A review on *In Situ* Burning

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Cedre information day

10th March 2015

Context
Deepwater Horizon spill

- 20 April 2010, 80 km off Louisiana shoreline
- 780 000 m^3 of Light Louisiana Sweet crude oil
- Dispersion, mechanical recovery and ISB deployed (pre-approved in local emergency plan)
- 40 days of ISB during 2,5 months (28th April – 19 july)
- 35 – 49 000 m^3 treated by ISB (≈ 5%)
- 411 oil collection and ignition, 376 significative burns (size, duration)
- Duration of a burning: few min to 12 hours

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Basics of burning

3 basics elements (Fire triangle):

1 – light product which generates flammable vapors

2 – air – vapor mixture at correct concentration

3 – activation energy

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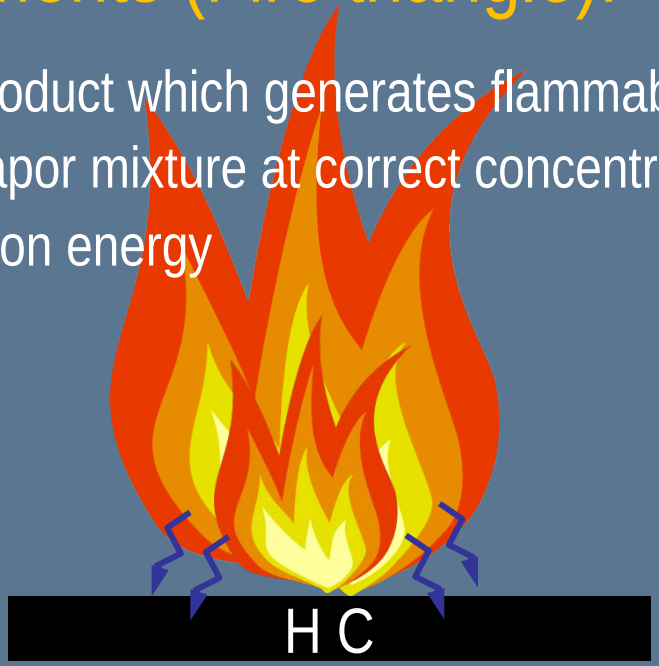

Most of the heat (97%) is transferred to the atmosphere through radiative processes, 3% of the heat is radiated from the flame back to the surface of the slick and brings the oil to its fire point temperature

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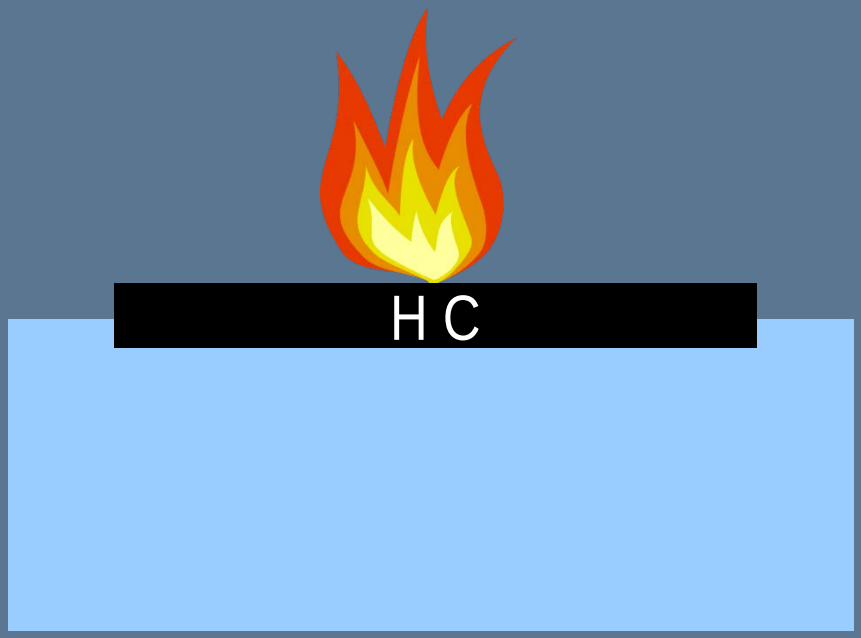
In Situ Burning

One additional elements ➔ water

- spreading / drifting of oil
- necessary of a minimal oil thickness to ignite the oil
- problem to collect and recover burned residue



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Pre-required conditions for ISB

- Flammable oil
- Oil thickness
  - ➔ > 2 mm for fresh crude oils
  - ➔ 2 – 5 mm for weathered crude oil
  - ➔ > 5 mm for HFO

- Emulsification : < 25 – 50 % (according to emulsion stability)
- Weathering : 20 – 35% of evaporation
- Oceanic parameters:
  - ➔ waves < 1,5 m
  - ➔ current < 0,5 m/s
  - ➔ wind <10-12 m/s

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Specific Equipment and Staff required for ISB

- Fireboom:
  - Control the slicks during burning (thickness, drifting, spreading)
  - Control the fire

Hydrofireboom

Pyroboom

American 3M

DWH:

Continuous feeding of oil to ongoing burn

From Allen A. A., Jaeger, D., Mabile, N. J. and Costanzo, D. 2011. “The Use of Controlled Burning during the Gulf of Mexico Deepwater Horizon MC-252 Oil Spill Response”. IN *Proceedings of the 2011 International Oil Spill Conference. Portland USA*, vol. 2011, n° 1, pp. 194.

Fire Boom Summary

(Used during Deepwater Horizon Spill – 2010)

Performance Factors	Elastec Hydro-Fire	Elastec American Marine-3M	AFT, Inc. Pyro	Oil Stop	Kepner
No. of Systems Used	27	37	13	3	2
Longest Continuous Burn	11 hours, 48 min.	11 hours, 21 min.	3 hours, 13 min.	27 min.	43 min.
Average No. of Barrels Burned per System	5,061	3,915	1,749	28	295

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- Ignition devices: gelled light refined oil (gasoline, diesel)

From helicopter

Helitorch

From boat

Hand held igniter

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1700 igniters used during DWH

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Advantages

- less equipment than mechanical recovery
- less waste collection, storage and treatment
- less contamination of water column compared to dispersion
- low toxicity of residue compared to original oil
- rapid and efficient treatment:
  - 1 – 4,5 mm/min,
  - ≈ 80% removed from seasurface

Disadvantages

- fire itself (risk of secondary fires not controlled)

(Allen, 2011)

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Disadvantages

- fire itself (risk of secondary fires not controlled)
- smoke plume

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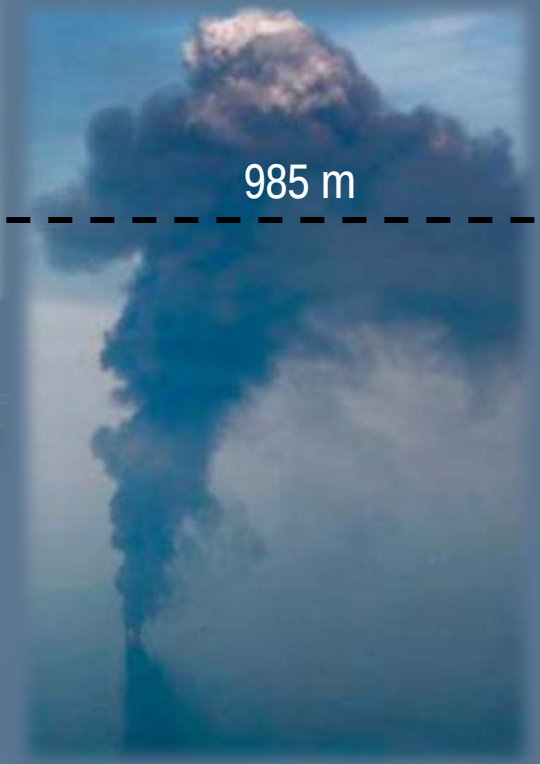
(Allen, 2011)



$C_{total\ atm}$ → 4,2 % BC (soot) —20/04 – 19/07→ 1350 t

$C_{total\ atm}$ → 2,1 % CO

$C_{total\ atm}$ → 93,7 % CO_2

erring et al., 2011. Characteristics of black carbon aerosol from a surface oil burn during the Deepwater Horizon oil spill. Geo. Res. Lett. Vol. 38.

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Disadvantages

- Fire itself (risk of secondary fires not controlled)
- Smoke plume
- Fate of residue (floating ? sinking ? composition ? toxicity ? persistence ?)

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Cedre activities on ISB

- 2011-2012: State of the art on ISB (for MEDDE and Total)
  - summary of development between 1990 to 2010
  - DWH feedbacks

- 2012: Field trial to test a solution (pumice stone) to improve ISB (Ecopomex)

Cedre activities on ISB

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- ***2013 - 2015:***

  ➔ ***Preparation of an information document on Combustion Plumes and Residues from ISB*** ***(for OGP IPIECA JIP5–WP2)***

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➔ ***Development of a tool dedicated to ISB:***

The Burning Bench

The burning bench

Objectives: according to oil nature and weathering degree
(with samples from weathering experiment – *polludrome*)

Interest of ISB ?

- Ignitability of the oil ?
- Efficiency of ISB ?(residue quantification)

Potential Impact ?

- Assess the behavior and composition of residue (viscosity, density, PAHs, SARA, toxicity)
- Assess a potential water contamination after ISB (PAHs transfer to water column)
- Characterization of plume (PM10, PM 2.5, PAHs)

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The burning bench

Smoke Exhaust system (with cyclone vaccum for soot recovery)

Smoke hood

Temperature logger at 4 positions (-1, 4, 8 and 12 cm)

Glazed enclosure (safety)

The burning cell

Temperature probes

Confinment ring

Seawater (5L)

Magnetic stirrer @ lowest speed

Necessary to simulate a water movement under the slick as observed in situ when slicks are continuously towed with fire boom.

Necessary to avoid any "vigorous phase burning" at the end of the test characterized by an oil ejection and flame temperature increase.

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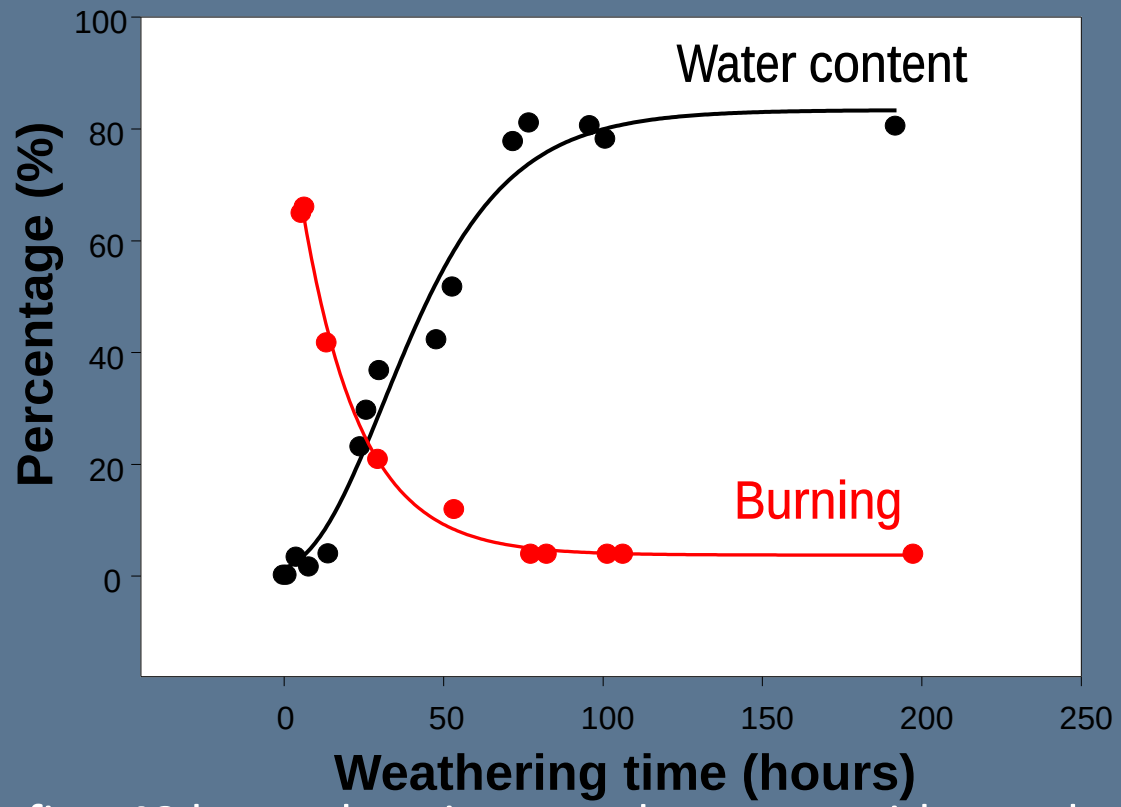
Example of results

Influence of oil weathering

Tests conducted on light crude oil samples collected after different weathering times in Cedre's flume test.

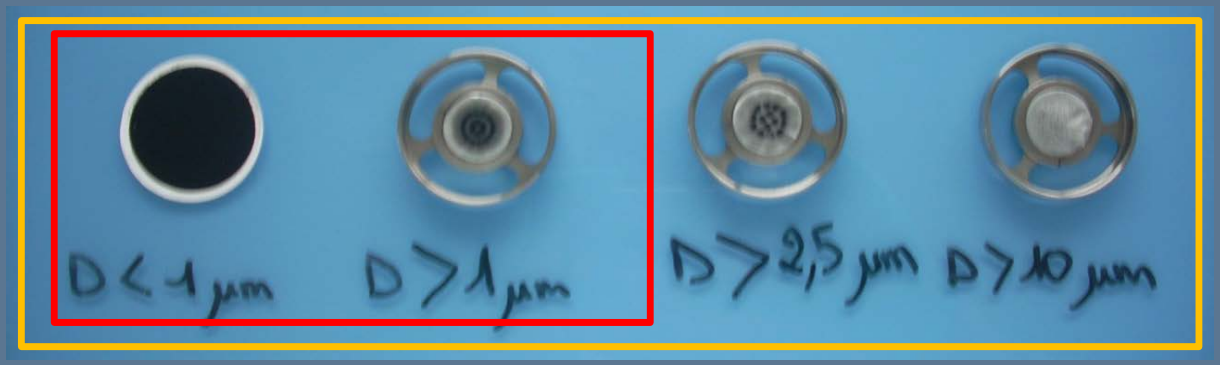


During the first 48 hours: burning rate decreases with weathering time

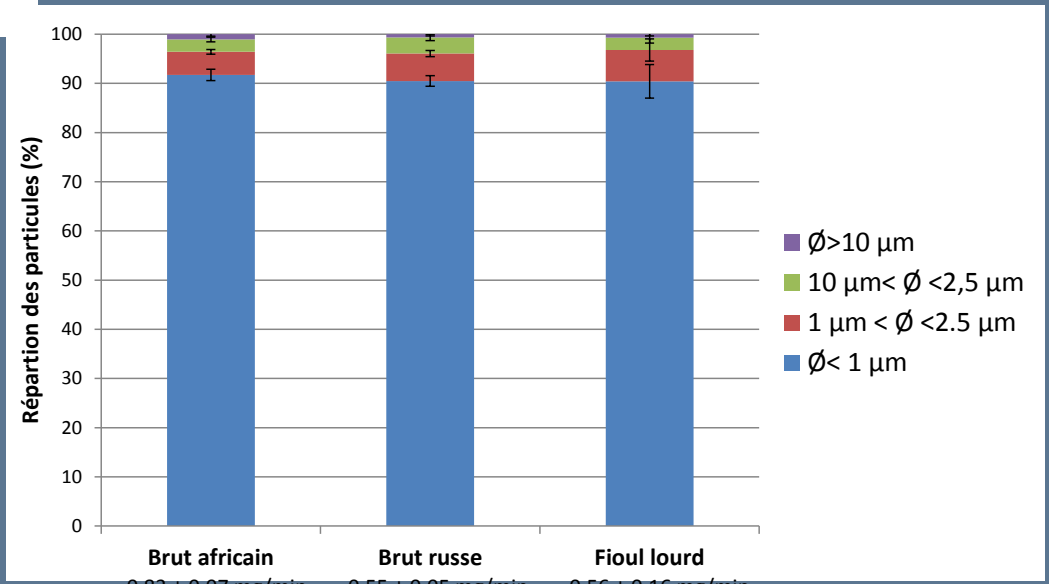
After 48 hours: not possible to ignite the oil due to evaporation and emulsification (> 60%).

Example of results

Soot caracterization



PM 2.5 PM 10



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➔ Development of a tool dedicated to ISB: The Burning Bench

- 2014

➔ OGP IPIECA project

➔ *BB* development (soot caracterization)

➔ ISB experimentation at pilot scale to validate *BB* results

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Simulation of In Situ burning on Kobbe Oil

29/09 – 4 /10 – Verneuil en halatte - France

INERIS facilities

Fire hall (50 x 4 m)

Smoke & gases recovery and on-line analyses

Simulation of In Situ burning on Kobbe Oil

29/09 – 4 /10 – Verneuil en halatte - France

Camera (3+ 1 thermal)

Tank (2 x 2 x 04 m)
with salted water
(circulation)

Different temperature probes (oil, water, flame, smoke)

Fire intensity measurement

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Simulation of In Situ burning on Kobbe Oil

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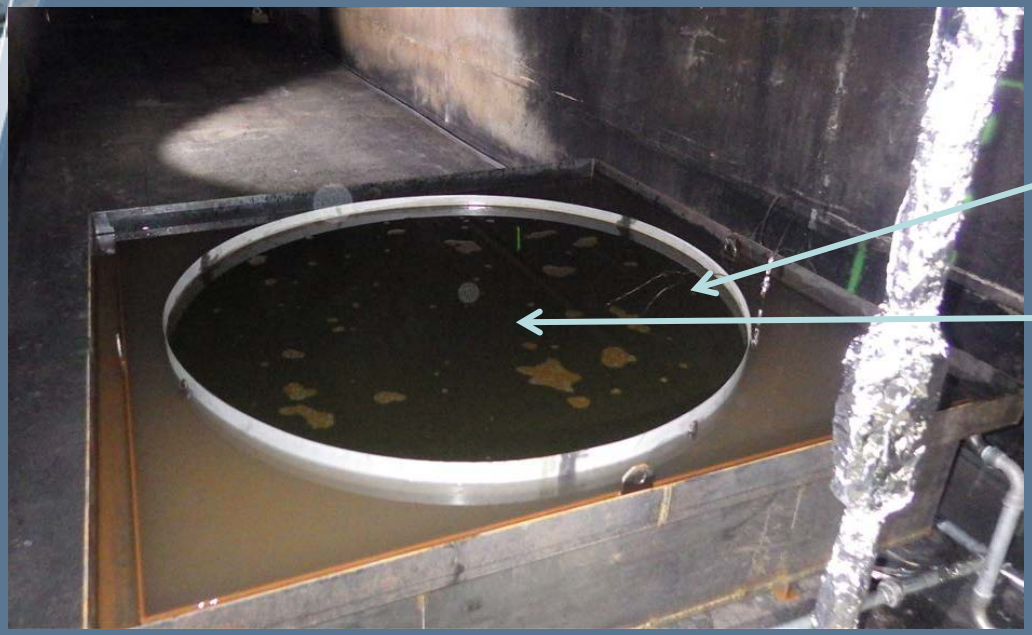


Confinment ring (1,60 x 0,1 m)

Kobbe Oil (20L = 10 mm thick)

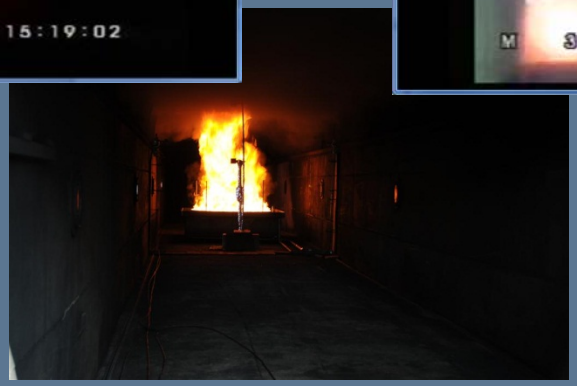
Simulation of In Situ burning on Kobbe Oil

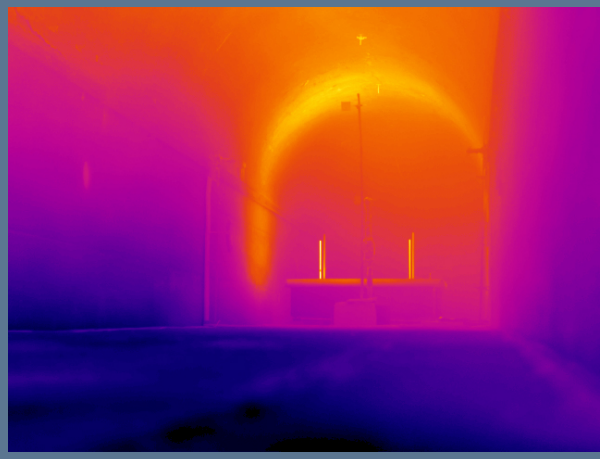
29/09 – 4 /10 – Verneuil en halatte - France

Around 3 min of burning


01 20
03 40
M 3%
<+> 2014/10/01 15:19:02


01 20
03 40
M 3%
<+> 2014/10/01 15:19:38





Simulation of In Situ burning on Kobbe Oil

29/09 – 4 /10 – Verneuil en halatte - France

Burn residue recovery and sampling for analyses

2 / 3L = 85 % burn

Oil quantification

Density

Viscosity

Alcanes, PAHs distribution

Water samples (SBSE)

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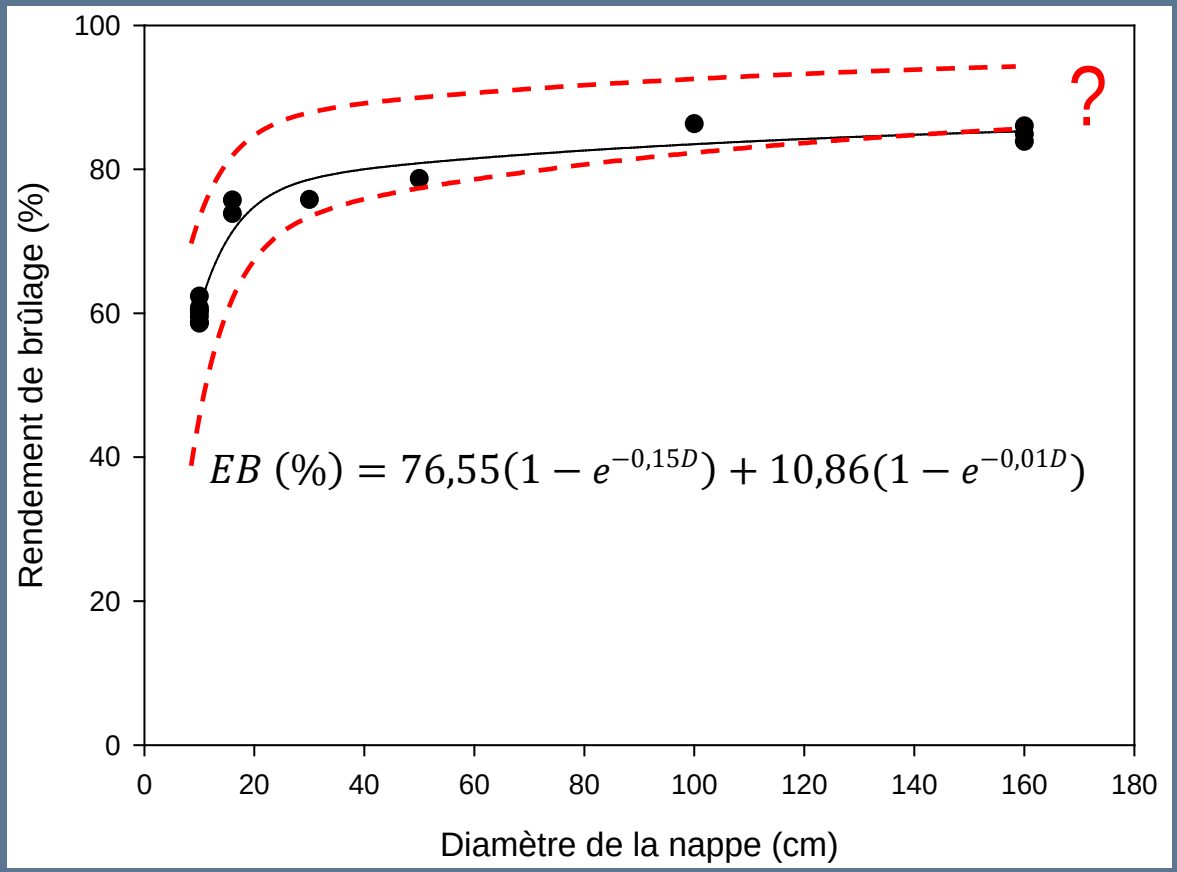
Comparison between BB and pilot scale results



- Rendement de brûlage augmente avec la taille de nappe
- Influence de la nature de l'hydrocarbure sur les paramètres de l'équation ?

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➔ OGP IPIECA project completion

➔ report on BB development

➔ "artic project": analyses of burned residues after few months in ice condition

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Thank you for your attention

Merci de votre attention

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