**SAE G-12 RDF Subcommittee Meeting**
**New Orleans, May 2013**
***Runway De-icer Performance Working Group***

# *Performance Test Methods for AMS1431/1435 Runways and Taxiways Deicing/Anti-icing Chemicals*


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# Background

## Before 2011

## AMS 1431(3.2.10) / 1435 (3.2.12)

## No Standardised Performance Tests for Runway Deicers

## SHRP Tests were used

## (SHRP were adapted 2002 : FAA & SMI)

# 2008 Warsaw G-12 Meeting

- ✓ **AMIL presented Adapted SHRP test results**
- ✓ **Suggestion to improve the methods**
- ✓ **Proposition to form a Working Group to evaluate SHRP test methods**

# Work started in Montreal 2008 - until 2012

- ✓ **Discussed the test parameters**
- ✓ **4 Round Robin Tests completed (4 labs)**
- ✓ **Comparison between proposed methods (2010) and Adapted SHRP test methods (2002)**
- ✓ **Proposed new AIR test methods**
- ✓ **Recommendation to ballot new AIR test methods**
- ✓ **Finally, New AIR were published**

# AIR Methods Publications - 2012

SAE Aerospace
An SAE International Group

**AEROSPACE INFORMATION REPORT**

SAE AIR6170

Issued 2012-01

## Ice Melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals

RATIONALE

This test method, for liquid and solid deicing/anti-icing chemicals, offers a quantitative procedure to evaluate of ice melted as a function of the time and temperature by such deicing/anti-icing chemicals and is based on 205.2- MODIFIED FOR AIRPORT APPLICATION (draft April 17/02) - Test Method for Ice Melting of Chemicals (or Solids).

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Ice Melting - AIR6170
January 2012

SAE Aerospace
An SAE International Group

**AEROSPACE INFORMATION REPORT**

SAE AIR6172

Issued 2012-02

## Ice Undercutting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals

RATIONALE

This test method, for liquid and solid deicing/anti-icing chemicals, offers a quantitative procedure to evaluate the ice undercut as a function of the time and temperature by such deicing/anti-icing chemical and is based on the SHRP H-205.6- MODIFIED FOR AIRPORT APPLICATION (draft April 17/02) Test Method for Ice Undercutting by Liquid Deicing Chemicals (or Solids).

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Ice Undercutting - AIR6172
February 2012

SAE Aerospace
An SAE International Group

**AEROSPACE INFORMATION REPORT**

SAE AIR6211

Issued 2012-04

## Ice Penetration Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals

RATIONALE

This test method for liquid and solid runway deicing/anti-icing chemicals, offers a quantitative procedure to evaluate the ice penetration as a function of the time and temperature by such deicing/anti-icing chemicals, and based on the SHRP H-205.4-MODIFIED FOR AIRPORT APPLICATION (draft April 17/02) - Test Method for Ice Penetration of Liquid Deicing Chemicals (or Solids).

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Ice Penetration AIR6211
April 2012

# June 2012 - AIR Methods Included in AMS Specs

SAE Aerospace
An SAE International Group

**AEROSPACE MATERIAL SPECIFICATION**

| SAE AMS1431 | REV. D |
|---|---|
| Issued 1992-01<br>Revised 2012-06<br><br>Superseding AMS1431C | |

Compound, Solid Runway and Taxiway Deicing/Anti-Icing

3.2.10 Performance

The compound, used in accordance with manufacturer's recommendation, shall remove accumulated frozen deposits of frost and ice from aircraft maneuvering areas, such as airport aprons, runways, and taxiways. The compound shall be tested in accordance with AIR6170 for ice melting effectiveness, with AIR6172 for ice undercutting effectiveness, and with AIR6211 for ice penetration effectiveness. Acceptance criteria shall be agreed upon by purchaser and vendor.

SAE Aerospace
An SAE International Group

**AEROSPACE MATERIAL SPECIFICATION**

| SAE AMS1435 | REV. C |
|---|---|
| Issued 1995-04<br>Revised 2012-06<br><br>Superseding AMS1435B | |

(R) Fluid, Generic, Deicing/Anti-Icing
Runways and Taxiways

3.2.12 Performance

The fluid, used in accordance with manufacturer's recommendation, shall remove accumulated frozen deposits of frost and ice from airport aprons (ramps), taxiways, and runways. The fluid shall be tested in accordance with AIR6170 for ice melting effectiveness, with AIR6172 for ice undercutting effectiveness, and with AIR6211 for ice penetration effectiveness. Acceptance criteria shall be agreed upon by purchaser and vendor.

## Runway Deicers Tested so far at AMIL
## as per AIR6170, AIR6172 & AIR6211
### (May 2013)

| Test Methods | Test Temperature (°C) | Deicer Form | | Total Runway Deicers Tested |
|---|---|---|---|---|
| | | Liquid | Solid | |
| Ice Melting AIR 6170 | - 10 | 26 | 6 | 32 |
| | - 2 | | | |
| Ice Undercutting AIR 6172 | - 10 | 24 | 6 | 30 |
| | - 2 | | | |
| Ice Penetration AIR 6211 | - 10 | 13 | 5 | 18 |

# 2012 Montreal Meeting Highlights

## Conclusions:

- **AIR6211 Ice Penetration Test Method :**
  - **Round Robin Test to validate a second test temperature**
  - **Planned for February 2013**
- **Adaptive WSET Test :**
  - **Still under investigation**
  - **Additional data are required**

# AIR6211 Ice Penetration

# 2013 Round Robin Test Summary

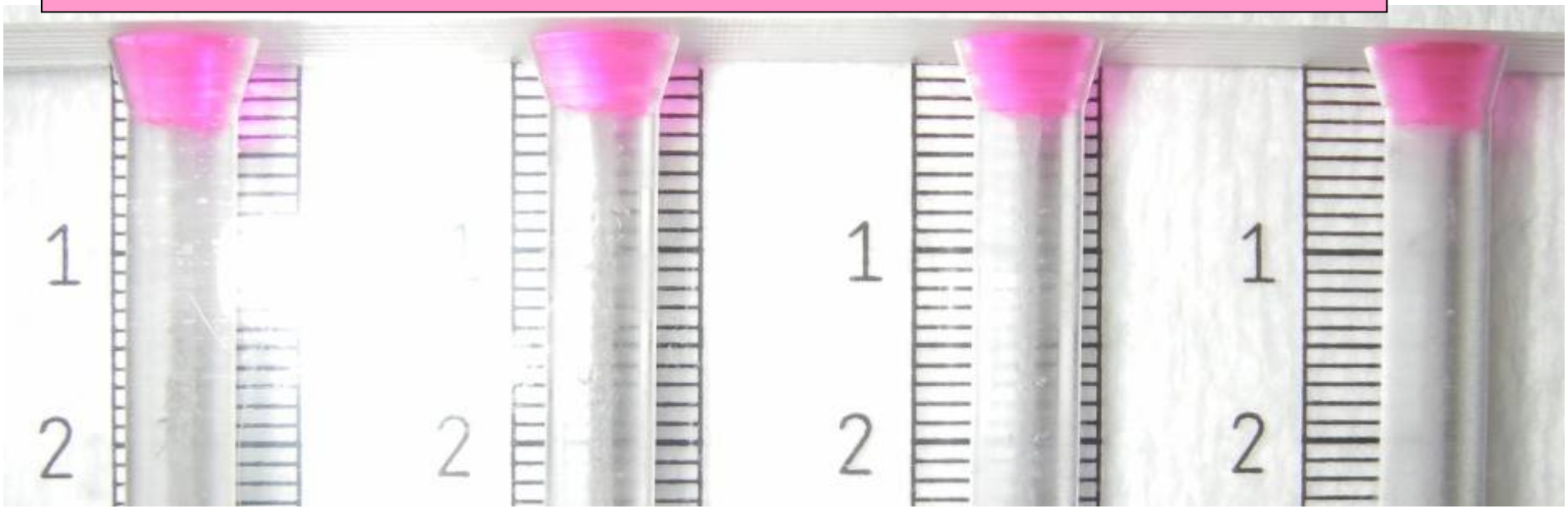
# Ice Penetration - RRT Description

## Round Robin Test initiated in January 2013

- ✓ **Participants :**
  - ➢ **ABAX Industries**
  - ➢ **AMIL**
  - ➢ **CETE Est – LRN, France (Ministry of Environment)**
  - ➢ **Clariant Produkte**
- ✓ **6 manufacturers provided with runway de-icers**
- ✓ **AIR6211 Round Robin Test Goal :**
  - ➢ **To validate - 5 °C as second test temperature**

# Why validate - 5 °C ?

- **Prague Meeting 2012**
- **AMIL presented preliminary results at -5 °C**
- **WG members recommended to go ahead with a Round Robin Test**



# Round Robin Test 2013

**16 Runway deicers in Round Robin Test Kit**

**6 solids**

**10 liquids**

**So far 8 Runway deicers tested by 4 labs**

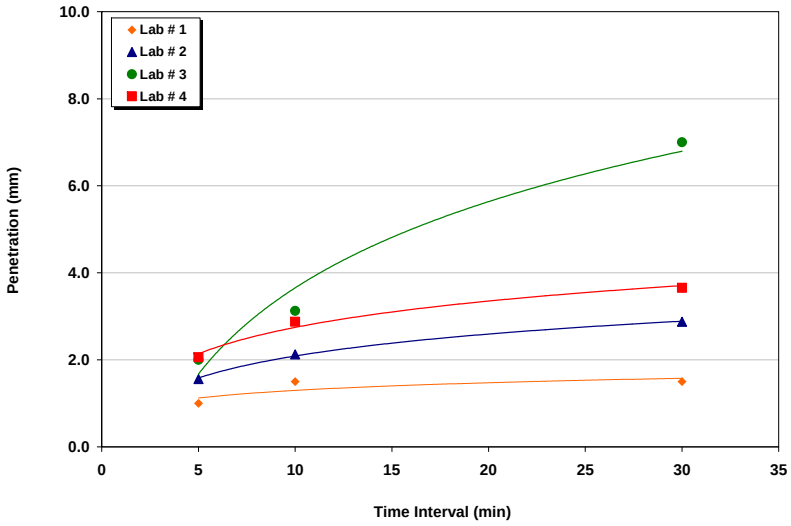
| RDF # ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Form | S | L | L | L | S | L | S | L | S | L | S | L | S | L | L | L |

**S : solid**

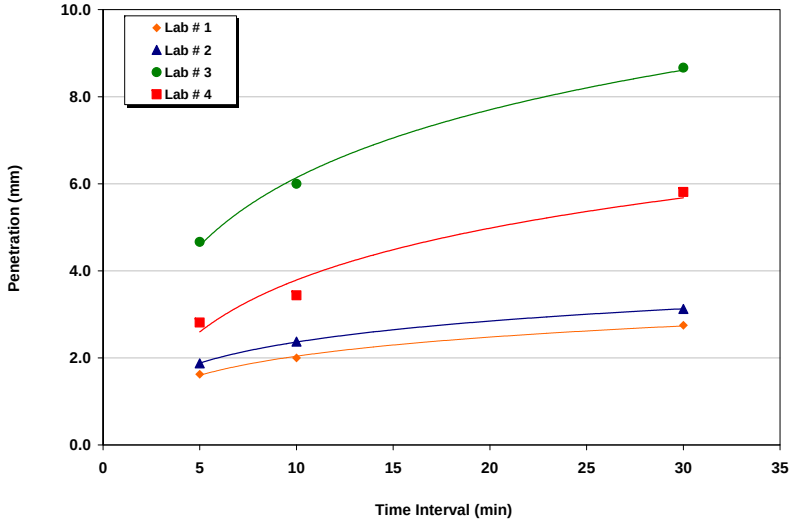
**L : liquid**

# Round Robin Test 2013 - General Trends - Runway Deicers A - D

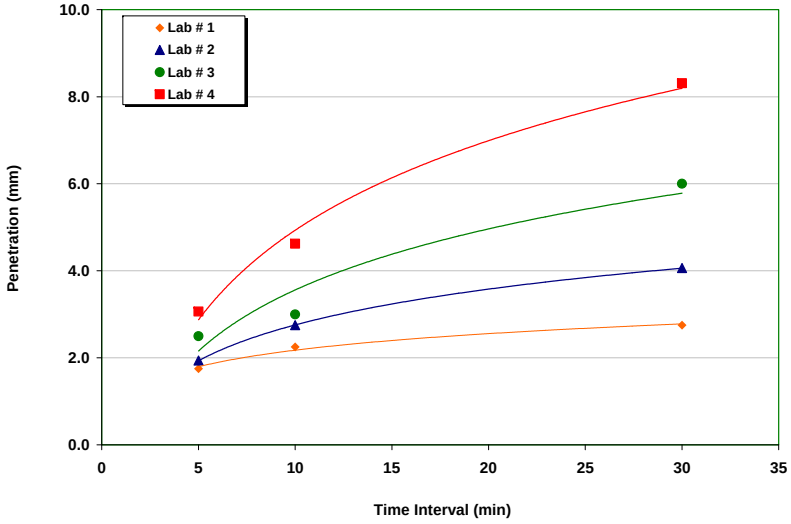
AIR6211 - Ice Penetration Results at -5°C - RDF # A



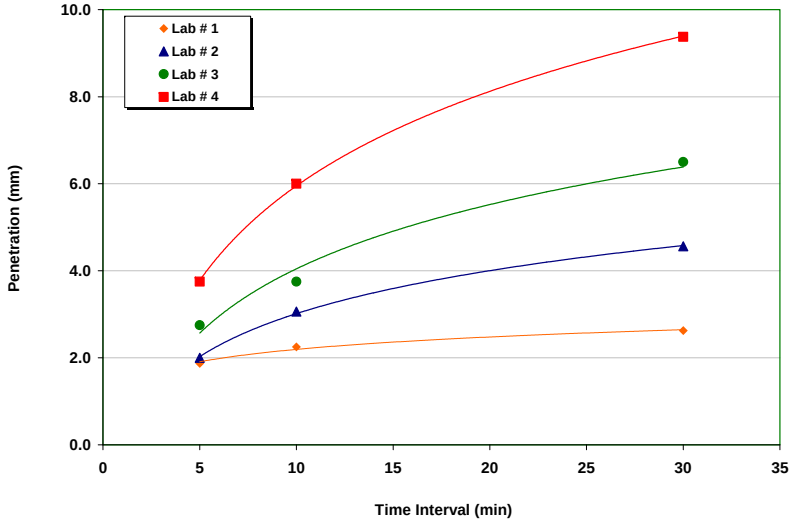

AIR6211 - Ice Penetration Results at -5°C - RDF # B




AIR6211 - Ice Penetration Results at -5°C - RDF # C

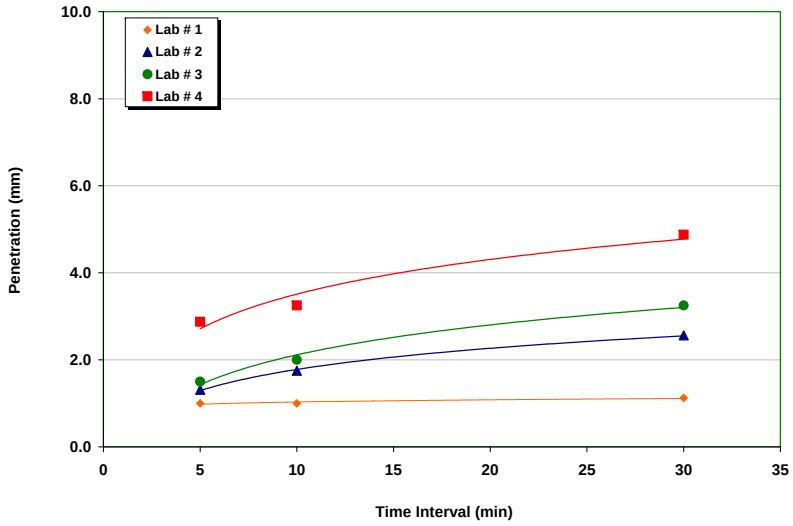



AIR6211 - Ice Penetration Results at -5°C - RDF # D

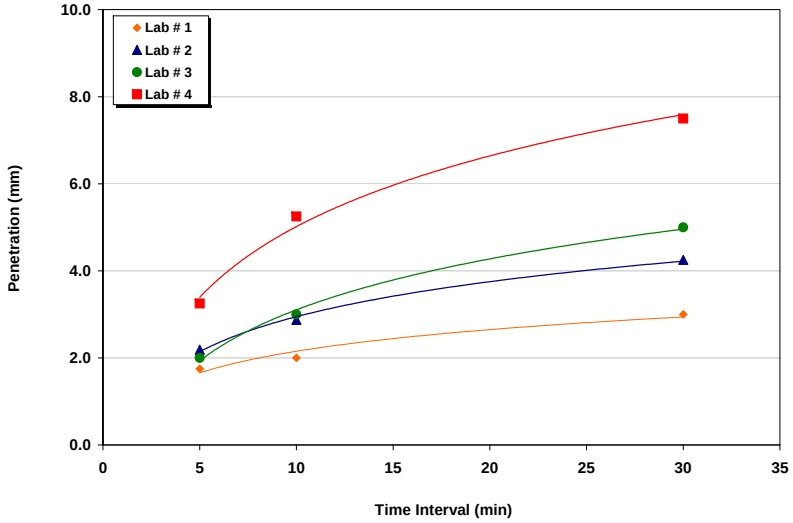


# Round Robin Test 2013 - General Trends - Runway Deicers E - H

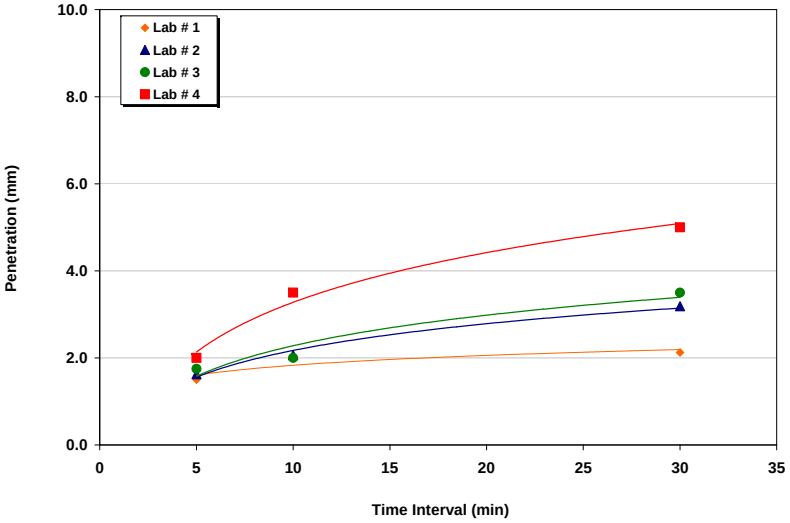
AIR6211 - Ice Penetration Results at -5°C - RDF # E



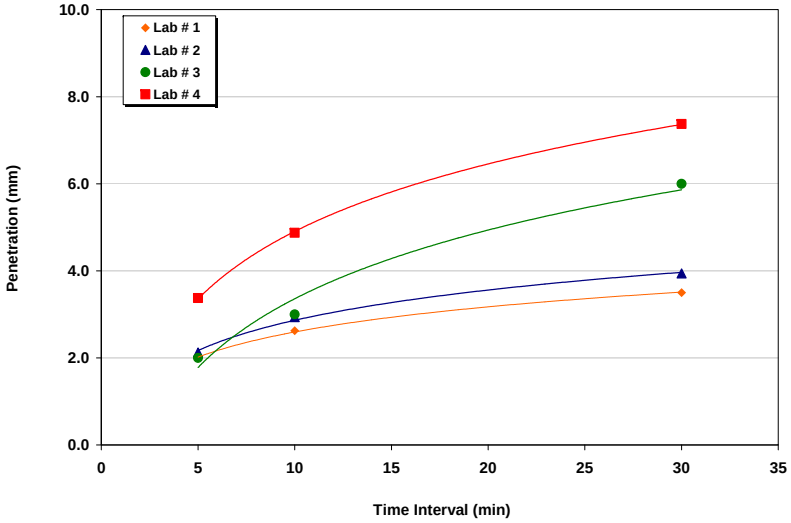

AIR6211 - Ice Penetration Results at -5°C - RDF # F




AIR6211 - Ice Penetration Results at -5°C - RDF # G

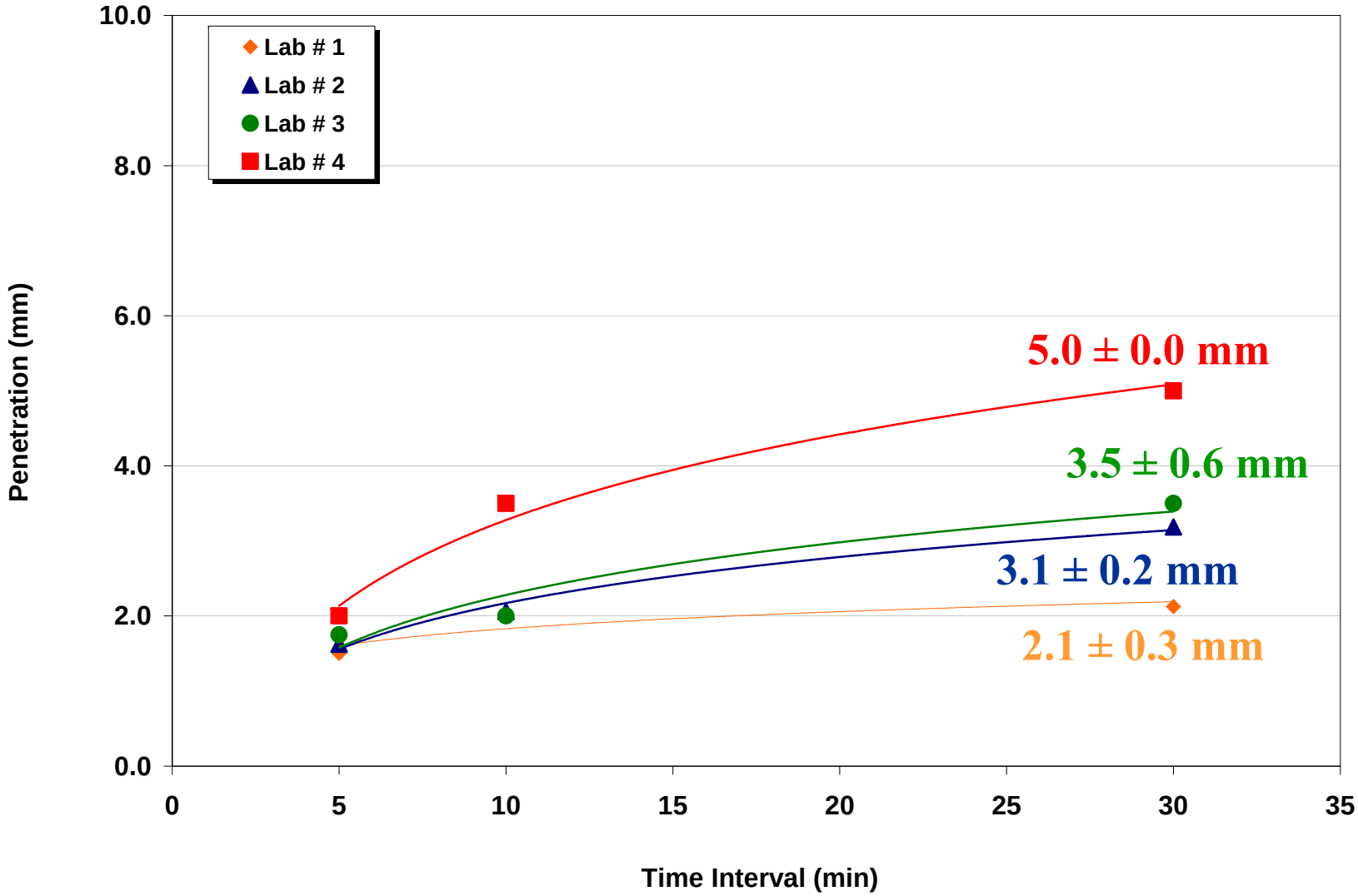



AIR6211 - Ice Penetration Results at -5°C - RDF # H



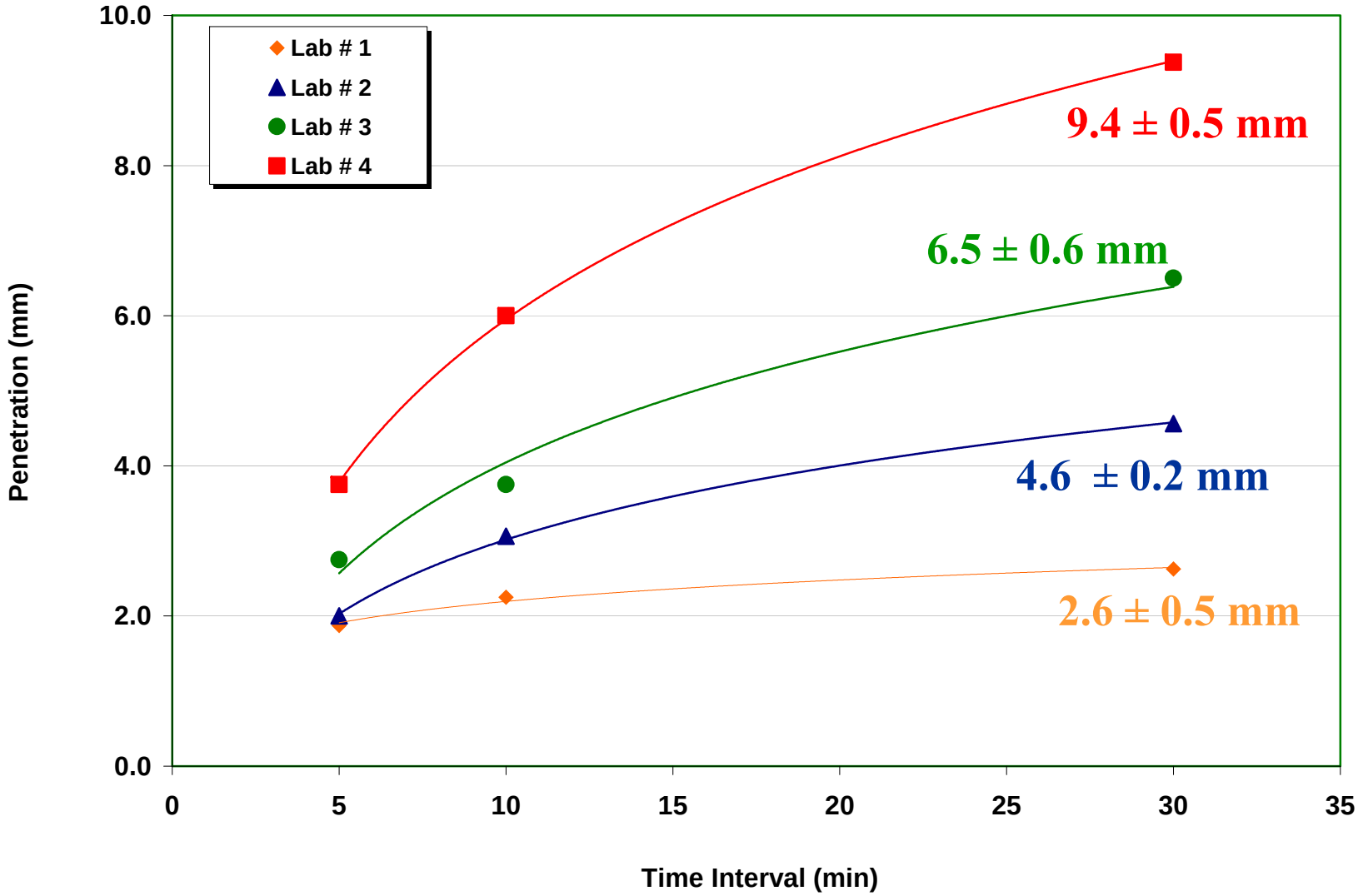
# Round Robin Test 2013 - Best Correlation

## AIR6211 - Ice Penetration Results at -5°C - RDF # G



# Round Robin Test 2013 - Worst Correlation

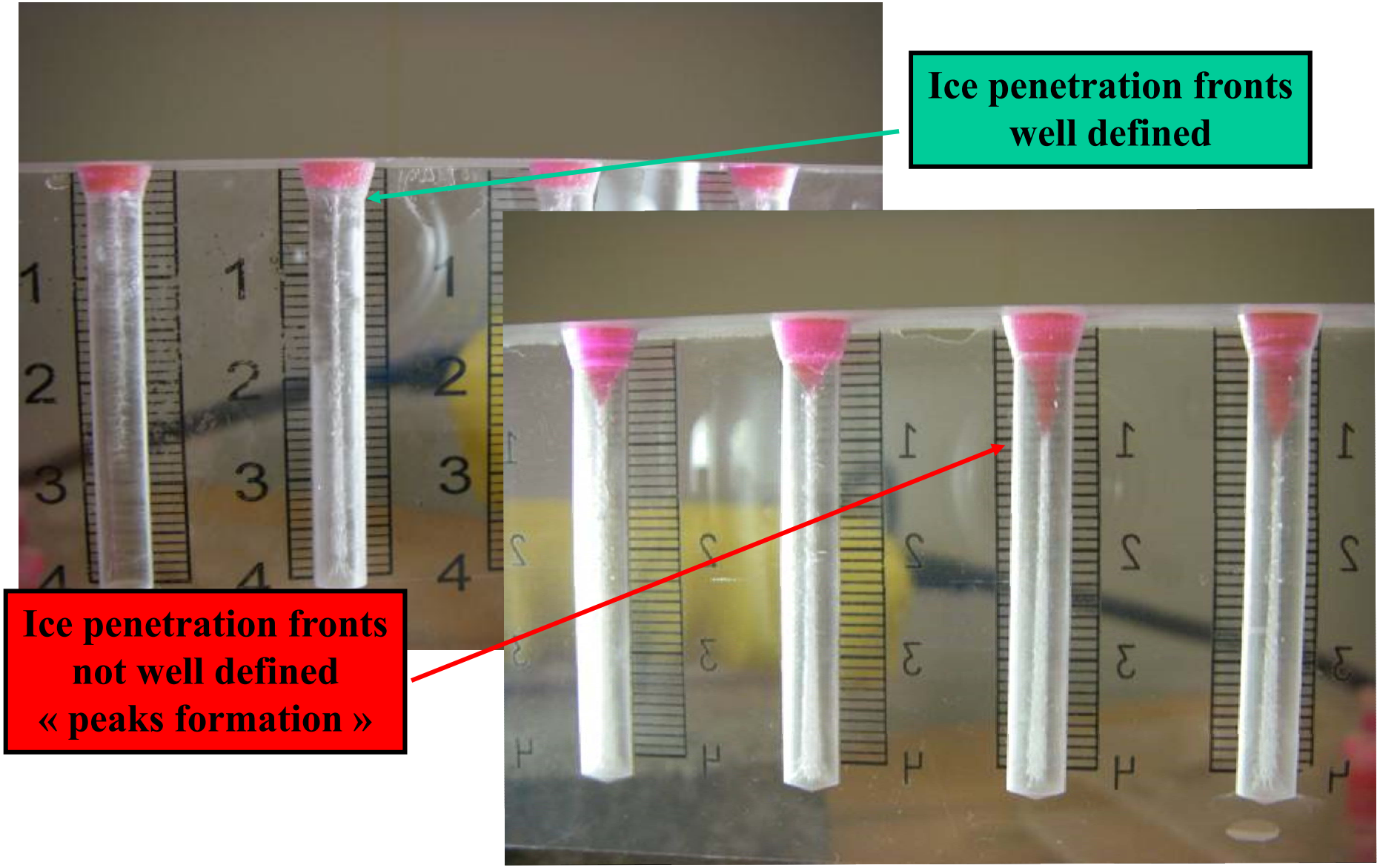
## AIR6211 - Ice Penetration Results at -5°C - RDF # D



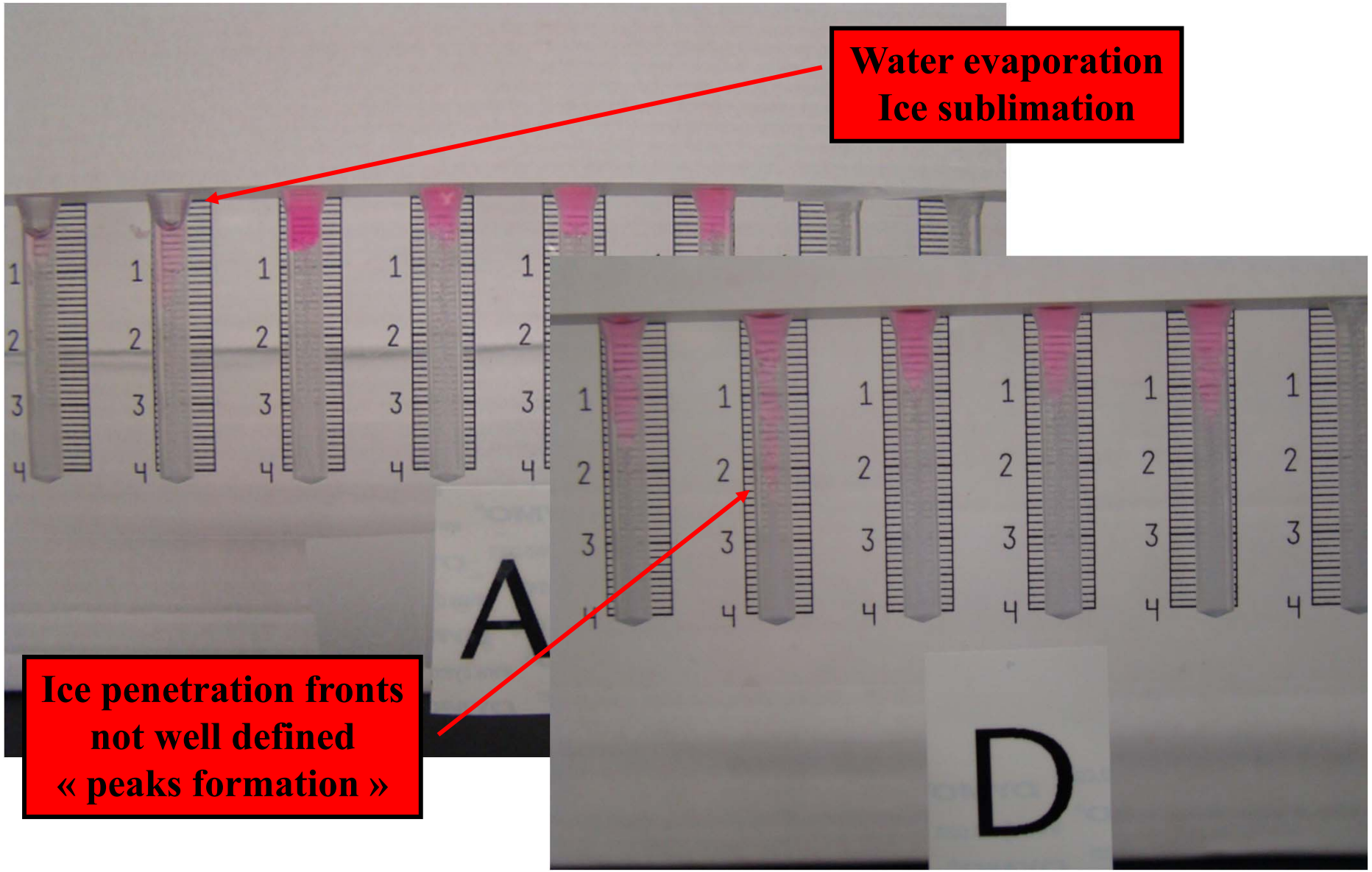
## Ice Penetration Test Results at -5°C

| 2013 Round Robin Test / Observations | | |
|---|---|---|
| **Lab #** | **Ice Preparation** | **Ice Penetration Measurement** |
| **# 1** | **Water evaporation**<br>**Water undercooling**<br>**for many cases** | **Ice penetration fronts not well defined**<br>**« peaks formation » for many cases** |
| **# 2** | **ok** | **Ice penetration fronts not well defined**<br>**« peaks formation » for many cases** |
| **# 3** | **Water evaporation**<br>**Ice sublimation**<br>**Water undercooling**<br>**for many cases** | **Ice penetration fronts not well defined**<br>**« peaks formation » for many cases** |
| **# 4** | | **Ice penetration fronts not well defined**<br>**« peaks formation » A-B-C** |

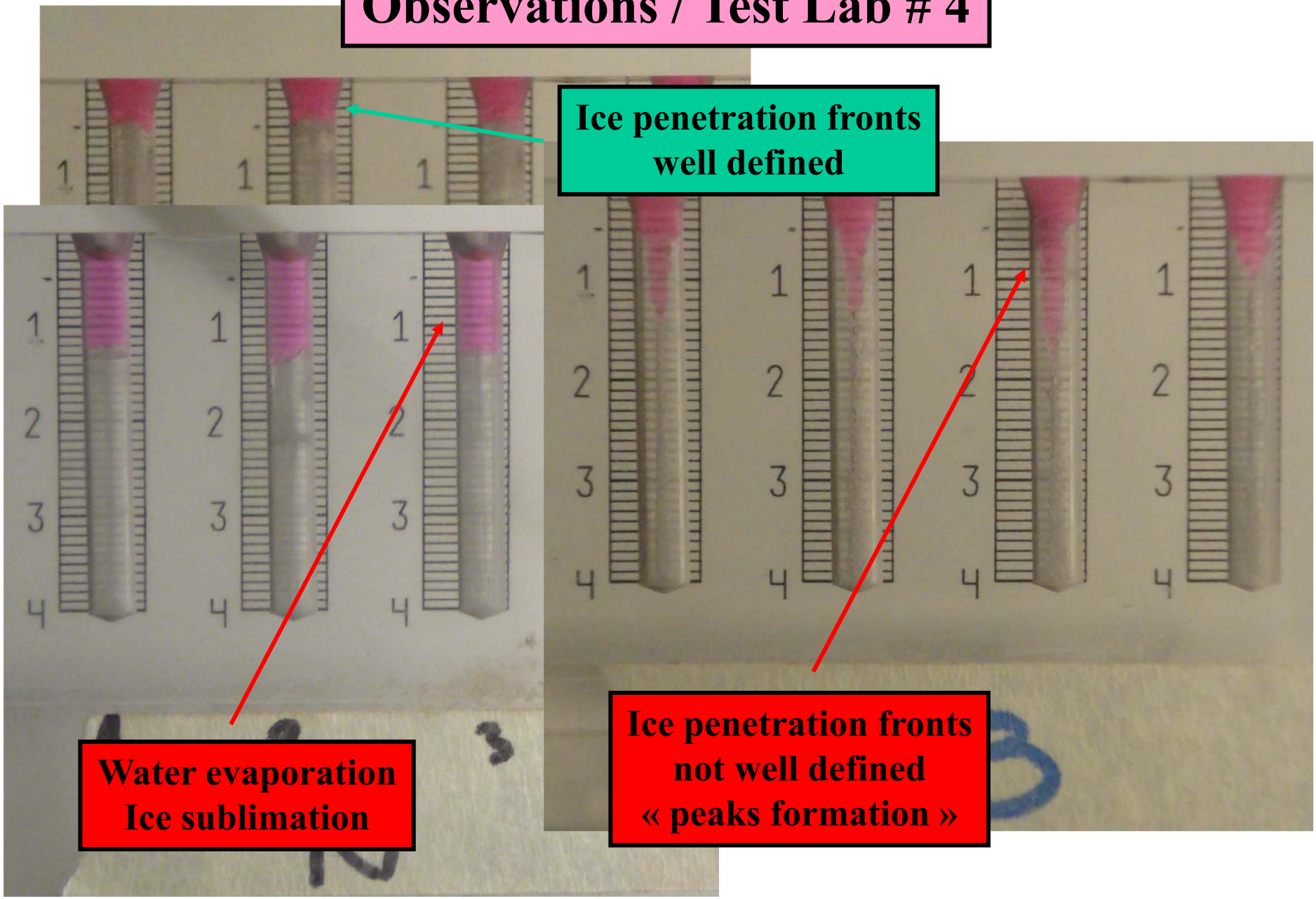
# Observations / Test Lab # 2



# Observations / Test Lab # 3



# Observations / Test Lab # 4



# Round Robin Test Conclusions

- ✓ **Gathering data of 8 Runway deicers (4 test labs comparison)**
- ✓ **Good trends from one lab to another**
- ✓ **Interlab results are inconsistent, except for two cases**
- ✓ **3 labs reported problems with ice preparation**
- ✓ **When the ice preparation is ok**
  - ➢ **Still inconsistent results from one lab to another**

# RRT 2013 Recommendations

## AIR6211 Round Robin Test status :

- **To complete Round Robin Test at - 5 °C ?**

- **To hold off Round Robin Test and investigate ice preparation process**
  - ✓ **To present recommendations at next Montreal meeting (Nov 2013) ?**

- **Suggestions ?**

# Adaptive WSET Test Update

# Adaptive WSET Test - Background
## 2010 Montreal Meeting

- ✓ **RDF Performance WG Members recommended**

**To investigate a Holdover Time test method including a slip test for Runway Deicers**

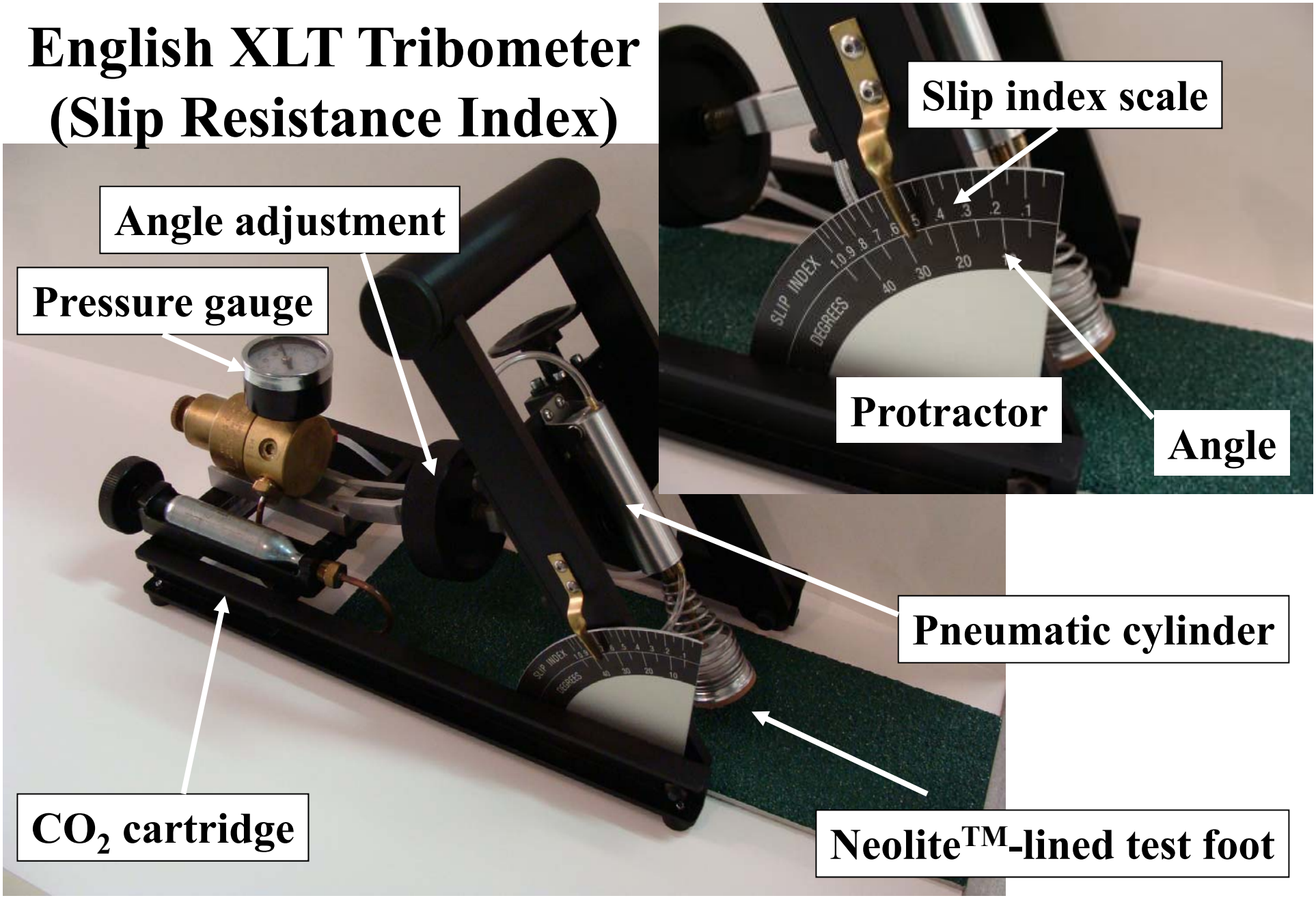
- ✓ **It was suggested to develop an «Adaptive» WSET Test**
  - ➢ **Using the WSET test device and protocol (AS5901)**
  - ➢ **With controlled T°: air / test panels**
  - ➢ **Have ice catch panels (icing intensity)**
  - ➢ **Use adapted test panels with standardized test surface**
  - ➢ **To compare commercial RDFs to generic fluids**

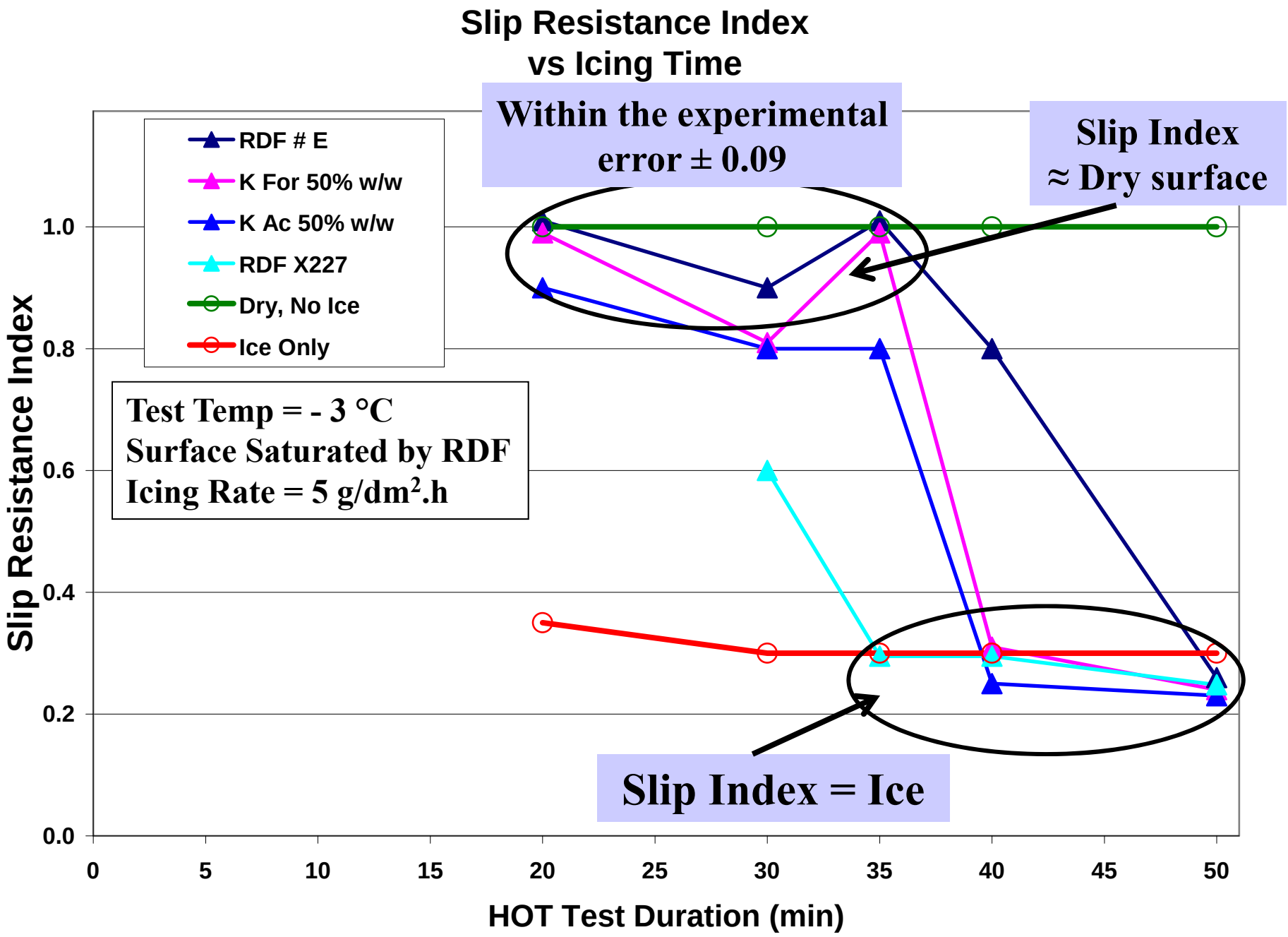
## Proposed Adaptive WSET Test - Background
## San Francisco Meeting 2011

1. **Application of RDF on test panels (standardized test surface)**
2. **Place the test Panel Upright : (Flow-off Time 1 minute)**
3. **To start ice precipitation (5.0 g/dm$^2$/h )**
4. **Using the English XLT Tribometer**
   - ✓ **Slip Resistance Index Measurement (test times = 20-30-35-40-50 min)**

## Material Description (SLIP RESISTANCE METER)

# English XLT Tribometer (Slip Resistance Index)




Slip Resistance Index
vs Icing Time
Within the experimental error ± 0.09
Slip Index ≈ Dry surface
RDF # E
K For 50% w/w
K Ac 50% w/w
RDF X227
Dry, No Ice
Ice Only
Test Temp = - 3 °C
Surface Saturated by RDF
Icing Rate = 5 g/dm².h
Slip Index = Ice
Slip Resistance Index
HOT Test Duration (min)
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
35
40
45
50

# Preliminary Adaptive WSET Test Conclusions (San Francisco 2011)

- ✓**WG members stated that the Slip Test seems to be a promising method to evaluate and compare the anti-icing endurance time of RDFs**

- ✓**However, we recognized that this method needs further investigation**

# 2011-2013 Many Questions Occured

## Technical comments

- Need discussion on what customers want
- Find an appropriate standardized test surface
- Concerns about the application procedure
- How to find a realistic way for using this method

- Main Concern :
  - ✓ The use of English XLT Tribometer
    - ❑ This instrument is not unanimously accepted
    - ❑ Concerns about the reliability of the instrument

ASTM F1679-04e1

# English XLT Tribometer vs ASTM Standard

**Withdrawn Standard:** ASTM F1679-04e1 Standard Test Method for Using a Variable Incidence Tribometer (VIT) (Withdrawn 2006)

## Information supporting those concerns

**This instrument had an ASTM test method (ASTM F1679) at one time, but was withdrawn for a very important reason; for failure to include an approved precision statement ….**

**Withdrawn Rationale:**

This test method covers the operational procedures for using a variable incidence tribometer (VIT) for determining the slip resistance of planar walkway surfaces or walkway surrogates (test surfaces) and can be used for footwear bottom materials and surrogates (test feet) in either the laboratory or field under dry, wet, or contaminated conditions. This test method does not address all methodological issues (for example, test surface and test foot material selection and preparation, experimental design, or report preparation).

Formerly under the jurisdiction of Committee F13 on Pedestrian/Walkway Safety and Footwear, this test method was withdrawn as an active ASTM standard by action of the Committee of Standards (COS) on September 30, 2006 for failure to include an approved precision statement (violating Section A21 of the Form and Style for ASTM Standards), and for including reference to proprietary apparatus where alternatives exist (violating Section 15 of the Regulations Governing ASTM Technical Committees).

# English XLT Tribometer Status

**All in all**

- ✓Did not make sense to continue to use this instrument
- ✓Still want to investigate the test method

Stéphanie Poissonnier CETE France

**Question ?**

- ✓Can we find a reliable instrument giving more credible results ?

**Suggested an instrument**

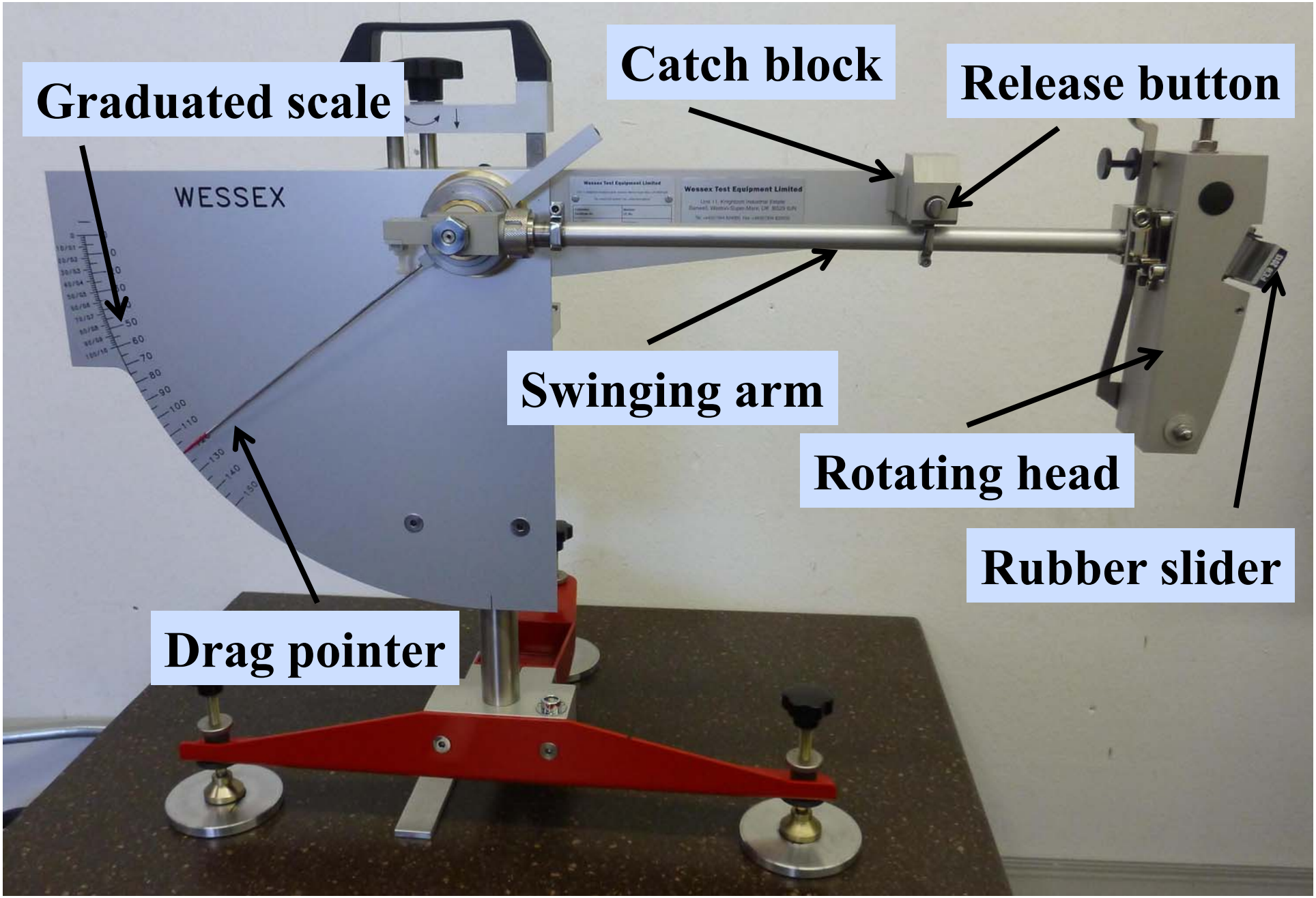
- ✓Having a current ASTM test method
- ✓Currently used in Europe and North America for road surface testing, testing of aggregates, floors …

# Portable Skid Resistance Tester
or
# British Pendulum Tester
# ASTM E303 Test Method

Standard Test Method for
Measuring Surface Frictional Properties Using the British Pendulum Tester[1]

| Skid Resistance Tester also meets | | Currently used |
|---|---|---|
| BS EN 13036-4 : 2003 | Road and Airfield surface characteristics | UK Transport Research Lab |
| EN 1436 : 1997 | Road Marking Materials | |
| BS EN 1097-8 | Determination of Polished StoneValue | CETE Est, France |
| BS 6077 Pt 1 | Slip resistance classification of new pedestrian surface materials | Ministry of Environment |
| BS 7044 | Artificial sports surfaces; person/surface interaction | Sherbrooke University Qc Canada |
| BS 7188 | Impact absorbina playground surfaces | |
| BS 8204 | Code of practice for polymer modified cementitious wearing surfaces | Norwegian University of Science and technology |
| BS 7976 | Method of operation and calibration of the pendulum tester | (Departement of Civil and Transport Engineering) |

# AMIL- Skid Resistance Tester



# Skid Resistance Tester – How it works

- **Fit the rubber slider onto the rotating head**
- **Place the test surface on the test table**
- **The pendulum is released from the horizontal position**
- **The distance travelled by the head after striking the sample is determined by the friction of the sample surface**
- **A reading of Skid Resistance is obtained on the scale at the drag pointer position**

  **Unit : BPN (British Pendulum Number)**

**Measuring principle :**

- ✓ **It slips easily: the pendulum will continue its rotating movement until it reaches a low BPN value**
- ✓ **It does not slip easily: the pendulum will slow down and will show a high BPN value**

# Skid Resistance Tester - Video

# Slip Index vs Skid Resistance (BPN)

**ADF fluids (1mm) on Al panel**
**0°C – Low S.I. / BPN values**

**Two ADF Type I fluids**
**Fluid A (PG) & Fluid B (NG)**

**BPN variation = 6**
**More sensitive instrument**

**Skid Tester**

**Slip Meter**




**BPN = 12 ± 1**

**BPN = 6 ± 2**



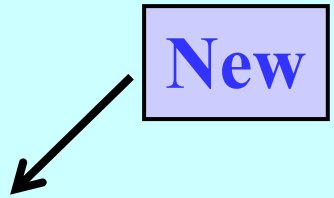

**No difference**
**S.I. = 0.05 ± 0.09**

## New Adaptive WSET Test Performed
## Anti-icing Screening Test (as previous method)

1. Application of the tested RDF on 5 test panels by immersion (1 minute)
2. Place test panels upright :
3. Flow-off time 30 seconds
4. Put test panels on the Frosticator
5. Start ice precipitation (5.0 g/dm$^2$.h )
6. Measure the Skid Resistance (BPN)

   On one plate for each icing time of :

   0 – 5 – 15 – 30 and 40 min



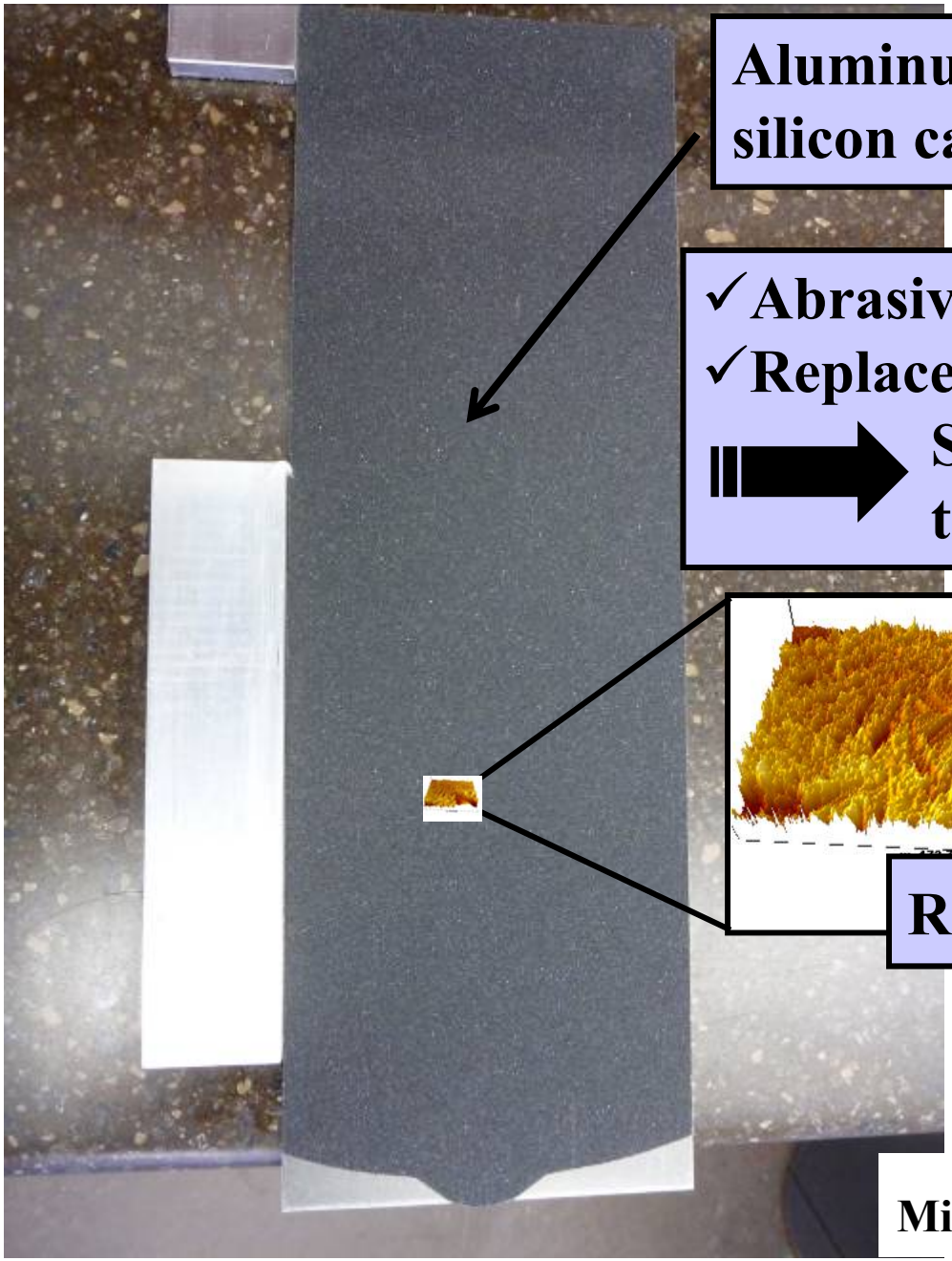
# Adaptive WSET Test Conditions

- ✓ Air
- ✓ Test panels
- ✓ Fluid application
- ✓ Skid resistance test

} -5 °C

- ✓ Ice intensity ≈ 5.0 g/dm².h
- ✓ Test surface : 120 grit

# Preliminary Adaptive WSET Test - Test Surface



**Aluminum plates coated with 120 grit silicon carbide abrasive paper**

- ✓ **Abrasive paper is stuck on Al plate**
- ✓ **Replaced between each tested fluid**

**Start each testing with new test surface sample**

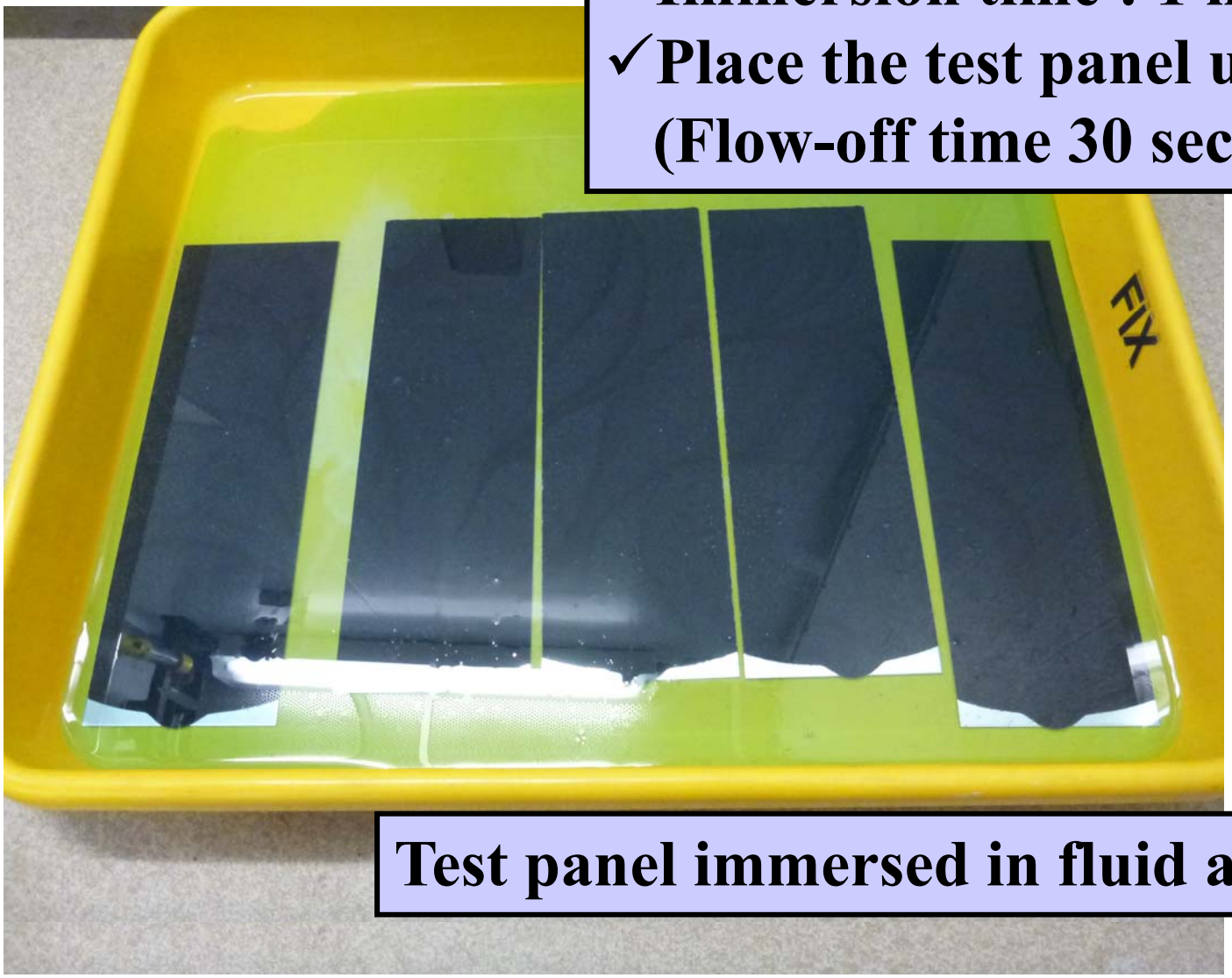


$R_a = 5.54\ \mu m \pm 1.2\ \mu m$

**MicroXAM-100 HR 3D surface Profilometer**

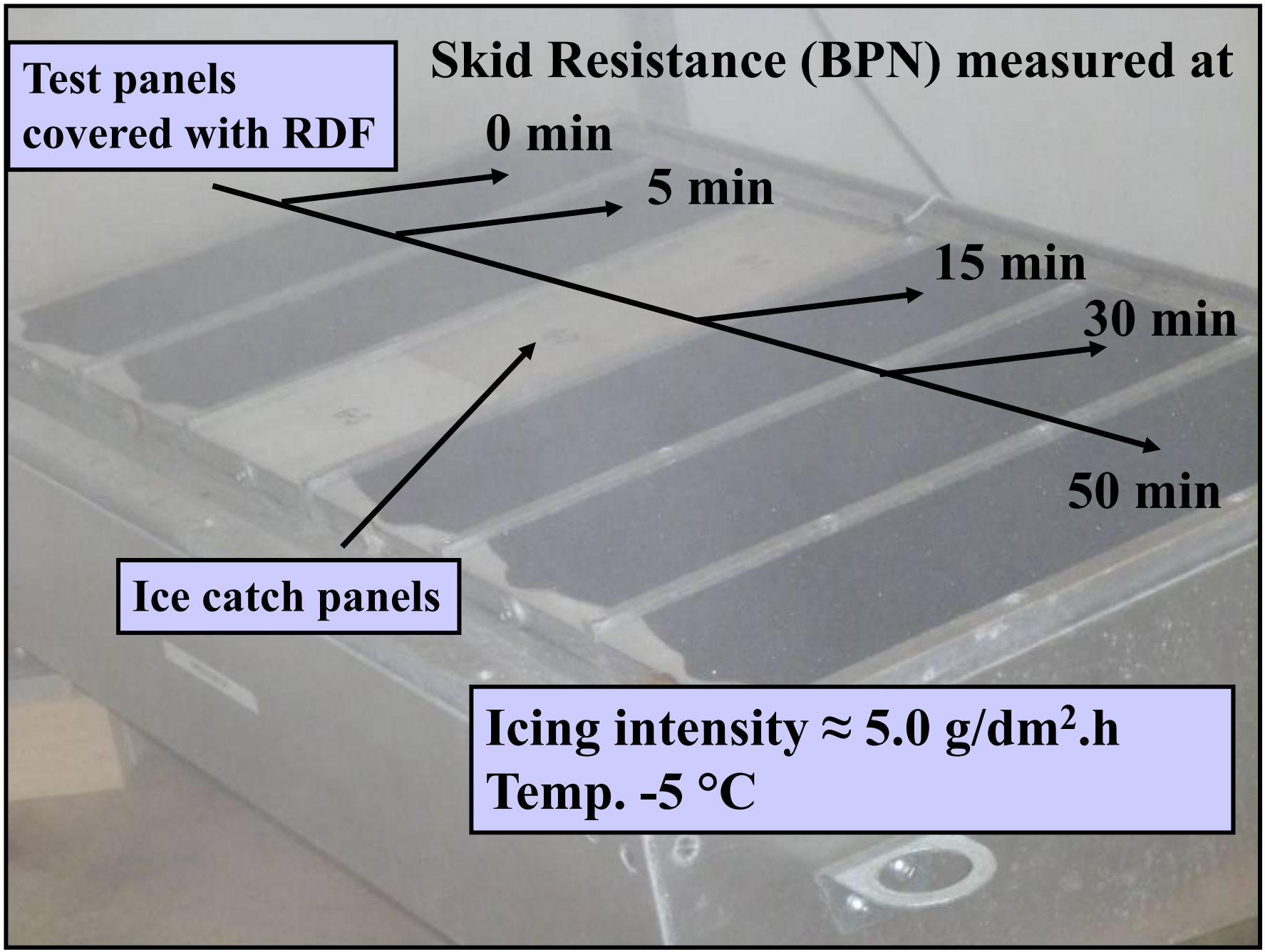
# Preliminay Adaptive WSET Test - Fluid Application

- ✓**Immersion time : 1 minute**
- ✓**Place the test panel upright : (Flow-off time 30 seconds)**

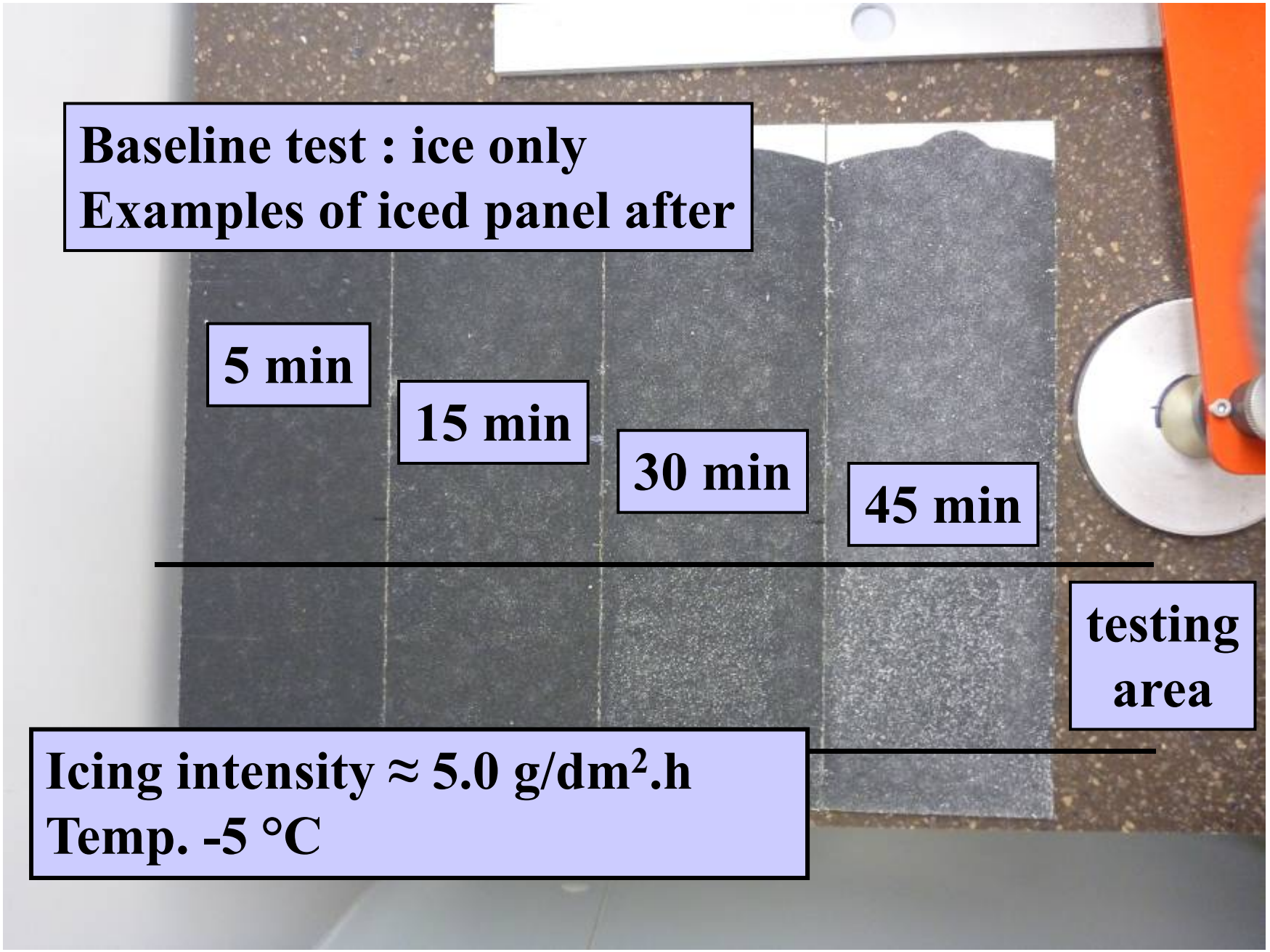



**Test panel immersed in fluid at -5 °C**

## Adaptive WSET Test in Progress - Frosticator



# Adaptive WSET Test - Icing Time

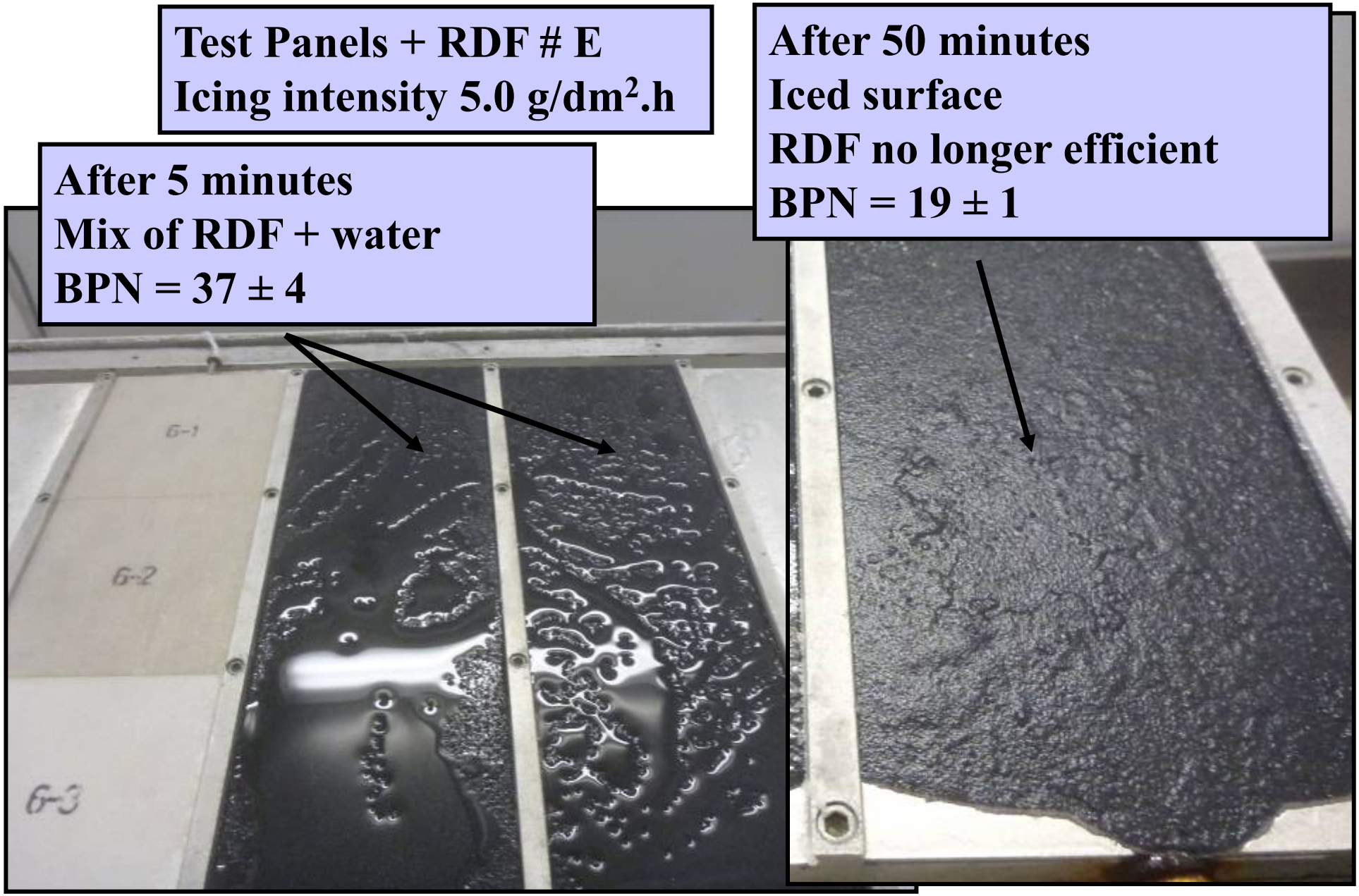


# Example of panels protected with RDF after icing precipitation

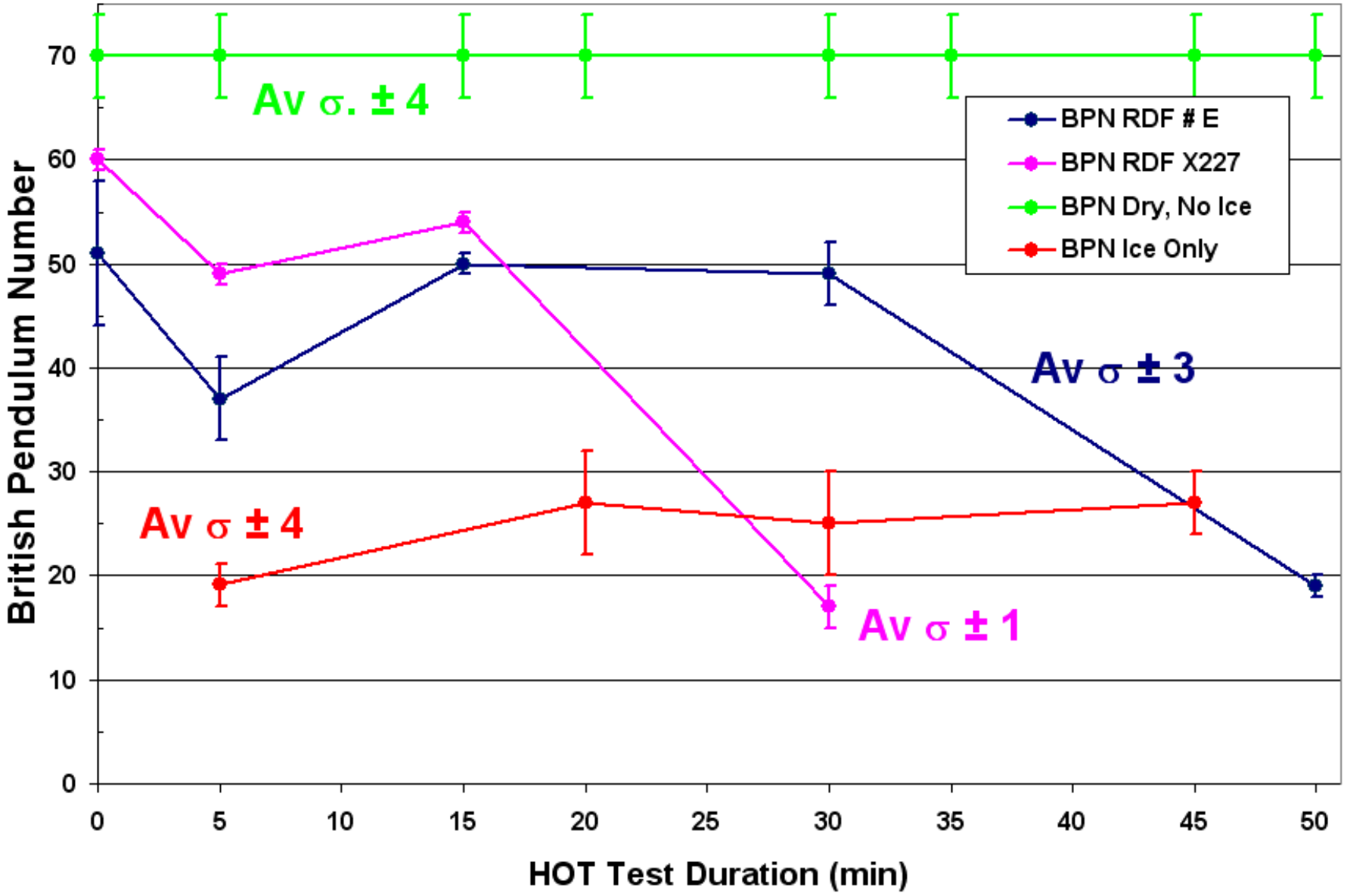
**Test Panels + RDF # E**
**Icing intensity 5.0 g/dm$^2$.h**

**After 5 minutes**
**Mix of RDF + water**
**BPN = 37 ± 4**

**After 50 minutes**
**Iced surface**
**RDF no longer efficient**
**BPN = 19 ± 1**



# Preliminary Adaptive WSET Test - Results
## Skid Resistance vs Icing Time (average of 5)



# Further Investigation

## Test Parameters

- **Find a standardized test surface**
  - **Concrete pavement ASTM C672 :**
    **Already used in AMS1431 (3.2.8.1) / AMS1435 (3.2.10.1) for Runway Concrete Surface Scaling Resistance Test**
  - **Asphalt concrete EN 12697-41 (AMS 1431/1435)**
    **Asphalt Concrete Degradation Resistance Test**
- **Test temperature**
  - **Air, Test panels : (0 °C to -10 °C)**
- **Fluid application**
  - **Spraying device**
  - **Weighing device**
- **Type of precipitation**
  - **Freezing Rain, Freezing Drizzle, Snow, etc …**

## Adaptive WSET Test Conclusions

- ✓ **English XLT Tribometer**
  - ➢ **was good to initiate the study, did not offer acceptable precision, under cold conditions**
- ✓ **Skid Resistance Tester**
  - ➢ **has current ASTM/BS test methods (ASTM E303/ BS EN 13036)**
  - ➢ **is already used in Europe and North America (road surface testing)**
  - ➢ **clearly gives more credible results (more sensitive)**
  - ➢ **is portable (for use in actual outdoor conditions)**
- ✓ **Screening tests clearly demonstrated that this method could be used to compare RDF anti-icing performance**
- ✓ **Possibility of Round Robin Testing**

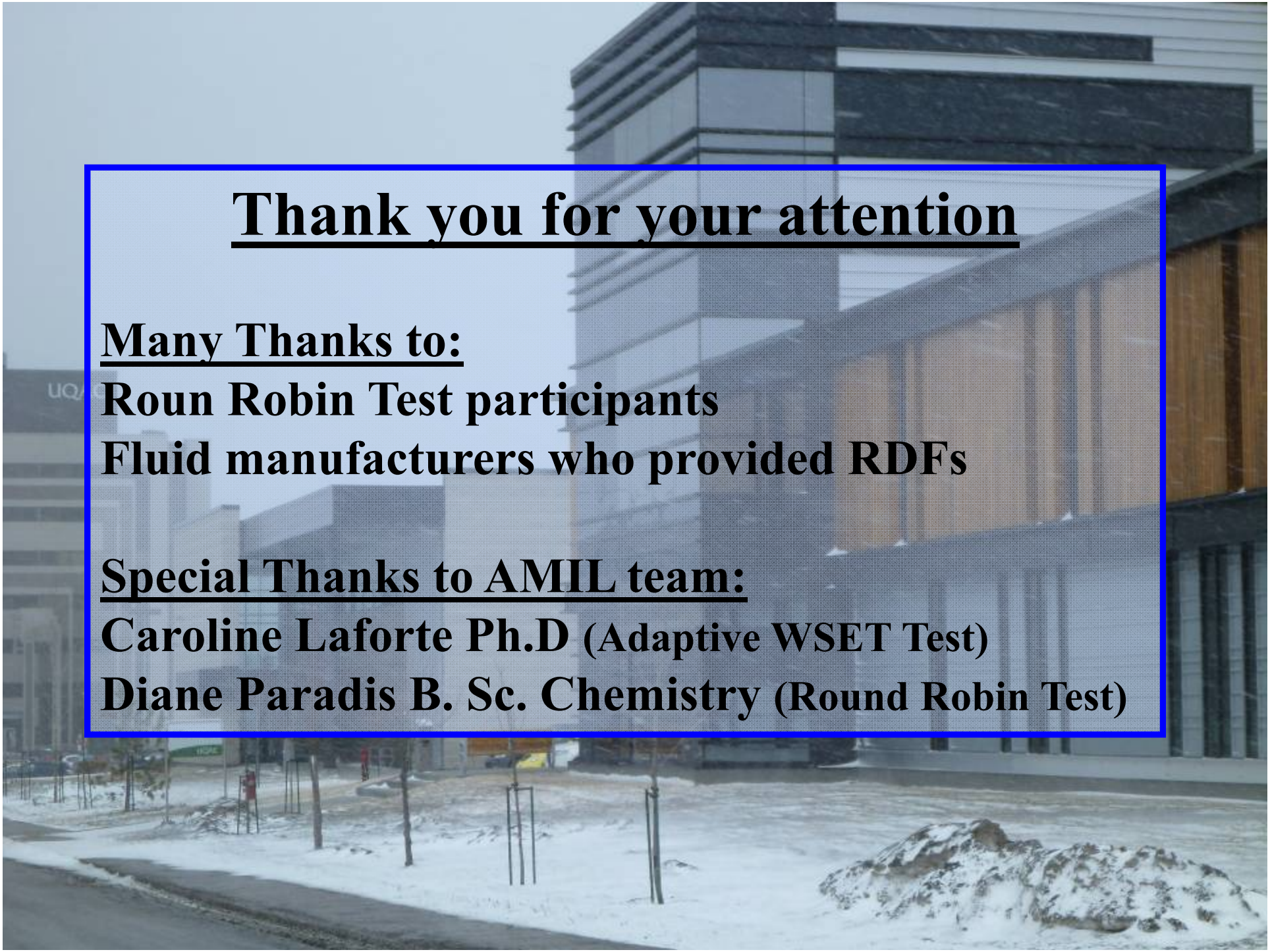
## Adaptive WSET Test Recommendations

# Why Adaptive WSET Test ? :

- ✓ **To develop more efficient and sustainable RDF (safe for landing)**
- ✓ **Priority is the safety**

# We suggest to continue the investigation AMIL volunteers to go ahead with further works for RDF Performance Working Group

- ❑ **AMIL has already hired a summer student (Engineering) to obtain further data with Skid Resistance Tester**
- ❑ **AMIL could present new data at the next Montreal meeting**



# Thank you for your attention


**Many Thanks to:**

**Roun Robin Test participants**

**Fluid manufacturers who provided RDFs**

**Special Thanks to AMIL team:**

**Caroline Laforte Ph.D (Adaptive WSET Test)**

**Diane Paradis B. Sc. Chemistry (Round Robin Test)**