

Presents

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GREEN & SUSTAINABLE IRON MAKING

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THINK BEYOND. SHAPE THE FUTURE.

Green Taphole clay

A Cleaner & Greener solution for future generation

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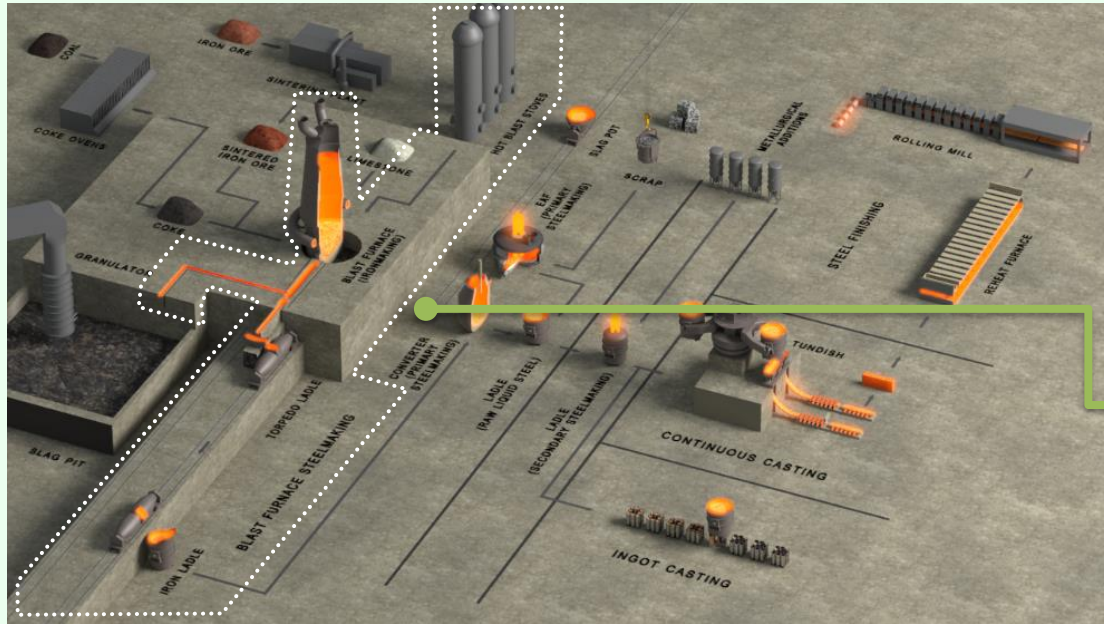
* Speaker

VESUVIUS

Outline of the presentation

- The Blast Furnace
- Taphole clay design, so-called THC
- Origin of hazardous component
- Why we need Green Taphole clay
- Method to develop a Eco-Friendly binder – NAFTA path
- Field References
- Conclusion

Role of Blast Furnace in the steel making process & Importance of the taphole area



Steel making process
(including Iron making)

Layers of iron ore, coke, and limestone

Hot blast air – 1200°C

Slag

Pig iron

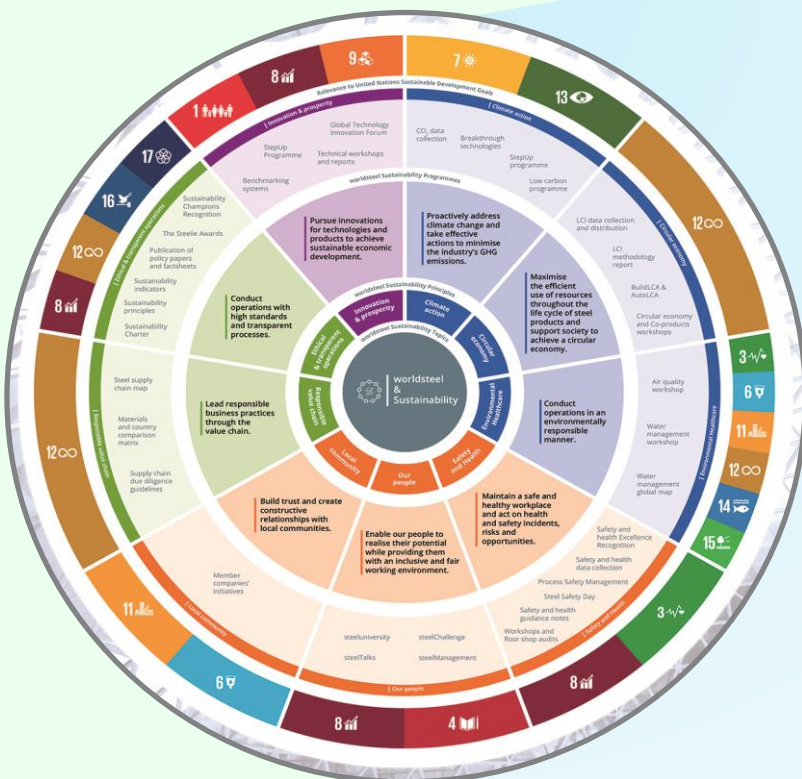
Jet stream

Taphole

Blast Furnace*

*CARON, P. *Introduction aux charpentes d'acier*, Montréal : Centre collégial de développement de matériel didactique, 2022.

Why we need Green Taphole Clay - Sustainability actions of WSA.



Topic	Principle	Criteria
1 Climate action	Proactively address climate change and take effective actions to minimise the industry's GHG emissions.	1. CO ₂ emissions or energy consumption data provided to worldsteel or national governments. 2. Plans and goals established for CO ₂ /GHG emissions reduction.
2 The circular economy	Maximise the efficient use of resources throughout the life cycle of steel products and support society to achieve a circular economy.	3. LCI data provided to worldsteel and/or available through certified environmental declarations. 4. Data on co-products, landfilled and incinerated material provided to worldsteel.
3 Environmental care	Conduct operations in an environmentally responsible manner.	5. Investment and/or implementation of environmental site-related improvement projects undertaken. 6. Information published on air pollutants and on water use.
4 Safety and Health	Maintain a safe and healthy workplace and act on health and safety incidents, risks and opportunities.	7. Use of an environmental management system. 8. Safety data provided to worldsteel. 9. Use of a safety and health management system.
5 Our people	Enable our people to realise their potential while providing them with an inclusive and fair working environment.	10. Safety performance statistics published. 11. Participation in worldsteel Day for Safety and Health. 12. Employee training time provided to worldsteel.
6 Local communities	Build trust and create constructive relationships with local communities.	13. Human resource management policies in place. 14. Community engagement, investment, and/or involvement in CSR activities.
7 Responsible value chains	Lead responsible business practices through the value chain.	15. Use of supply chain and/or procurement management codes or systems. 16. Code of business conduct in place.
8 Ethical & transparent operations	Conduct operations with high standards and transparent processes.	17. Publication of Sustainability or CSR report. 18. Stakeholder engagement and communications.
9 Innovation and prosperity	Pursue innovations for technologies and products to achieve sustainable economic development.	19. Investment in new processes and products (CAPEX + R&D) data provided to worldsteel. 20. Economic Value Distributed (EVD) data provided to worldsteel.

2023 signatories to worldsteel's Sustainability Charter

Members of worldsteel are committed to a vision where steel is valued as a vital material for a sustainable world, taking leadership to generate positive impacts on people, our planet and the prosperity of society. We will base all our actions on our sustainability principles to achieve this.

Our Sustainability Charter recognises member companies and associations that proactively embrace our sustainability principles.



Taphole Clay – Composition

Raw material used in Taphole mixes:

Aggregate System

- ✓ BFA
- ✓ Bauxite,
- ✓ Fireclay,
- ✓ Sand...

Matrix

- ✓ Alumina,
- ✓ Kyanite,
- ✓ Ball-clay,
- ✓ Carbon sources...

Additives

- ✓ Silicon Carbide,
- ✓ Fe-Si₃N₄,
- ✓ Metal powders...

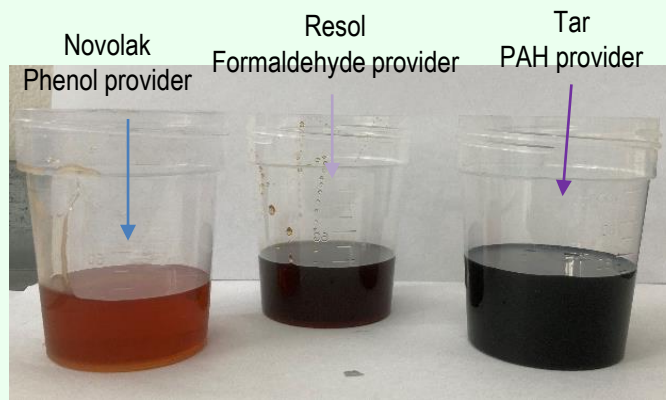
Binders

- ✓ Tar,
- ✓ Pitch powders,
- ✓ Resins,
- ✓ Synthetic-pitch,
Solvents...

Taphole Clay (Plastic refractory material) = Ceramic (dry powders) + Polymer (liquid materials)



Taphole Clay – Origin of hazardous components from the standard binder system



Solvent	Category	Specific limit (mg/kg)
Novolak Phenol donor		
Phenol		
Formaldehyde		
Furfuryl Alcohol	C, STOT RE2, SE3	10,000
Ethane-1,2 diol	STOT RE2	50,000
Nonylphenol	R	30,000

Removed from the portfolio

16 PAH	Number of Rings	Category	Specific limit (mg/kg)
Naphthalene	2	C	10,000
Acenaphthylene	3		
Acenaphthene	3		
Fluorene	3		
Phenanthrene	3	C	10,000
Anthracene	3	C	10,000
Fluoranthene	4		
Pyrene			
Benzo[a]anthracene			1,000
Chrysene			1,000
Benzo[b]fluoranthene	5	C	1,000
Benzo[k]fluoranthene	5	C	1,000
Benzo(a)pyrene	5	CMR	100
Dibenzo[a,h]anthracene	5	C	100
Benzo[g,h,i]perylene	6		
Indeno[1,2,3-cd]pyrene	6	C	10,000

Removed from the portfolio

- Objectives**
- No phenol
 - No formaldehyde
 - No PAH

Method for the development of a binder to replace Coal Tar / Petroleum tar

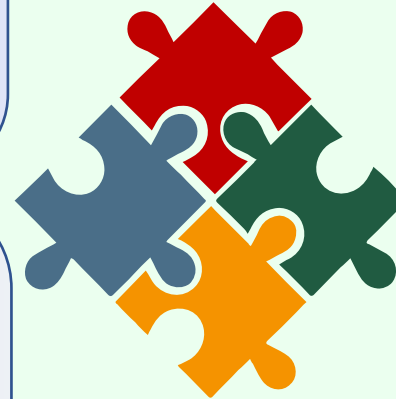
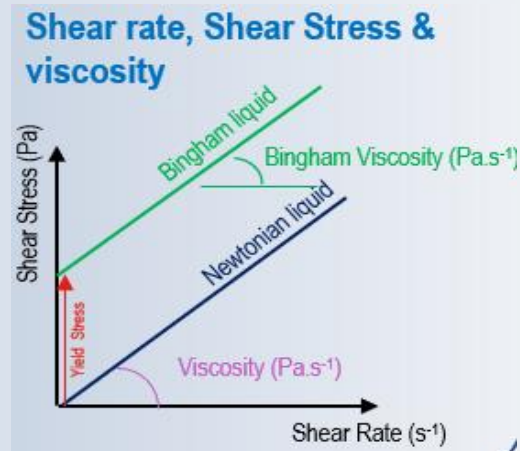
Method & Target

Selection of raw materials containing neither formaldehyde nor PAH
Blending of different selected raw material
Rheological behavior as close as possible to that of Petroleum / Coal Tar.
Aim – simplest path by replacement one by one

Rheology of binder

Tar is refined residue from the distillation of crude oil / crude tar from Coke oven.

Tar has viscoelastic properties at room temperature



Experimental Procedure

Tool – Anton Paar MCR 302 rheometer

Flow curve analysis – Measurement viscosity vs. Shear rate
Yield point determination
Calculation of Herschel Bulkley index
Evolution of viscosity vs. T°



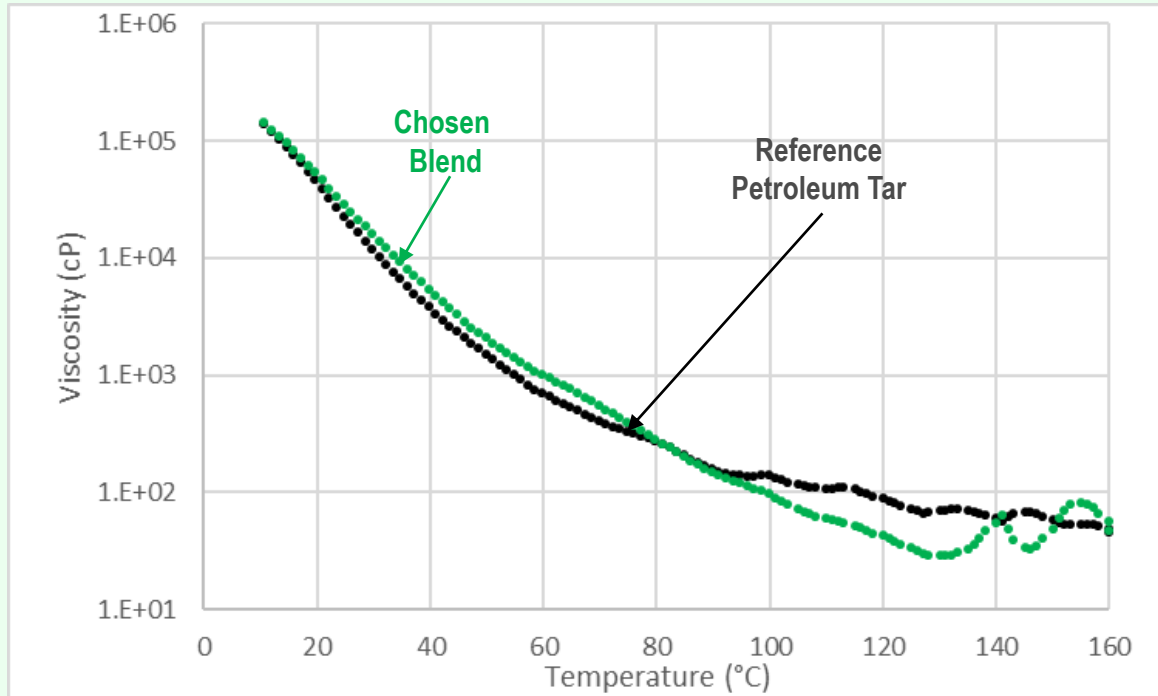
Herschel-Bulkley index (p)

The Herschel-Bulkley regression describes the flow curve of a material with a yield stress and shear-thinning or shear-thickening behavior at stresses above the yield stress
In one dimension, the constitutive regression of the Herschel-Bulkley model can be written in the form:

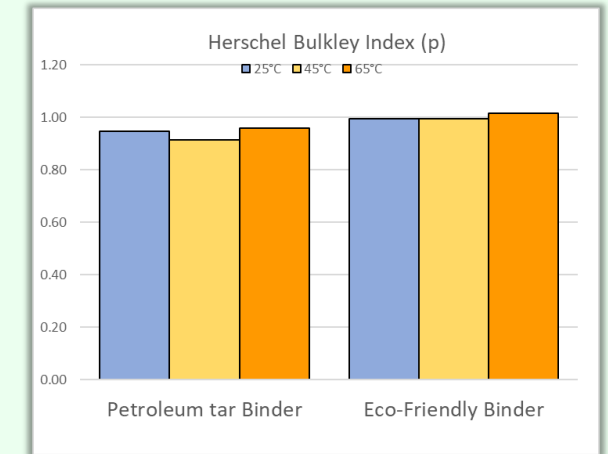
- $p < 1$: shear-thinning
- $p > 1$: shear-thickening
- $p = 1$: Bingham flow behavior

Lab Results - Viscosity & Herschel Bulkley Index

Viscosity vs. T°

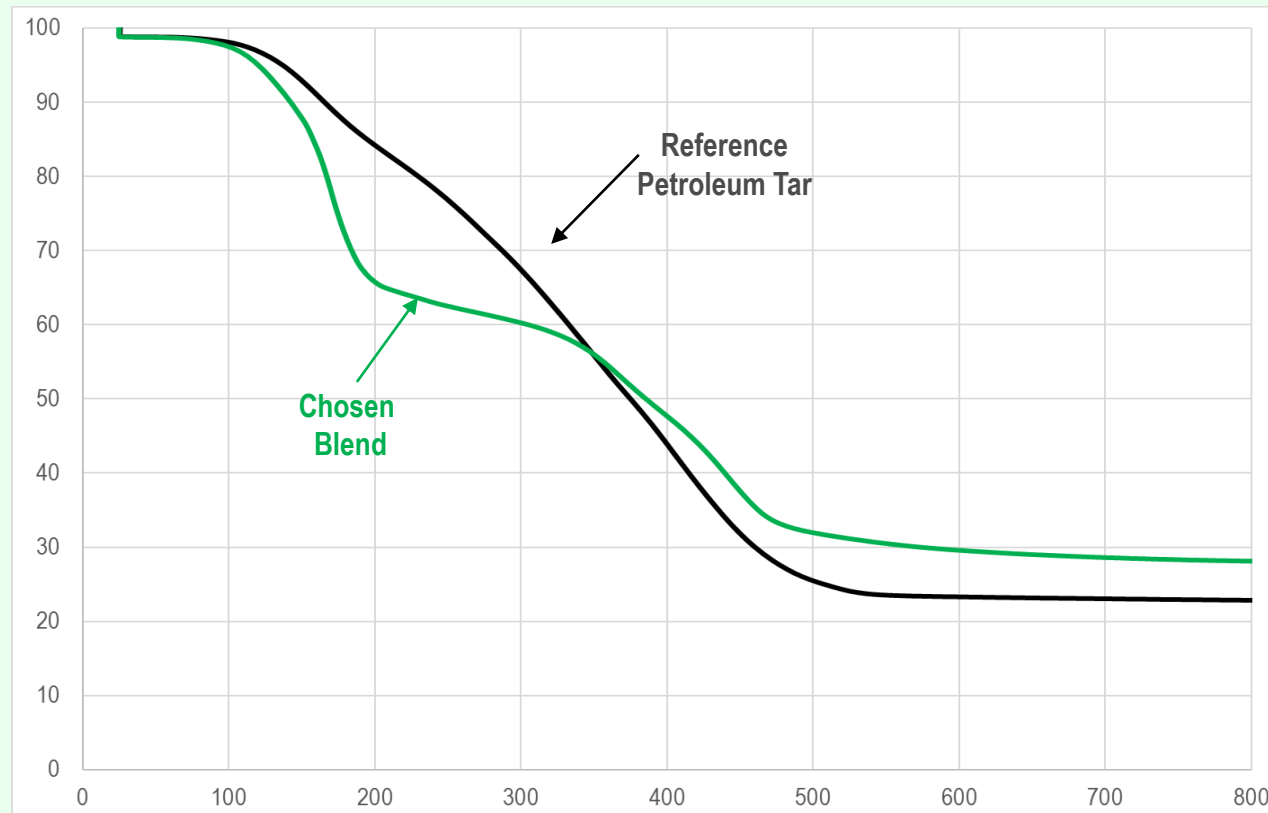


Herschel Bulkley Index



- $p < 1$: shear-thinning
- $p > 1$: shear-thickening
- $p = 1$: Bingham flow behavior

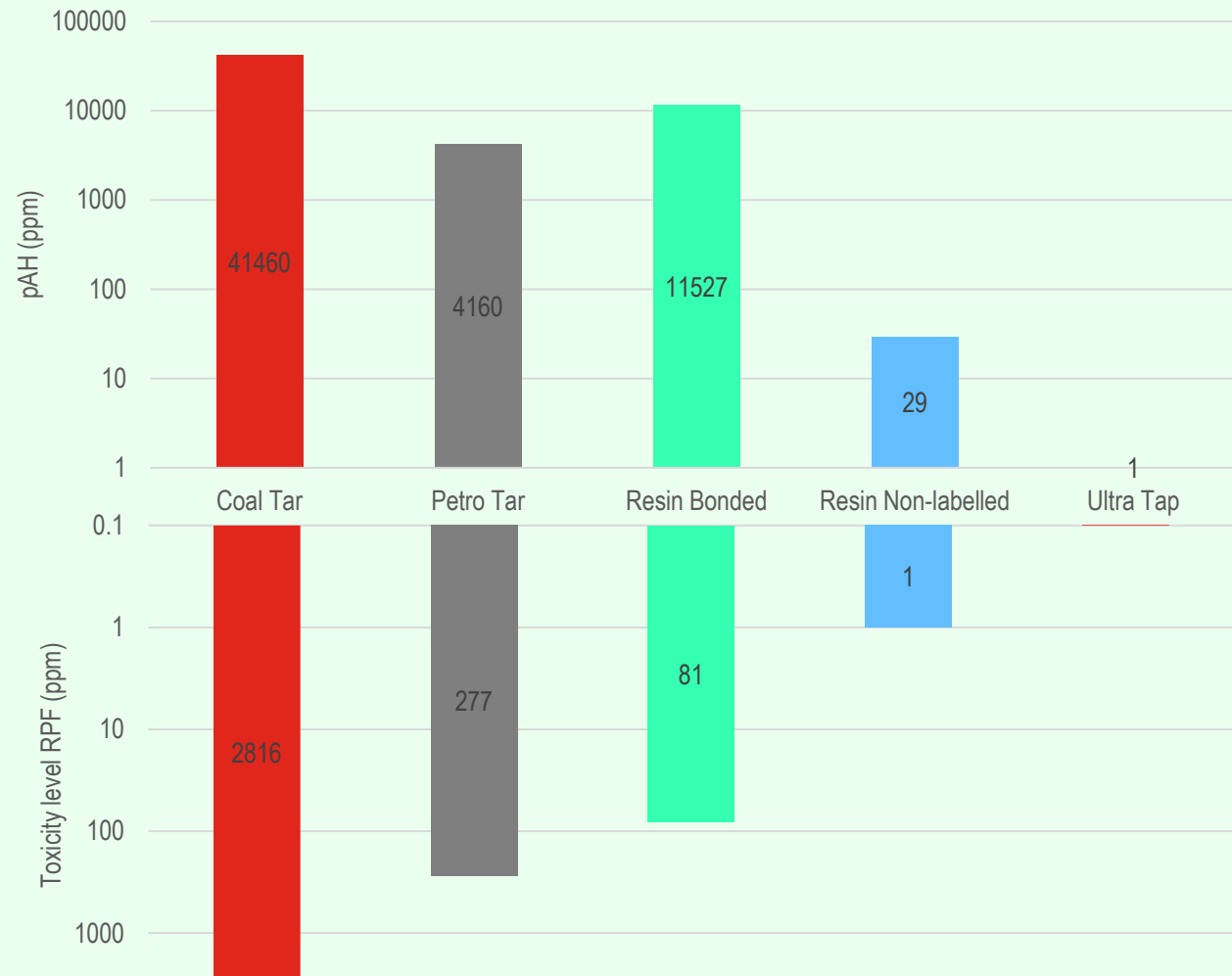
□ TGA (STA 449F3 Netzsch - 5°C / min – Argon atmosphere)



□ Comments

- Faster degassing
- Reduced dwell time
- Low Splashing.
- Wet taphole conditions.

PAH Calculation and Toxicity level estimation



In Simple Vesuvius is reducing the amount of PAH level as well as the RPF.

This is the evolution of Vesuvius Clay

SURTAP

(Tar: Coal /Petro)

KINGTAP – 1st Generation (labeled)

(Resin + Pitch)

KINGTAP – 2nd Generation (Non- labeled)

(Resin)

KINGTAP / SURTAP XTRA

(Green Binder + Ultra low pAH)

■ Main information

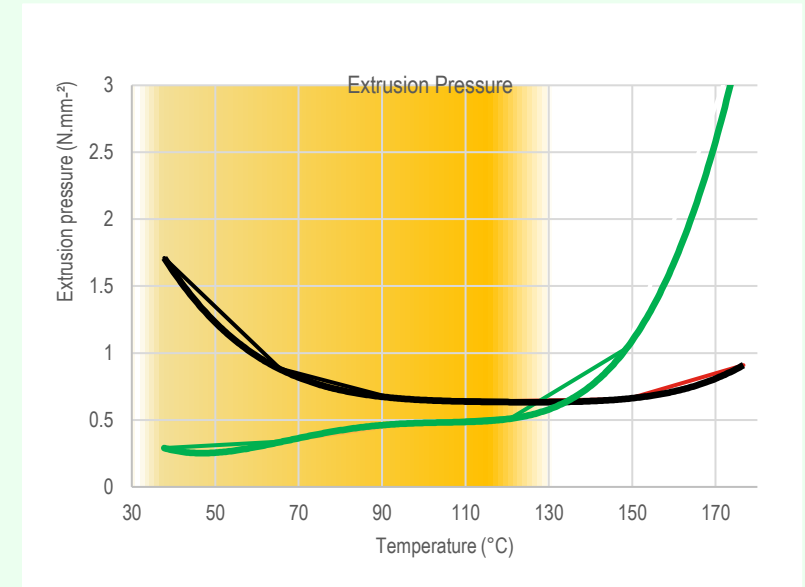
- Substitution of the Petroleum Tar and Pitch
- Very low amount of Phenol ($X < 2500$ ppm)
- Formaldehyde and PAH Free



From Field results

- Performance is better
- Usage is easier
- Decrease of specific consumption by 17 %

■ Stable extrusion pressure over wide mudgun temperature range



SUR-TAP (Petroleum Tar)
SUR-TAP XTRA (Eco-Friendly binder)

Dip Test Results : Coal Tar vs. Green Binder



Coal Tar Binder



Green Binder

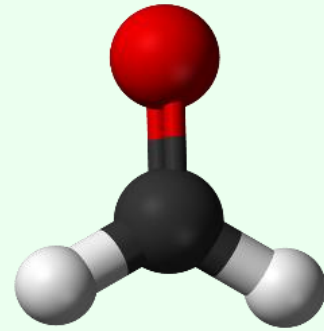
References

Blast Furnace	A		B	C	D		E	F
	Std	Eco-F			Std	Eco-F		
Working volume (m3)	2540	2540	2210	2600	2645	2625	2420	1610
Hearth diameter (m)	11.4	11.4	11.2	10.8	10.7	10.7	10.3	8.5
Daily Output (thm/d)	6250	6250	7760	7000	6500	6500	5750	4000
Taphole length (m)	2.8	3	4	3	2.8	3	2.5	2.5
Cast duration (min)	135	145	100	115	100	158	124	120
Slag ratio (%)	95	95	80	76	63	65	65	40
Ability to drill	Easy	Easy	Easy	Easy	Easy	Easy	Easy	Easy

6 recurrent customers

Deployment in progress in Europe with similar concept and a solution Phenol Free

Outlook for the future - No phenol, no formaldehyde, no PAH, no RCS



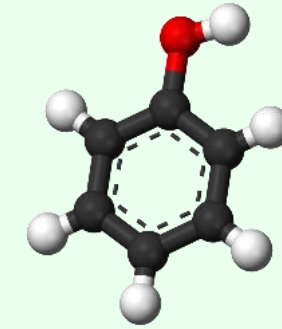
• Achieved

FORMALDEHYDE
FREE



• Achieved

PHENOL
FREE

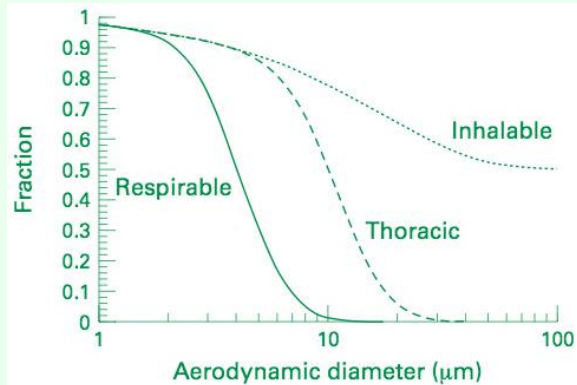


Formaldehyde free

Phenol Free

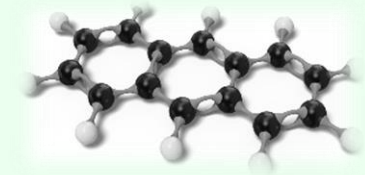
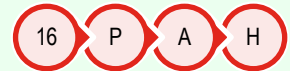
Respirable
Crystalline Silica
Free

PAH Free



• Next target

• Achievable with
some adjustments
for market



- **What is taphole clay?**

Taphole clay (THC) is a plastic refractory material with ceramic & polymer composite used in Blast Furnace for controlling the removal of iron and slag from the furnace.

- **The usual binders**

Phenolic resins contain volatile organic compounds such as phenol or formaldehyde. Coal or petroleum tar, contains PAHs (harmful to human health)

- **Formaldehyde and PAH free technology**

Development of a new binder based on rheological properties



- **Field Results and physical properties**

Development of a new taphole clays range

Conclusion

The Eco-Friendly Binder has zero formaldehyde and zero PAH contents. Application in the field shows increased performance. Eco-Friendly Binder does not require any reworking of the formulation, so it can be easily substituted for conventional binder.



Thank you for your attention.

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