Contamination, wettability and the ski running surface gliding ability

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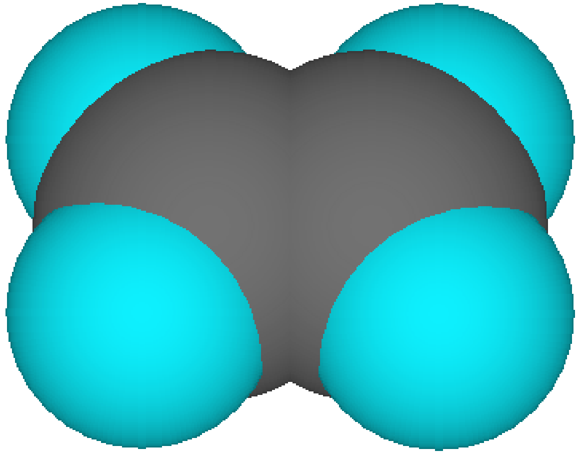
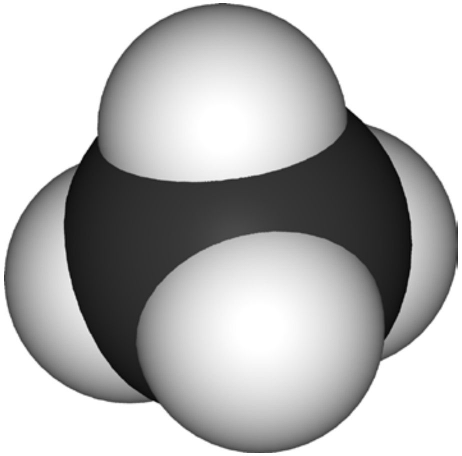
Glide waxes and ski base are a consanguineous population.

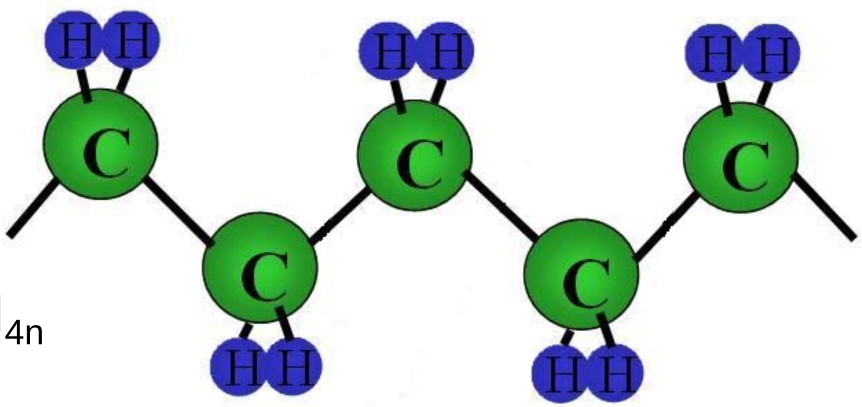


Ethylene C_2H_4



Methane CH_4

Polyethylene: $C_{2n}H_{4n}$



Paraffin: C_nH_{2n+2}

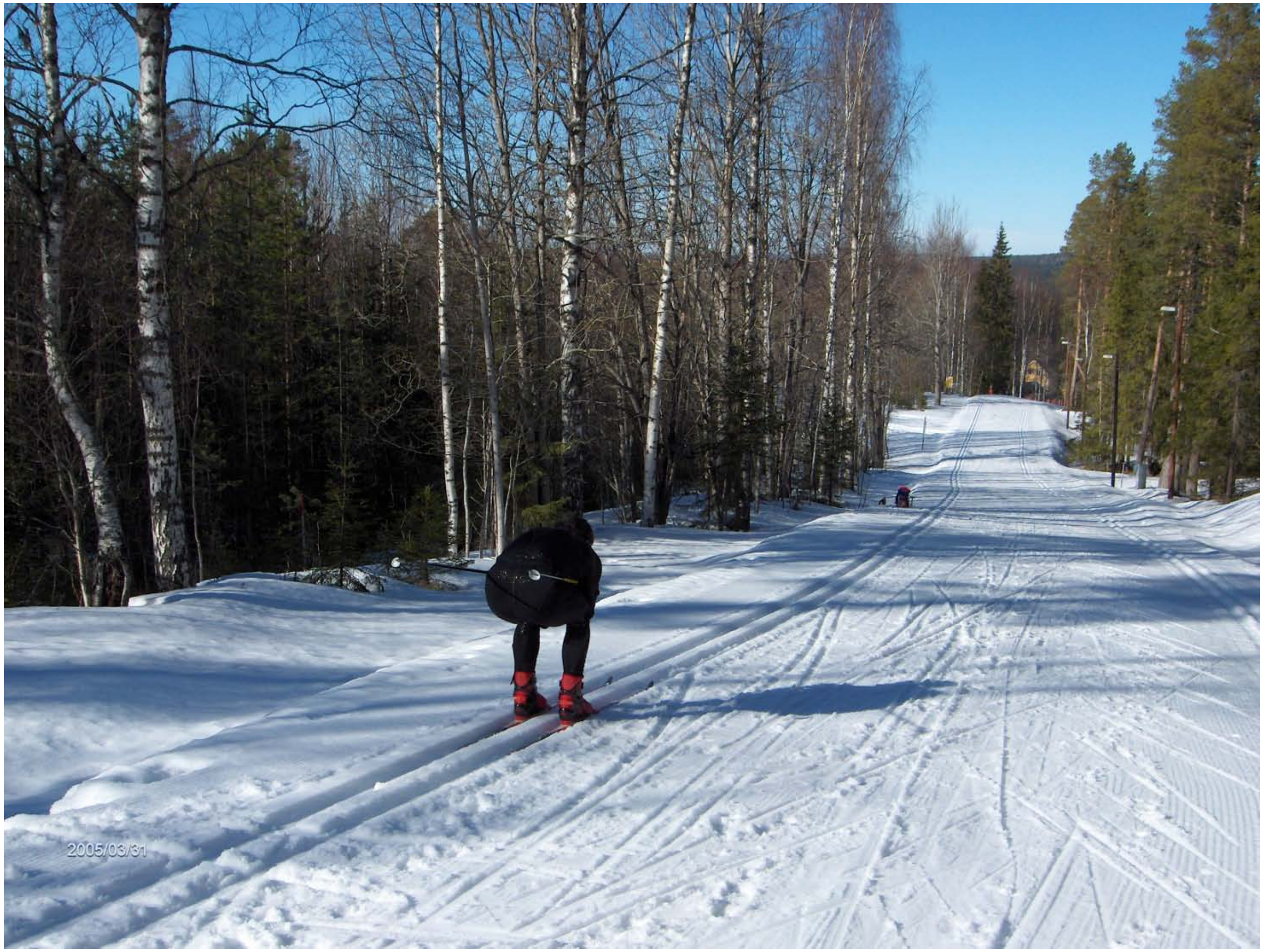
Why we have to treat skis with glide wax?

- Glide waxes (paraffins, microcrystalline waxes, synthetic waxes, etc.) and Ultra High Molecular Weight Polyethylene (UHMWPE) are very similar substances. Essential distinctions lie in molecular chain length.
- Why can not UHMWPE have the same or higher gliding ability?

Steel scraped skis compared to waxed ski.

- Steel scraped (peeled) unwaxed skis were compared to steel scraped and waxed.
- Glide test was performed on a slope.
- Ski base contamination was determined by an USB camera.
- The running surface hydrophobicity was determined by a goniometer.

Glide velocity was registered by one well established procedure.



Black on black is invisible.

- Madshus A/S kindly did help us and made a few pairs skis with transparent base (P-Tex® 2000) and white background.

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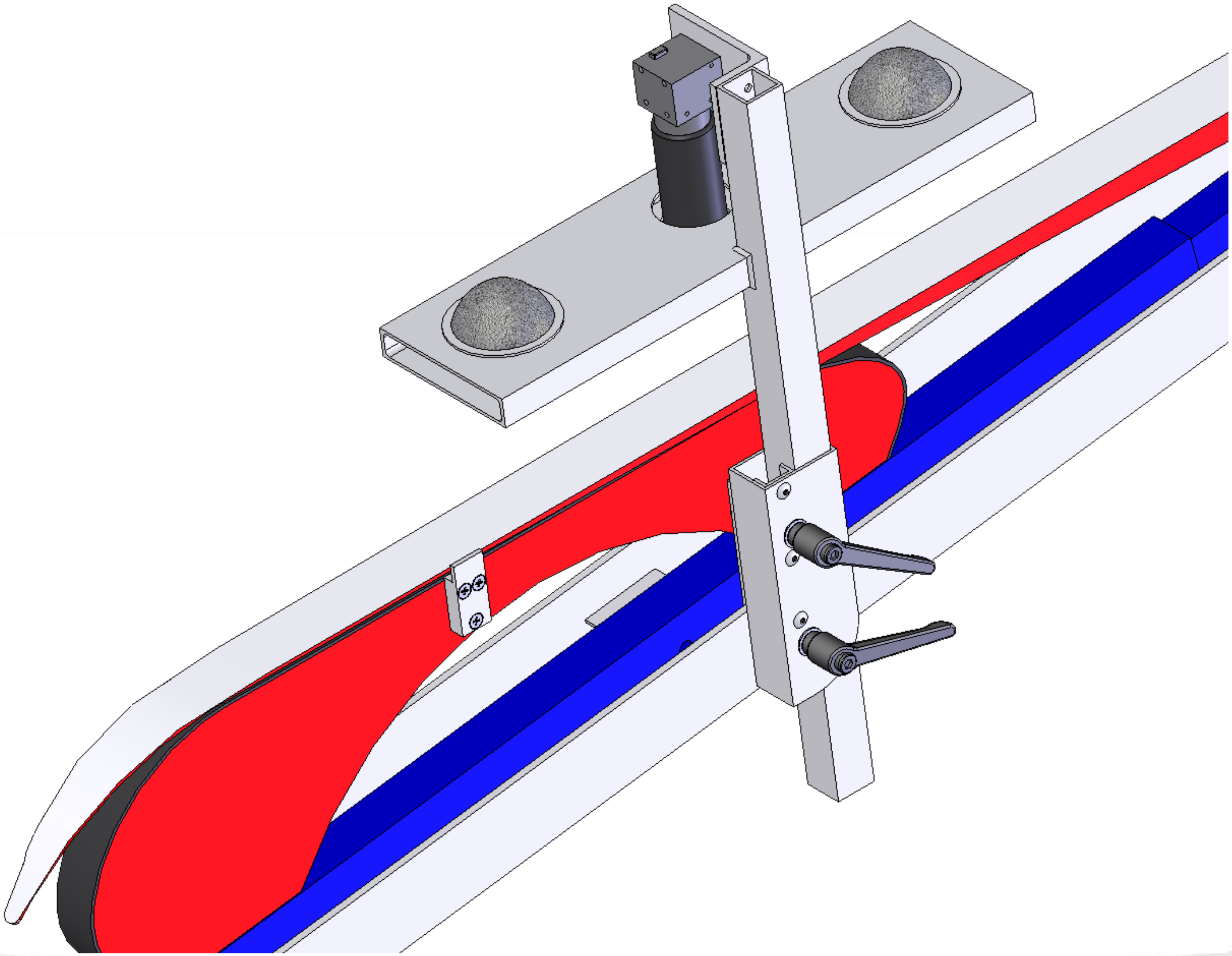
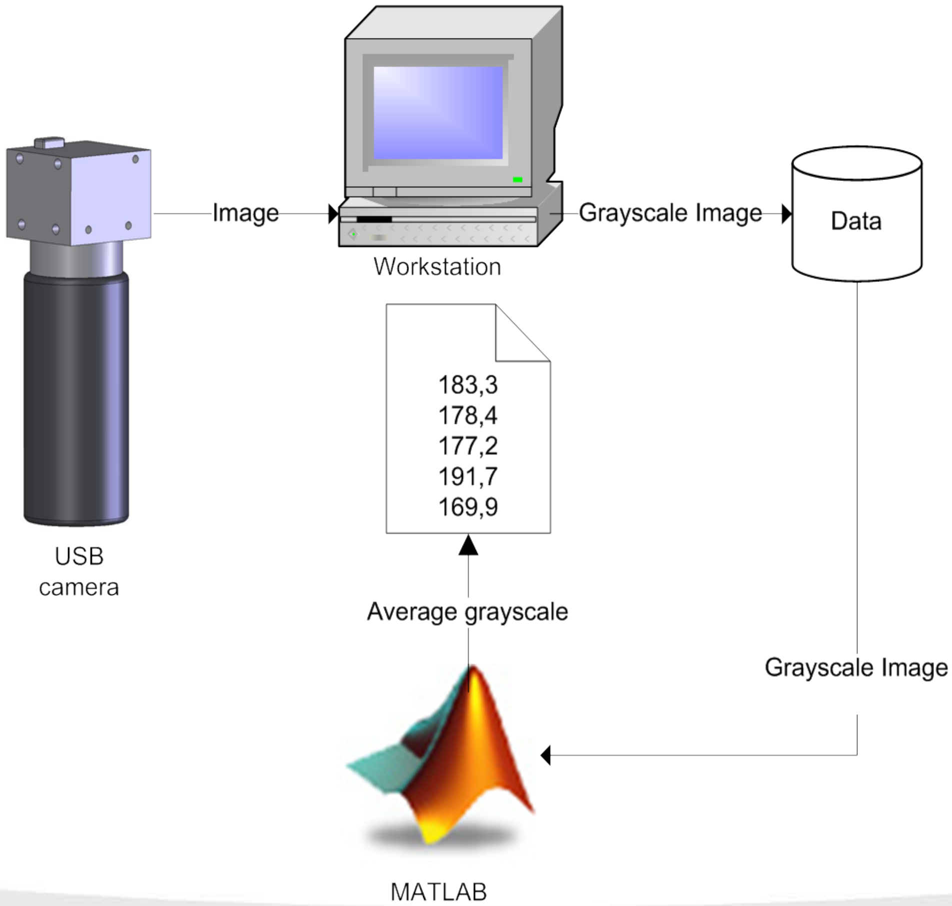
Ski under the camera.

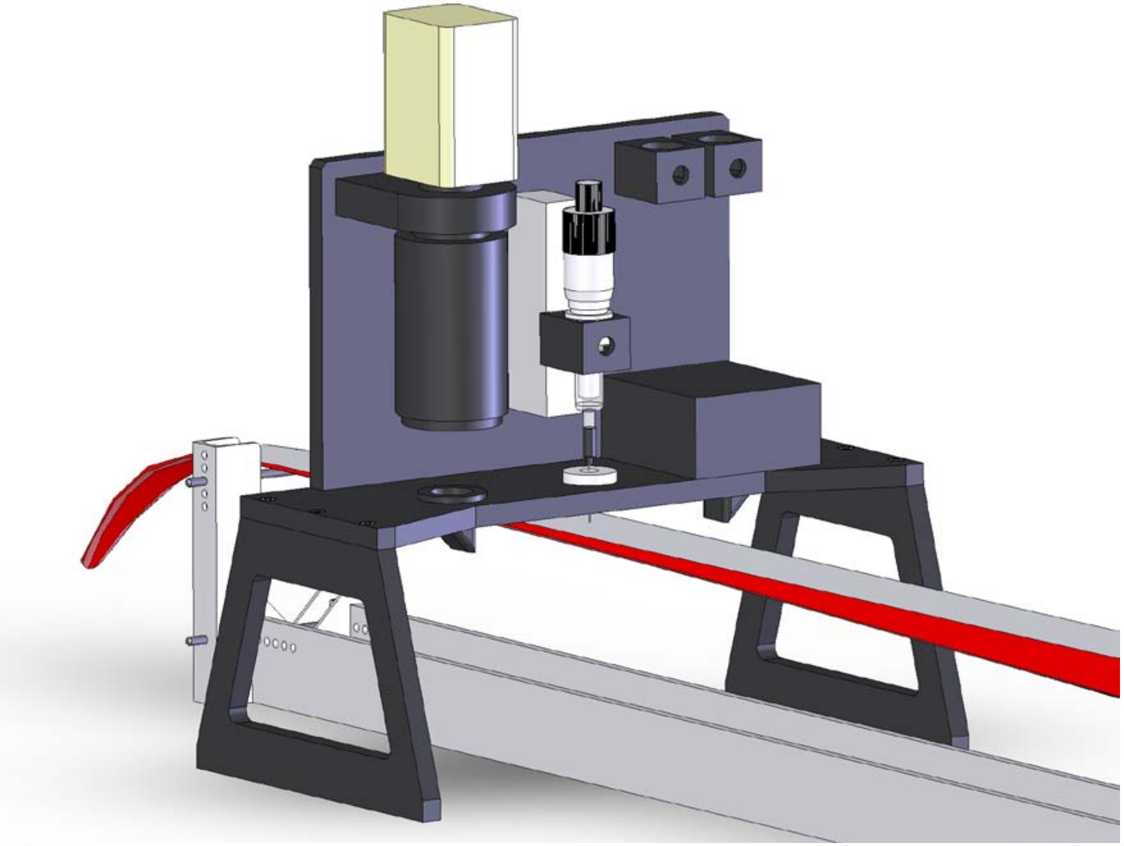


Whiteness recorded as an average of grayscale matrix (0-255).



Measurement – hydrophobicity.

- A goniometer FTA125 and the software Fta32_Video from “First Ten Ångstroms” were used



Comparative testing.

- The comparative value is presented as a ratio between an absolute value (glide velocity, whiteness, etc.) of waxed skis and an absolute value of reference (unwaxed) skis, these skis is our benchmark:

$$C(s_i) = \frac{A_w(s_i)}{A_r(s_i)}$$

$C(s_i)$ - a comparative value of a parameter of a certain pair of skis

$A_w(s_i)$ - an absolute value of a parameter of a waxed pair of skis

$A_r(s_i)$ - an absolute value of a parameter of a reference pair of skis

s_i - the distance covered

Normalization.

- The normalized value is presented as a ratio between a new comparative value and an initial comparative value (glide velocity, whiteness, etc.):

$$N(s_i) = \frac{C(s_i)}{C(0)}$$

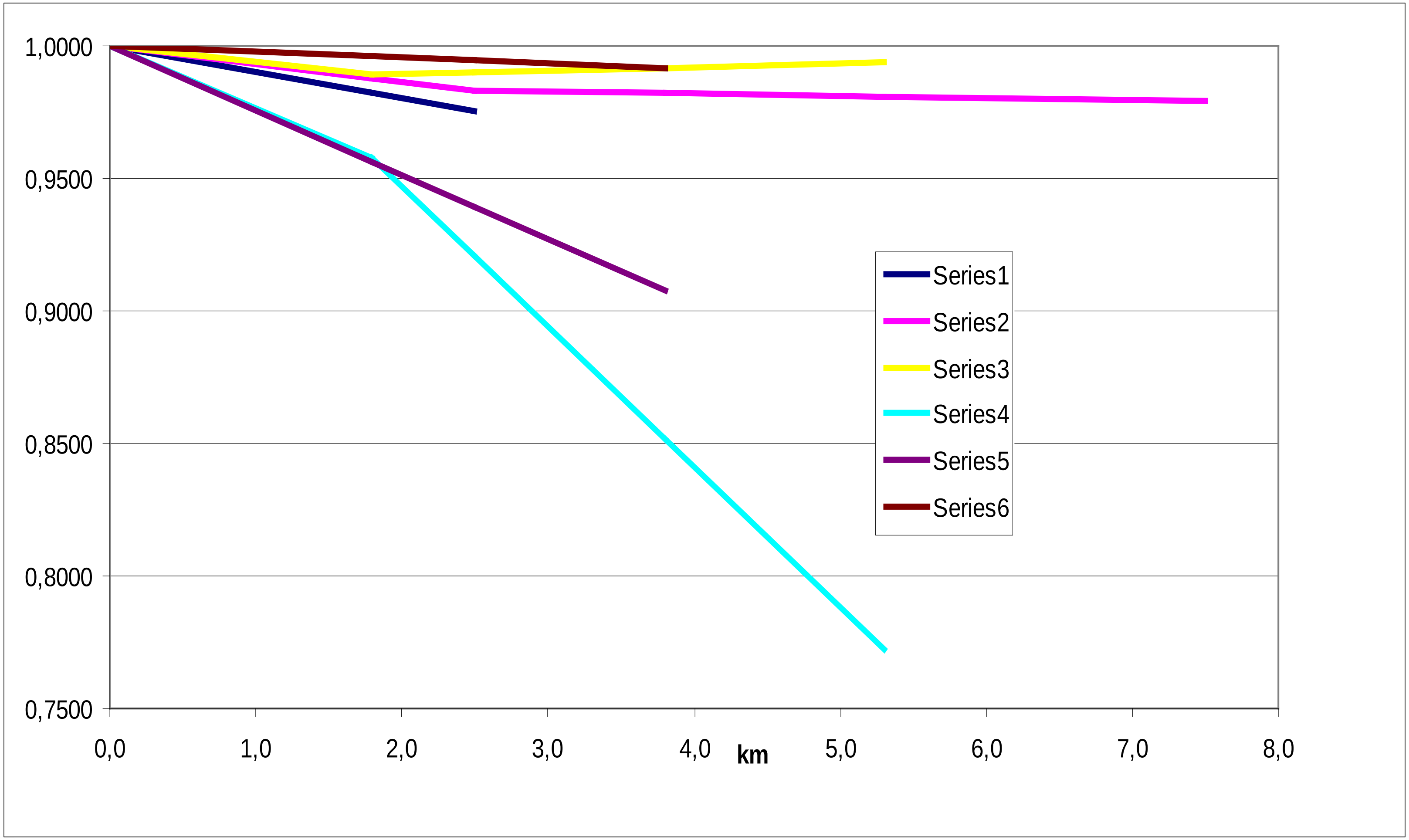
Therefore the initial normalized value $N(0) = 1$

If $N(s_i) < 1$, then waxed skis lose some (N) quality faster than the reference skis, and vice versa.

In-situ testing.

- Measurements under wet snow conditions were performed March-April 2005. Average air temperature was 5,5°C in interval 2,2 ÷ 7,2°C.
- Measurements under dry snow conditions were performed 03.2006. Average snow temperature was -7,6°C in interval -3,8 ÷ -10,8°C.
- On wet snow conditions, grime covers the ski gliding surface extremely fast and contact angle measurement does not produce any useful values.
- On dry snow, grime covers the ski gliding surface utterly insignificantly and grayscale measurement lies inside margin of error.

Normalized comparative whiteness of running surface and distance covered.



Presentation of the principal trend

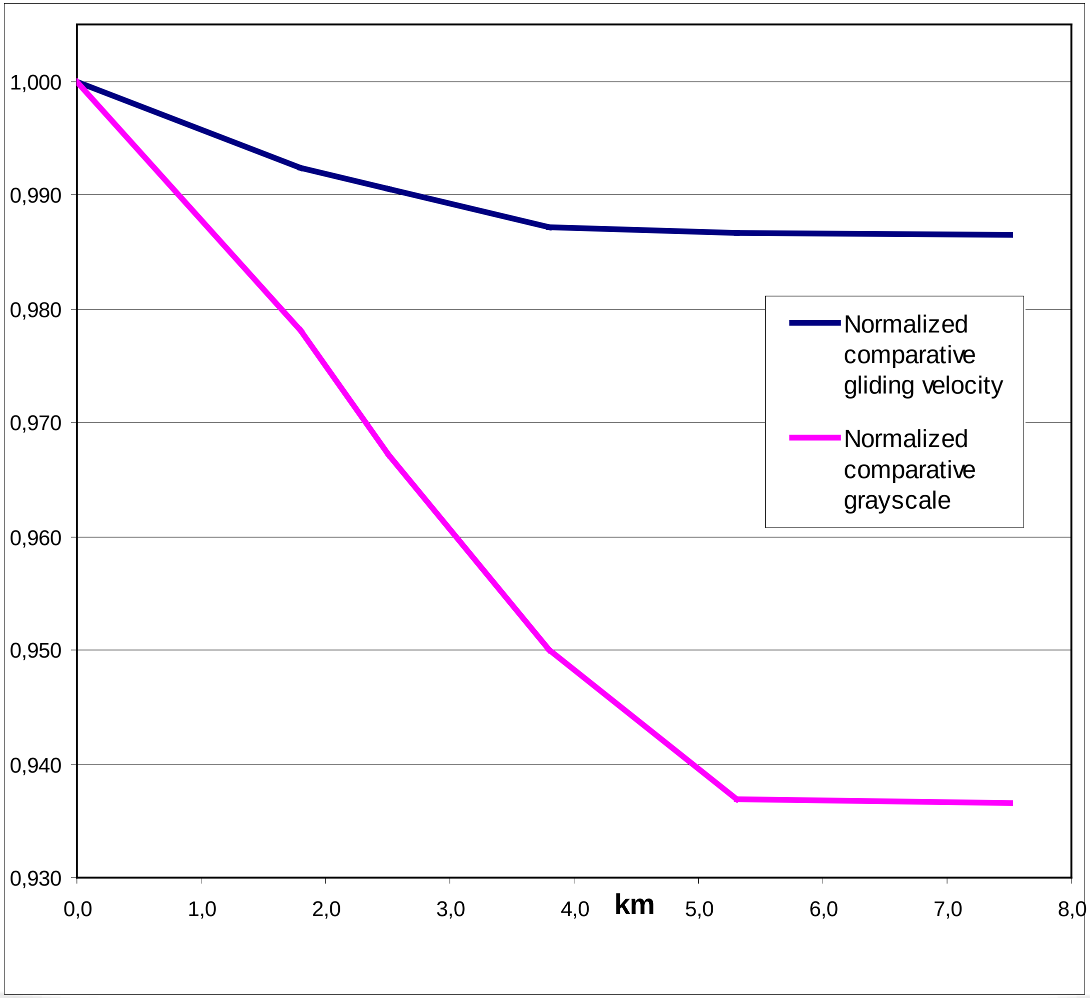
- By linear interpolation, flat (constant) extrapolation and averaging of all normalized comparative values we may present the principal trend much more visual.

$$\bar{N}(s_i) = \frac{1}{m}\sum_{j=1}^{m} N_j(s_i)$$

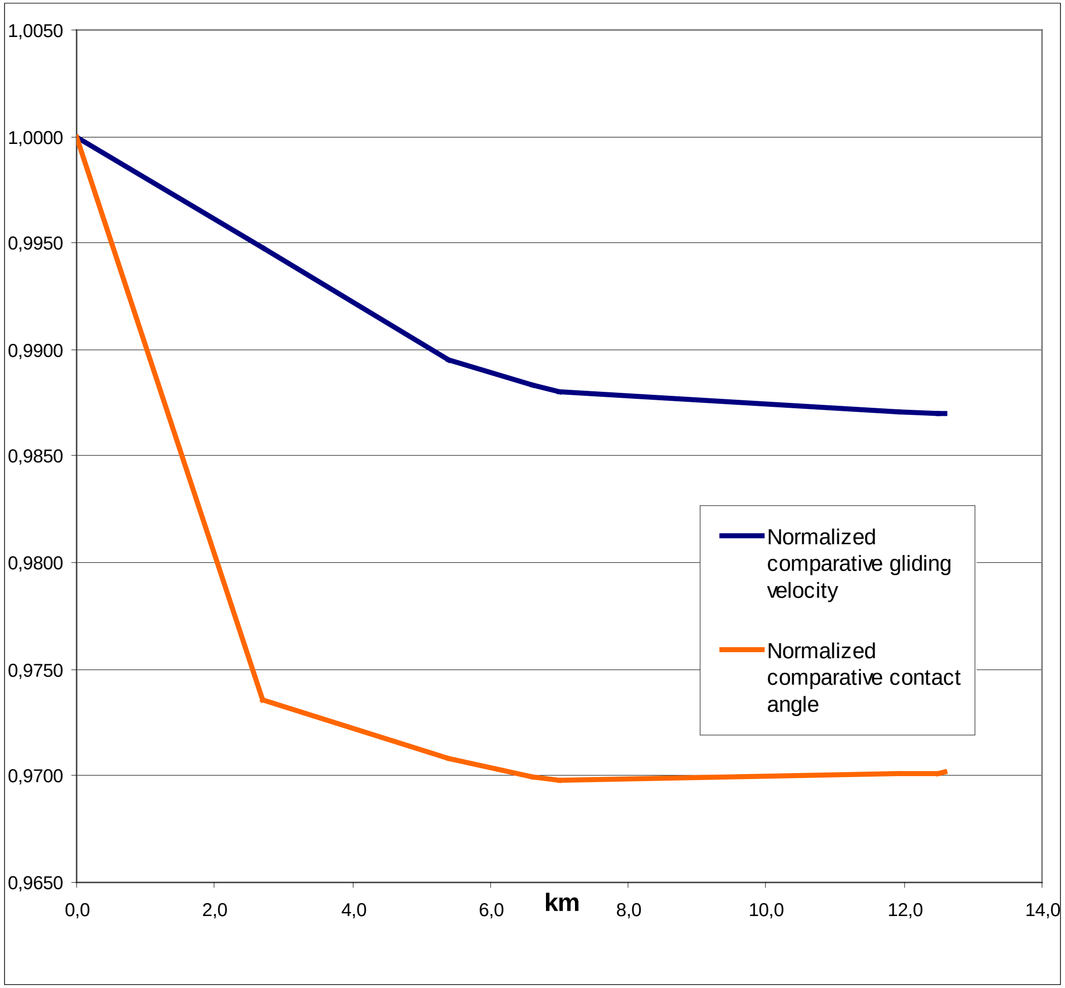
j - test series number

m - total amount of series

Velocity and whiteness relative to distance on wet snow.



Velocity and contact angle relative to distance on dry snow.



Discussion – wet snow.

- From our results we can draw the conclusion that the waxed skis lose their glide ability faster than the reference skis (scraped skis).
- The augmentation of softness and tenacity of the outer layer of the ski base increases dirt absorption on the ski running surface. UHMWPE is a hard and repulsive material.

STAR Ski Wax (NA):	**Hardness - Shore D**
0°/-4°C	13,90
-2°/-6°C	28,40
-4°/-12°C	40,10
-8°/-20°C	48,60
P-Tex® 2000	64,20
P-Tex® 4000	67,30
P-Tex® 5000	68,60

Discussion – dry snow.

- From our results we can draw the conclusion that the waxed (Star NA6) skis lose their glide ability faster than the reference skis (scraped skis).
- In (D.C. Sun, 1996) described accelerated ageing of UHMWPE at a heating rate of 0.6°C/min to 80°C for either 11 or 23 days. This was considered to be equivalent to 4 to 6 or 7 to 9 years of ageing, respectively.
- In (Widmer, 2002) presented significant decrease of UHMWPE surface hydrophobicity after oxygen plasma treatment.
- From above we may see that heat impairs useful properties of the ski base.

- **Our hypothesis: the glide wax wears out quickly and then the ski running surface that has a poor glide ability gets in contact with the snow.**

Is it any substance in the today's glide waxing doctrine?

nr. 62 ROM Antal Zolt is in the lead

nr. 62 is caught up

abt 1 min. of descent

1´15´´ of descent, but nr. 62 is still in the lead

Why 24 technicians and 8*10^6 NOK can not outperform one poor Romanian wax expert?

References

- D.C. SUN, C. S., J.H. DUMBLETON (1996) *Development of an accelerated aging method for evaluation of long term irradiation effects on UHMWPE*, American Chemical Society.
- WIDMER, M. R. (2002) Modified Molecular Friction in Artificial Hip Joints. Zurich, Swiss Federal Institute of Technology (ETH).

Acknowledgments

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Kiitos!

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