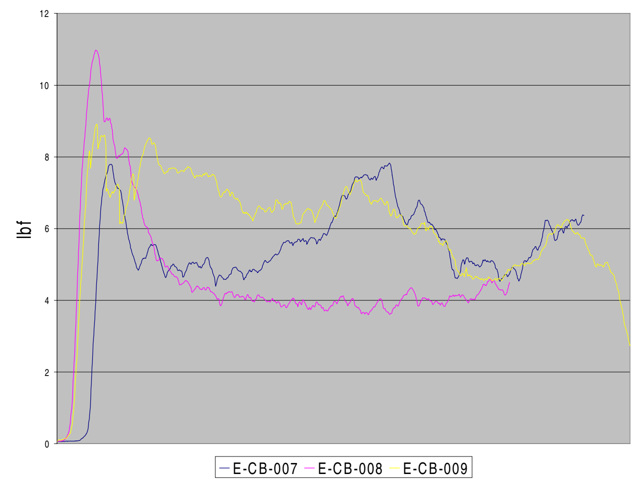
Concrete Block

Benchmark



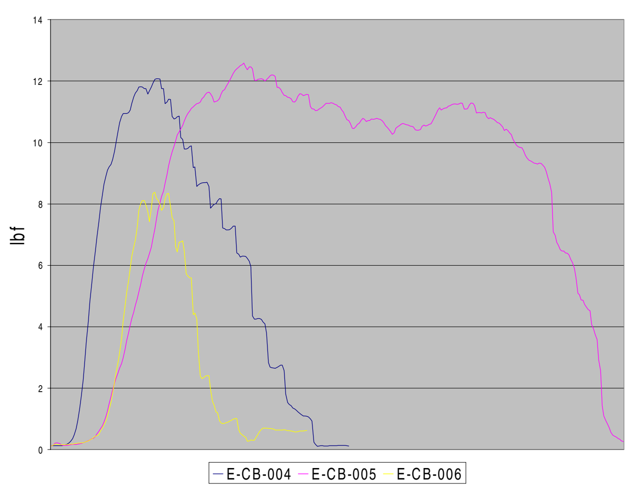
	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-CB-001:	MEMBRANE/RESIDUE	18.1 (3.17 kN/m)
E-CB-002:	MESH	18.4 (3.22 kN/m)
E-CB-003:	MESH	18.5 (3.24 kN/m)

Low-Temperature



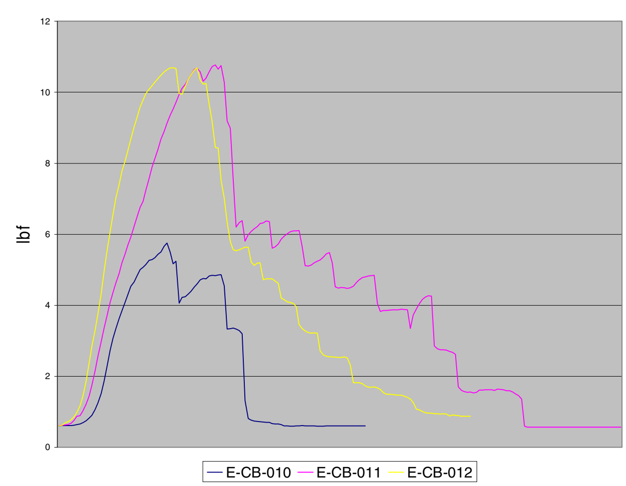
	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-CB-007:	MEMBRANE	7.8 (1.37 kN/m)
E-CB-008:	MEMBRANE	11.0 (1.93 kN/m)
E-CB-009:	MEMBRANE	8.9 (1.56 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-CB-004:	MESH	12.1 (2.12 kN/m)
E-CB-005:	MESH	12.6 (2.21 kN/m)
E-CB-006:	MESH	8.4 (1.47 kN/m)

Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
E-CB-010:	MESH	5.8 (1.02 kN/m)
E-CB-011:	MESH	10.8 (1.89 kN/m)
E-CB-012:	MESH	10.7 (1.87 kN/m)

APPENDIX H

PRODUCT-F

Appendix H1 – Material Description (from Manufacturer's Technical Literature)

The membrane is a two-component, synthetic rubber, cold vulcanized, fluid applied membrane. It cures to form a resilient, monolithic, fully bonded elastomeric sheet. It will protect wall assemblies against water and water vapour ingress, and provides a barrier against air infiltration and exfiltration and associated energy loss and condensation problems.

Appendix H2 – Summary of Test Results

Tensile Adhesion.
Benchmark: The membrane generally withstood tensile loads in excess of 25.0 psi, to a high of 39.2 psi, without detaching from the substrate. However, test results were significantly lower on Dens Glass Gold, where the membrane detached from the substrate on four of the nine tests, at tensile loads between 14.4 psi and 19.3 psi.

Tensile adhesion did not appear significantly effected by any of the three conditioning cycles.

Slow-Peel Resistance.
Benchmark: The membrane exhibited good short-term resistance to sustained load; there was little to no detachment of the membrane during the 28-day test period.

Slow-peel resistance did not appear significantly effected by any of the three conditioning cycles, as there was little to no detachment of the membrane during the 28-day test period.

Fast-Peel Resistance.
Benchmark: The membrane generally peeled from drywall, poured-in-place concrete and concrete block at peak peel loads less than 11.0 lbf/in (1.93 kN/m). On Dens-Glass Gold, there was separation in the body of the membrane material at the point of the mesh, with a layer of material remaining adhered to the substrate. This separation occurred at peak peel loads between 9.1 lbf/in (1.59 kN/m) and 14.9 lbf/in (2.61 kN/m).

Fast-peel resistance appeared to decrease after both low-temperature conditioning and saturation conditioning. The decrease was most evident on poured-in-place concrete and concrete block, where specimens peeled at loads 40% to 50% lower than the benchmark. The membrane did not peel off of Dens-Glass Gold, but there was separation in the body of the membrane material at the point of the mesh at peak peel loads up to 50% lower than the benchmark.

Fast-peel resistance did not appear significantly effected by high-temperature/high-humidity conditioning.

Appendix H3 - Tensile Adhesion Test Results

DRYWALL

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF
20.2	SUBSTRATE	16.1	MEMBRANE	10.3	SUBSTRATE
21.0	SUBSTRATE	13.4	SUBSTRATE	7.8	SUBSTRATE
18.6	SUBSTRATE	10.4	SUBSTRATE	8.6	SUBSTRATE
17.9	SUBSTRATE	19.6	SUBSTRATE	8.6	SUBSTRATE
16.4	SUBSTRATE	17.6	SUBSTRATE	9.8	SUBSTRATE
15.0	SUBSTRATE	21.5	MEMBRANE	9.7	SUBSTRATE
13.0	SUBSTRATE	15.8	SUBSTRATE	12.0	SUBSTRATE
15.6	SUBSTRATE	22.1	MEMBRANE	9.4	SUBSTRATE
13.3	SUBSTRATE	18.7	MEMBRANE	9.5	SUBSTRATE

DENS-GLASS GOLD

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF	SATURATION LOAD (psi)	SATURATION SEPARATION OF
15.5	MEMBRANE	20.5	SUBSTRATE	10.8	MEMBRANE	20.5	SUBSTRATE
20.8	SUBSTRATE	18.0	SUBSTRATE	11.5	SUBSTRATE	12.0	SUBSTRATE
15.9	MEMBRANE	15.0	SUBSTRATE	12.2	MEMBRANE	9.8	SUBSTRATE
14.4	MEMBRANE	16.8	SUBSTRATE	11.3	MEMBRANE	19.8	SUBSTRATE
19.3	MEMBRANE	20.7	SUBSTRATE	9.2	MEMBRANE	19.2	SUBSTRATE
16.8	SUBSTRATE	14.6	SUBSTRATE	10.5	SUBSTRATE	14.1	SUBSTRATE
25.0	SUBSTRATE	20.5	SUBSTRATE	10.9	SUBSTRATE	16.6	SUBSTRATE
25.8	SUBSTRATE	17.3	SUBSTRATE	14.9	SUBSTRATE	11.7	SUBSTRATE
29.8	SUBSTRATE	22.4	SUBSTRATE	14.6	SUBSTRATE	13.9	SUBSTRATE

CONCRETE

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF	SATURATION LOAD (psi)	SATURATION SEPARATION OF
28.6	MEMBRANE	30.6	MEMBRANE	22.0	MEMBRANE	19.8	MEMBRANE
31.7	MEMBRANE	26.9	MEMBRANE	29.4	MEMBRANE	25.3	MEMBRANE
31.3	MEMBRANE	29.9	MEMBRANE	29.3	MEMBRANE	17.8	MEMBRANE
33.5	MEMBRANE	30.3	MEMBRANE	27.2	MEMBRANE	20.9	MEMBRANE
26.3	MEMBRANE	25.1	MEMBRANE	30.6	MEMBRANE	20.4	MEMBRANE
31.3	MEMBRANE	27.3	MEMBRANE	32.7	MEMBRANE	18.1	MEMBRANE

CONCRETE BLOCK

BENCHMARK LOAD (psi)	BENCHMARK SEPARATION OF	LOW-TEMPERATURE LOAD (psi)	LOW-TEMPERATURE SEPARATION OF	HIGH TEMP/ HIGH HUMIDITY LOAD (psi)	HIGH TEMP/ HIGH HUMIDITY SEPARATION OF	SATURATION LOAD (psi)	SATURATION SEPARATION OF
37.5	MEMBRANE	29.8	MEMBRANE	37.5	MEMBRANE	31.6	TEST PAD
39.2	MEMBRANE	36.8	MEMBRANE	36.0	MEMBRANE	30.6	MEMBRANE
35.2	MEMBRANE	27.8	MEMBRANE	34.4	MEMBRANE	29.4	MEMBRANE

Appendix H4 - Slow-Peel Resistance Test Results

Drywall

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HIGH TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	N/A																											
mm	N/A																											
mm	N/A																											

Dens-Glass Gold

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Poured-In-Place Concrete

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Concrete Block

BENCHMARK

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1

LOW-TEMPERATURE

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

HIGH-TEMP/HIGH-HUMIDITY

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

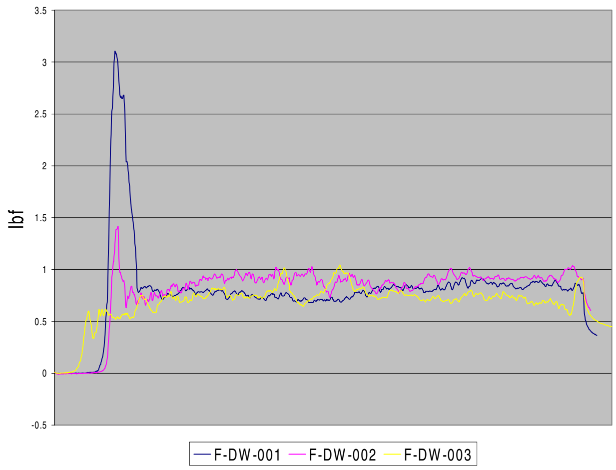
SATURATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix H5 – Fast Peel Resistance Test Results

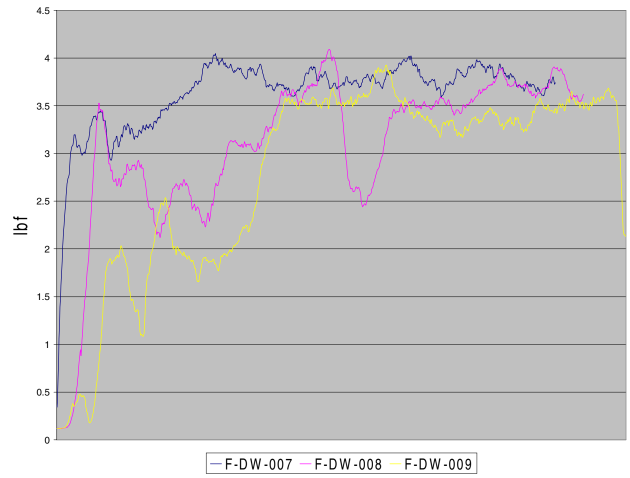
Drywall

Benchmark



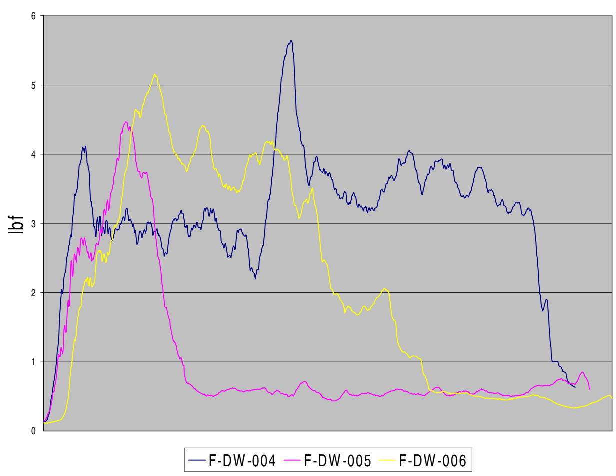
	SEPARATION,	ULTIMATE LOAD (lbf/in)
F-DW-001:	MEMBRANE	3.1 (0.54 kN/m)
F-DW-002:	MEMBRANE	1.4 (0.25 kN/m)
F-DW-003:	MEMBRANE	1.1 (0.19 kN/m)

Low-Temperature



	SEPARATION,	ULTIMATE LOAD (lbf/in)
F-DW-007:	MEMBRANE	4.1 (0.72 kN/m)
F-DW-008:	MEMBRANE	4.1 (0.72 kN/m)
F-DW-009:	MEMBRANE	4.0 (0.70 kN/m)

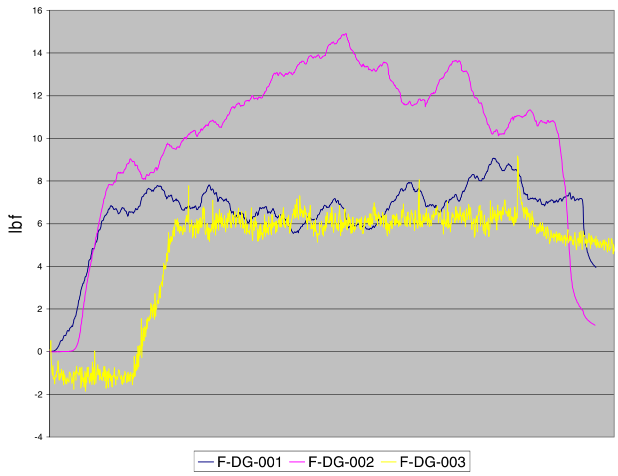
High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
F-DW-004:	PAPER	5.7 (1.00 kN/m)
F-DW-005:	PAPER	4.5 (0.79 kN/m)
F-DW-006:	PAPER	5.2 (0.91 kN/m)

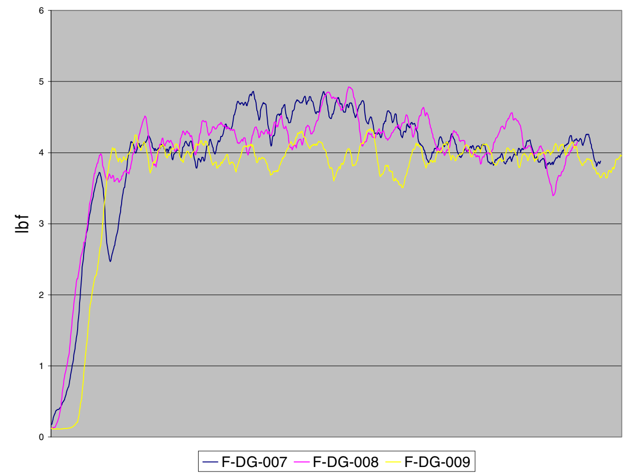
Dens-Glass Gold

Benchmark



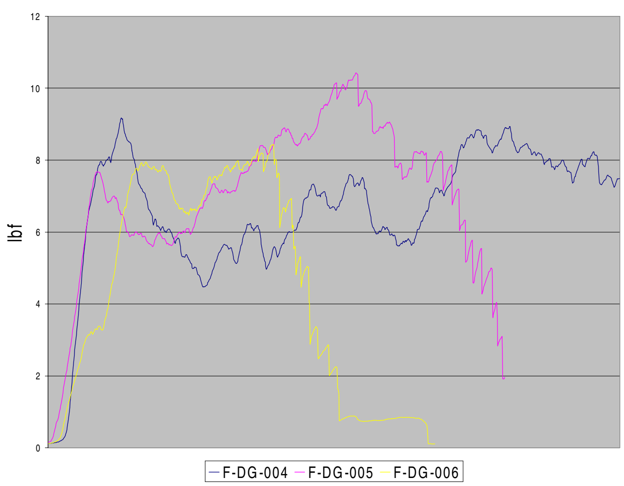
	SEPARATION,	ULTIMATE LOAD (lbf/in)
F-DG-001:	MESH	9.1 (1.59 kN/m)
F-DG-002:	MESH	14.9 (2.61 kN/m)
F-DG-003:	MESH	9.2 (1.61 kN/m)

Low-Temperature



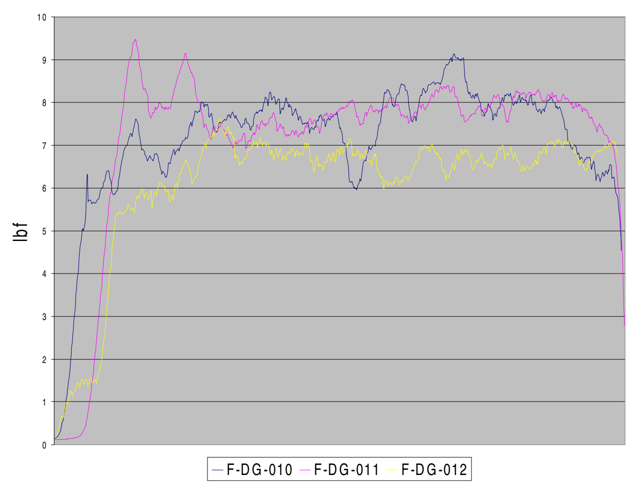
	SEPARATION,	ULTIMATE LOAD (lbf/in)
F-DG-007:	MESH	4.9 (0.86 kN/m)
F-DG-008:	MESH	4.9 (0.86 kN/m)
F-DG-009:	MESH	4.4 (0.77 kN/m)

High-Temperature/High-Humidity



	SEPARATION,	ULTIMATE LOAD (lbf/in)
F-DG-004:	MEMBRANE	9.2 (1.61 kN/m)
F-DG-005:	MEMBRANE/RESIDUE	10.4 (1.82 kN/m)
F-DG-006:	MEMBRANE/RESIDUE	8.5 (1.49 kN/m)

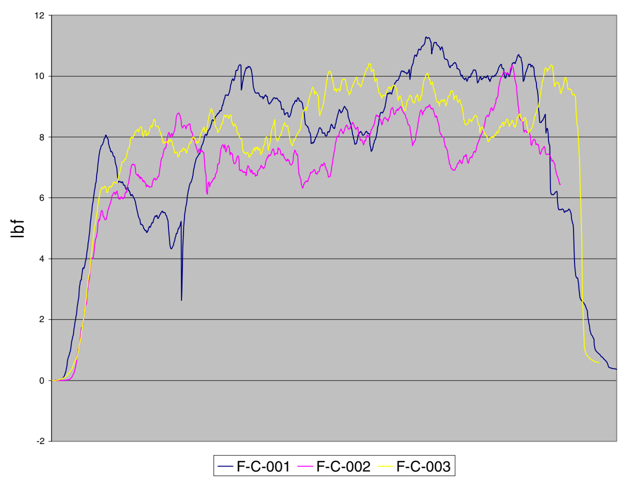
Saturation



	SEPARATION,	ULTIMATE LOAD (lbf/in)
F-DG-010:	MESH	9.2 (1.61 kN/m)
F-DG-011:	MESH	9.5 (1.66 kN/m)
F-DG-012:	MESH	7.7 (1.35 kN/m)

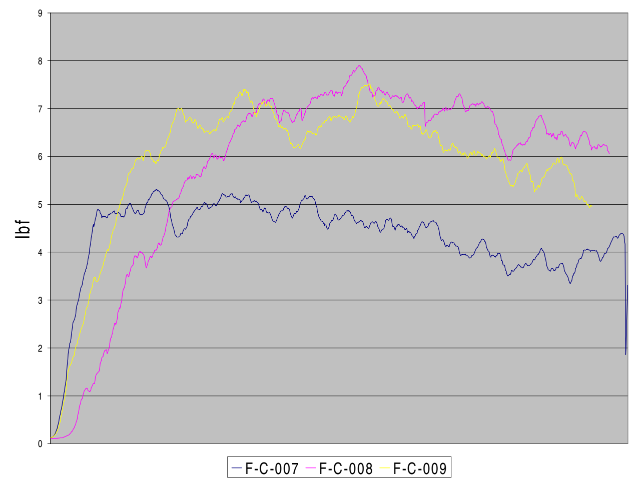
Poured-In-Place Concrete

Benchmark



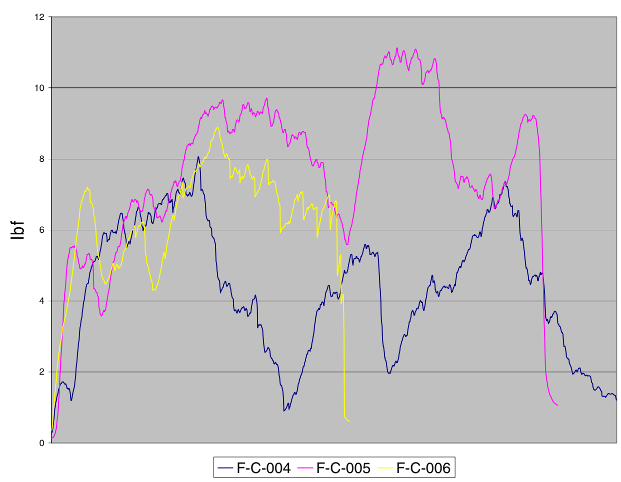
	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-C-001:	MEMBRANE	11.3 (1.98 kN/m)
F-C-002:	MEMBRANE	10.4 (1.82 kN/m)
F-C-003:	MEMBRANE	10.4 (1.82 kN/m)

Low-Temperature



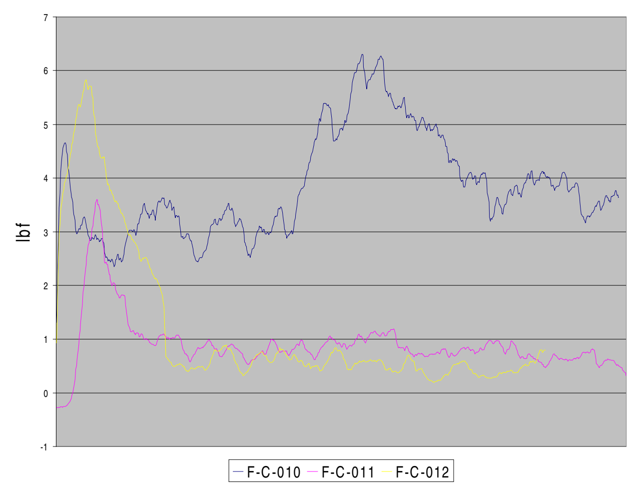
	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-C-007:	MEMBRANE	5.3 (0.93 kN/m)
F-C-008:	MEMBRANE	7.9 (1.38 kN/m)
F-C-009:	MEMBRANE	7.5 (1.31 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-C-004:	MEMBRANE	8.1 (1.42 kN/m)
F-C-005:	MEMBRANE	11.2 (1.96 kN/m)
F-C-006:	MEMBRANE	8.9 (1.56 kN/m)

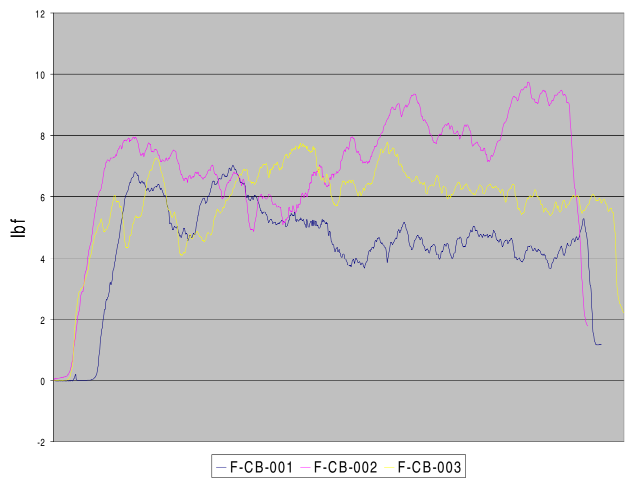
Saturation



	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-C-010:	MEMBRANE	6.3 (1.10 kN/m)
F-C-011:	MEMBRANE	3.6 (0.63 kN/m)
F-C-012:	MEMBRANE	5.9 (1.03 kN/m)

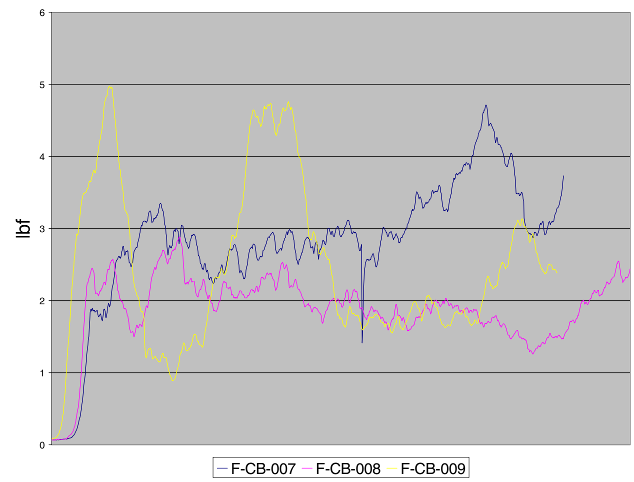
Concrete Block

Benchmark



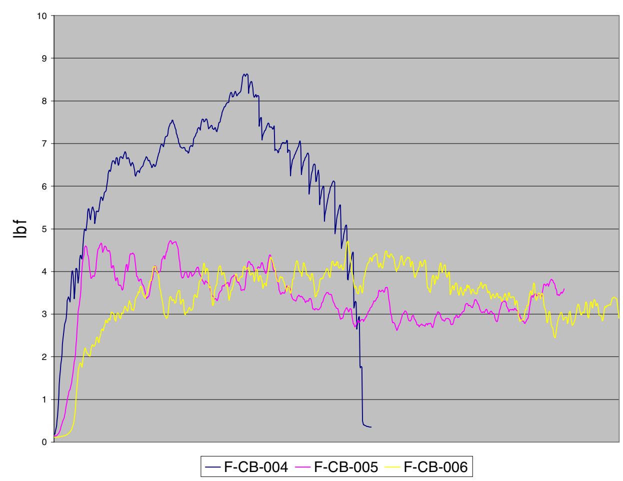
	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-CB-001:	MEMBRANE/RESIDUE	7.0 (1.23 kN/m)
F-CB-002:	MEMBRANE/RESIDUE	9.8 (1.72 kN/m)
F-CB-003:	MEMBRANE	7.8 (1.37 kN/m)

Low-Temperature



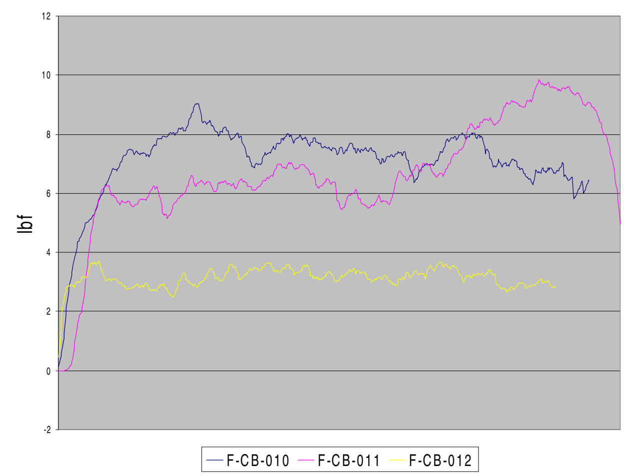
	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-CB-007:	MEMBRANE	4.7 (0.82 kN/m)
F-CB-008:	MEMBRANE	2.9 (0.51 kN/m)
F-CB-009:	MEMBRANE	5.0 (0.88 kN/m)

High-Temperature/High-Humidity



	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-CB-004:	MEMBRANE/RESIDUE	8.7 (1.52 kN/m)
F-CB-005:	MEMBRANE	4.7 (0.82 kN/m)
F-CB-006:	MEMBRANE	4.7 (0.82 kN/m)

Saturation



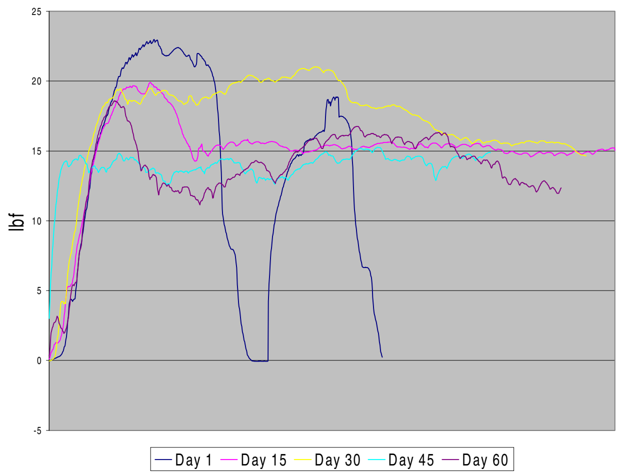
	SEPARATION, ULTIMATE LOAD (lbf/in)	
F-CB-010:	MESH	9.1 (1.59 kN/m)
F-CB-011:	MEMBRANE	9.8 (1.72 kN/m)
F-CB-012:	MEMBRANE	3.7 (0.65 kN/m)

APPENDIX I

LONGEVITY CONDITIONING

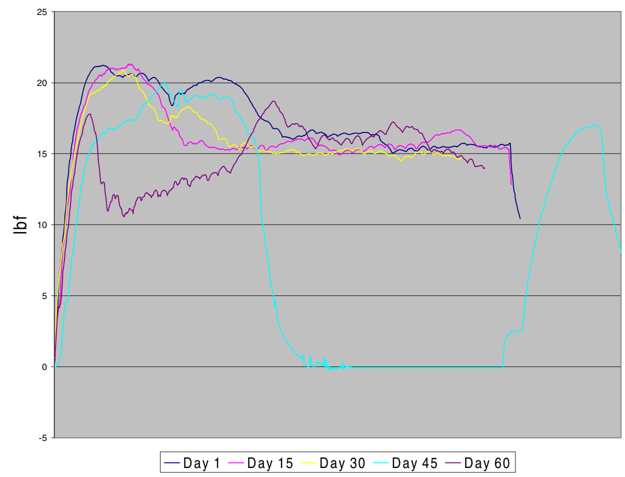
Product A/SB

Specimen 1



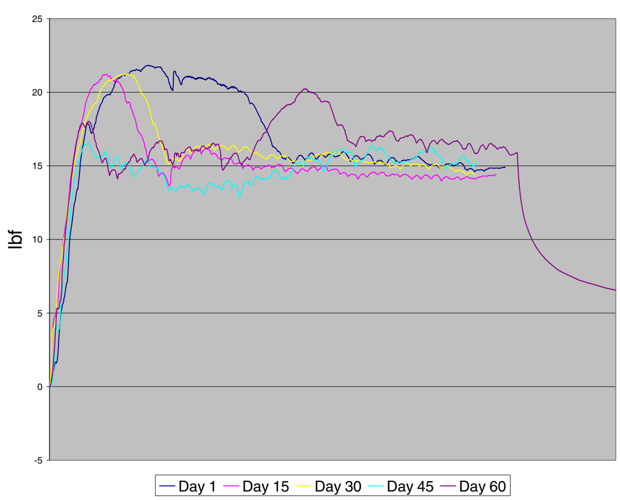
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-013-1:	POLYETHYLENE	23.0 (4.03 kN/m)
A/SB-013-2:	POLYETHYLENE	19.9 (3.49 kN/m)
A/SB-013-3:	POLY/MEMBRANE	21.0 (3.68 kN/m)
A/SB-013-4:	MEMBRANE	15.3 (2.68 kN/m)
A/SB-013-5:	MEMBRANE	18.6 (3.26 kN/m)

Specimen 2



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-014-1:	POLYETHYLENE	21.3 (3.73 kN/m)
A/SB-014-2:	POLY/MEMBRANE	21.4 (3.75 kN/m)
A/SB-014-3:	POLY/MEMBRANE	20.9 (3.66 kN/m)
A/SB-014-4:	MEMBRANE	20.0 (3.50 kN/m)
A/SB-014/5:	MEMBRANE	18.7 (3.27 kN/m)

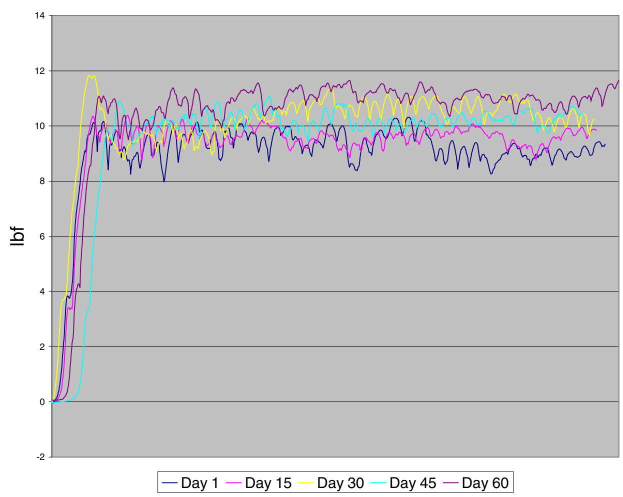
Specimen 3



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/SB-015-1:	POLYETHYLENE	21.9 (3.84 kN/m)
A/SB-015-2:	POLY/MEMBRANE	21.2 (3.71 kN/m)
A/SB-015-3:	POLY/MEMBRANE	21.3 (3.73 kN/m)
A/SB-015-4:	MEMBRANE	16.6 (2.91 kN/m)
A/SB-015-5:	MEMBRANE	20.3 (3.56 kN/m)

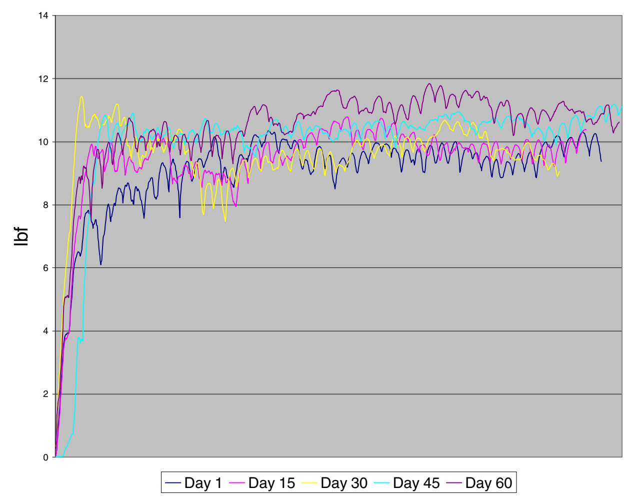
Product A/WB

Specimen 1



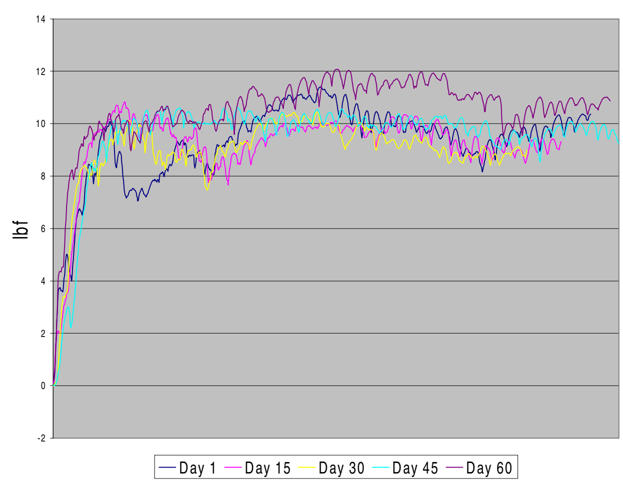
	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-013-1:	MEMBRANE	10.3 (1.80 kN/m)
A/WB-013-2:	MEMBRANE	10.4 (1.82 kN/m)
A/WB-013-3:	MEMBRANE	11.9 (2.08 kN/m)
A/WB-013-4:	MEMBRANE	11.1 (1.94 kN/m)
A/WB-013-5:	MEMBRANE	11.7 (2.05 kN/m)

Specimen 2



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-014-1:	MEMBRANE	10.4 (1.82 kN/m)
A/WB-014-2:	MEMBRANE	10.8 (1.89 kN/m)
A/WB-014-3:	MEMBRANE	11.5 (2.01 kN/m)
A/WB-014-4:	MEMBRANE	11.1 (1.94 kN/m)
A/WB-014-5:	MEMBRANE	11.9 (2.08 kN/m)

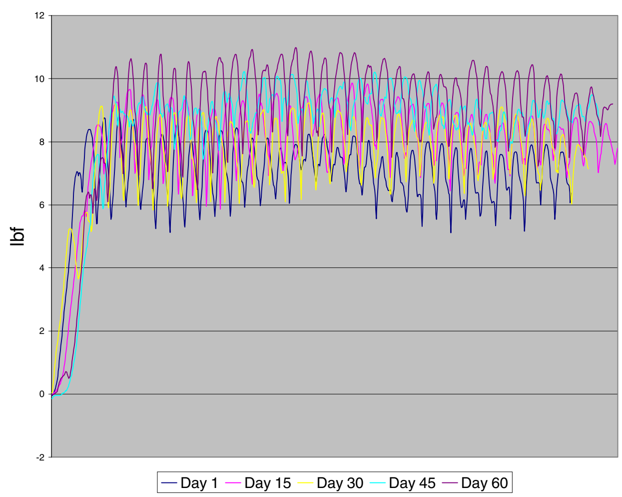
Specimen 3



	SEPARATION, ULTIMATE LOAD (lbf/in)	
A/WB-015-1:	MEMBRANE	11.4 (2.00 kN/m)
A/WB-015-2:	MEMBRANE	10.9 (1.91 kN/m)
A/WB-015-3:	MEMBRANE	10.5 (1.84 kN/m)
A/WB-015-4:	MEMBRANE	10.7 (1.87 kN/m)
A/WB-015-5:	MEMBRANE	12.1 (2.12 kN/m)

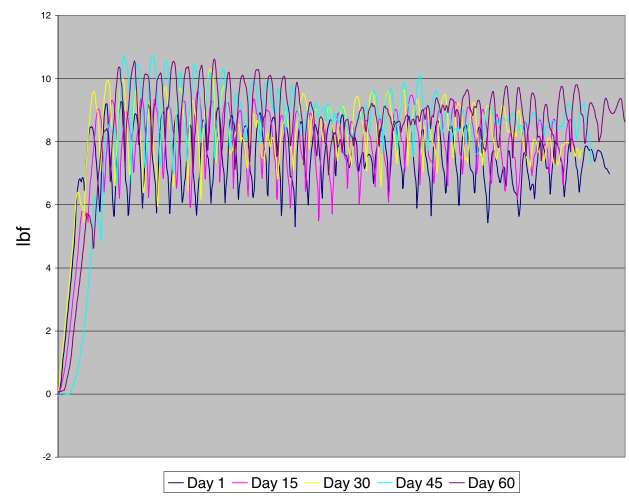
Product B/WB

Specimen 1



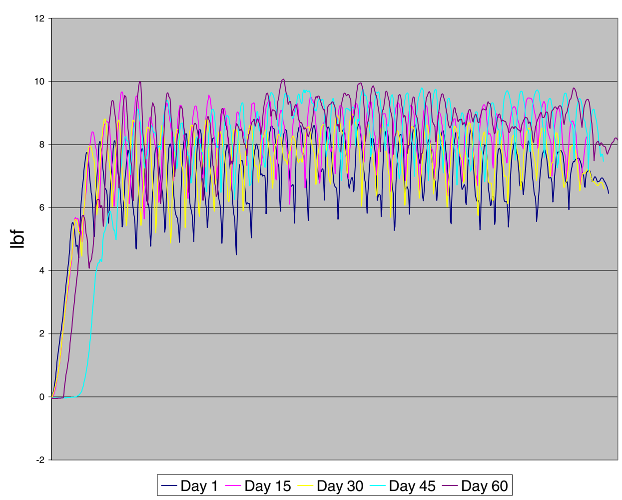
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WB-013-1:	MEMBRANE	8.8 (1.54 kN/m)
B/WB-013-2:	MEMBRANE	9.9 (1.73 kN/m)
B/WB-013-3:	MEMBRANE	9.3 (1.63 kN/m)
B/WB-013-4:	MEMBRANE	10.3 (1.80 kN/m)
B/WB-013-5:	MEMBRANE	11.0 (1.93 kN/m)

Specimen 2



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WB-014-1:	MEMBRANE	9.3 (1.63 kN/m)
B/WB-014-2:	MEMBRANE	9.6 (1.68 kN/m)
B/WB-014-3:	MEMBRANE	10.3 (1.80 kN/m)
B/WB-014-4:	MEMBRANE	10.8 (1.89 kN/m)
B/WB-014-5:	MEMBRANE	10.6 (1.86 kN/m)

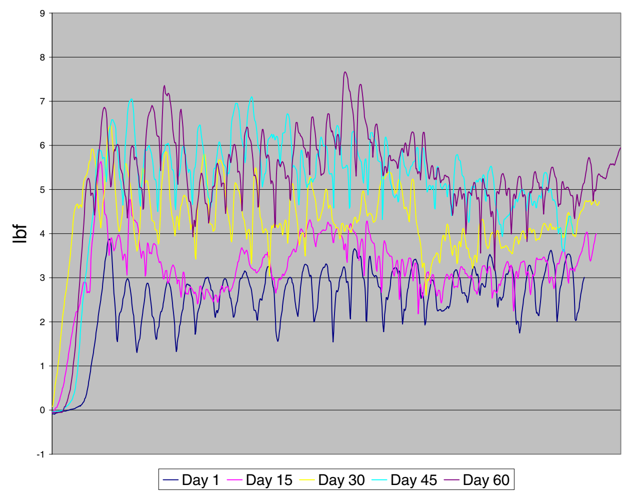
Specimen 3



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WB-015-1:	MEMBRANE	8.7 (1.52 kN/m)
B/WB-015-2:	MEMBRANE	9.7 (1.70 kN/m)
B/WB-015-3:	MEMBRANE	9.0 (1.58 kN/m)
B/WB-015-4:	MEMBRANE	9.8 (1.72 kN/m)
B/WB-015-5:	MEMBRANE	10.1 (1.77 kN/m)

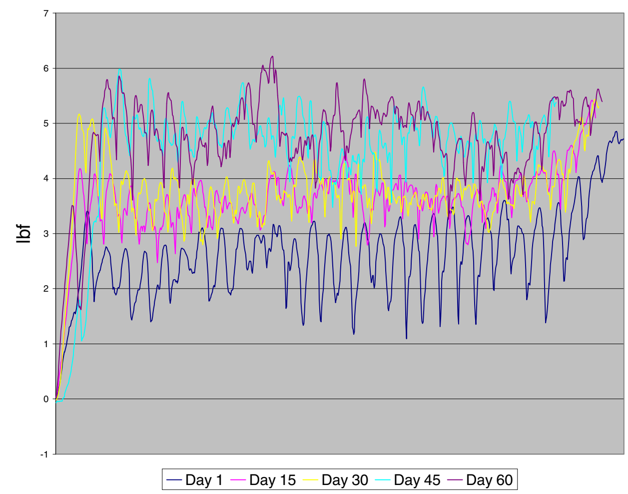
Product B/WBX

Specimen 1



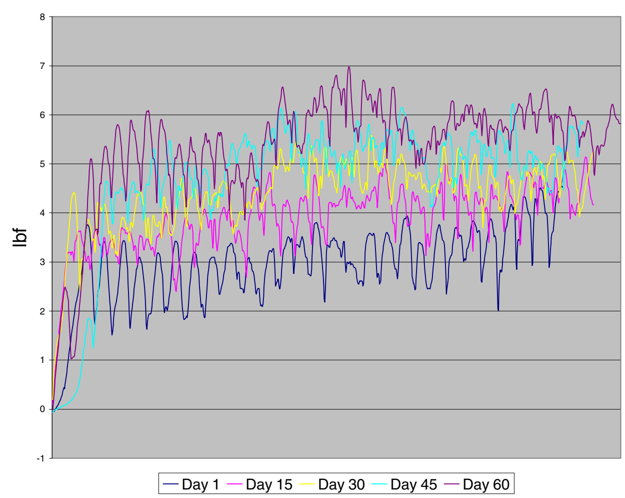
	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-013-1:	MEMBRANE	3.9 (0.68 kN/m)
B/WBX-013-2:	MEMBRANE	5.7 (1.00 kN/m)
B/WBX-013-3:	MEMBRANE	6.5 (1.14 kN/m)
B/WBX-013-4:	MEMBRANE	7.1 (1.24 kN/m)
B/WBX-013-5:	MEMBRANE	7.7 (1.35 kN/m)

Specimen 2



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-014-1:	MEMBRANE	4.9 (0.86 kN/m)
B/WBX-014-2:	MEMBRANE	5.4 (0.95 kN/m)
B/WBX-014-3:	MEMBRANE	5.5 (0.96 kN/m)
B/WBX-014-4:	MEMBRANE	6.0 (1.05 kN/m)
B/WBX-014-5:	MEMBRANE	6.2 (1.09 kN/m)

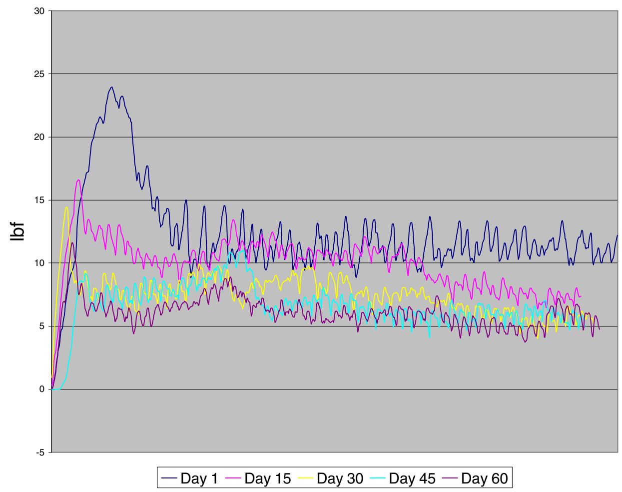
Specimen 3



	SEPARATION, ULTIMATE LOAD (lbf/in)	
B/WBX-015-1:	MEMBRANE	4.6 (0.81 kN/m)
B/WBX-015-2:	MEMBRANE	5.2 (0.91 kN/m)
B/WBX-015-3:	MEMBRANE	5.6 (0.98 kN/m)
B/WBX-015-4:	MEMBRANE	6.3 (1.10 kN/m)
B/WBX-015-5:	MEMBRANE	7.0 (1.23 kN/m)

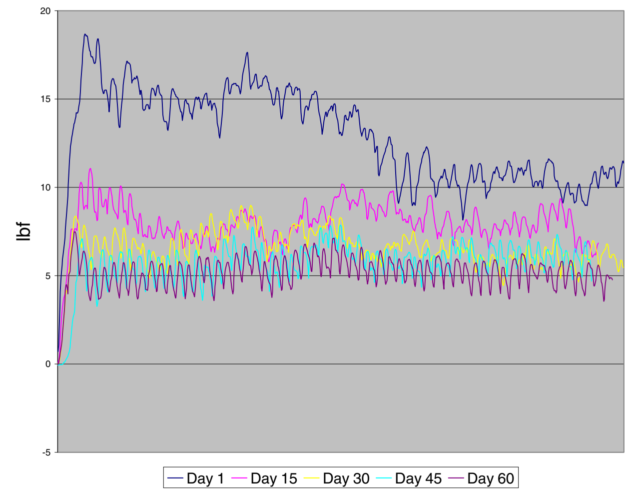
Product C/SB

Specimen 1



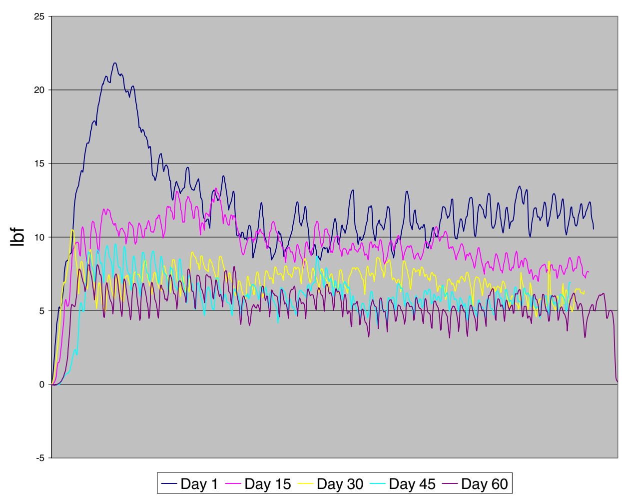
	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-013-1:	POLY/MEMBRANE	24.0 (4.20 kN/m)
C/SB-013-2:	MEMBRANE	16.6 (2.91 kN/m)
C/SB-013-3:	MEMBRANE	14.4 (2.52 kN/m)
C/SB-013-4:	MEMBRANE	11.0 (1.93 kN/m)
C/SB-013-5:	MEMBRANE	11.6 (2.03 kN/m)

Specimen 2



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-014-1:	POLY/MEMBRANE	18.7 (3.27 kN/m)
C/SB-014-2:	POLY/MEMBRANE	11.1 (1.94 kN/m)
C/SB-014-3:	POLY/MEMBRANE	9.0 (1.58 kN/m)
C/SB-014-4:	POLY/MEMBRANE	7.9 (1.38 kN/m)
C/SB-014-5:	POLY/MEMBRANE	7.5 (1.31 kN/m)

Specimen 3



	SEPARATION, ULTIMATE LOAD (lbf/in)	
C/SB-015-1:	POLY/MEMBRANE	21.9 (3.84 kN/m)
C/SB-015-2:	MEMBRANE	13.4 (2.35 kN/m)
C/SB-015-3:	MEMBRANE	11.5 (2.01 kN/m)
C/SB-015-4:	MEMBRANE	9.5 (1.66 kN/m)
C/SB-015-5:	MEMBRANE	8.2 (1.44 kN/m)

APPENDIX J

PHOTOGRAPHS

Photo 1: Tensile adhesion test.

Photo 2: Tensile adhesion test; membrane detached from substrate.

Photo 3: Tensile adhesion test; test pad detached from membrane.

Photo 4: Tensile adhesion test; drywall ruptured.

Photo 5: Tensile adhesion test; Dens-Glass Gold ruptured.

Photo 6: Setup for slow-peel resistance test.

Photo 7: Slow-peel resistance test.

Photo 8: Slow-peel resistance test.

Photo 9: Fast-peel resistance test.

Photo 10: Fast-peel resistance test.

Photo 11: Fast-peel resistance test.

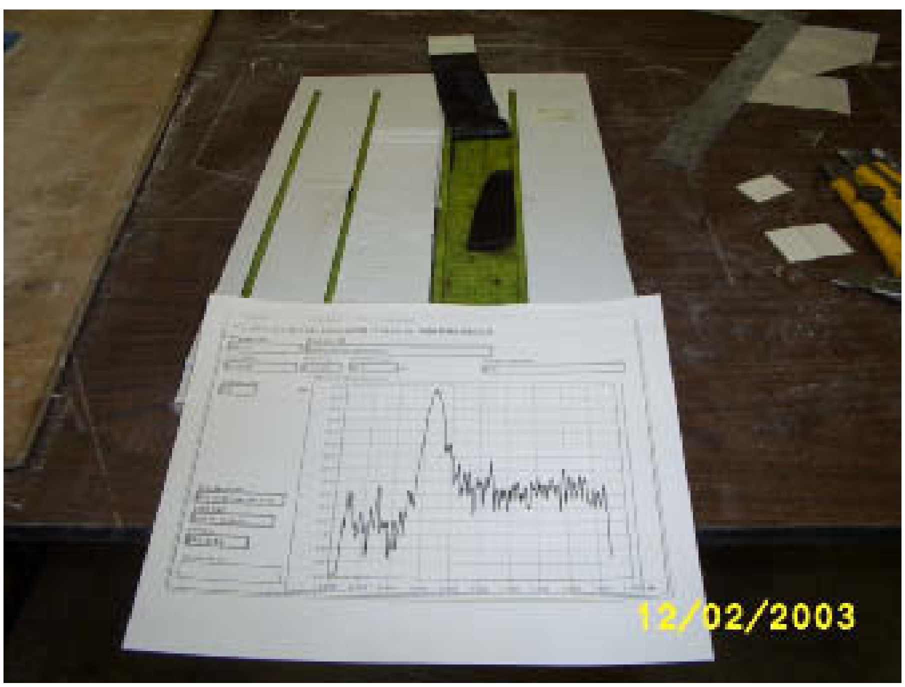


Photo 12: Fast-peel resistance test specimen with graph of test results.

Photo 13: ITC Environmental Chamber.

Photo 14: Inside ITC Environmental Chamber.

Photo 15: Saturation conditioning.

Photo 16: Saturation conditioning.

Photo 17: Saturation conditioning.

Photo 18: Membrane detaching from substrate during saturation conditioning.

Photo 19: Condition of drywall after saturation conditioning.

Photo 20: Specimens after longevity testing.

Photo 21: Specimen after longevity testing.

Photo 22: Specimens after longevity testing.