

NDT for refractories

from quality control to final use in glass furnaces

The logo for AGC (Asahi Glass Company) is displayed in a white box. It consists of the letters 'AGC' in a bold, blue, sans-serif font. A small red square is positioned between the 'A' and the 'G'.

2024-10-21 for TC11

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Your Dreams, Our Challenge

- For more than 60 years, NDT has been used for the refractories with 4 different methods:

Ultra-sound

Microwaves

γ – Radiation

X- Rays

- 2 of them are described in this report: US & μ -Waves

	Ultra-Sound	μ - Waves
Wavelength (typical for NDT)	MHz	GHz
Wave form	Pulse	Constant transmission
Measured quantity	Acoustic attenuation / speed	Intensity decrease
Method	Transmission	Reflection
Coupling	Water or Gel or Plasticine	Air
Absorption coefficient \rightarrow f (material)	Acoustic impedance $v = \frac{Z_{ac}}{\rho_{mat}}$	Dielectric constant $v = \frac{c}{\sqrt{Dielect}} $

Why performing Ultrasonic measurements ?

- ② Ultrasonic waves : widely used to characterise materials (concretes, metals, etc..)

Quick and reliable Non Destructive method ➡ Quality / Defect detection/ E-modulus

Our application : Refractories

- Check the homogeneity of the batch
- Find anomalous brick result **during inspection**

What is measured ?
**Velocity of the wave travel
inside the brick (m/s)**



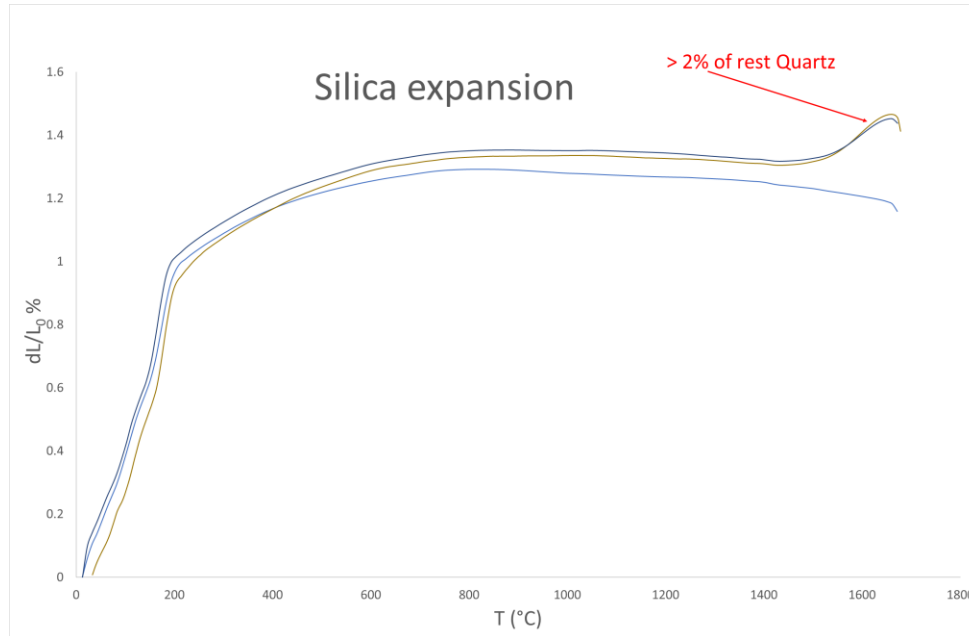
**Unexpected /
abnormal values**



Can be linked to:
Issues in Forming
Issues in Firing
Changes in raw material

NDT (Sonic & US) on silica bricks



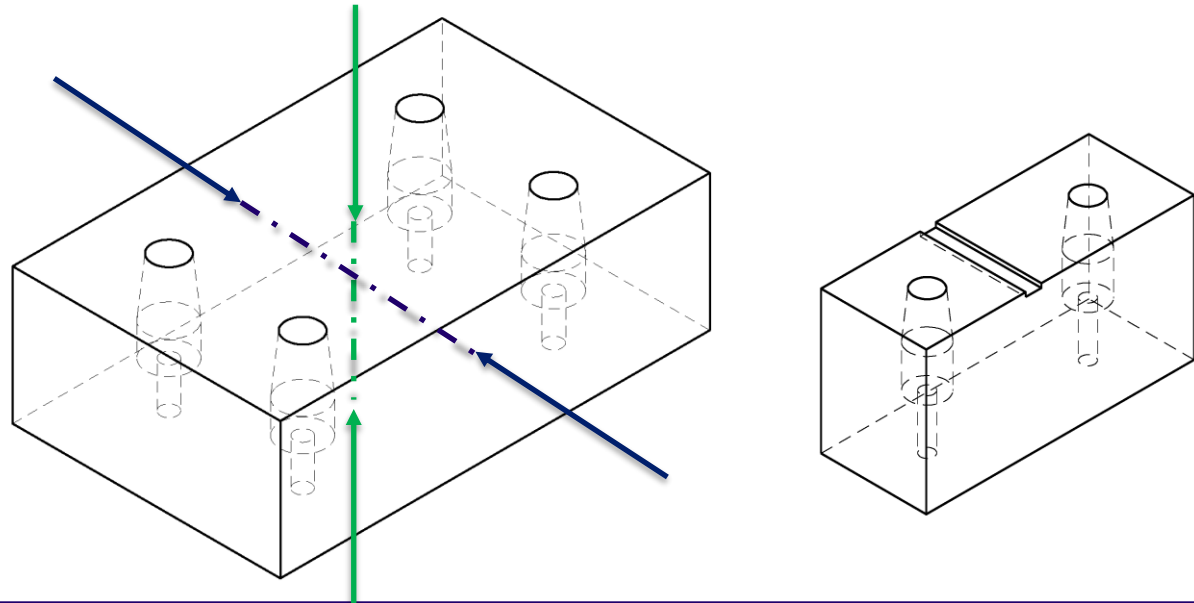


Uncontrolled silica expansion at high T

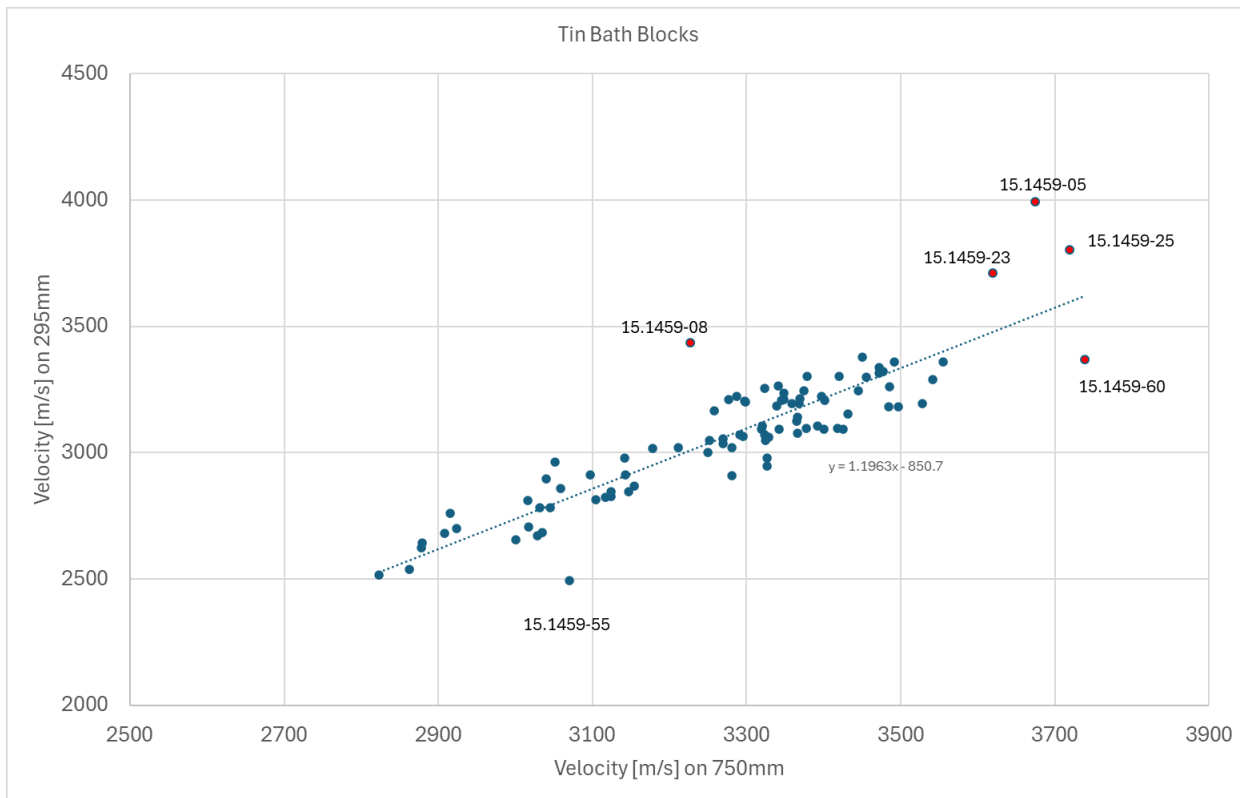


Ultra Sonic control on tin bath blocs (principle)

1. Measurement done in 2 perpendicular directions (take into account the pressing direction or casting & stud holes position)
2. Plot the values on a chart and check the homogeneity and the linearity
3. Evaluate if the average μ & standard deviation σ fit the specification



Ultra Sonic control on tin bath blocs (case 1)



- 305 TBB (several shapes) were inspected.
- 5 TBB blocks have been rejected :
 - 15.1459 #05 (black core & crack)
 - 15.1459 #08 (black core & crack)
 - 15.1459 #23 (black core)
 - 15.1459 #25 (black core)
 - 15.1459 #60 (crack)

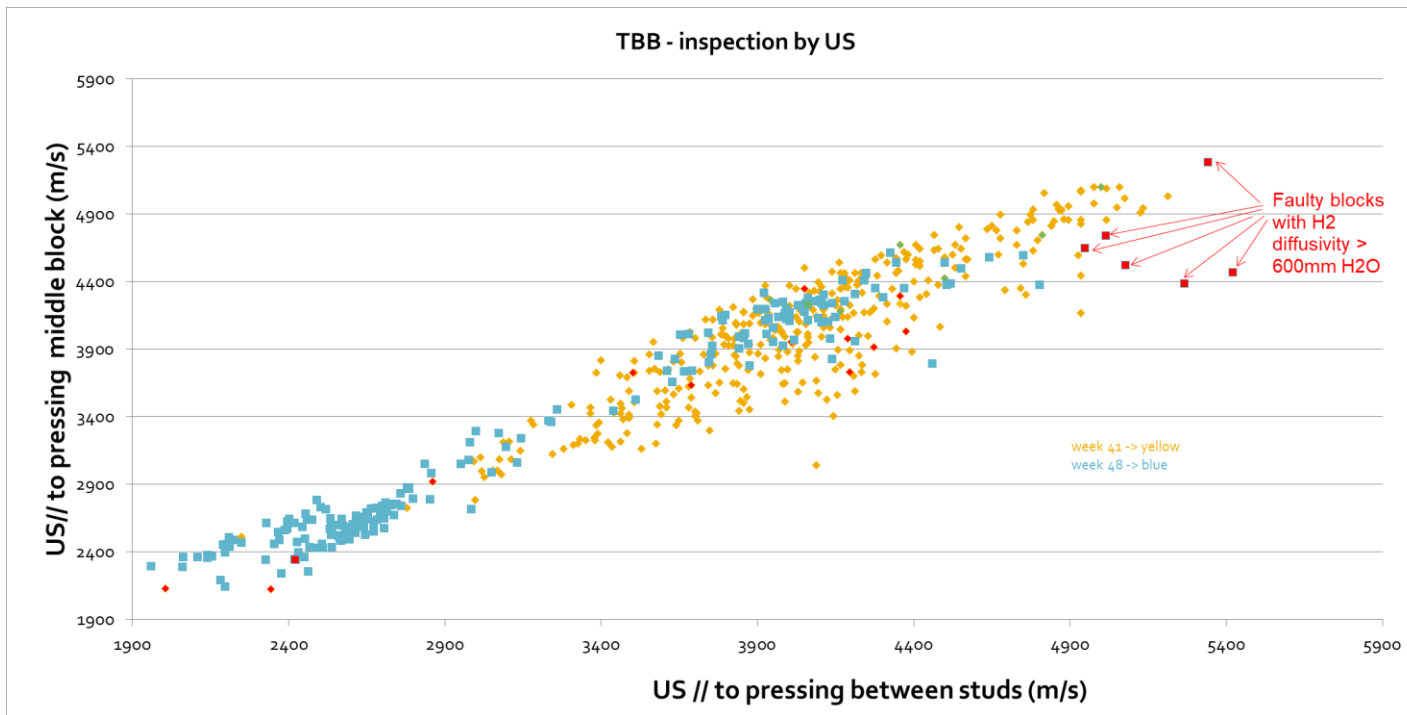


Black cores

Ultra Sonic control on tin bath blocs (case 2)

603 TBB (several shapes) were inspected.

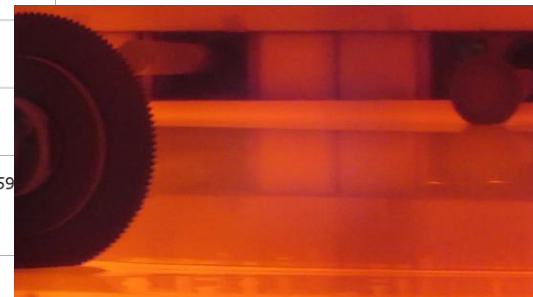
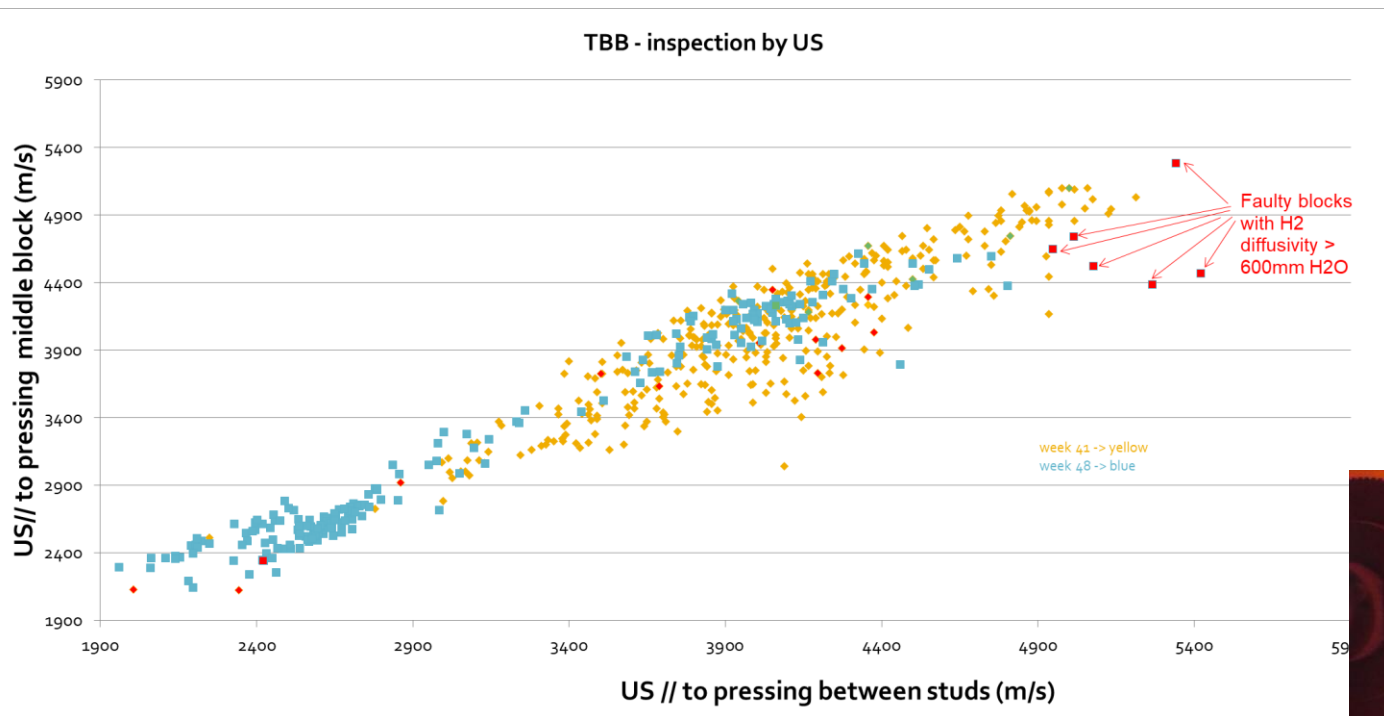
6 TBB blocks have been found with higher US speed than the statistic. All of them had a hydrogen diffusivity above 600 mm H₂O that could lead to Large Open Bottom Bubble (LOBB)



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Since the late 1990s, ground-penetrating radar (GPR) has found various applications in the survey of the structure and substructure of nonconductive material (pavements, bridge decks, airport runways, roads...)

It can be used to assess the layers, reinforcement, moisture content, presence of voids, and other anomalies in the substructure.

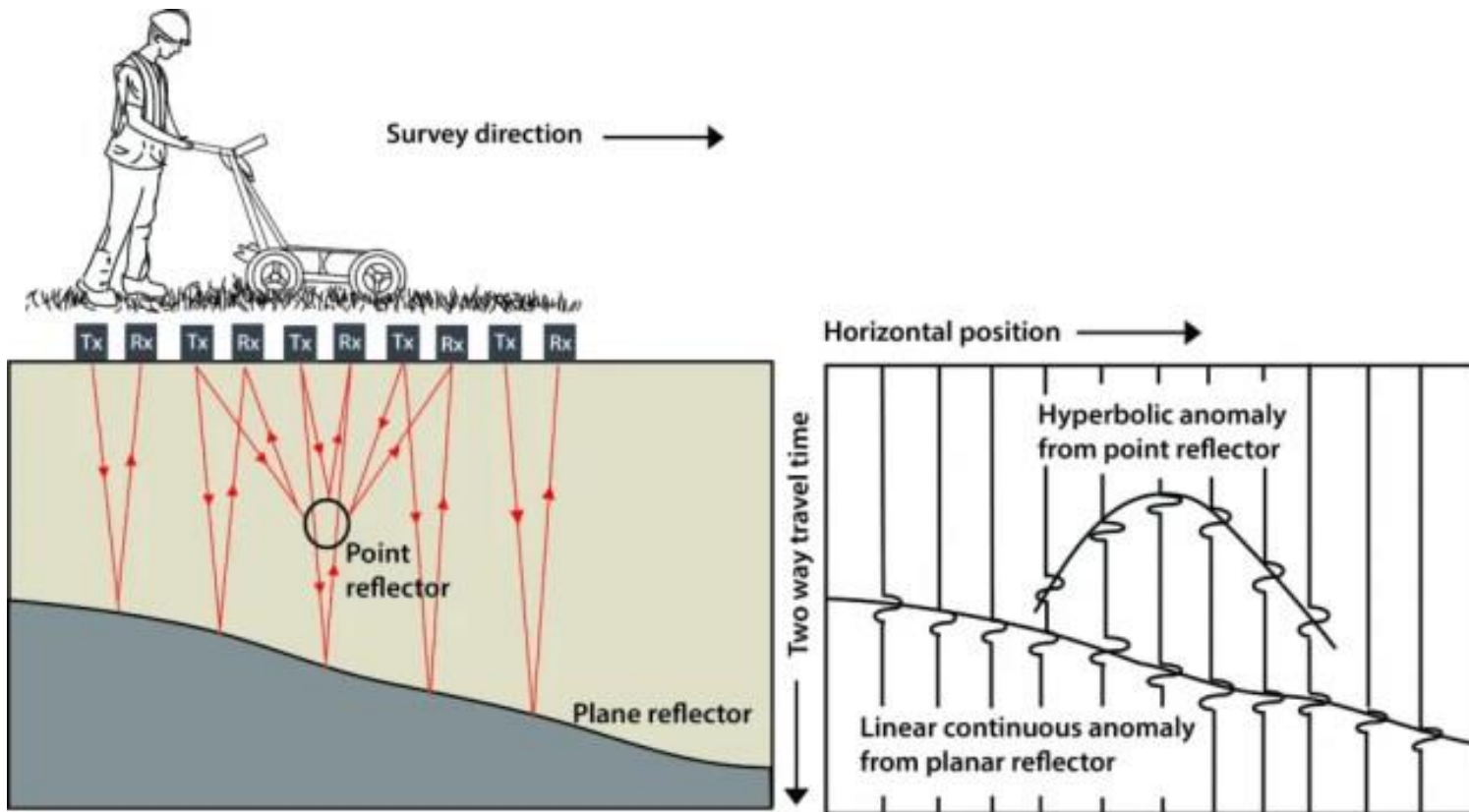
The extension to the refractories is now well known and used by the producers as well by the end users.



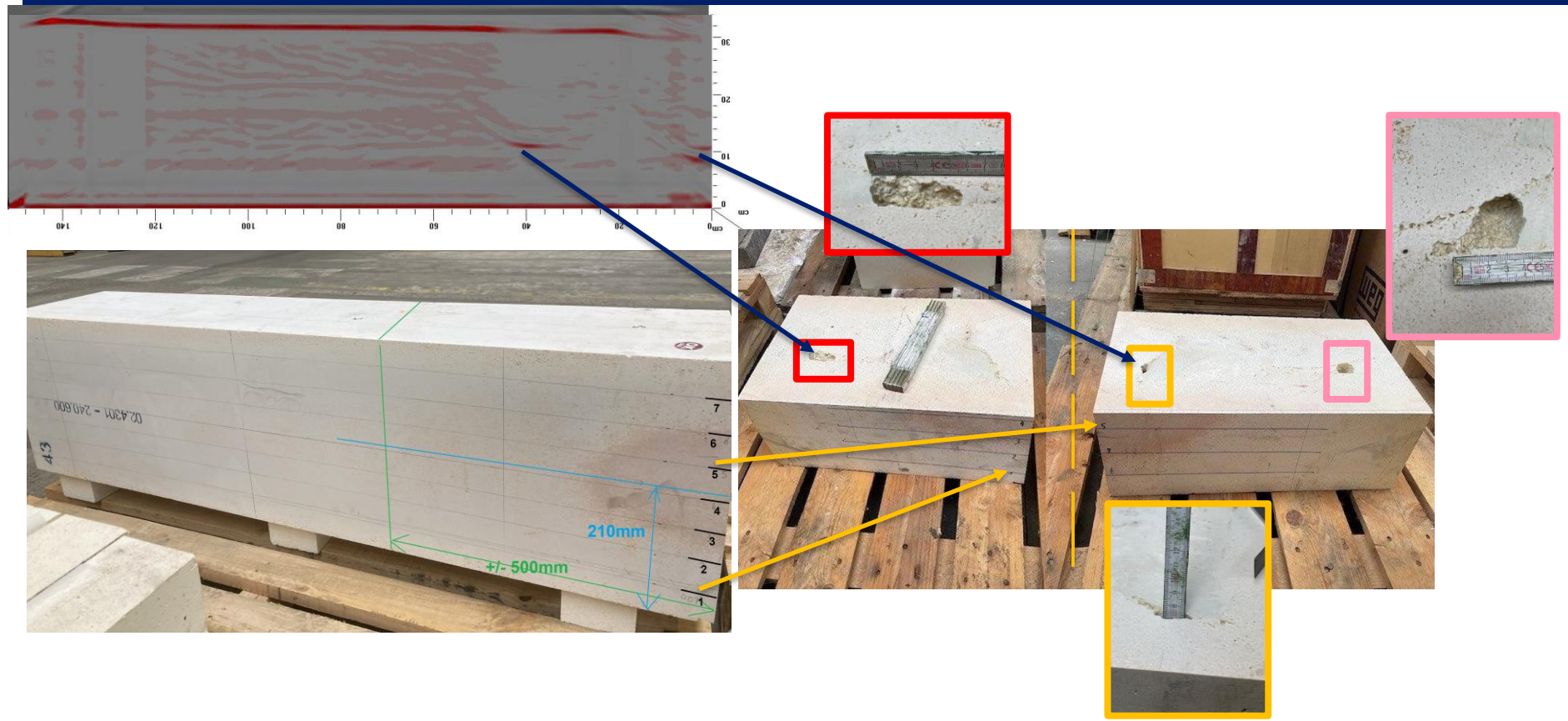
2 physical properties of the material impact the GPR response:

1. **Electrical conductivity**: The Radar is suitable for inspection of any material with low electrical conductivity.
2. **Dielectric constant**: Descriptive number that indicates how fast radar energy travels through a specific material. ($v = \frac{c}{\sqrt{Dielect\ constant}}$)

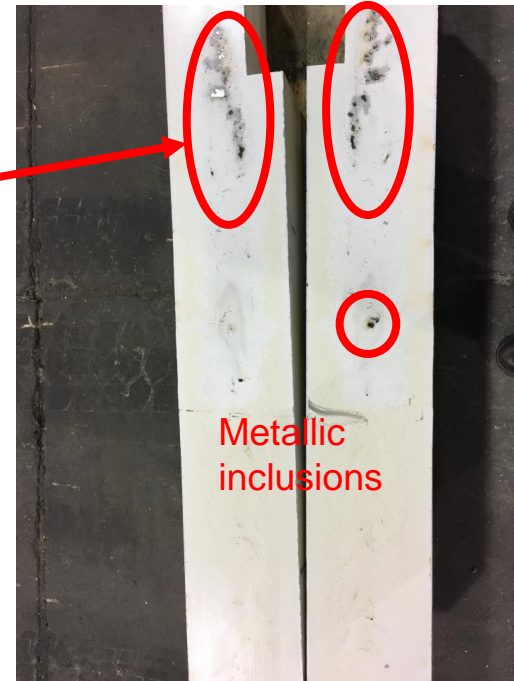
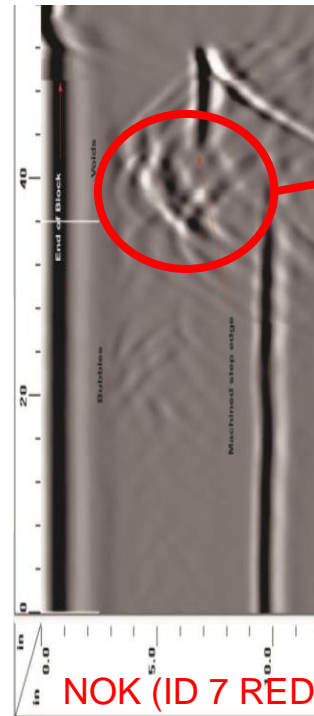
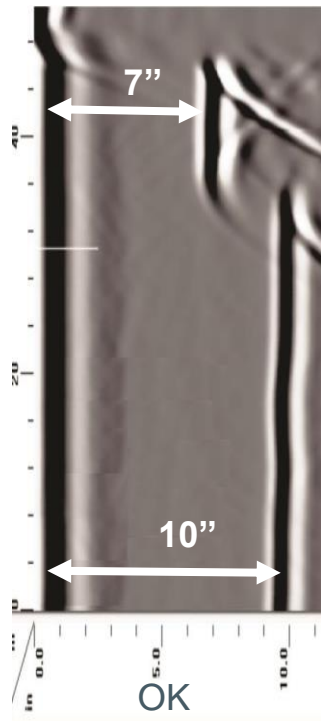
GPR Principle (example of soil survey)



GPR – void detection in AZS Fused Cast



GPR – metal detection in AZS Fused Cast



Challenge: define specification for GPR

Typical problems to be avoided by GPR control of AZS FC



Local corrosion due to voids & / or upward drilling

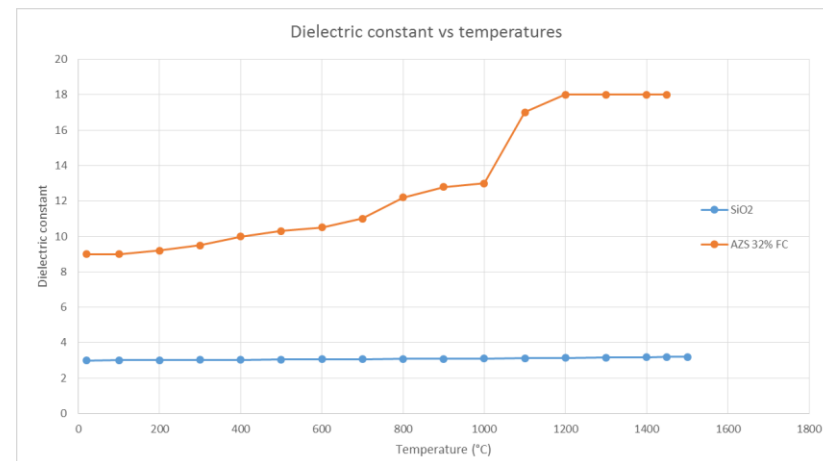
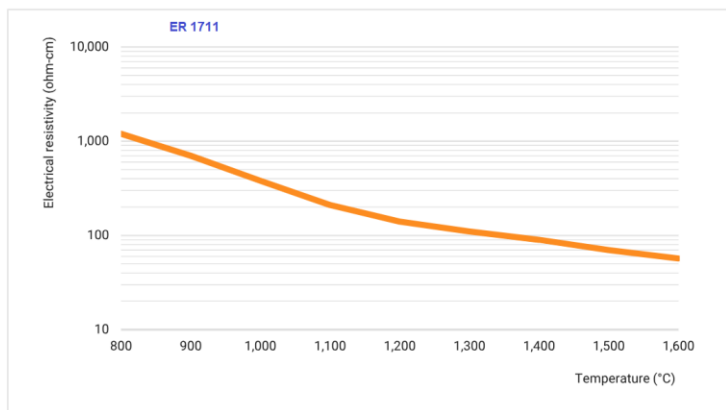
GPR at high temperatures → limitations for electrocast

Dielectric constant can be easily measured or found in the material handbooks at room temperatures

Material	Dielectric Constal
Air	1
Silica brick	2.5
Fireclay	4
Granite	5
AZS Fused Cast	9
Volcanic Ash	13
Wet soils	24
Water	81

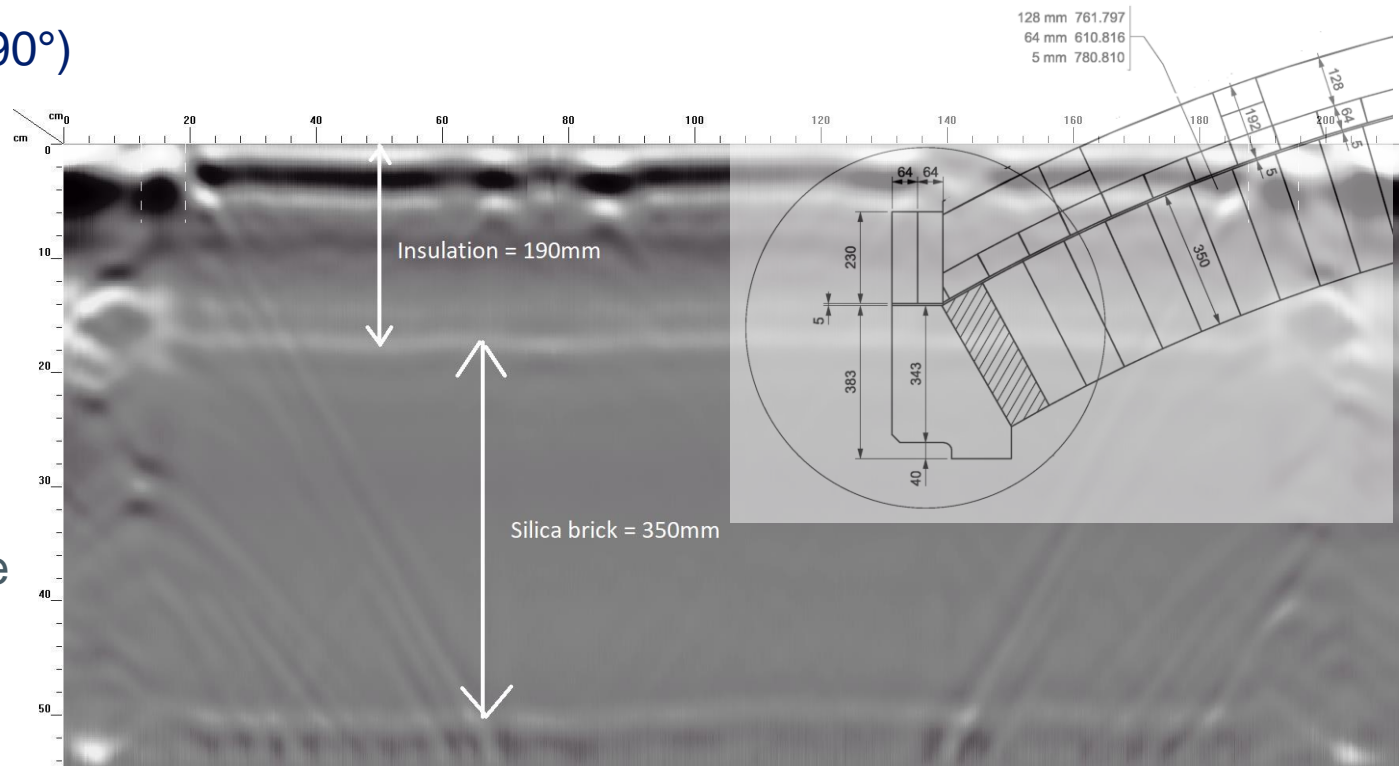
However electric conductivity of hot AZS electrocast materials and change in dielectric constant with T gives rise to a very high attenuation of the microwave signal.

Electrical resistivity curve



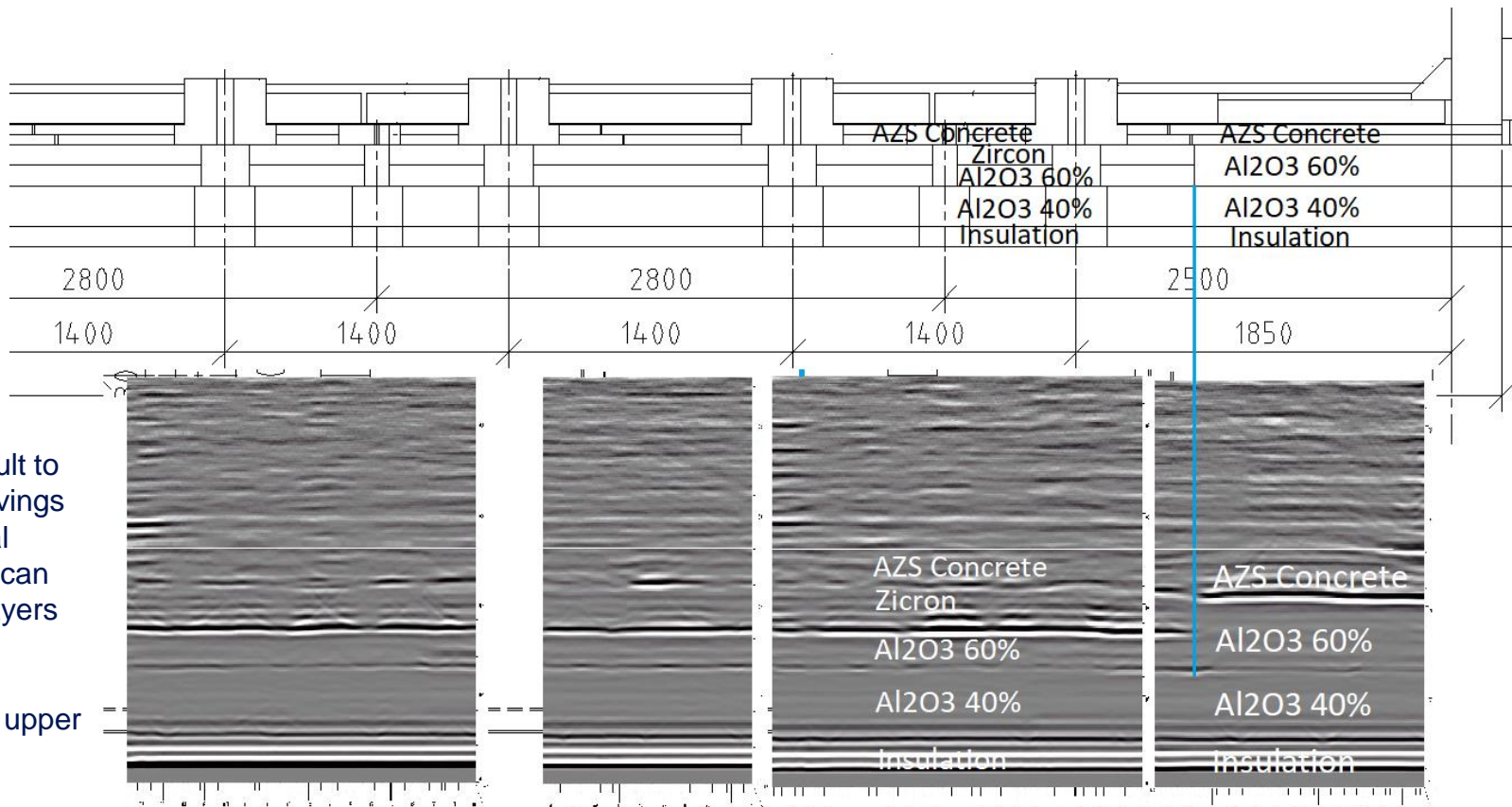
GPR hot - Residual thickness (hot) – TC 11 2018

Silica crown
(regenerator +/- 1490°)



Clear visibility of the
refractories
thicknesses
(insulating & silica)

GPR hot (bottom survey)



Whilst it is difficult to see the AZS pavings due to the signal attenuation, we can detect the sublayers and deduce the presence or the corrosion of the upper AZS paving

- Amongst the NDT, Ultra-sound and μ -Waves have been applied for the refractories selection.
- US is intensively in transmission and used to assess the refractories batch homogeneity. Examples with silica bricks and tin bath blocs have been described.
- μ -Waves is used for the AZS electrocast refractories selection at room temperature. Since this method uses the reflection, it offers the advantage to be used at hot temperature.
 - Depending upon the material properties at hot temperatures, the residual refractories thickness can be measured directly (case of silica crown) or indirectly by checking the state of the sub layers, in contact with the electrocast material.