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AIR INTRUSION AND ITS IMPACT ON THE PERFORMANCE OF ROOFING SYSTEMS

Suda Molleti

Bas A. Baskaran

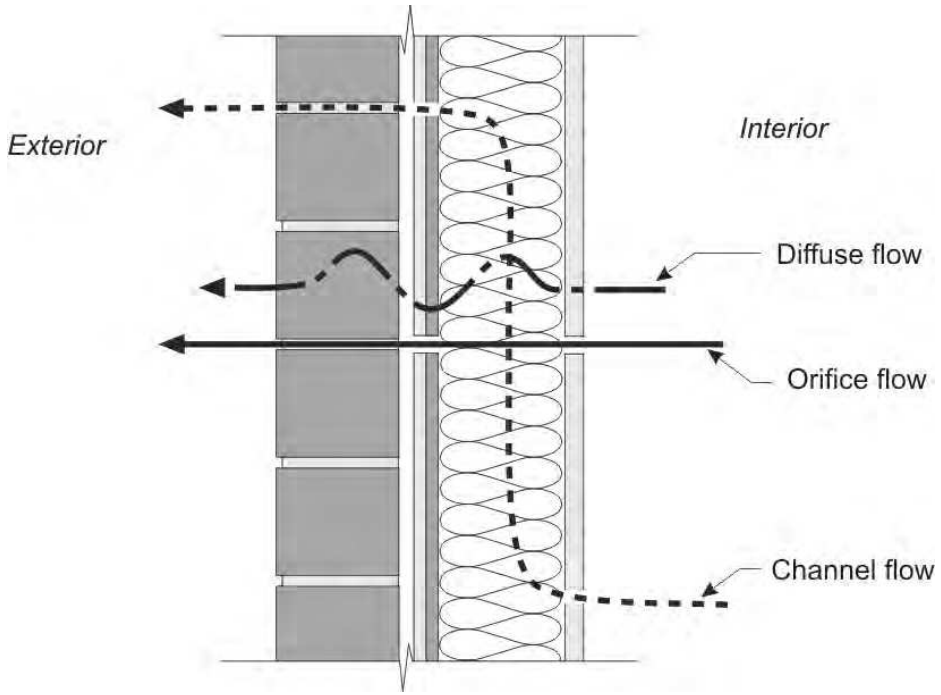
National Research Council of Canada (NRCC)

Outline

- Overview of Air Intrusion
- Quantification of Air Intrusion
- Impacts of Air Intrusion

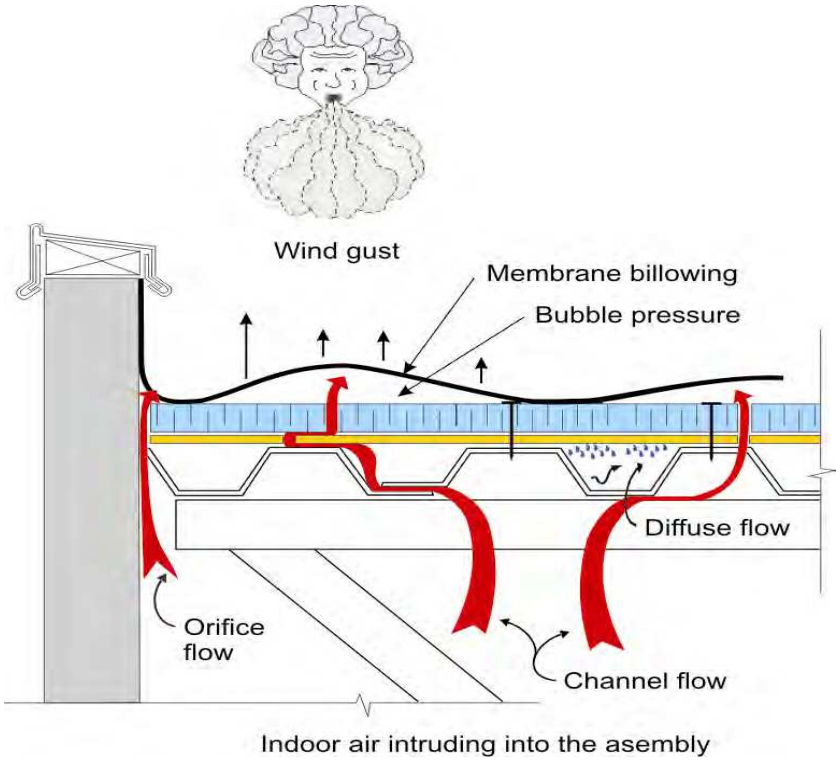
Air Movement

When air enters or leaves from one environmental condition to the other environmental condition through the building envelope assembly, it is termed as "Air Leakage".



Air Movement

When conditioned indoor air enters into a building envelope assembly but cannot escape to the exterior environment, it is termed as "Air Intrusion".



Indoor air intruding into the asembly

Field vs. Laboratory Response

Field

Courtesy: Hans Gerhardt

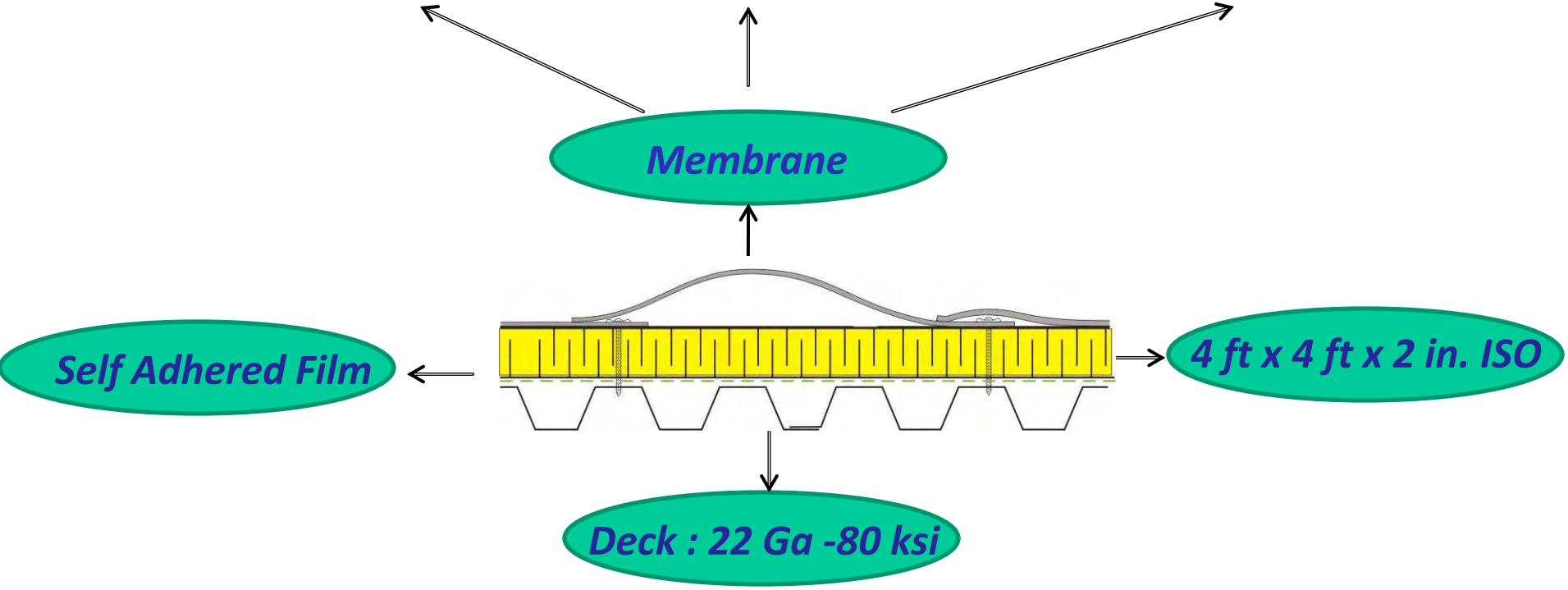
Dynamic Roofing Facility (DRF)

Thermoplastic

AIR INTRUSION QUANTIFICATION : DRF-AI

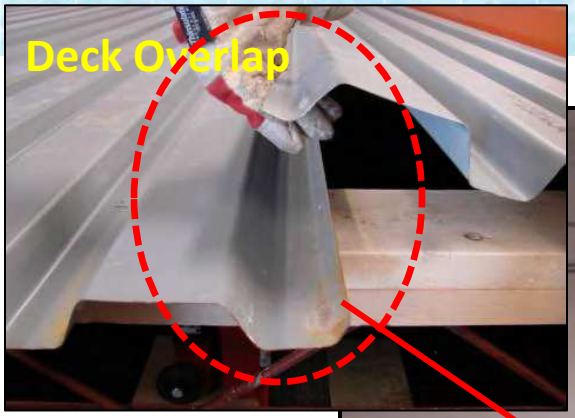
EXPERIMENTAL LAYOUT

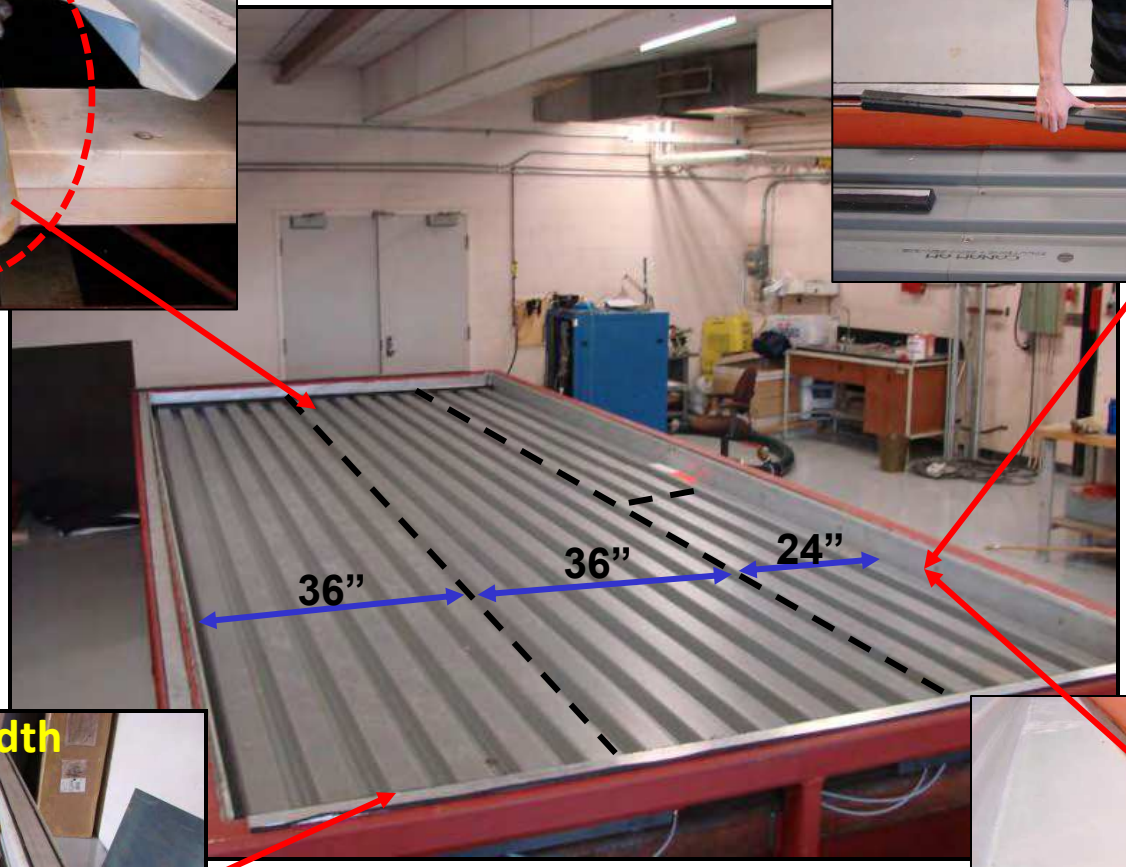
MOD-BIT		PVC		EPDM	
WITHOUT AIR RETARDER	WITH AIR RETARDER	WITHOUT AIR RETARDER	WITH AIR RETARDER	WITHOUT AIR RETARDER	WITH AIR RETARDER



EXCEPT MEMBRANE (BUBBLE SIZE) ALL OTHER COMPONENTS ARE IDENTICAL INCLUDING THEIR LAYOUT AND ARRANGEMENT

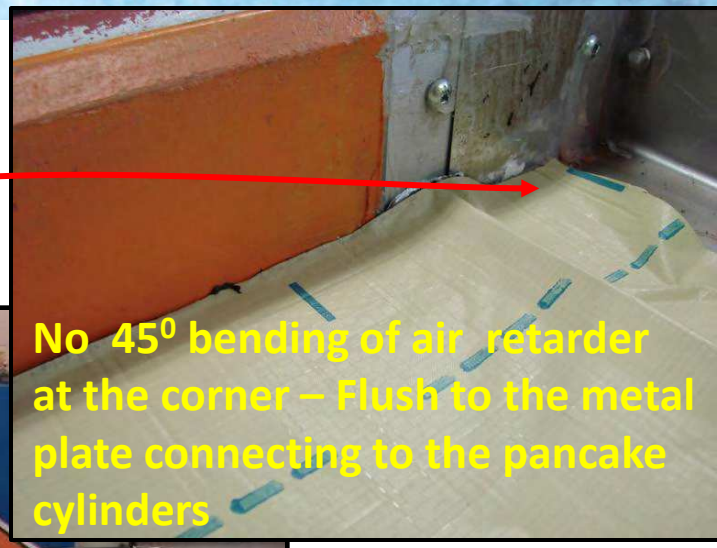
DECK INSTALLATION

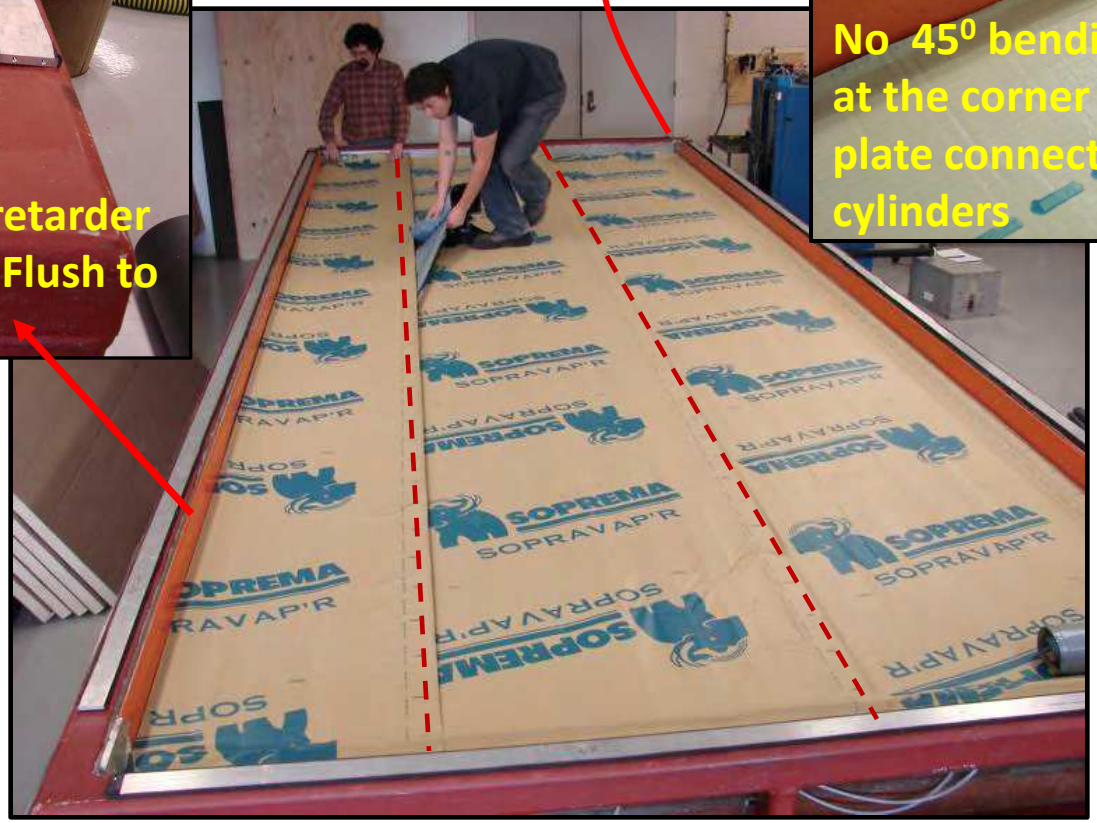




Consistent For All Assemblies

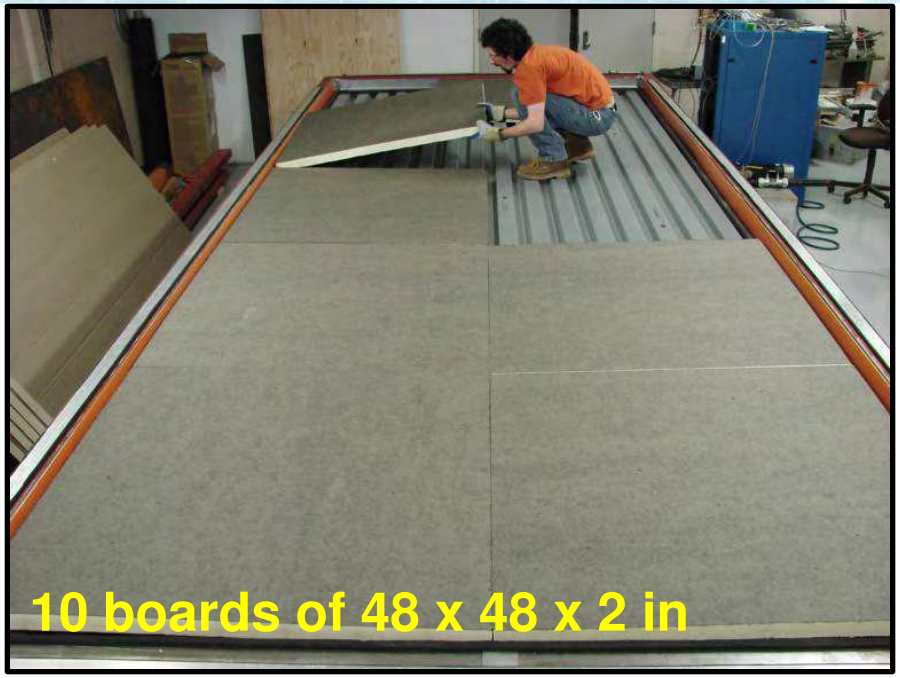
AIR RETARDER INSTALLATION



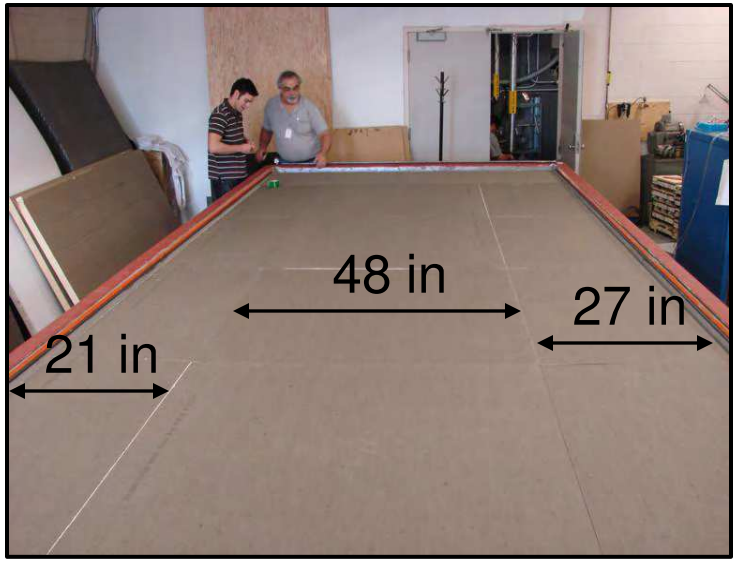


Consistent For All Assemblies Tested with Air Retarder

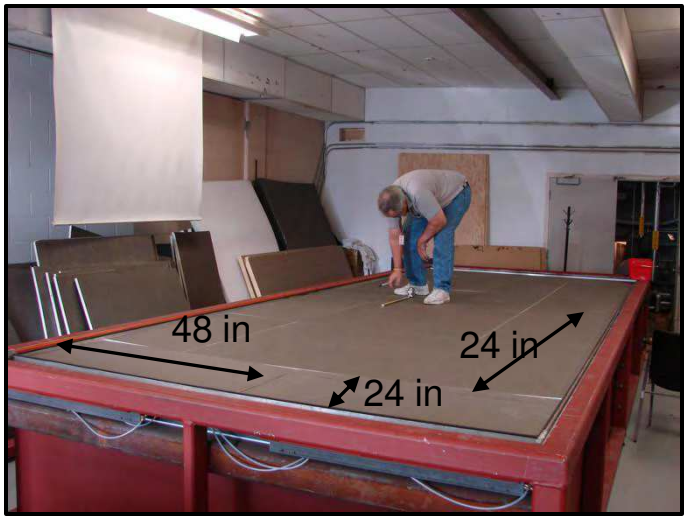
INSULATION INSTALLATION

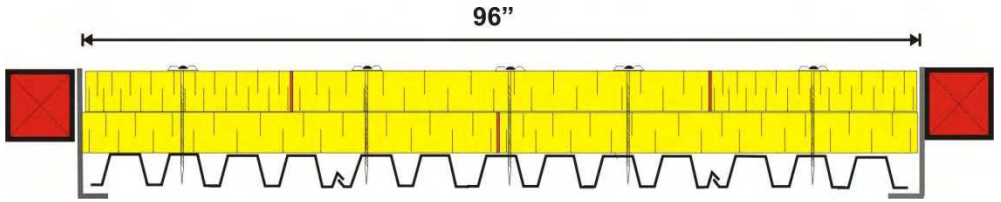


INSULATION INSTALLATION: STAGGERED LAYOUT



INSTALLATION OF THE TOP INSULATION LAYER





INSULATION INSTALLATION: STAGGERED LAYOUT

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FASTENING OF THE INSULATION

50 FASTENERS

MEMBRANE LAYOUT

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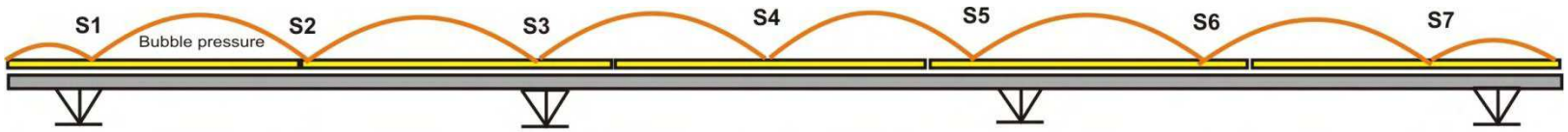
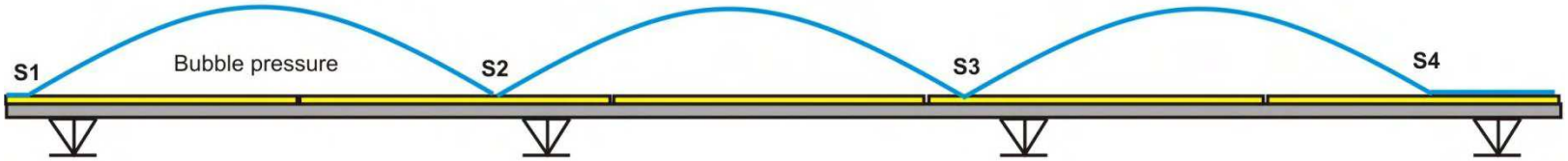
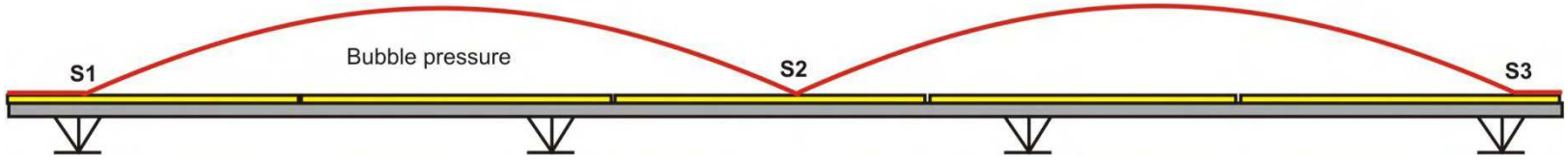
MB: FR = 36 IN FS = 18 IN.



TP: FR = 66 IN FS = 12 IN.



TS: FR = 114 IN FS = 12 IN. [ALSO TP]



MEMBRANE INSTALLATION

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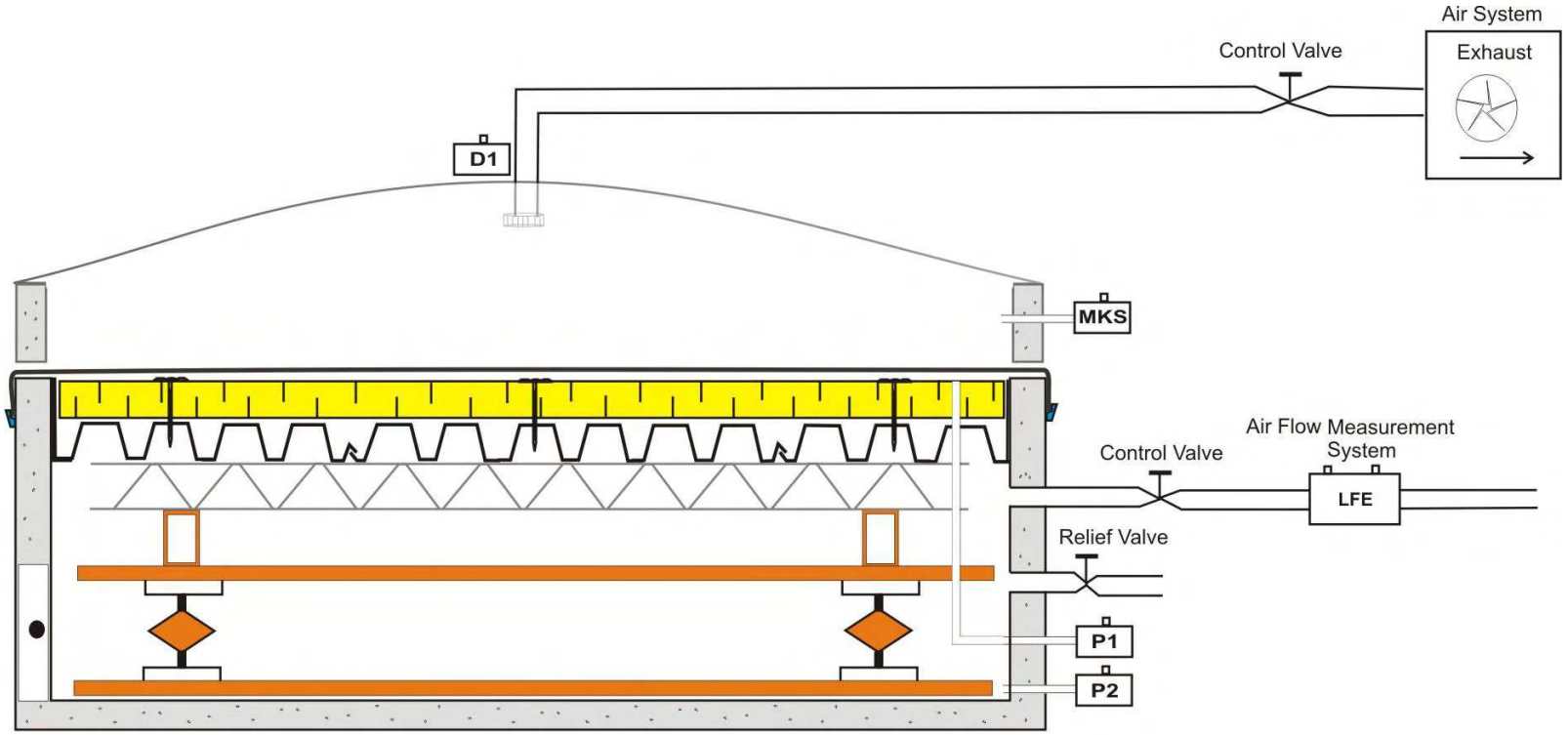
MOD-BIT

TP

TS

DRF-AI : INSTRUMENTATION



MKS= Membrane pressure

P1= Insulation pressure (top of insulation)

P2= Bottom Chamber pressurer (below deck)

D1= Deflection Sensor

LFE= Laminar Flow Element

TEST PROCEDURE : ASTM WK 23684

DESIGNATION: D XXXX-XX

Standard Test Method For Quantification of Air Intrusion in Low-Sloped Membrane Roof Assemblies

1. Scope

1.1 This test method covers a standard laboratory procedure for determining the air intrusion in low-sloped membrane roof assemblies under specified negative air pressures differences. The test method described is for tests with constant temperature and humidity across the specimen.

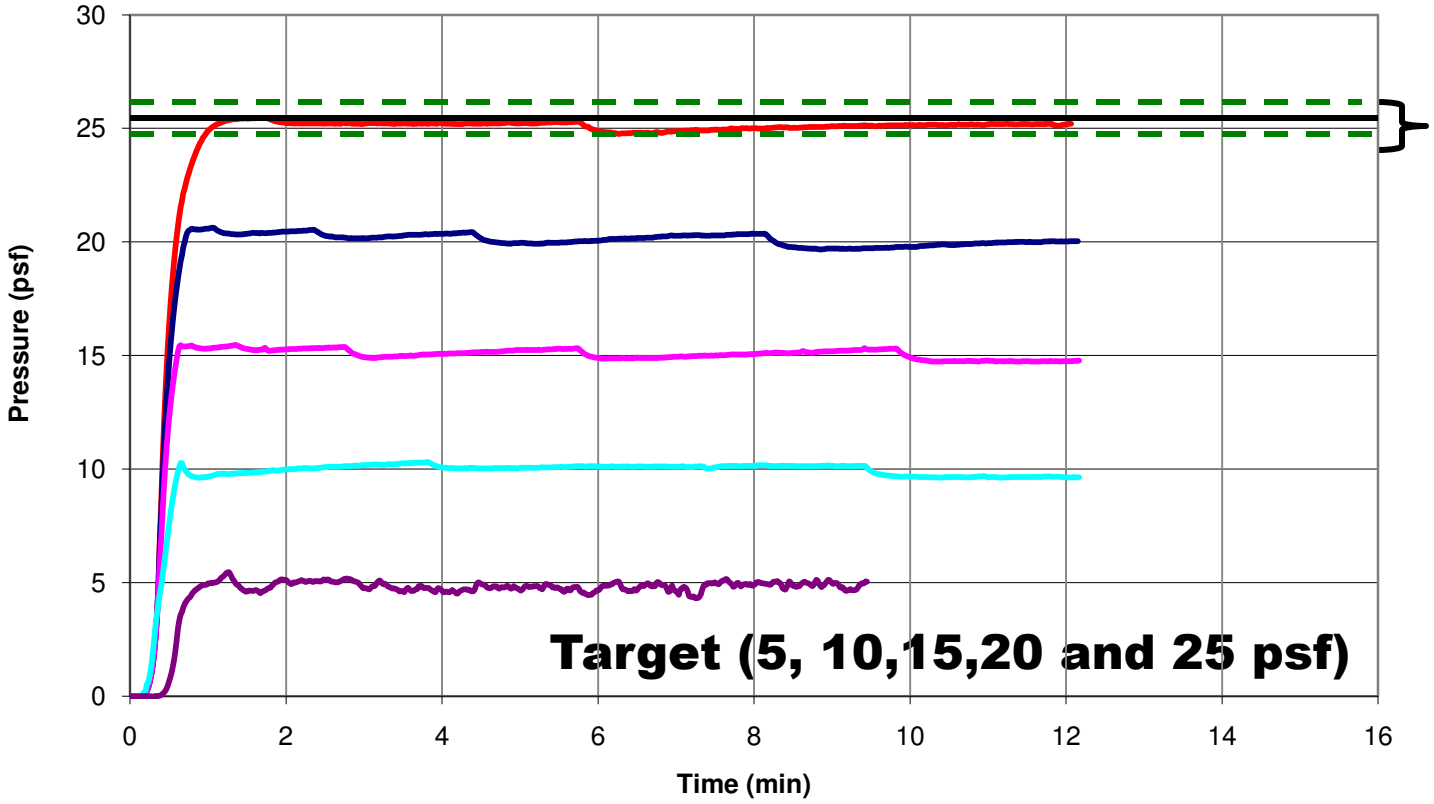
1.2 This laboratory procedure is intended to measure only the air intrusion associated with the opaque roof assembly free from the penetrations of mechanical devices, roof junctions and terminations. Hence, it is intended to measure air intrusion associated with the assembly and not the installation.

1.3 The values given in SI units are the standard. English or Imperial units are provided in the parentheses are for information.

1.4 The standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Currently it is in the balloting process

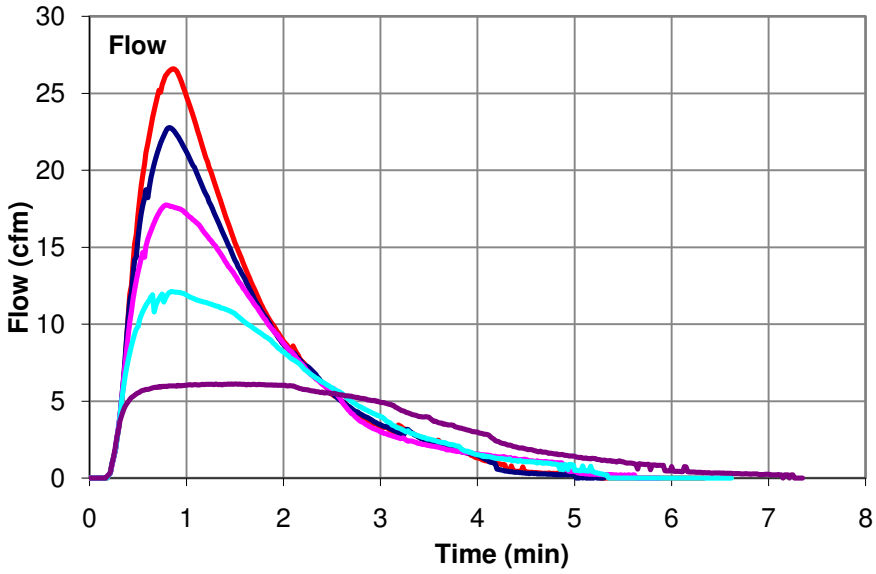
RESULTS – TIME HISTORIES



Applied Suction Pressure with in the range of ± 1 psf of the target pressure

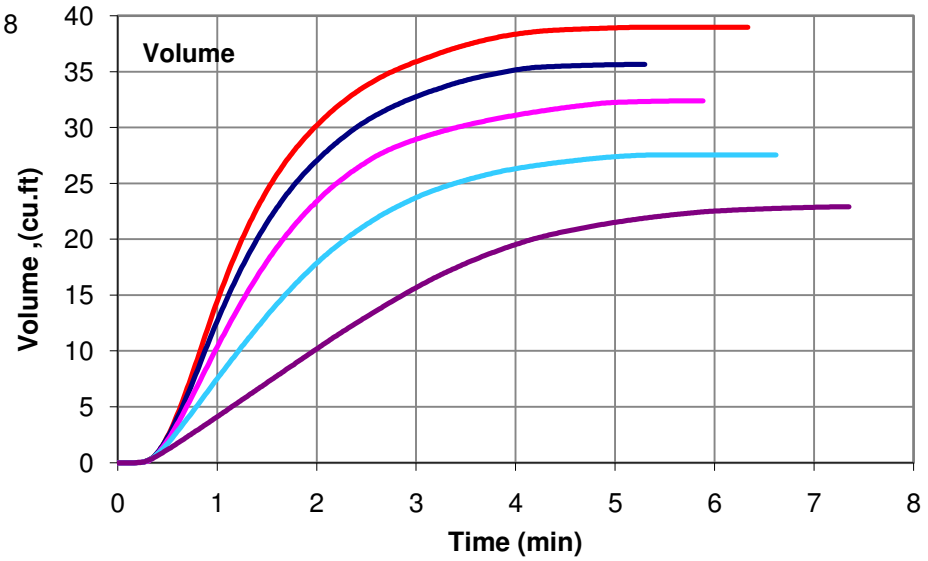
MEMBRANE SUCTION PRESSURE

TIME HISTORIES

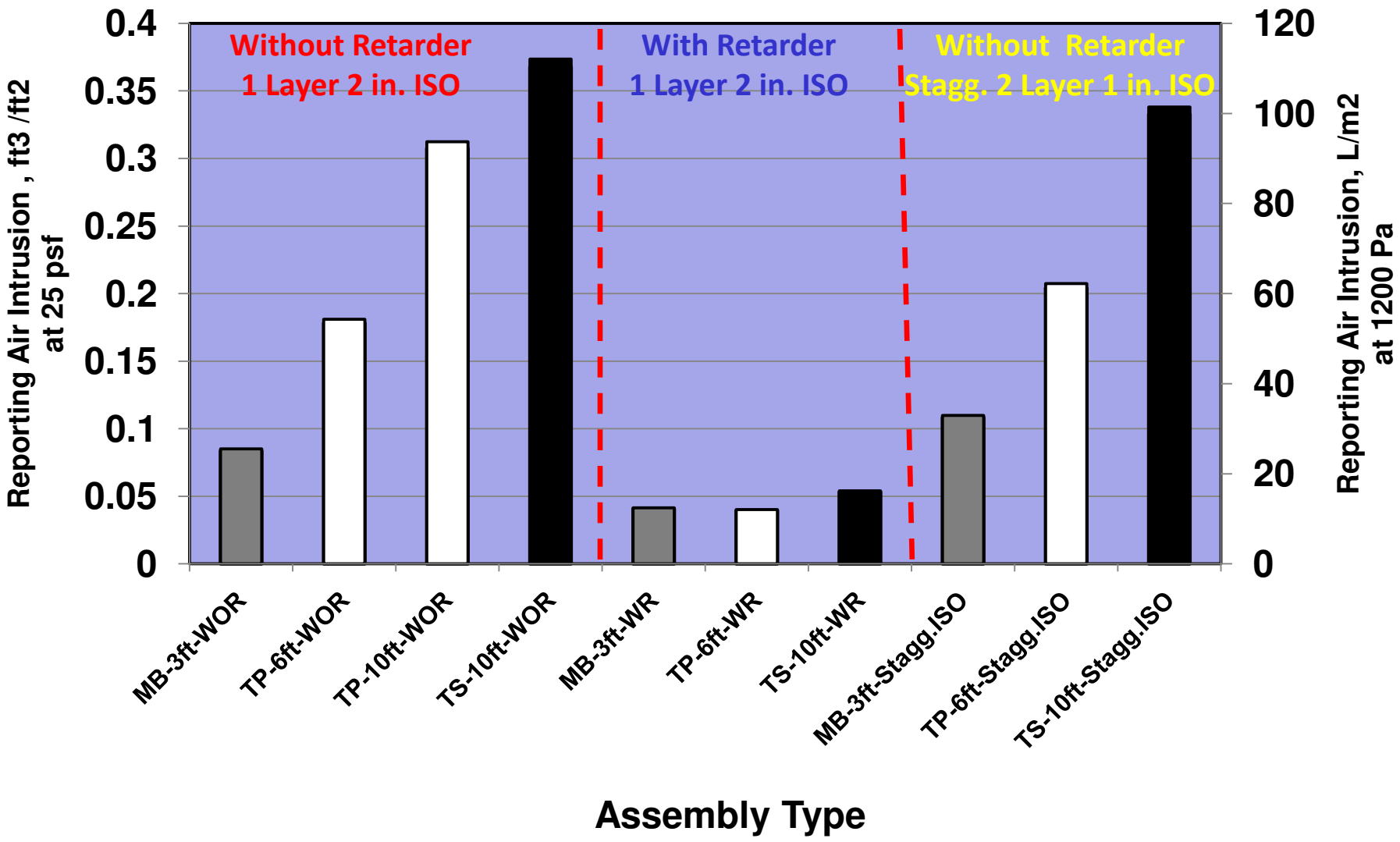


FLOW RATE

AIR INTRUSION VOLUME

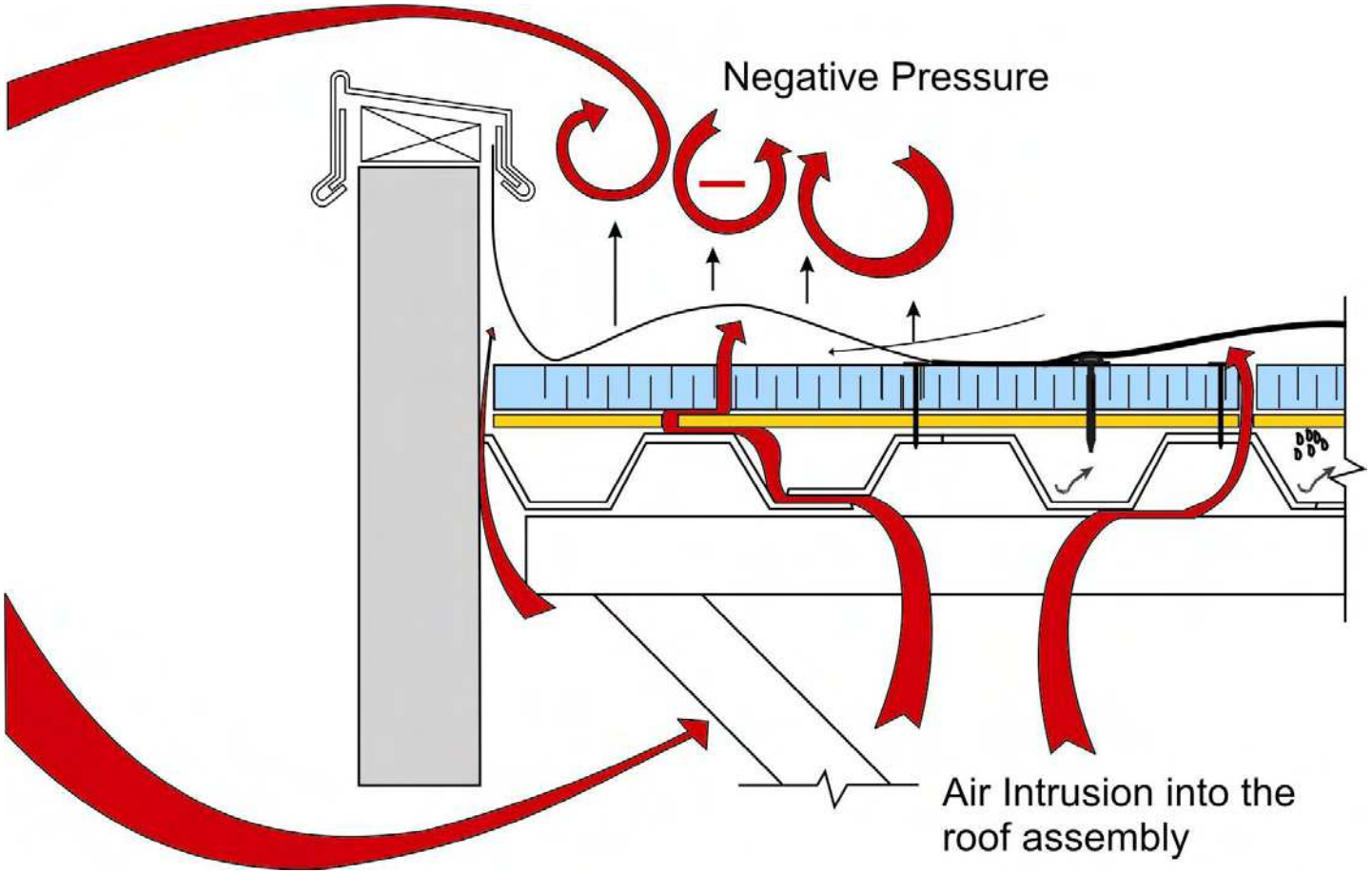


AIR INTRUSION RATE – REPORTING

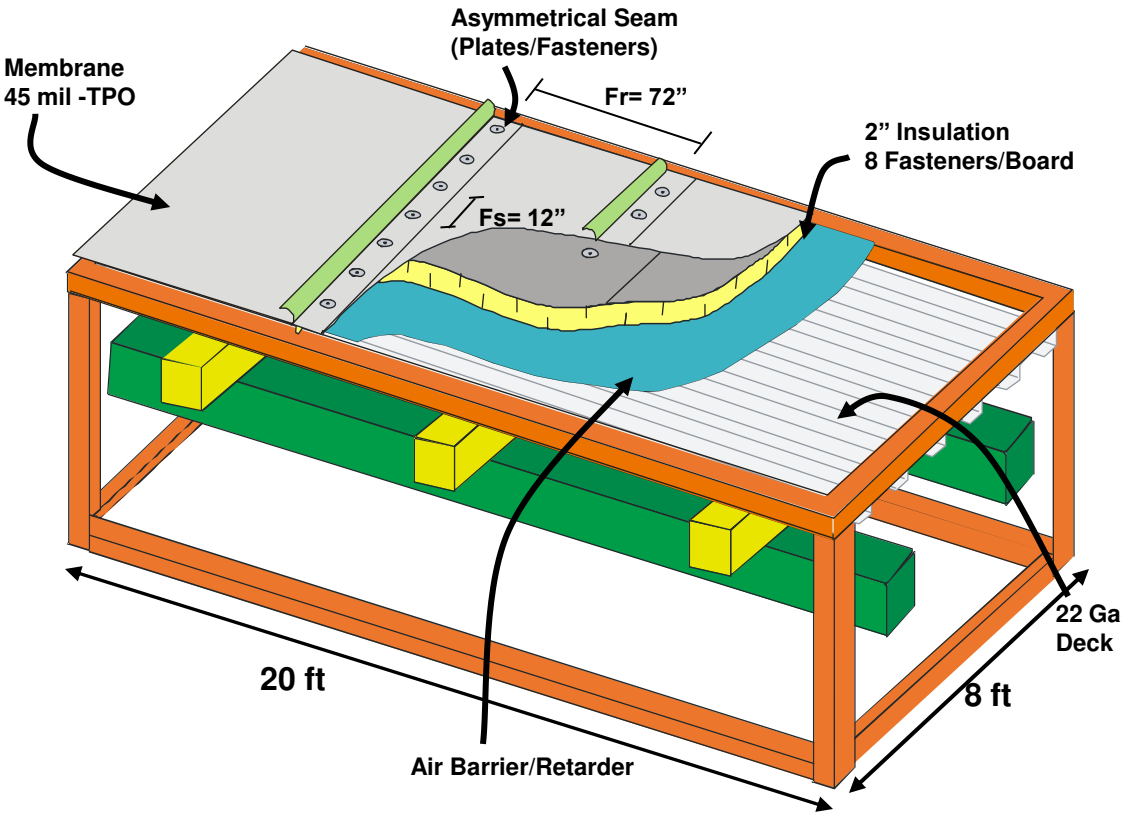


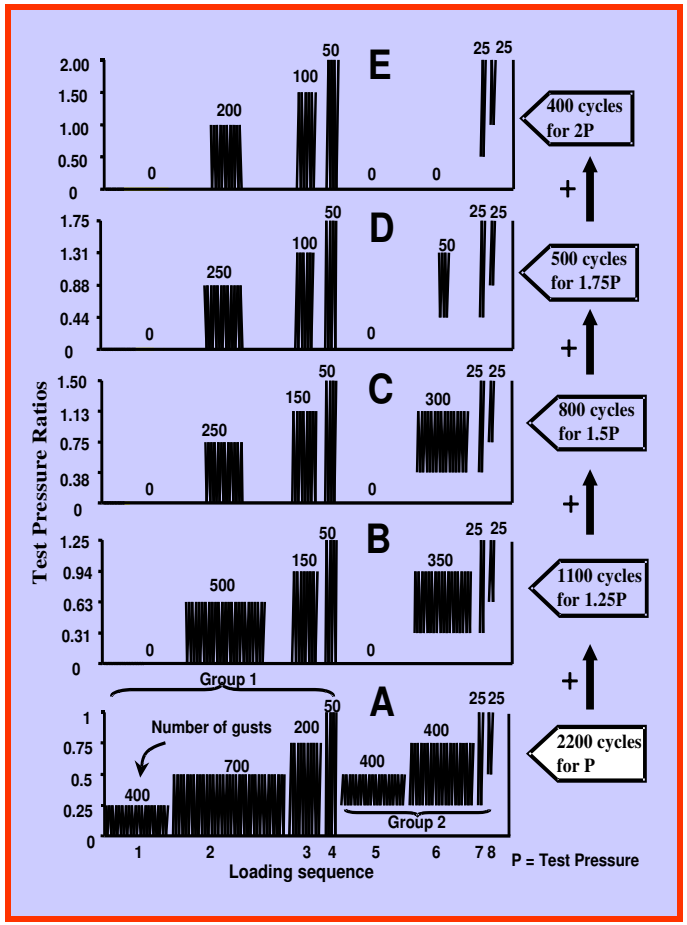
AIR INTRUSION IMPACTS ON THE PERFORMANCE OF MARS

WIND UPLIFT RESISTANCE



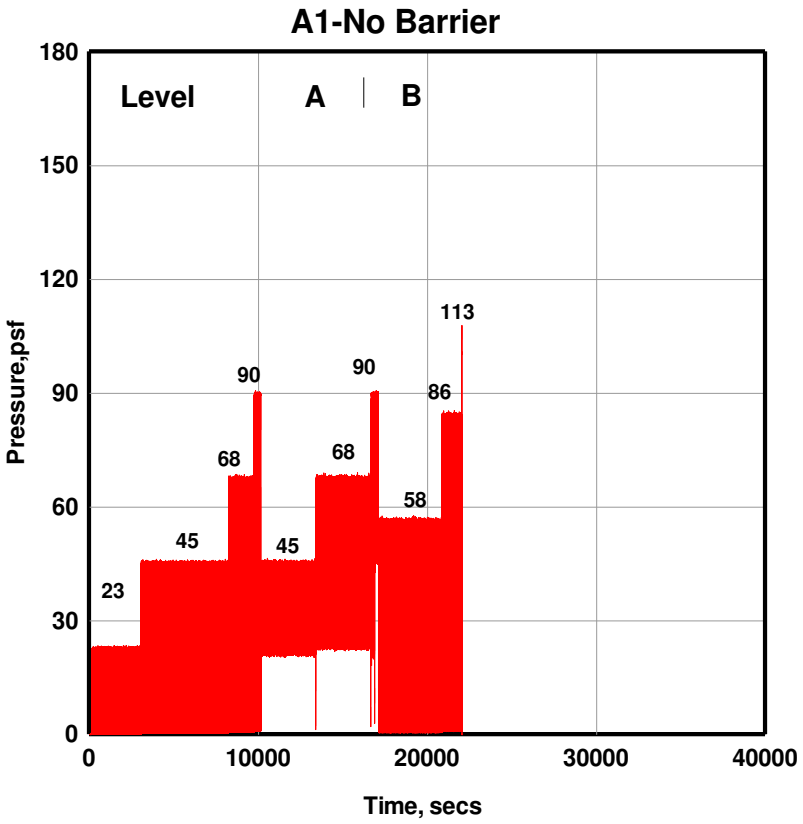
EXPERIMENTAL APPROACH

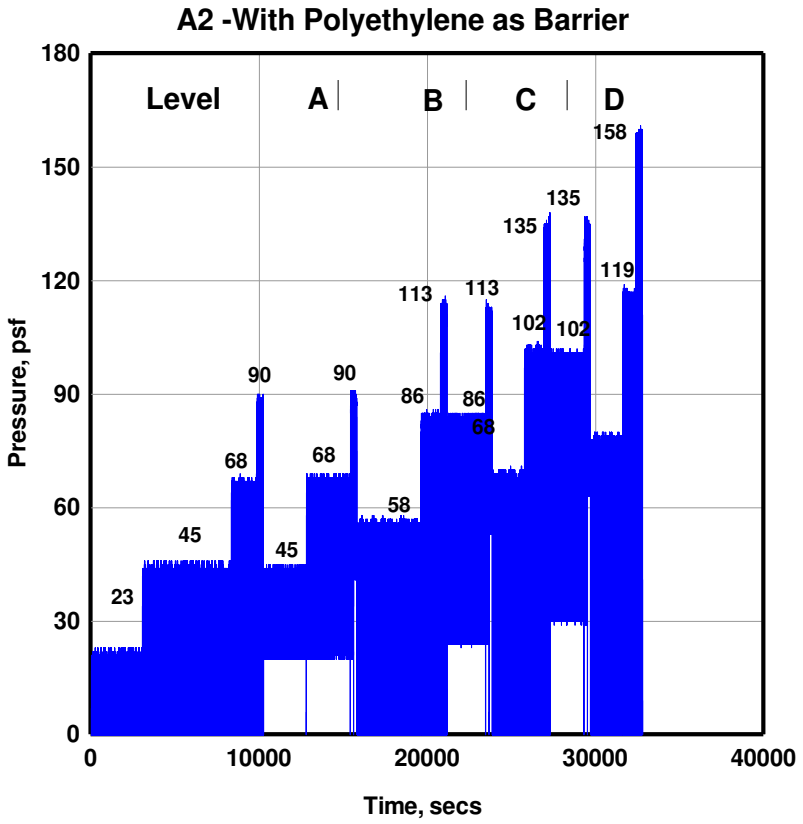




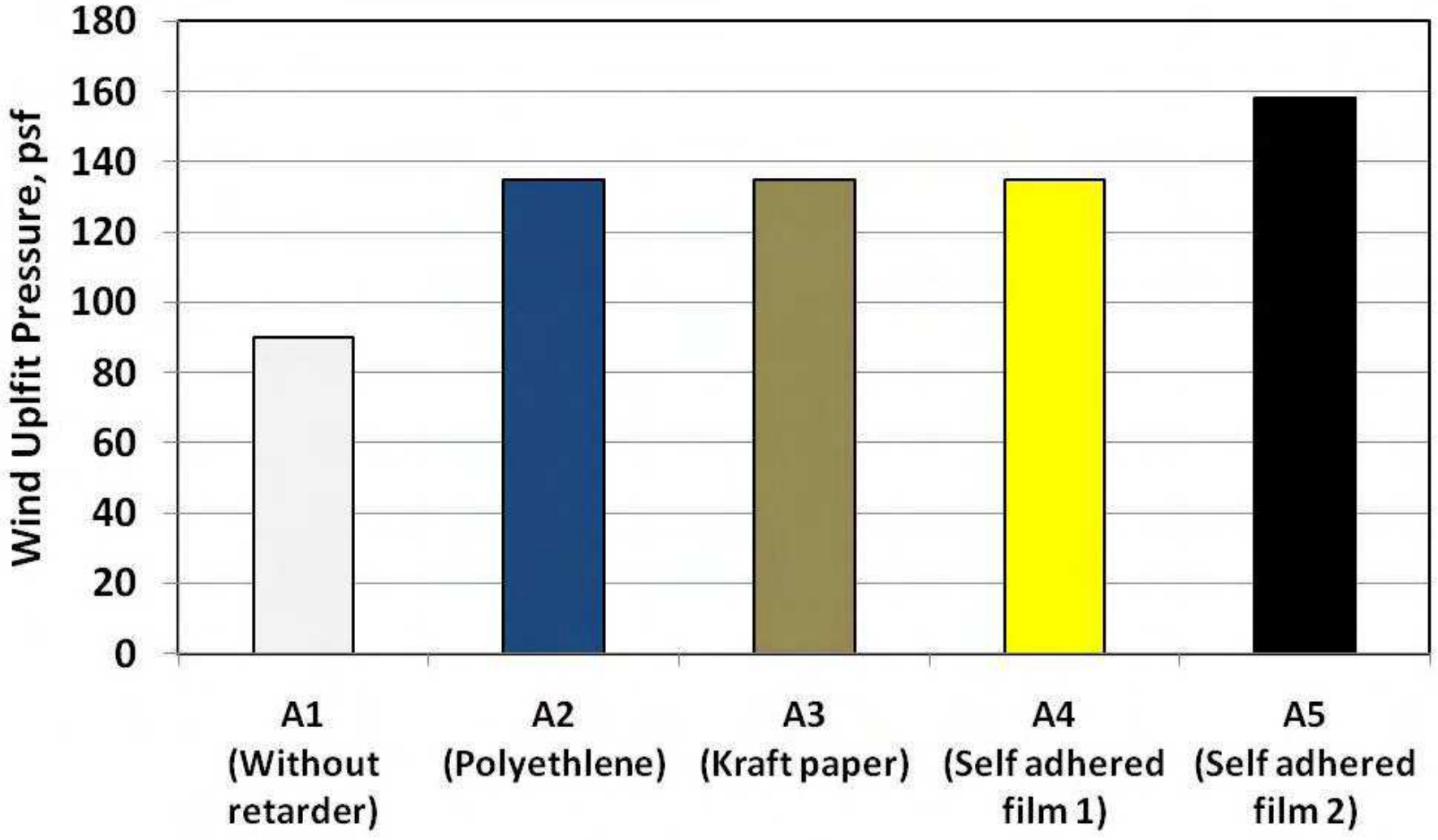
CSA A123.21
Dynamic Test Protocol

TIME HISTORY PLOTS

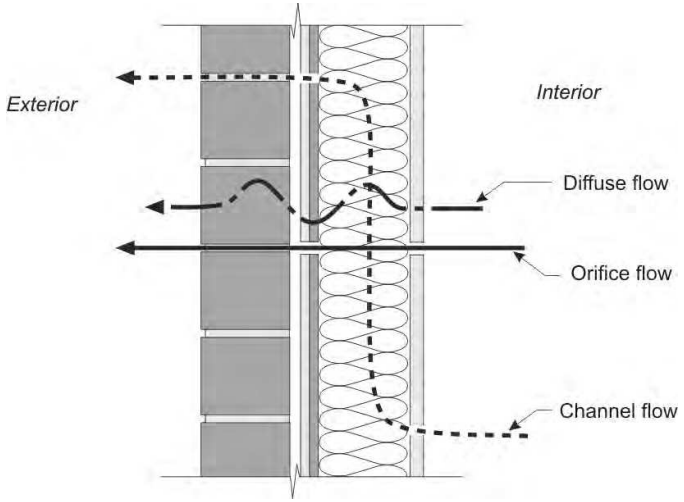




WIND UPLIFT RATING

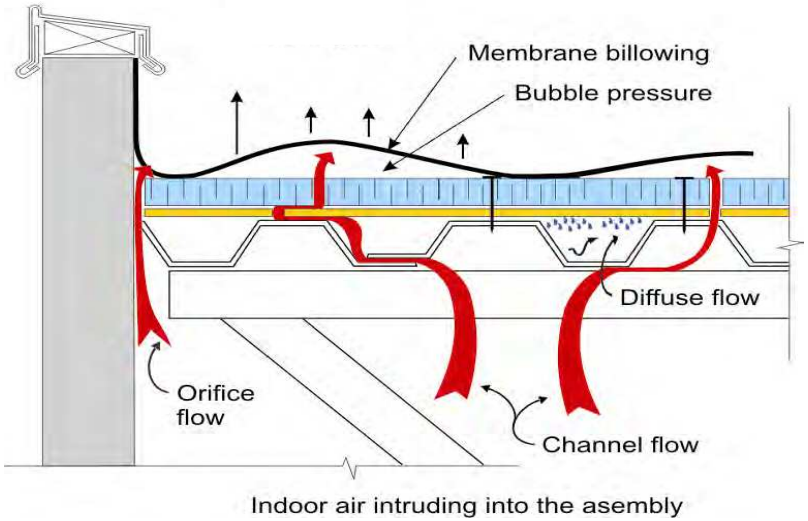


ENERGY PERFORMANCE



With Air leakage – Heat is transferred resulting in energy loss

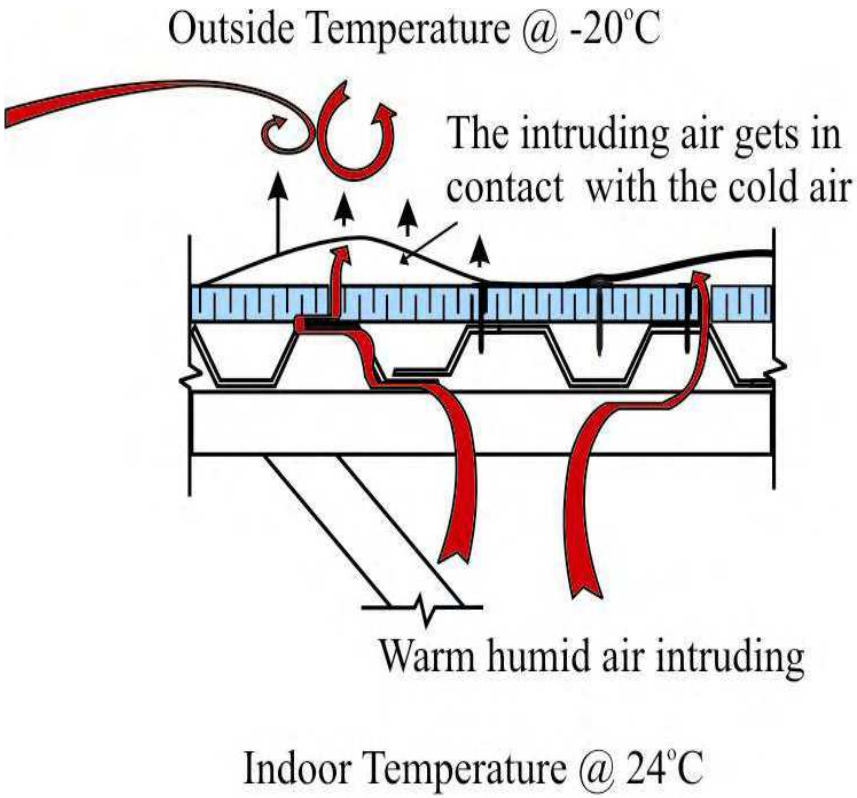
Membrane if constructed properly is a perfect air barrier.
With Air intrusion – There is no direct heat loss from interior to exterior or vice versa.

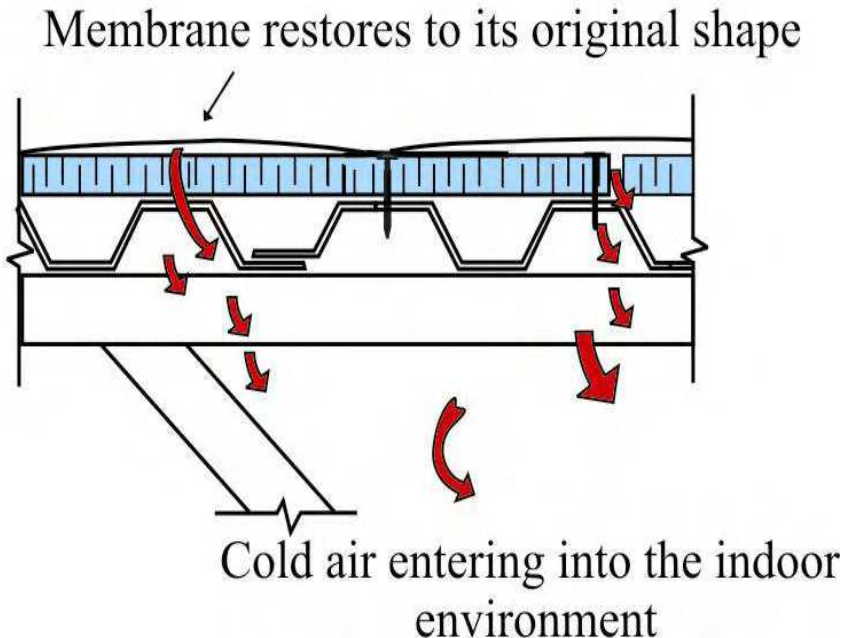


Indoor air intruding into the asembly

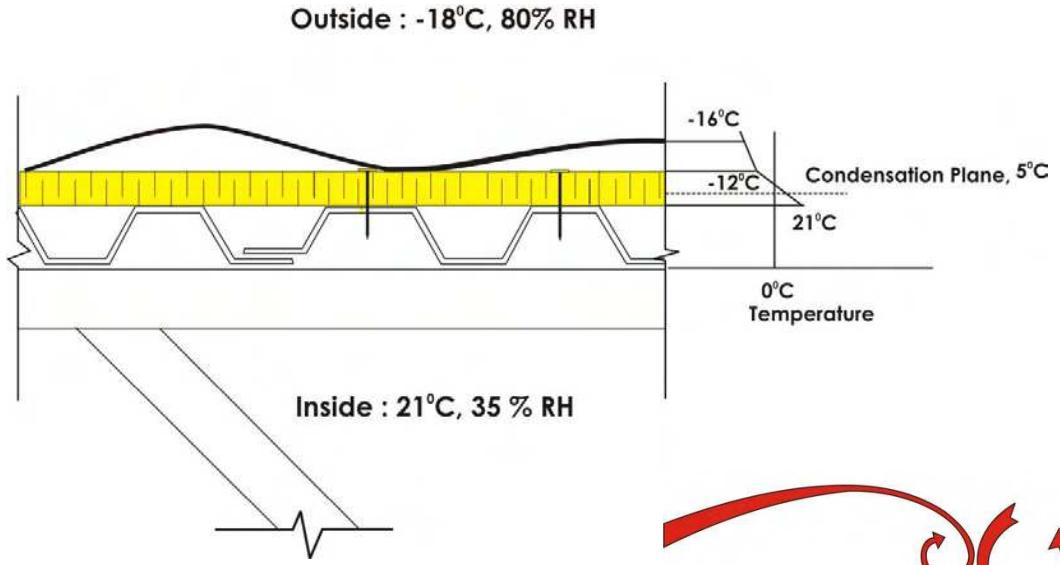
ENERGY PERFORMANCE

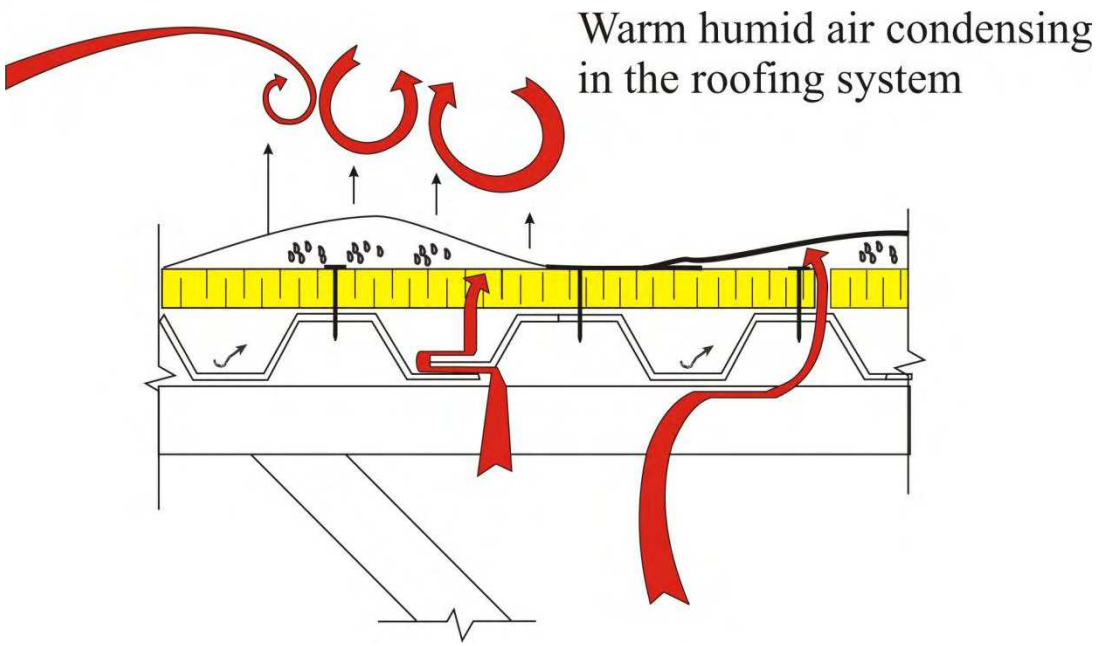
Heat exchange can occur from the momentarily billowing of the membrane



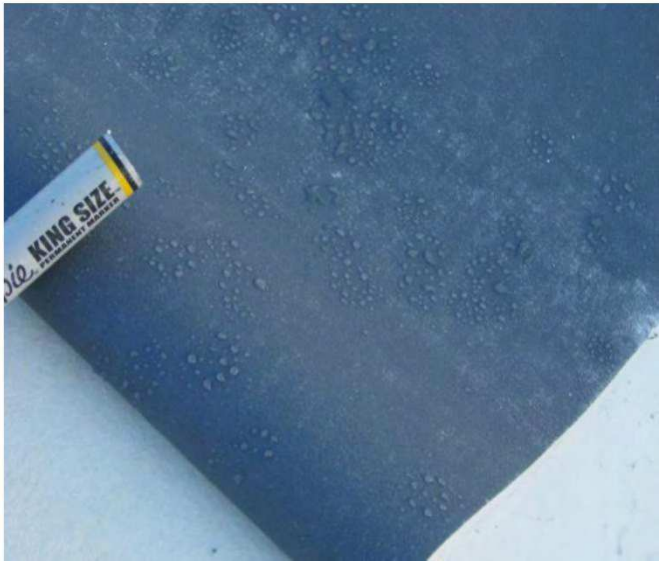


CONDENSATION





CONDENSATION



ONGOING RESEARCH PROJECT

Roofing Associations

NATIONAL ROOFING CONTRACTORS ASSOCIATION

CANADIAN ROOFING CONTRACTORS' ASSOCIATION

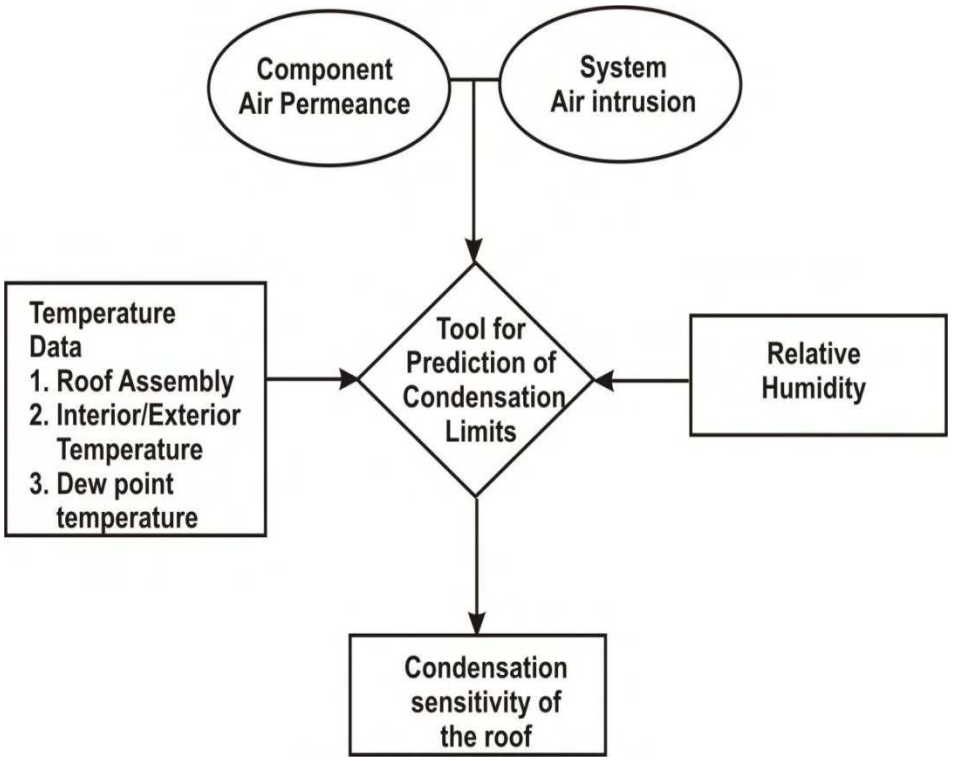
Roofing Manufacturers

CARLISLE
Carlisle SynTec Incorporated

Dow
ROOFING SYSTEMS

Firestone
BUILDING PRODUCTS

Sika®
Sarnafil®



CONCLUSIONS

- Through a new ASTM International test protocol, research work at NRC quantified air intrusion rates for mechanically attached roof systems.

- Data indicates that systems with wider sheets have higher air intrusion rates compared with systems with narrower sheets.

- The air retarder installed on the deck creates the first line of defence against the air intrusion through the deck joints. As the retarder has certain air permeance, and also as its layout comprises of seams and fastener penetrations, it cannot completely prevent air intrusion but it significantly minimizes the volume of air intruding into the WR systems.

- The reduction in air intrusion contributes directly for the improvement in the wind uplift rating.

CONCLUSIONS

- At present there is an assumption that staggered insulation layout could minimize air intrusion which leads to design practice of eliminating the air retarder component in systems with staggered insulation layout. The limited measured data fails to support the above assumption and design practice.

- As the roofing membrane is a perfect air barrier, there is no direct heat loss across the system due to air intrusion.

- However, there exists a potential vulnerability to moisture laden air and condensation on the roofing system performance. The question how much air intrusion can cause destruction to the system performance is being investigated.

Acknowledgements

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SIGDERS
Special Interest Group for Dynamic Evaluation of Roofing Systems
Established November 1994

Phase I : 1994 - 1997 • Phase II : 1997 - 2000 • Phase III: 2000 - 2003 • Phase IV: 2003 - 2007 • Phase V : 2008 - 2011

Phase V - Members

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Duro-Last Roofing Systems
Firestone Building Products
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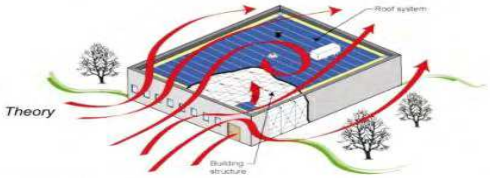
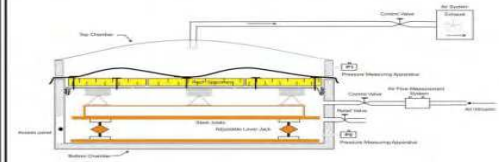
IKO Industries Ltd.
Johns Manville Inc.
OMG Roofing Products
Soprema Canada Inc.
SIKA Sarnafill
Tremco Inc.
Trufast LLC.

Objective 1: Field Monitoring



Objective 2: Air Intrusion Quantification



Objective 3: CSA Standard Update

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