Energy efficient Drying and Profiling

Infrared radiation and hot air combined for improved performance

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China International Paper Technology Exhibition

Shanghai, Oct. 12th, 2016

- Introduction
- Application Examples
- Basics of Drying
- Technology of XenTec Emitters

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Introduction

- XenTec dryers from Compact Engineering are a novel approach to drying and profiling
- Combining high performance energy saving infrared radiation with hot air dryers for optimum evaporation
- Designed for optimum drying and immobilization of initial sedimentation layer due to modified infrared radiation
- Peak radiation at 1.42 µm compared to 1.18 of other electric emitters and 2.5 to 3.0 of gas fired infrared emitters
- Typically twice as efficient as other electric driven infrared emitters, as cost efficient as gas-fired infrared

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Application Examples

- Top Coat Drying of Liquid Packaging Board
- Pre and Top Coat Drying of Fine Paper
- Pre Coat Drying of Board
- Barrier Coat Drying Specialty Paper
- Moisture Profiling
- Capacity Increase Pulp Dryer

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Pre Coat Board
Starting Point

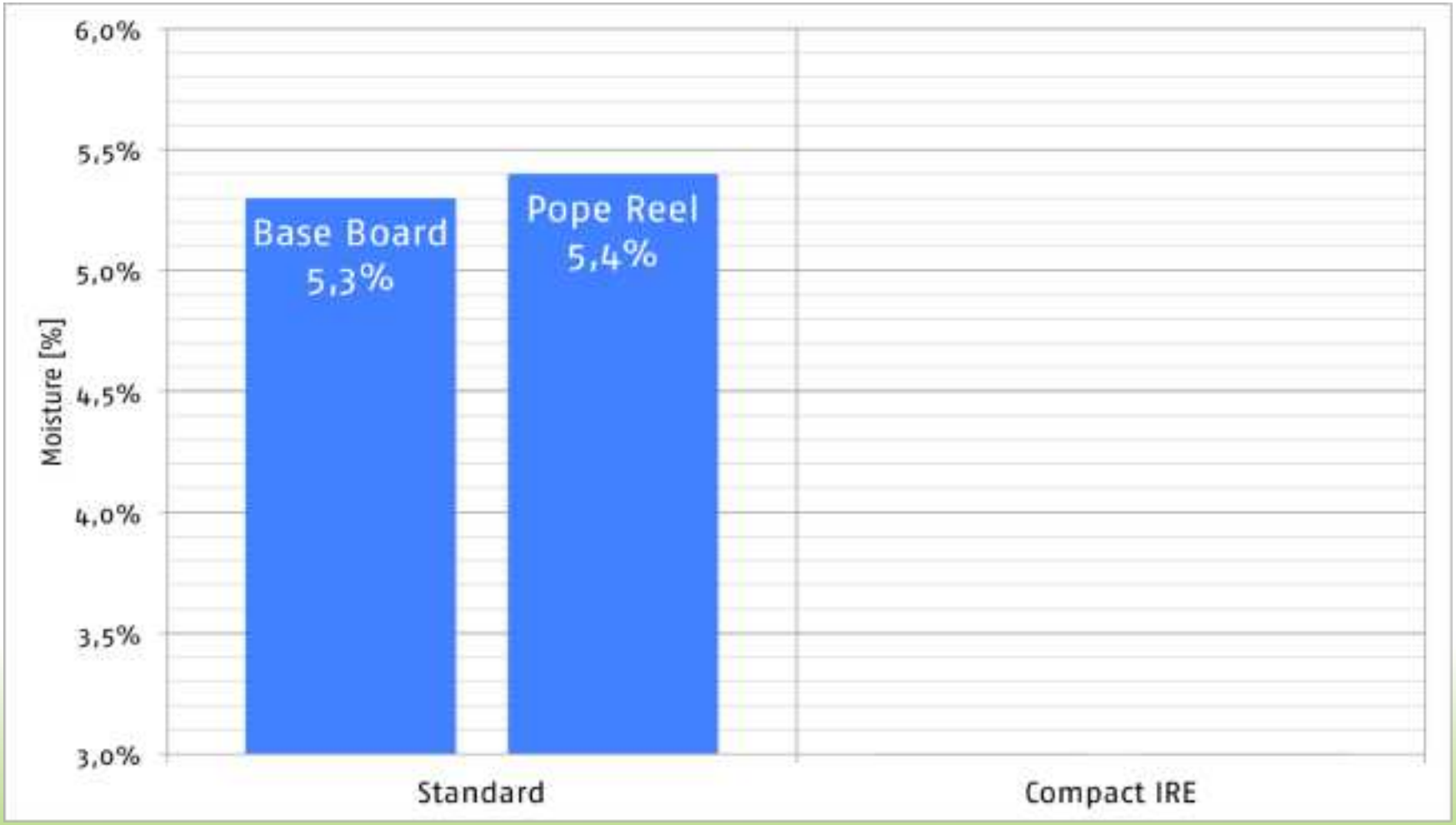
- Double Coated Board
- 200 to 400 gsm

- V_{prod} max. 700 mpm
- Pre coat weight max. 15 gsm
- Infrared emitters with 30 kW each

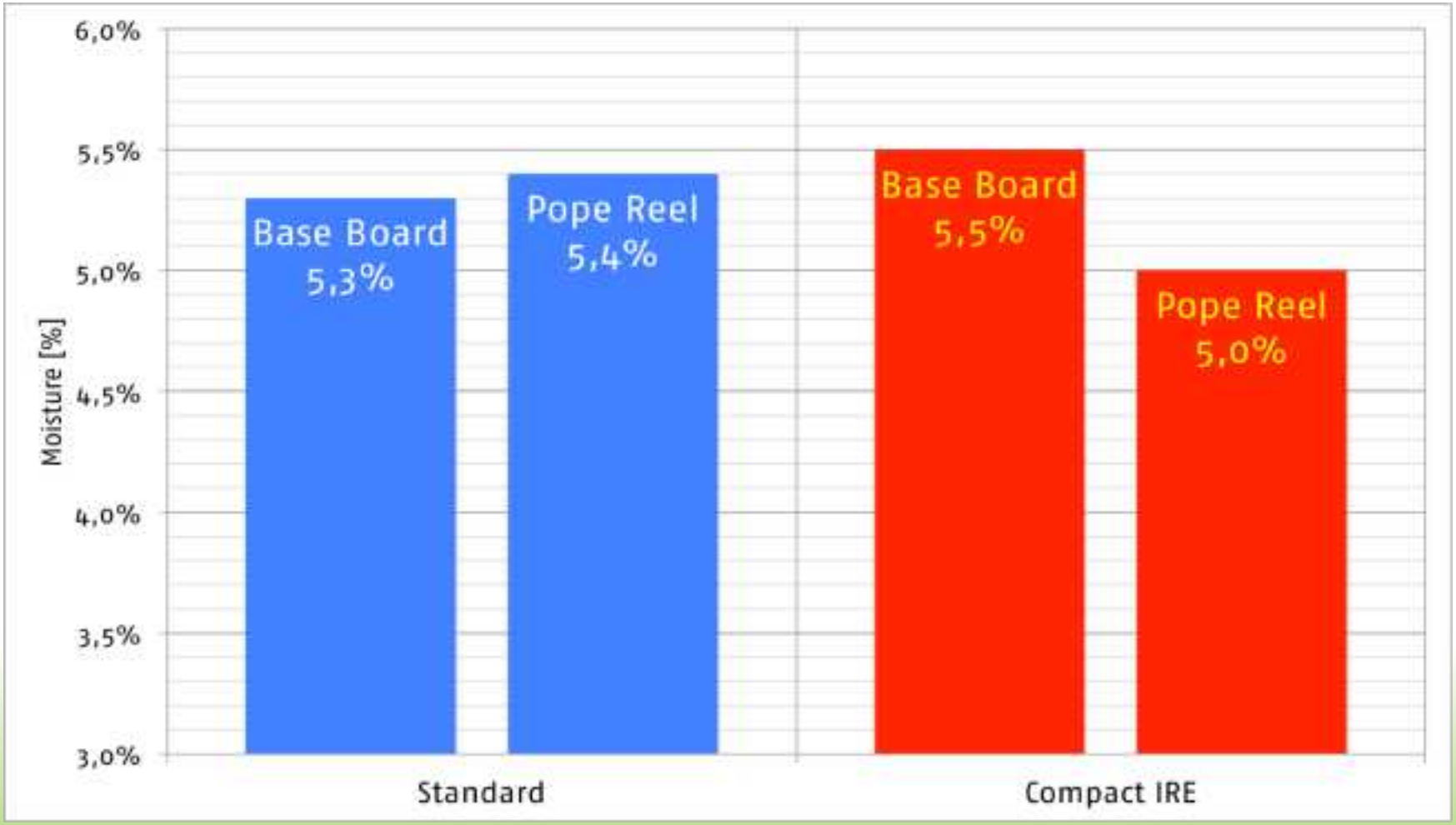
Pre Coat Board:
Implementation

- Future speed increase up to 1.000 mpm
  (after further rebuilds of machine and approach system)
- Increase pre coat weight up to 30 gsm
- Reduce top layer weight
- XenTec IRE from Compact with 24kW each

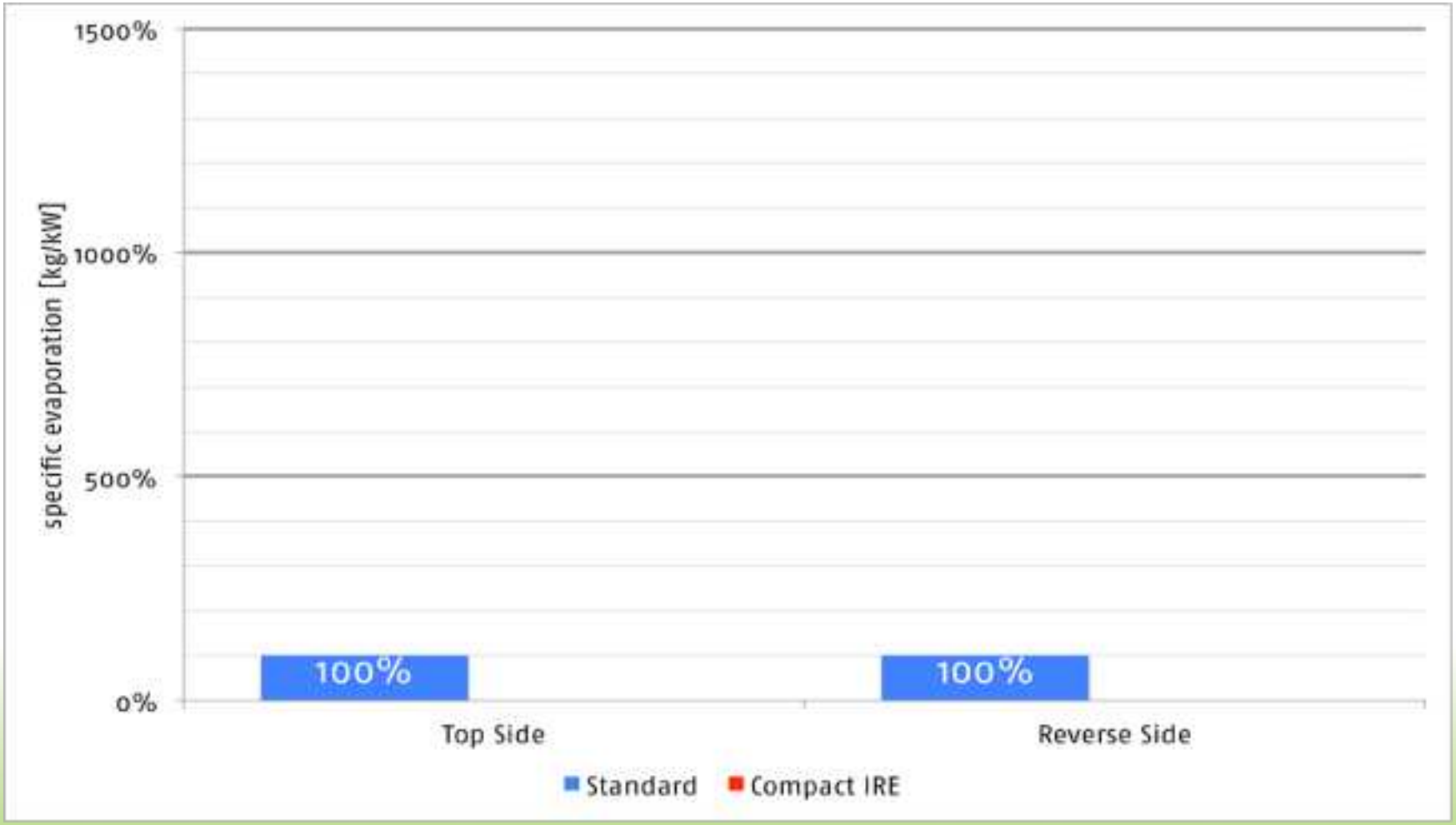
Pre Coat Board:
Results: moisture with competitor



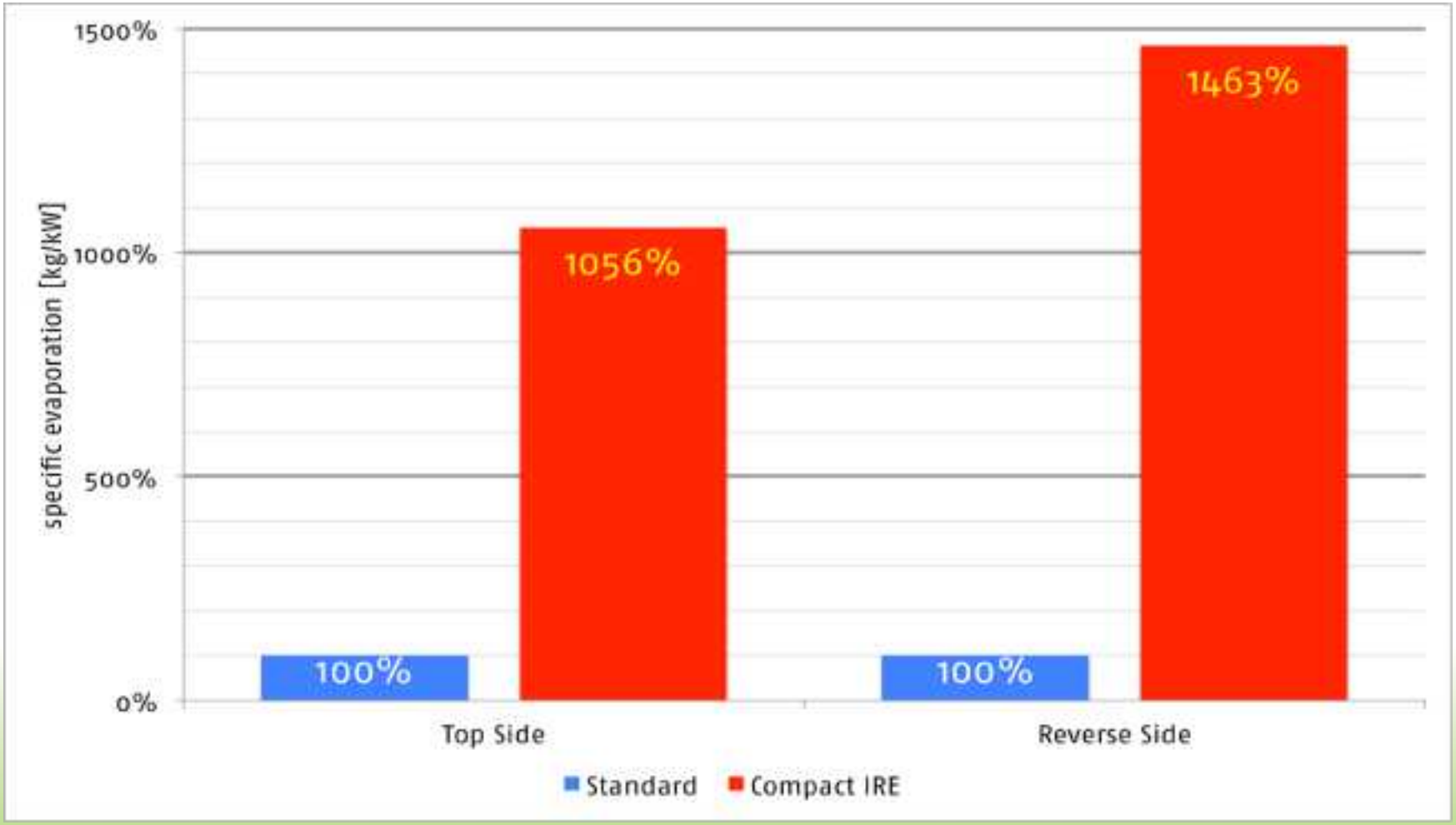
Pre Coat Board:
Results: moisture with XenTec



Pre Coat Board:
Results: specific evaporation competitor



Pre Coat Board:
Results: specific evaporation XenTec



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Barrier Coat Specialty Paper
Starting Point

- Double coated specialty paper
- 50 to 250 gsm
- 300 to 900 mpm
- 2.500 mm sheet width

- Offline coater for double coating
- Drying limited for barrier top coat
- Sufficient drying for barrier pre coat

Barrier Coat Specialty Paper
Starting Point

- Pre coat drying with gas fired infrared hoods plus hot air hoods
- Top coat drying with hot air hoods
- Previous trials had proved that PVA barrier can't be dried with gas fired infrared,
  - as wet coat weight is too high
  - only top of wet coating was dried
  - as 80% of gas fired infrared radiation is absorbed within the first 20 µm
- Previous trials have shown that other electrical infrareds were not energy efficient enough

Barrier Coat Specialty Paper
Project Implementation

- XenTec Apollo as booster with 160 kW/m
- Installed between coater and hot air hoods

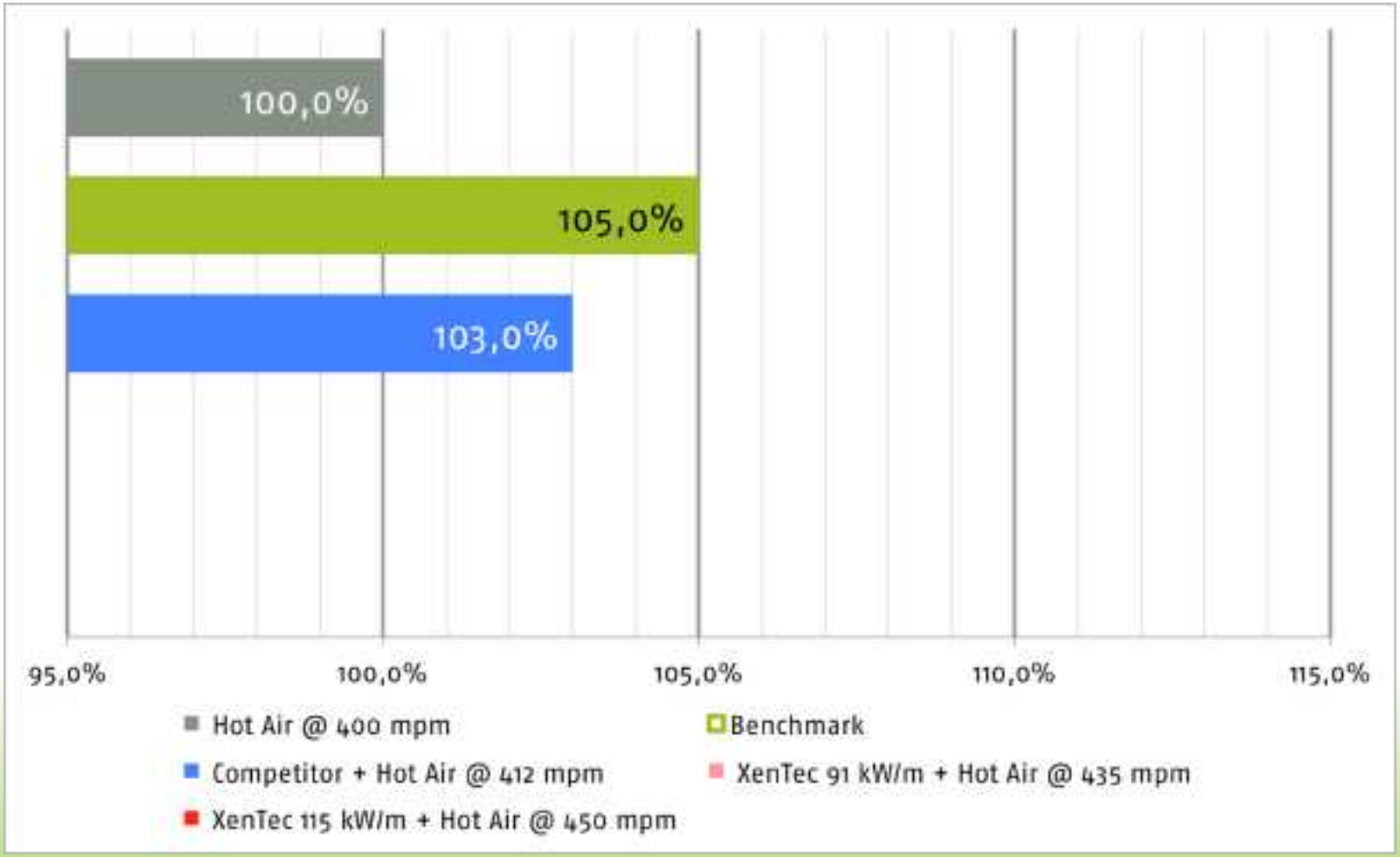
Barrier Coat Specialty Paper
Results

- Reference runs with
  - Hot air dryers
  - XenTec Apollo at 91 kW/m and hot air dryers set as above
  - XenTec Apollo at 115 kW/m and hot air dryers set as above
  - Evaporated water: 18 gsm

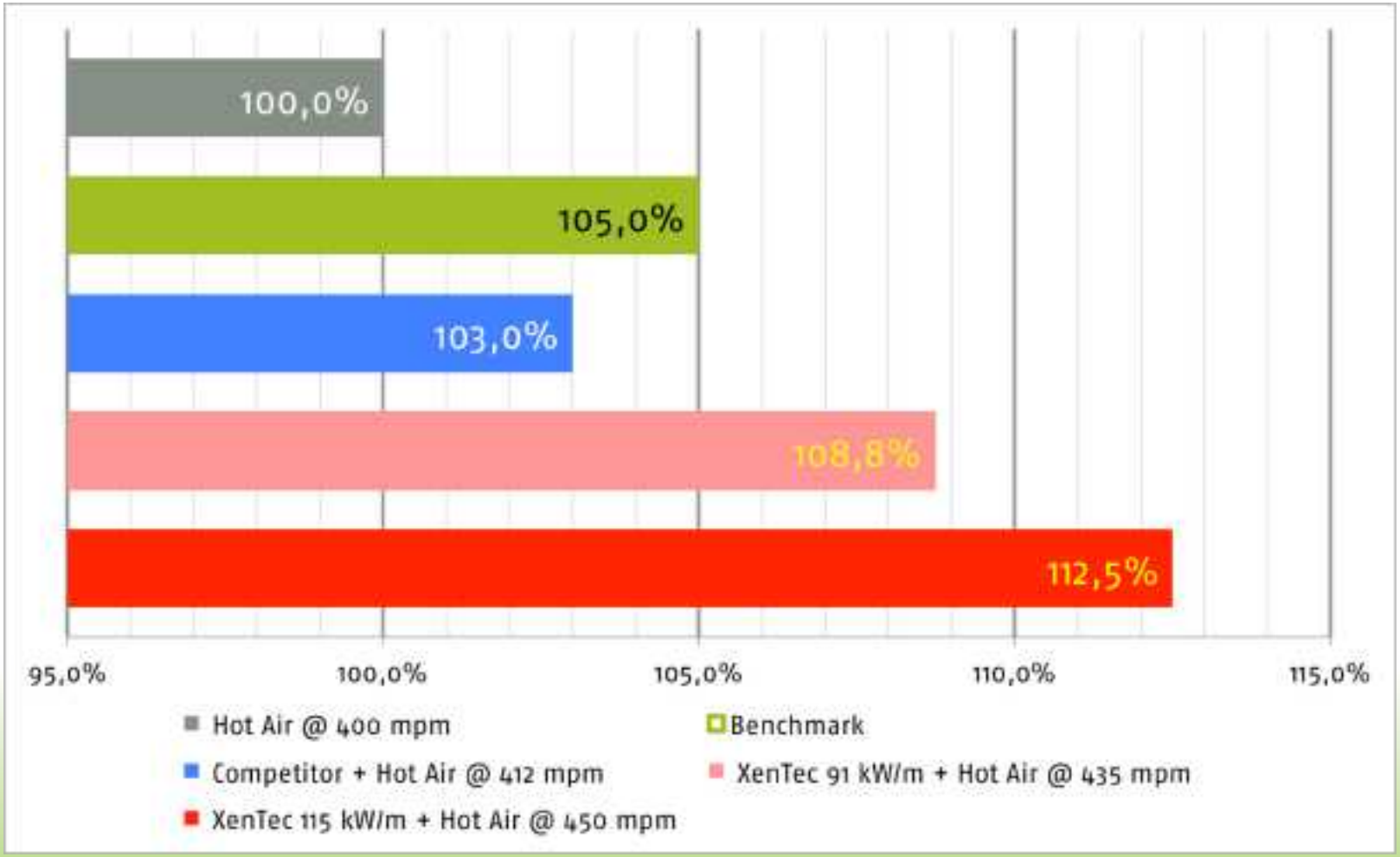
- Quality parameter **must** be maintained as standard !

- Speed increase must be 5 % for reasonable payback (competitor IR delivered too little increase, thus infinite amortisation period)

Barrier Coat Specialty Paper
Results: capacity increase competitor

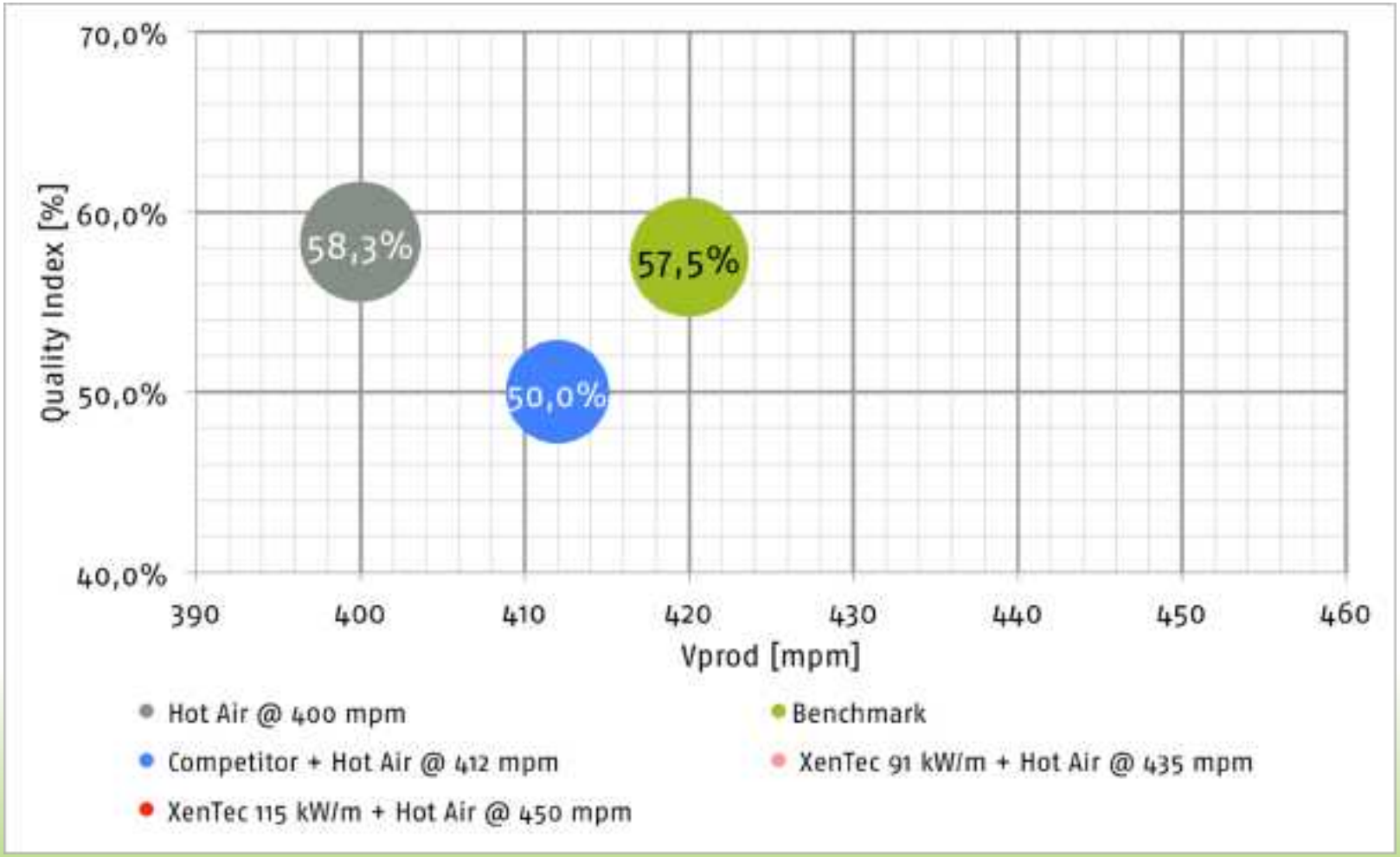


Barrier Coat Specialty Paper
Results: capacity increase XenTec



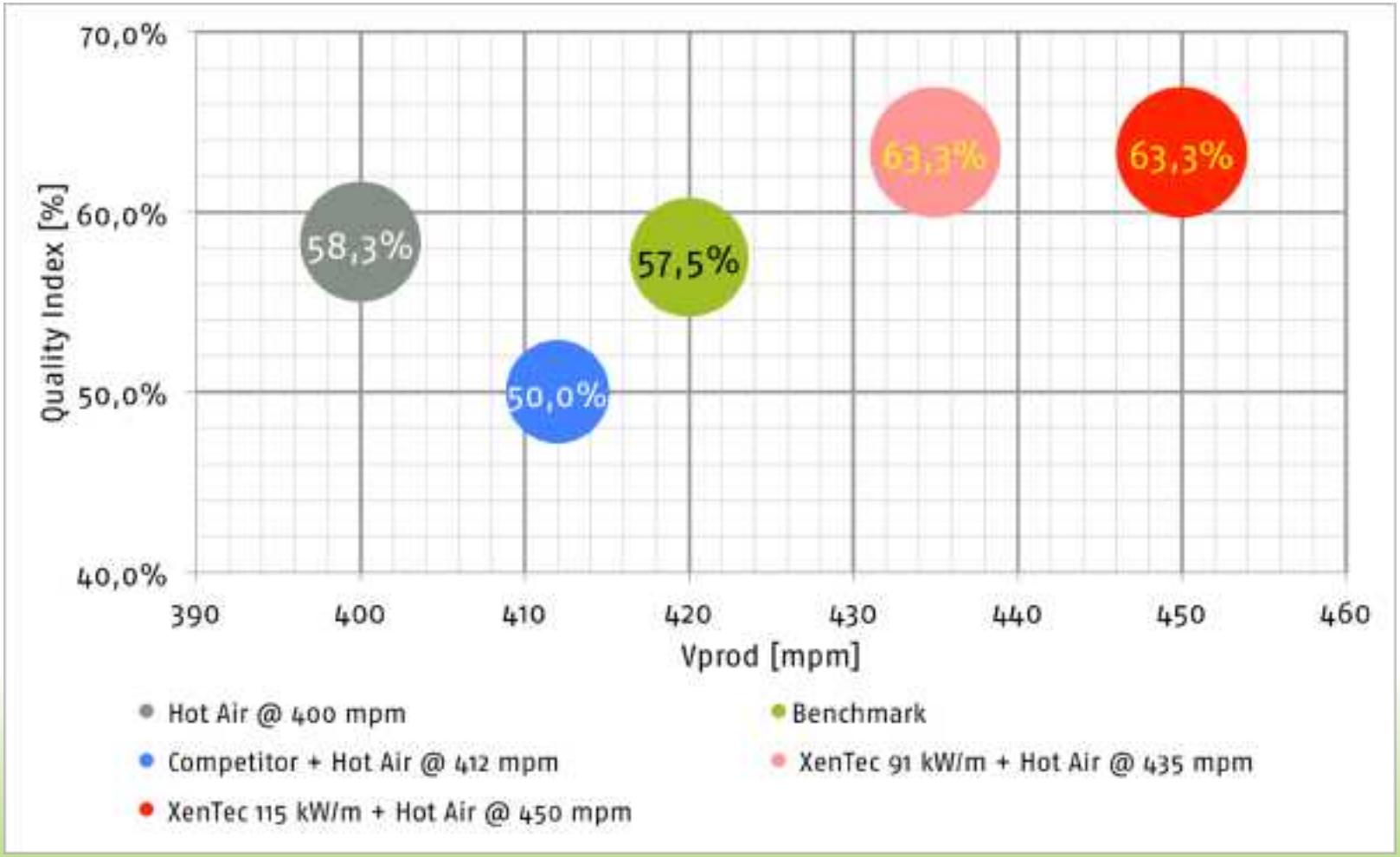
Barrier Coat Specialty Paper

Results: quality vs. capacity increase competitor



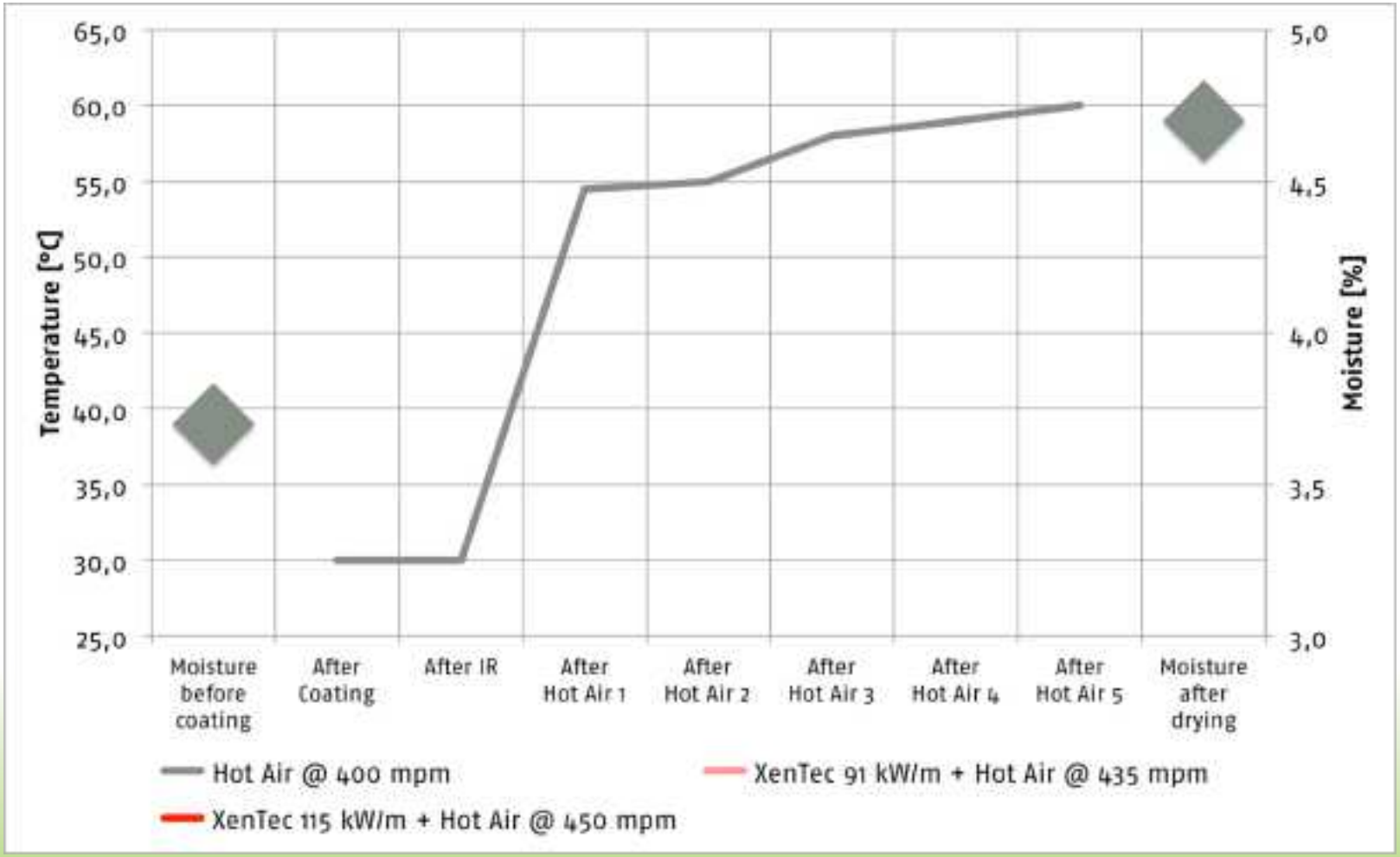
Barrier Coat Specialty Paper

Results: quality vs. capacity increase XenTec



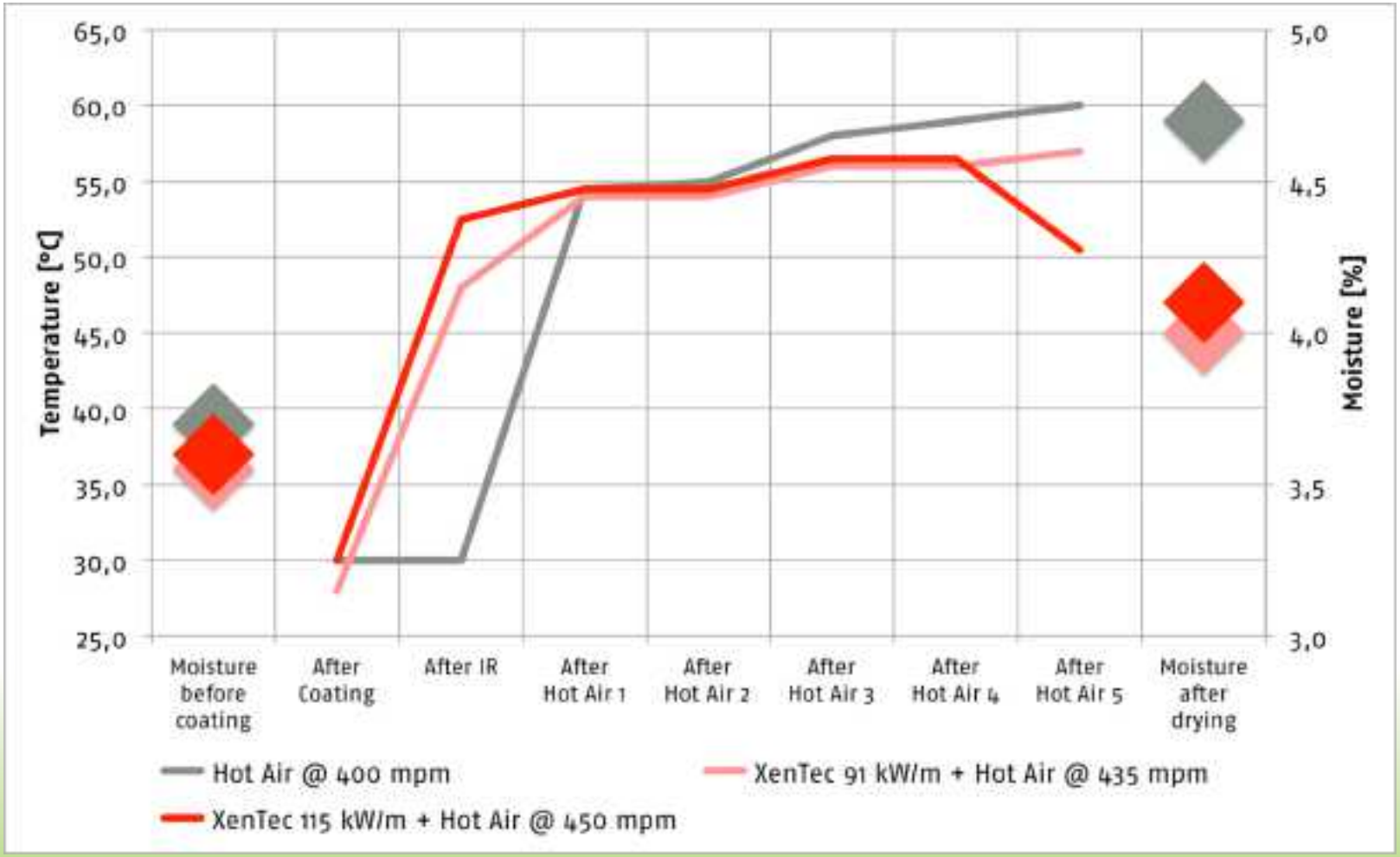
Barrier Coat Specialty Paper

Temperature curve and moisture standard



Barrier Coat Specialty Paper

Temperature curve and moisture XenTec



Barrier Coat Specialty Paper
Results

- Significant speed increase
- Quality improvement
- Moisture increase smaller than with standard drying procedure – despite increased speed:
  - Much improved evaporation of hot air dryers
- Temperature curve below standard:
  - Because evaporation is done already at XenTec dryer, not just the heating
  - Water is accelerated towards surface, where hot air dryers easily evaporate it – increased evaporation enthalpy cools more.

Application Examples

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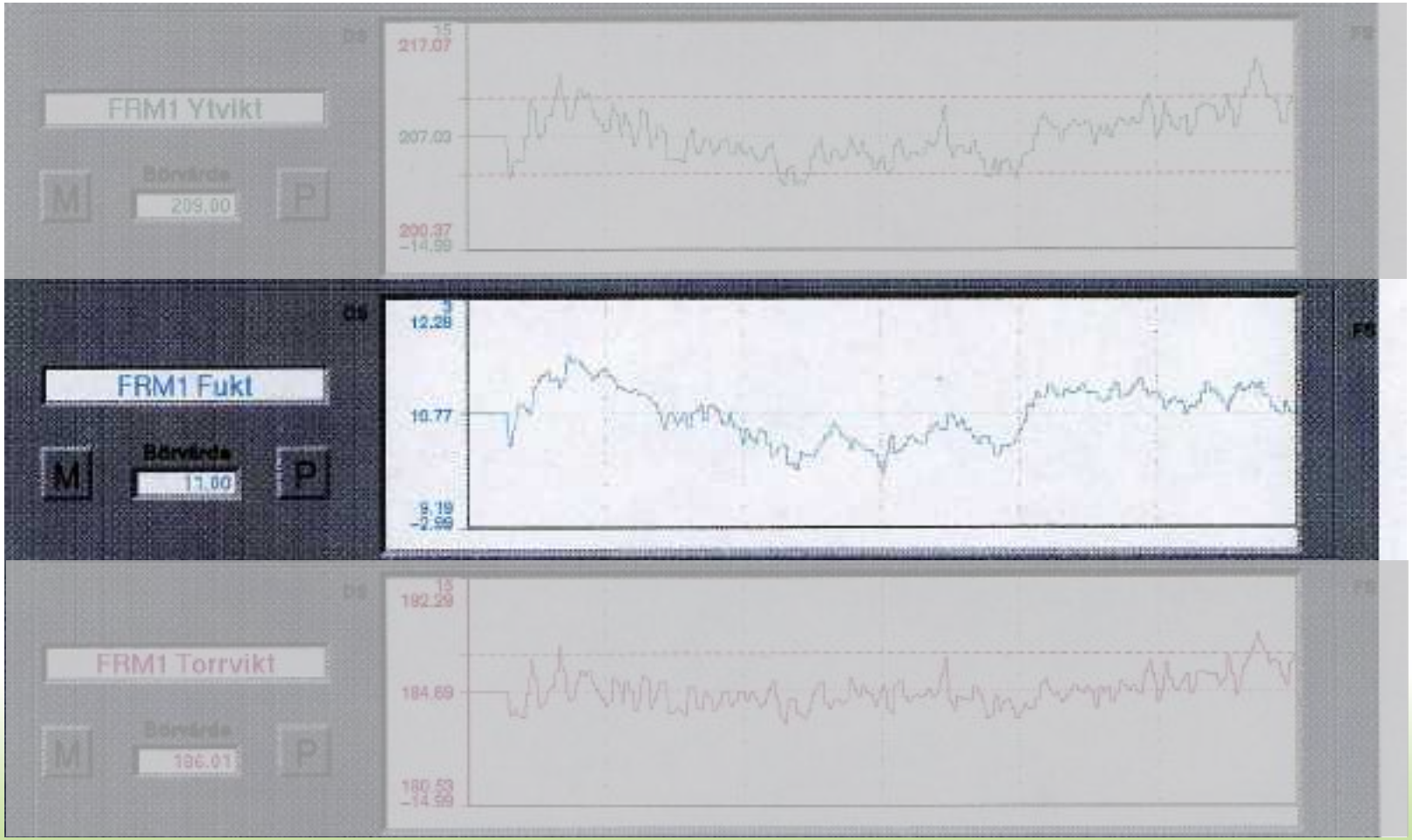
Moisture Profiling
Starting Point

- Plasterboard liners 200 gsm
- Huge moisture variations, roughly 2% peak-to-peak (not 2σ)
- Thus speed and capacity limited, else problems with lay flat and quality
- goal: reduce moisture variations peak-to-peak to 1/3

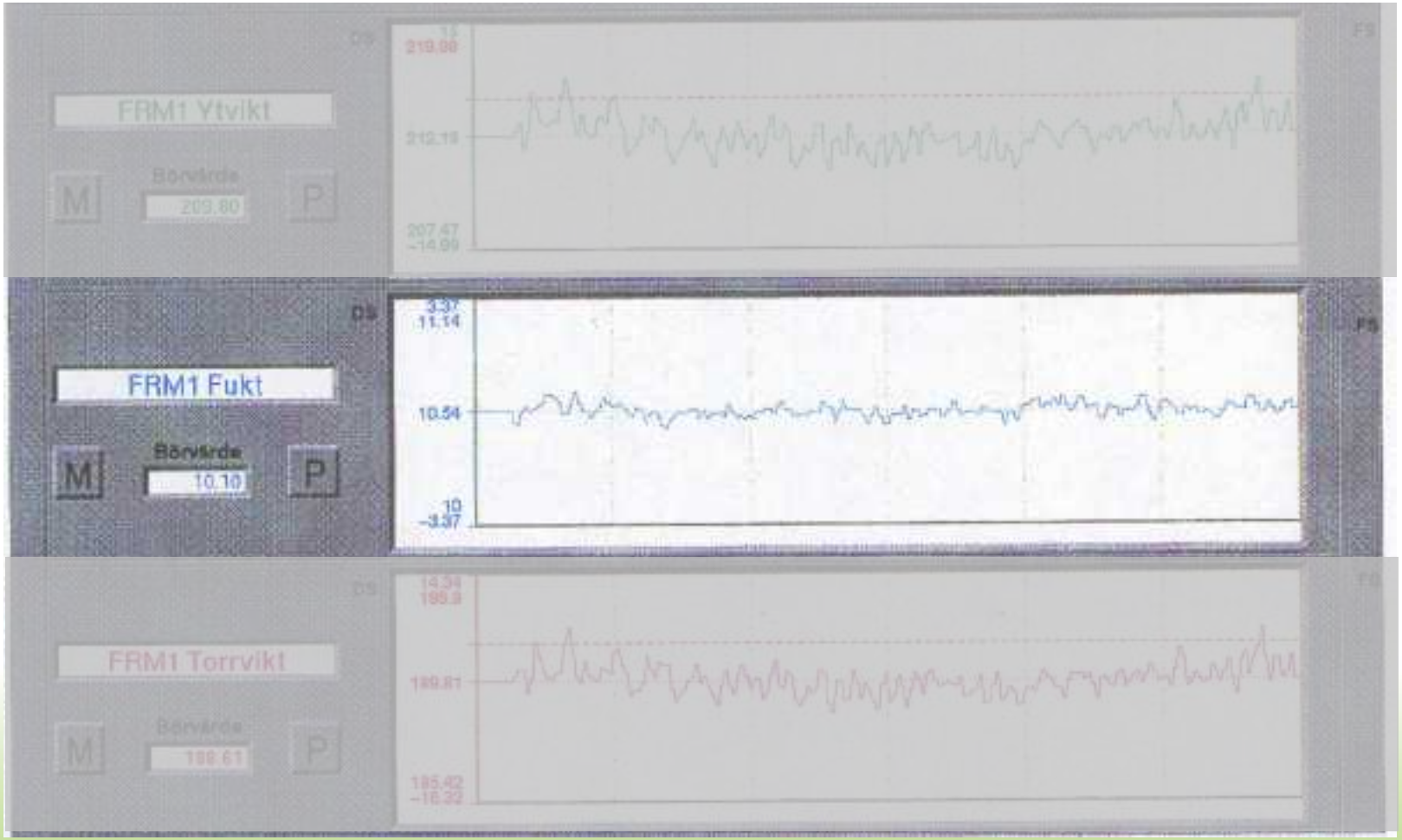
Moisture Profiling
Standard profile before rebuilt



Moisture Profiling
Implementation

- XenTec Apollo on last cylinders on top and reverse side
- Profiling in md, cd, and z
- goal: reduce moisture variations peak-to-peak to 1/3

Moisture Profiling
Profile with XenTec



Moisture Profiling
Profile with XenTec

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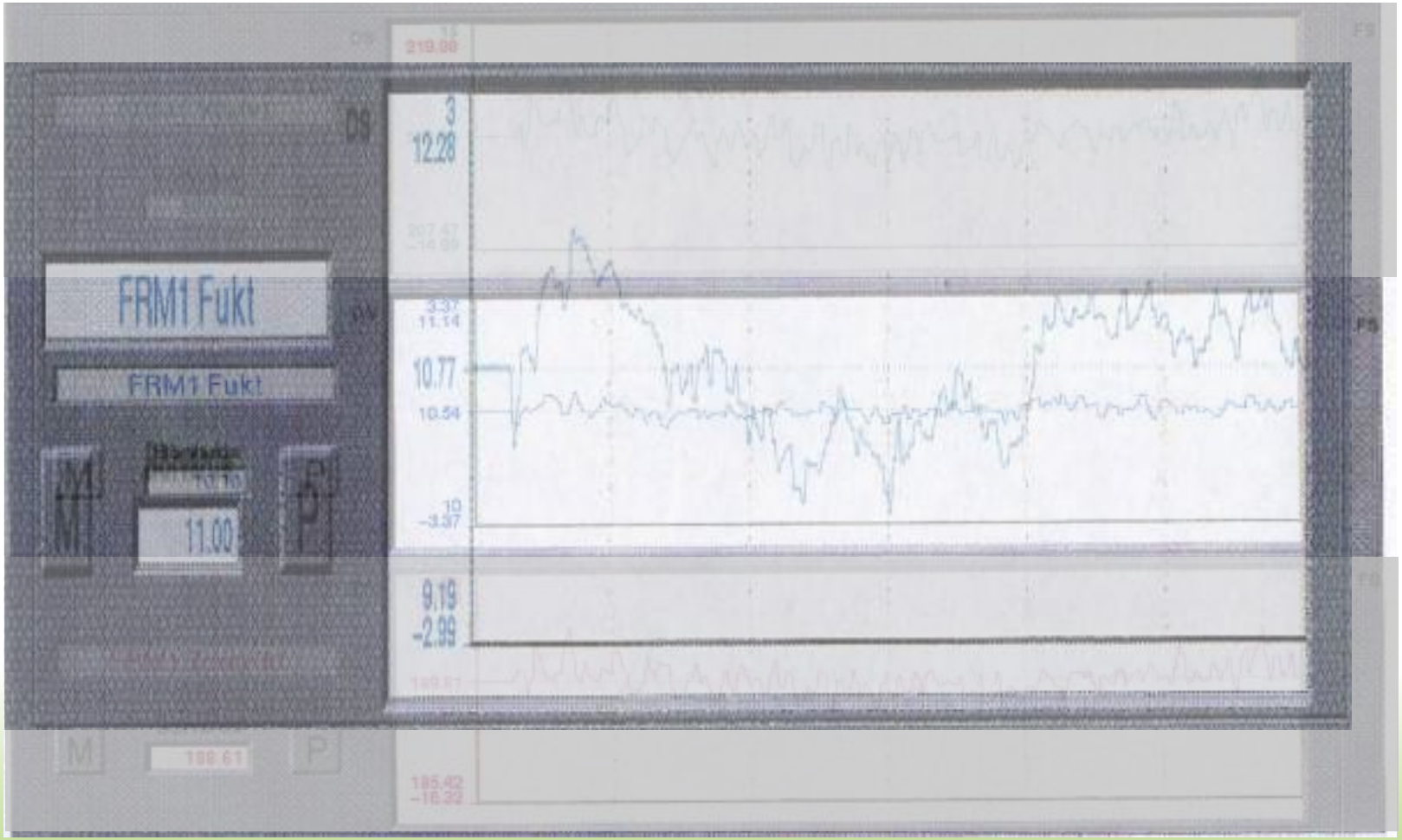

Moisture Profiling
Results

- moisture variations peak-to-peak to 20% of original value at most important grade
- Spread reduction reduces moisture by 1.6% – corresponding to speed increase between 4% and 6% on key grades
- Significantly improved quality, namely lay-flat and dimension stability

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Drying

- Drying is a two step process:

    1. Energy transfer

    2. Mass transfer

Drying
Step 1: energy transmission

- The energy transfer increases the difference between partial vapour pressure in the coating/paper and the ambient air.

- energy transmission is achieved by means of

  - Conduction = contact drying

  - Thermal radiation = electromagnetic radiation

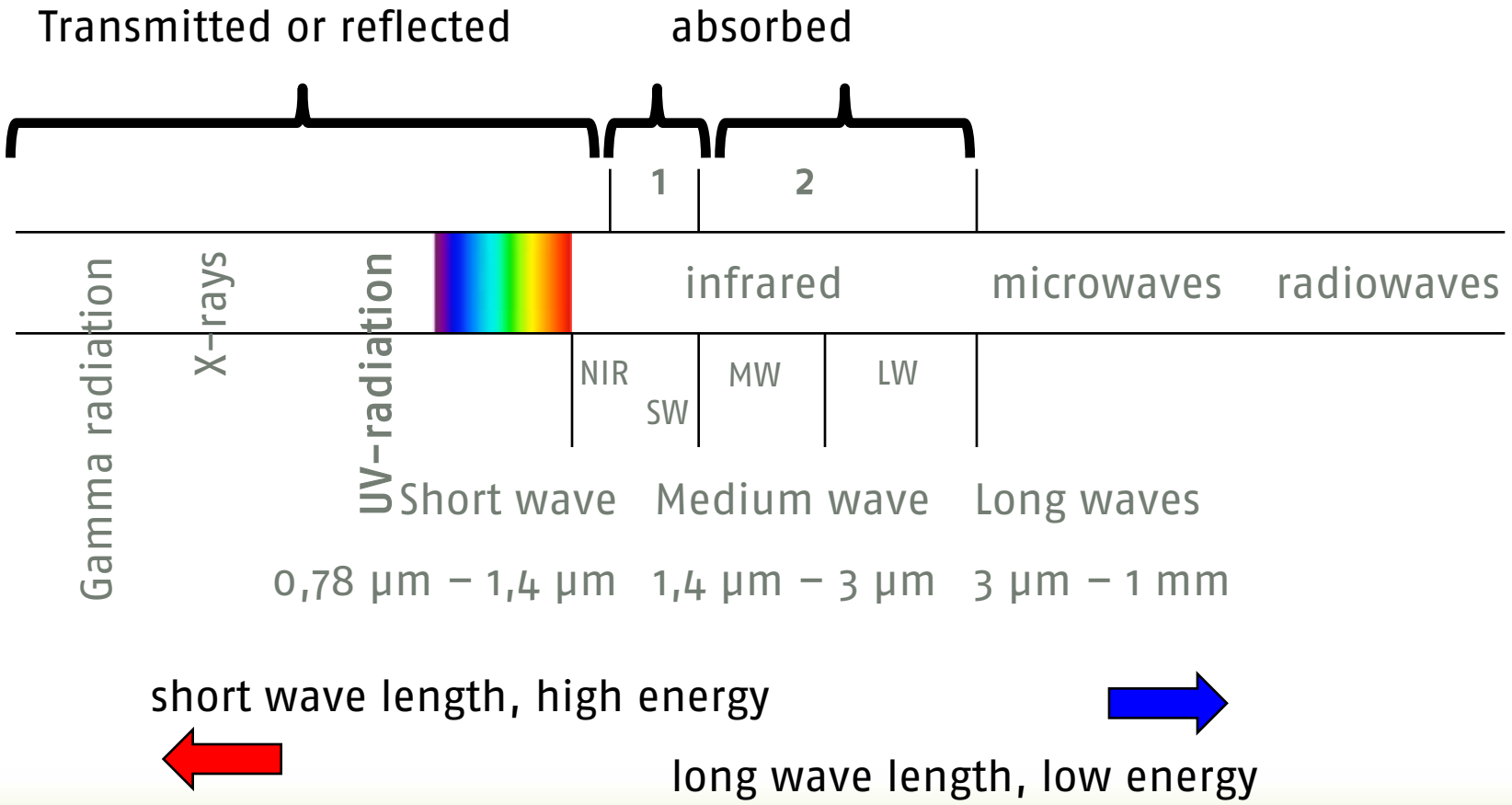
  - Convection = through medium, like water, oil, air

Drying
Step 2: mass transfer

- The mass transmission is the physical movement of the vapour out of the coating/paper

- Only after the mass transfer, the paper/coating is dried

Electromagnetic radiation

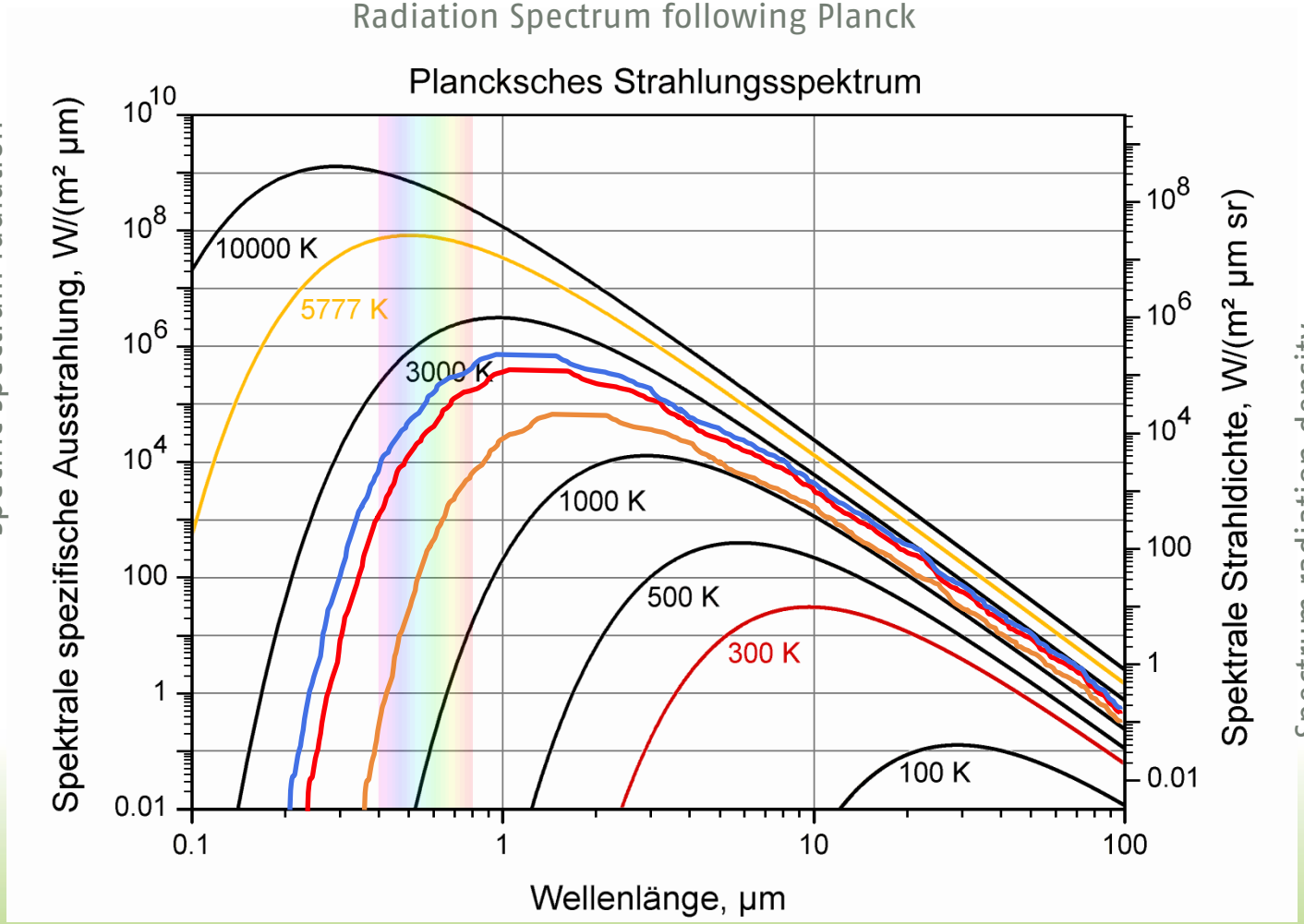


1 = weakly absorbed, with good penetration 250 to 400 µm into the sheet

2 = strongly absorbed, 80% within first 20 µm of the sheet or coating

Specific spectral emission and Planck's radiation spectrum

Radiation Spectrum following Planck



Wavelength and efficiency
standard emitters 30 kW @ 1.18 µm

Wavelength and efficiency
XenTec Dryers 24 kW @ 1.40 µm

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Wavelength and efficiency

- Does 0.22 µm wavelength difference really matter?

Wavelength and efficiency

- Does 0.22 µm wavelength difference really matter?

- The difference between red light (0.65 µm) and green light (0.51 µm) on a traffic sign is just 0.14 µm

Infrared absorption of H_20 and paper

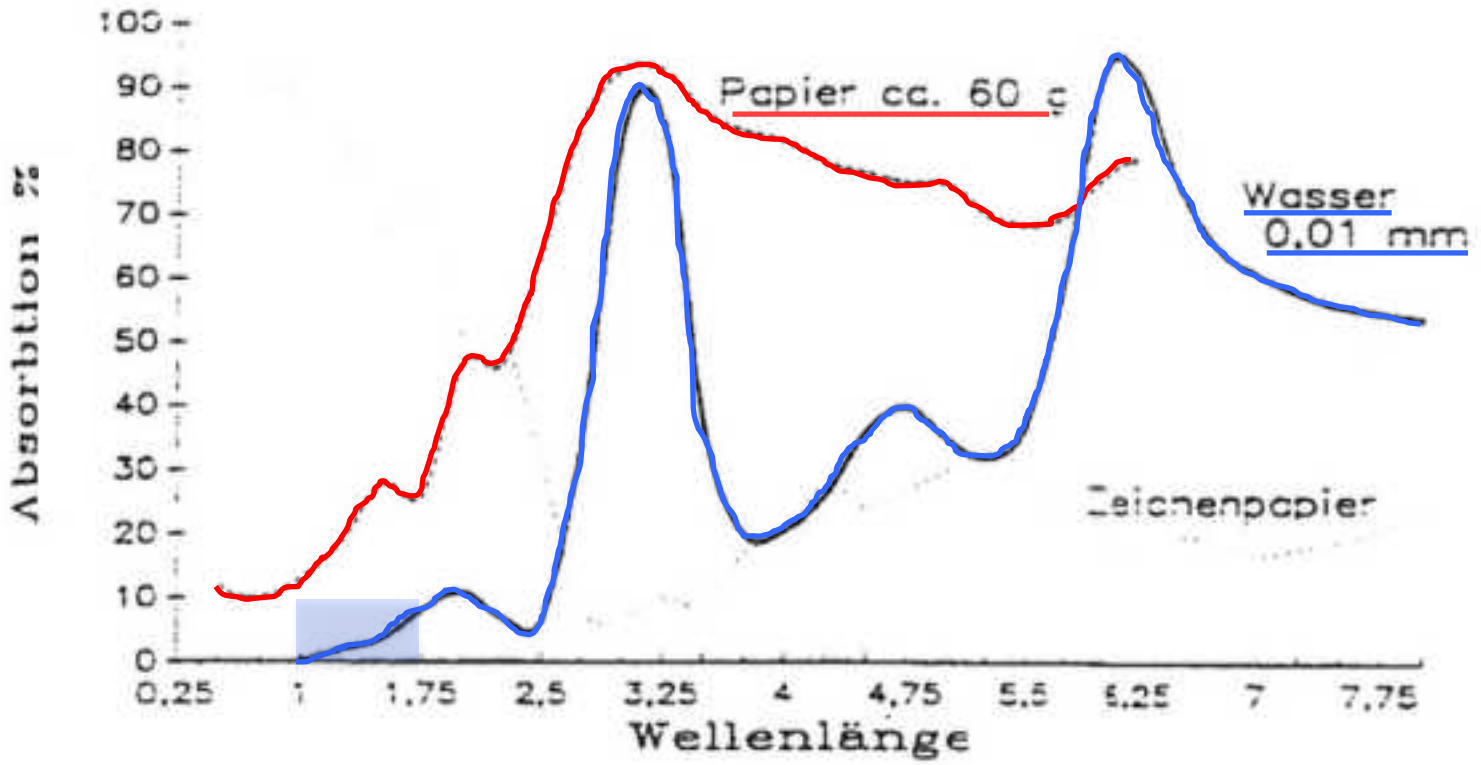
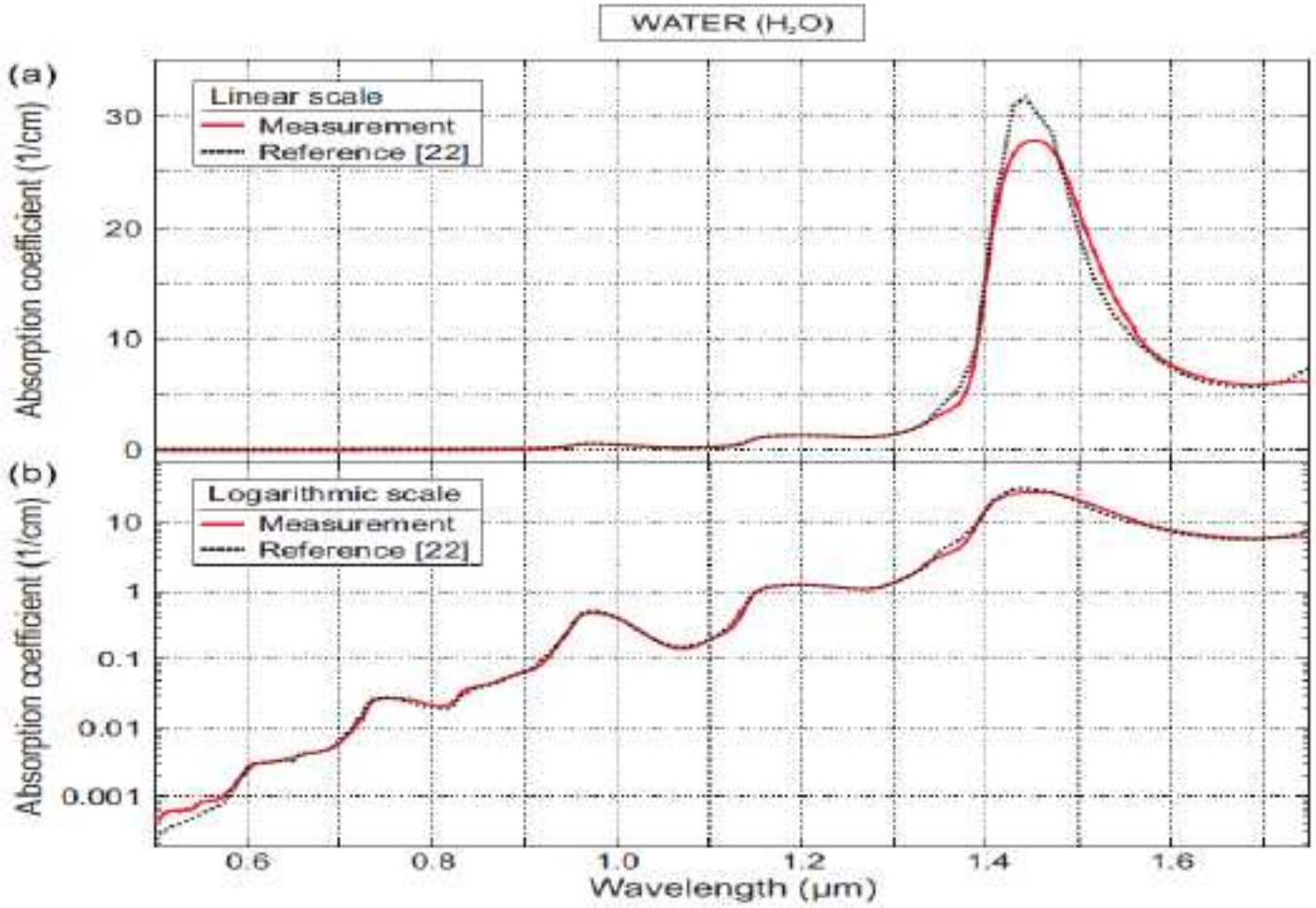


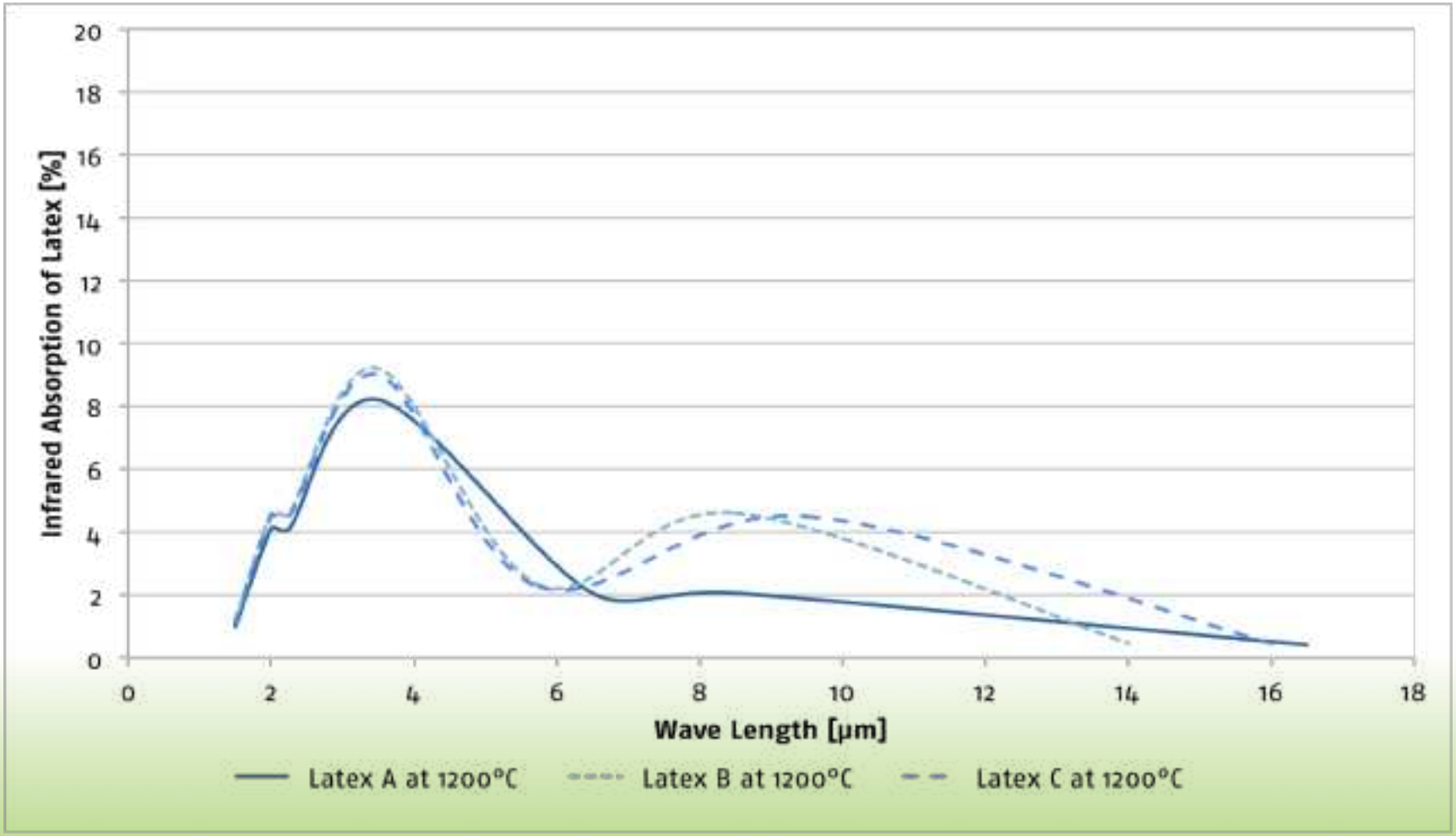
Abb. 7: IR-Reflexion und Absorption von Papier und Wasser

Source: Influence of emitter temperature of infrared emitters upon drying performance
Helmut Graab, Wochenblatt für Papierfabrikation 19/1991

Infrared absorption of H_20 at Short Wave Infrared



Infrared absorption of lattices
film formation and migration



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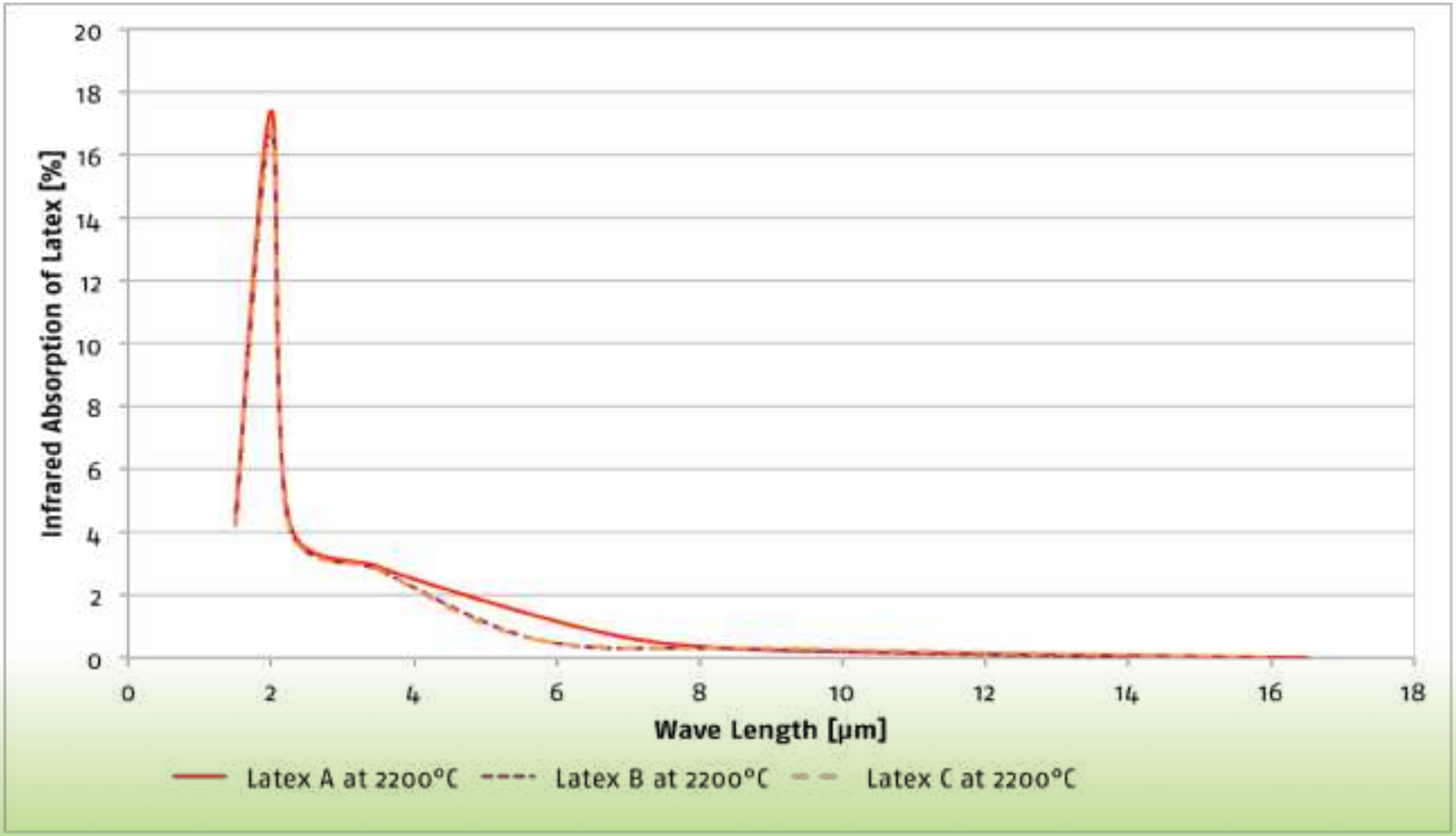

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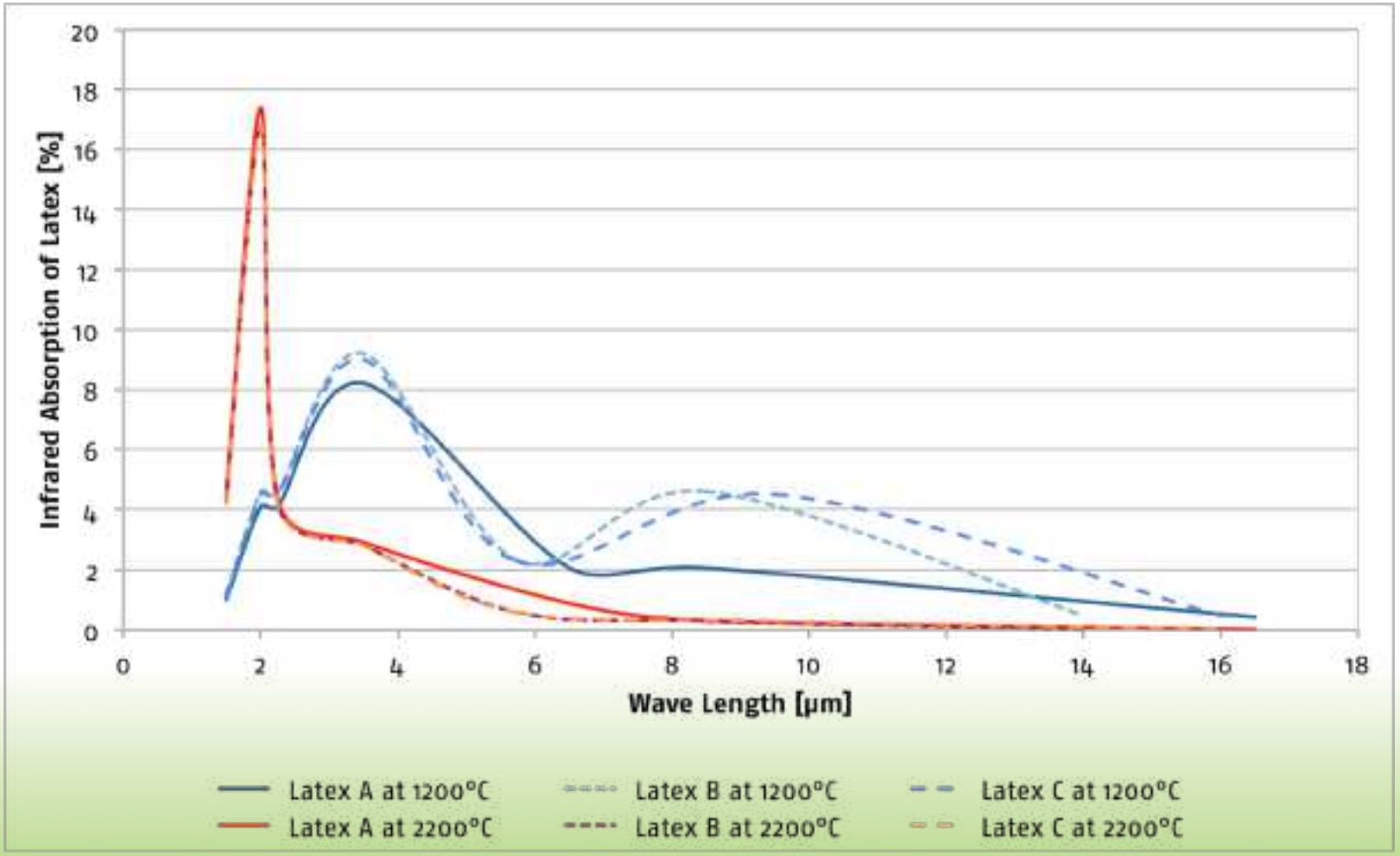
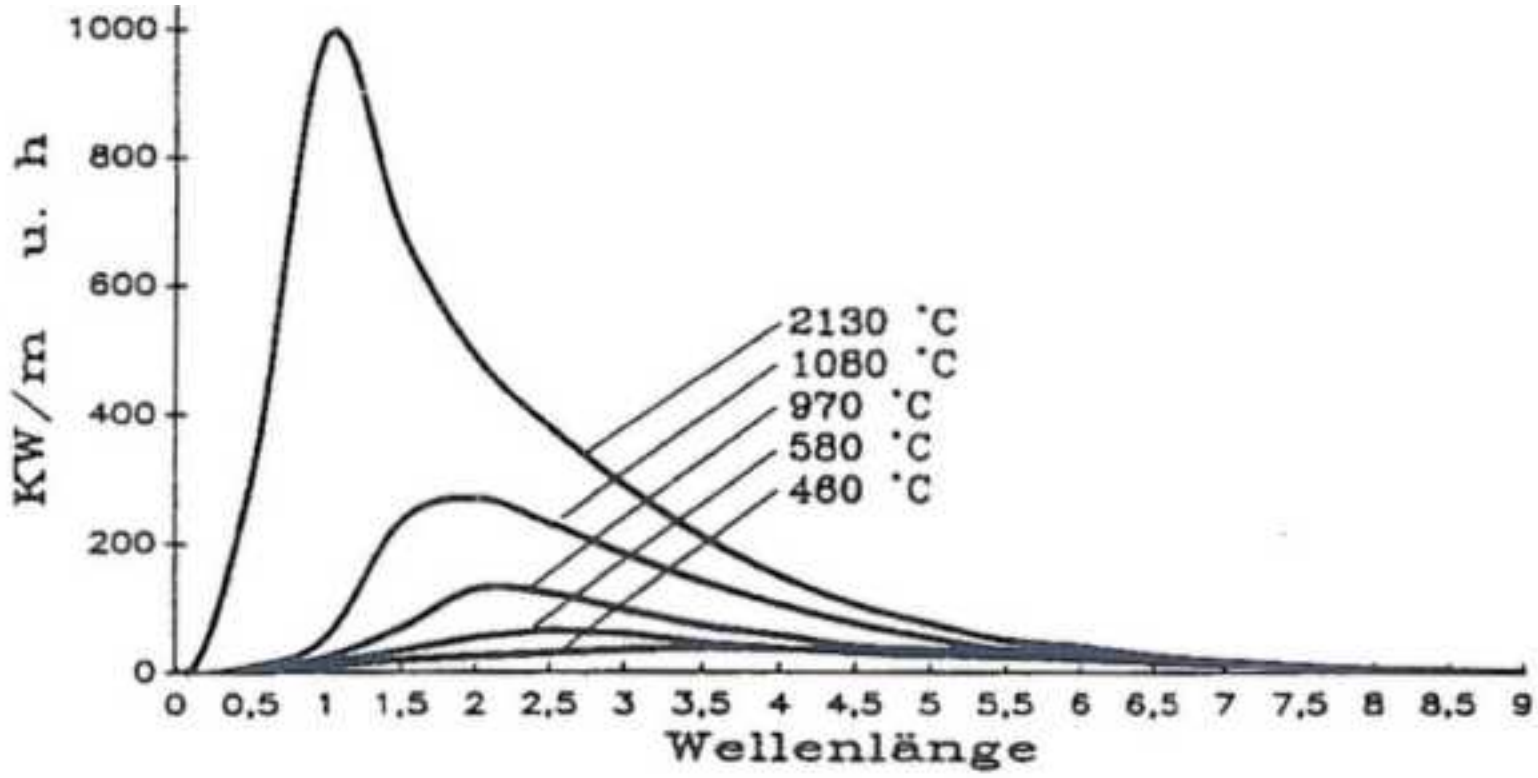


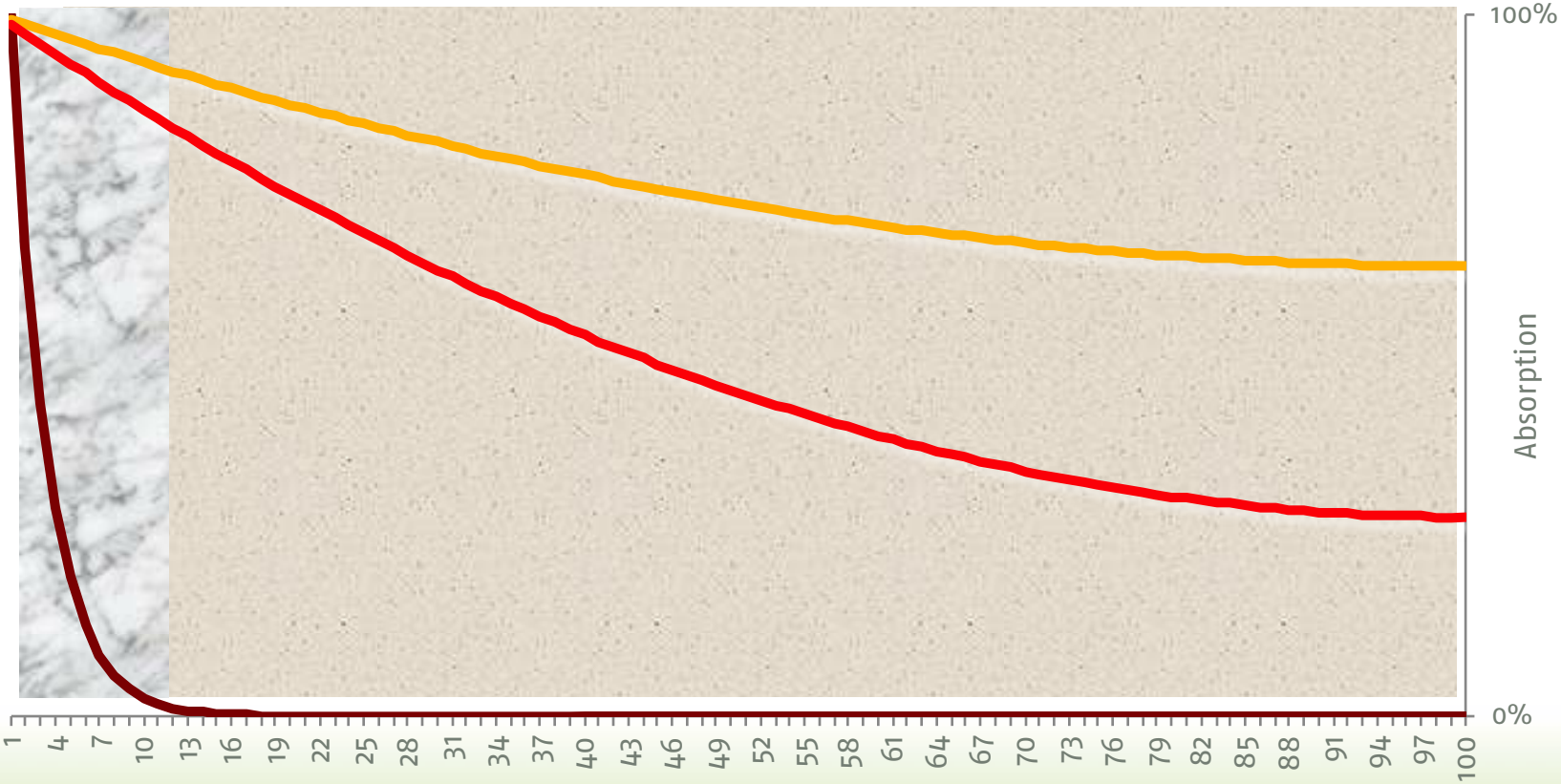
Wavelength and Radiation Density



A b b. 1: Energieverteilung von Strahlern unterschiedlicher Temperatur

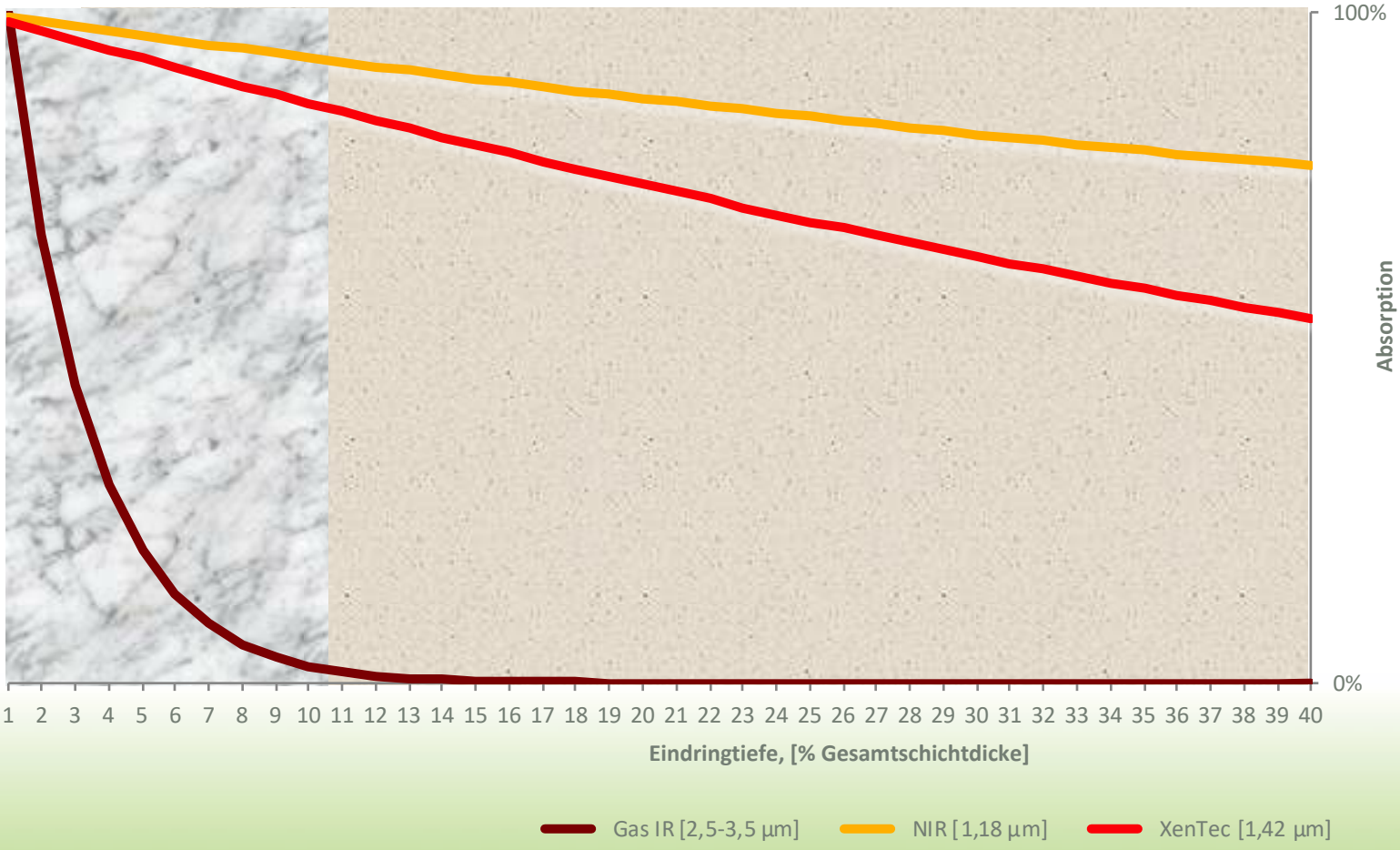
Source: Influence of emitter temperature of infrared emitters upon drying performance
Helmut Graab, Wochenblatt für Papierfabrikation 19/1991

Penetration depth vs. Wavelength
Board 200 to 300 gsm



Approximation to Lambert-Beer's Law with typical values for medium weight board

Penetration depth vs. Wavelength
Fine Paper 60 to 100 gsm



Approximation to Lambert-Beer's Law with typical values for medium weight board

Infrared –
just the first step of drying

- Infrared radiation just delivers energy transfer
- The sheet or coating is warmed up
- Steam and warm water move toward surface
- But 0,2 m to 1,5 m after energy input the laminar boundary layer is saturated
- Drying stops!

Laminar Boundary Layer

- For efficient drying, the laminar boundary layer must be disturbed by turbulent air, to avoid vapour saturation!

Drying

- Only after having evaporated to the laminar boundary layer, the paper and coating is dried!

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Drying Technology

- XenTec Lamps
- Gold plated reflectors
- Quartz Protection Tubes
- Active boundary layer management

XenTec Technology

- Compact Engineering develops and manufactures the lamps and filaments
- Maximum output at 1.40 µm at full load
  - Ideal for overcoming hydrogen bonds between water molecules and fibres
  - Ideal for deep penetration and thus drying with reduced binder and fines migration

XenTec Lamps

- Increased filament surface
  - For improved specific radiation
  - Higher energy density

XenTec Lamps

- Special gas fill
  - allows increased radiation output
  - reduces energy losses by conduction
- Special quartz glass with *tenfold* transmission of infrared
  - reduced radiation losses
  - reduced cooling losses

XenTec Lamps
Infrared transmission of glass

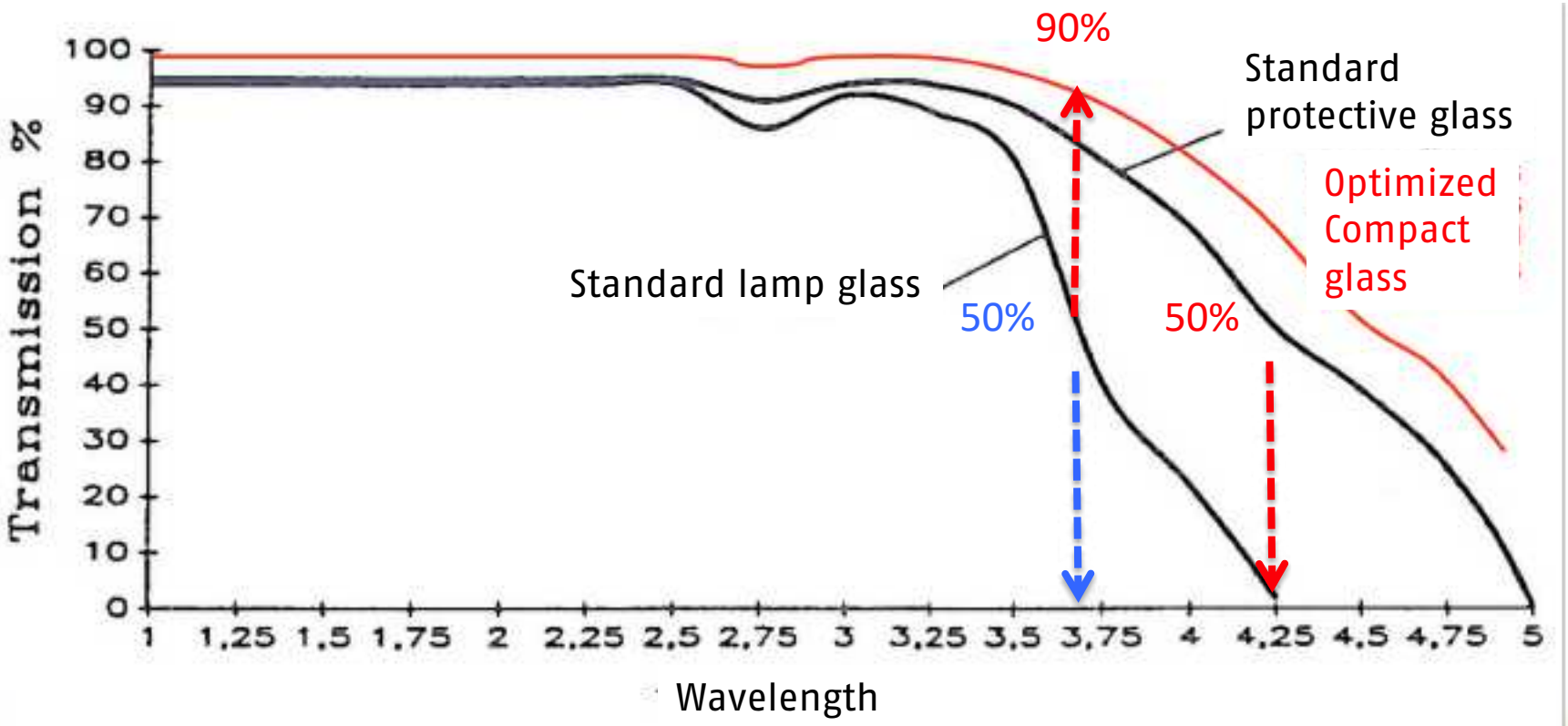

Abb. 3: Transmission of Quartz glass as function of wavelength

Source: Influence of emitter temperature of infrared emitters upon drying performance
Helmut Graab, Wochenblatt für Papierfabrikation 19/1991

Gold coated reflectors

- Perfect reflector for infrared radiation
- Special cooling for low operational temperature
- Radiation emitted from lamp and reflected from sheet will be reflected to web until complete absorption

Quartz protection tubes

- Protection tubes for same protection with lesser wall thickness
- Special quartz glass for least possible absorption of infrared radiation
- Will not consume energy, cool to touch in less than 2 seconds
  - Reduced fire danger in case of sheet break
  - Increased work safety
  - Reduced losses of radiation
  - Reduced cooling energy required

Active Laminar Boundary Layer Management

- Use of turbulent air
  - Replaces saturated laminar layer from the sheet surface
  - Garantees low partial vapour pressure in the laminar layer above the sheet
- Enables further mass transport of vapour = drying
- Sheet surface stays cool thanks to evaporation enthalpy

Key advantages of XenTec dryers

Drying from bottom to top thanks to ideal wavelength

- Immediate immobilisation of initial sedimentation layer
- Perfect control of migration of binder and fines into the substrate
- Reduced blistering
- Eases load of hot air dryers, as water and steam are propelled to the surface
- Eases load of drying cylinders, as water and steam are propelled to the surface

Summary

- Highly energy efficient, typically twice as good as other electric infrared emitters
- Typically as cost efficient as gas fired infrared dryers
- Drying from inside out through ideal wave length distribution
- Gentle drying at low web temperatures thanks to immediate evaporation
- Despite very high energy density no damage to the coated surface

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Further information at

www.compact.co.uk

www.wolfheilmann.eu

Or during your next pilot trial at VESTRA pilot coater of PTS