



**Development of a New Sustainable Thermal
Remediation and Recovery Technology Using Low
Energy Rapid Exothermal Reaction Technique**

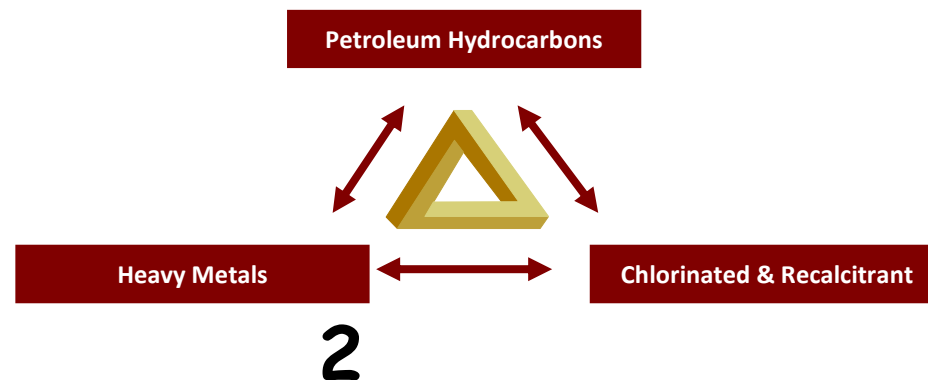
REMTECH 2016

October 12, 2016

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TRIUM - “Innovation Executed”

- Proprietary products & services
 - Chemical Oxidation (ChemOx[®])
 - Soil and groundwater remediation
 - Low Temperature Thermal (T-REX[™])
 - Soil, sludge and hazardous waste remediation
 - Metals Soil Stabilization (T-SS[™])
 - Soil, sludge and sediment stabilization of heavy metals



AGENDA

- Background – Thermal Remediation
- Development Principles of “*Thermal Reaction Enhanced Extraction*” (T-REX™)
- Protocol and Performance
- Future Development



Thermal Treatment Industry

High Temp Thermal Treatment

Incineration

Plasma

Pyrolysis



Low Temp Thermal Desorption

Thermal Desorption

Geo Thermal (In-situ Heating)



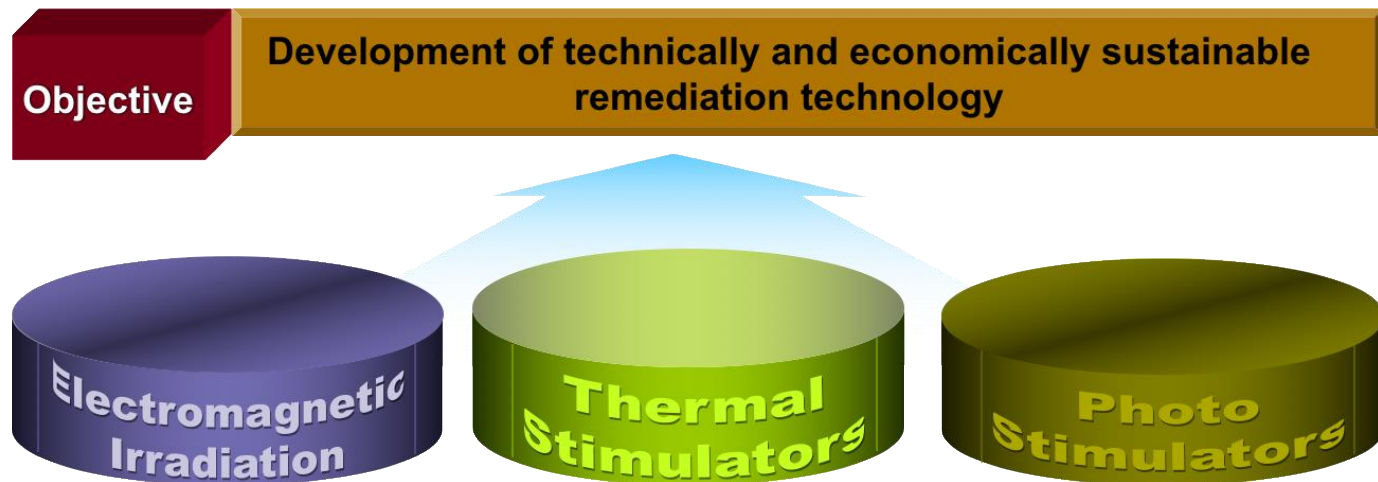
Low Energy Alternative Heating

Microwave
Induction



Development Concept

- Reduce – Increase efficiency “inside and out”
- Recover - Functional reusable soil
- Recycle – Contaminant recovery

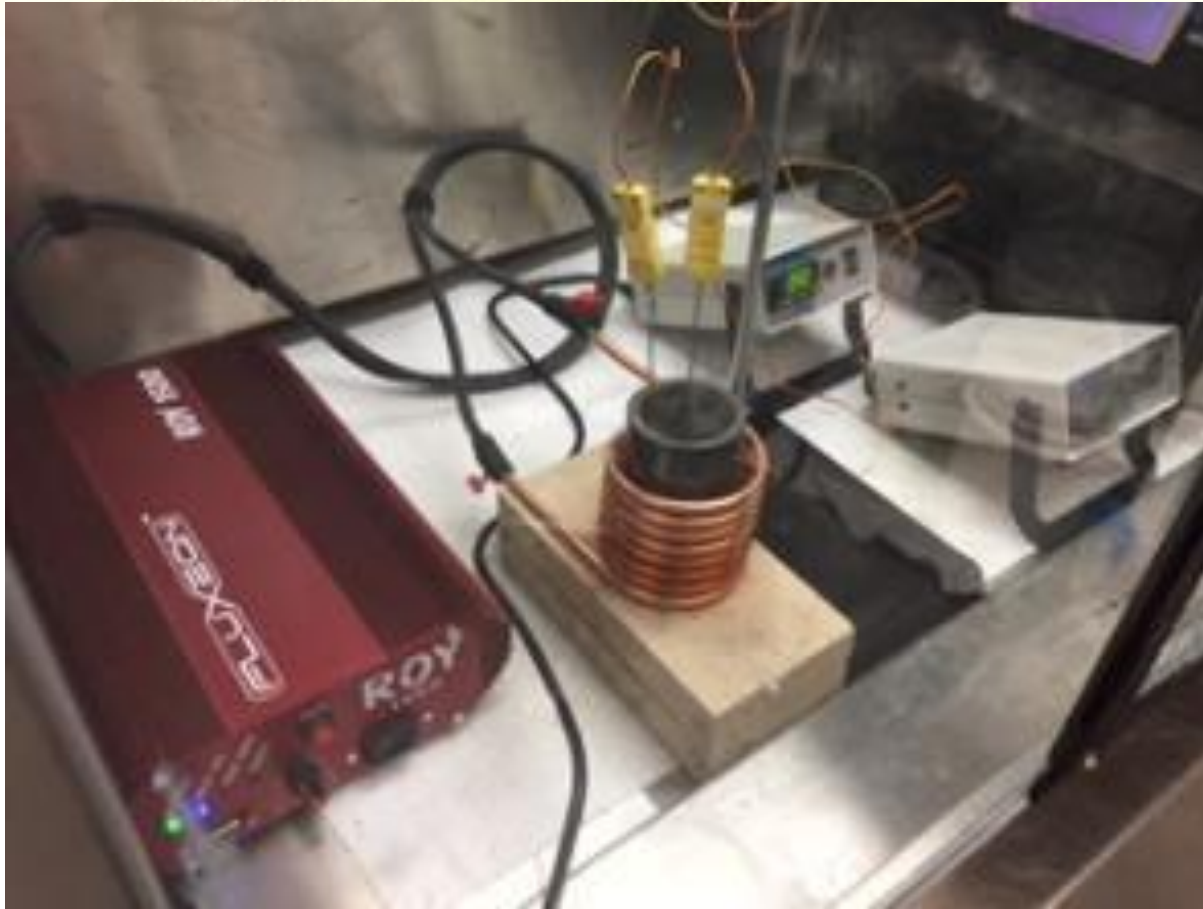


Fundamentals of T-Rex

- Low energy, rapid thermal heating and nano-scale chemical stimulation technique for enhanced organic contaminant extraction.
- ✓ Exothermic reactions for
 - ✓ Pressure
 - ✓ Cracking
 - ✓ Extraction



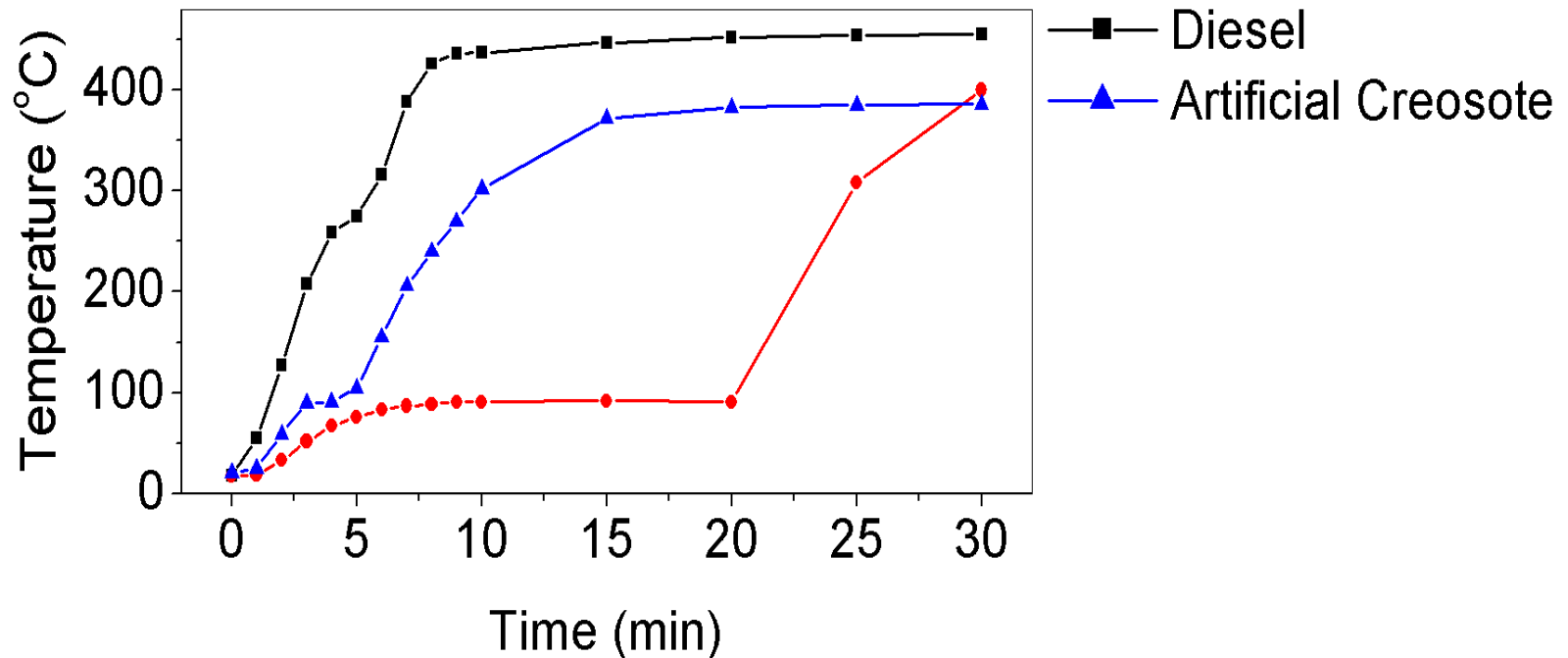
Proof of Concept



Concept Performance

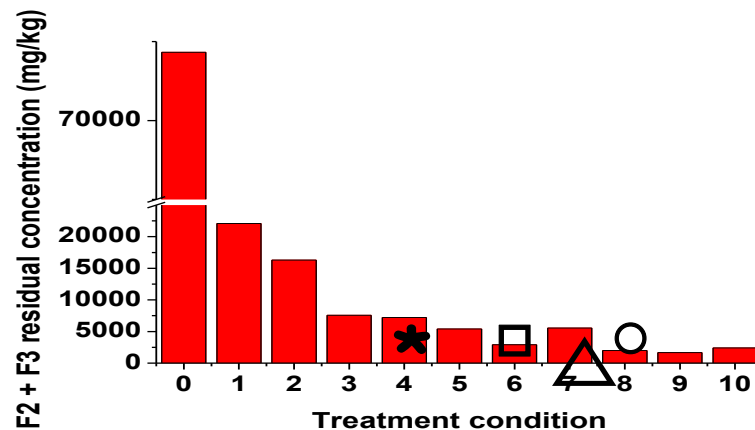
■ Accelerated Thermal Capacity

□ Two stage heating process



Blending Optimization

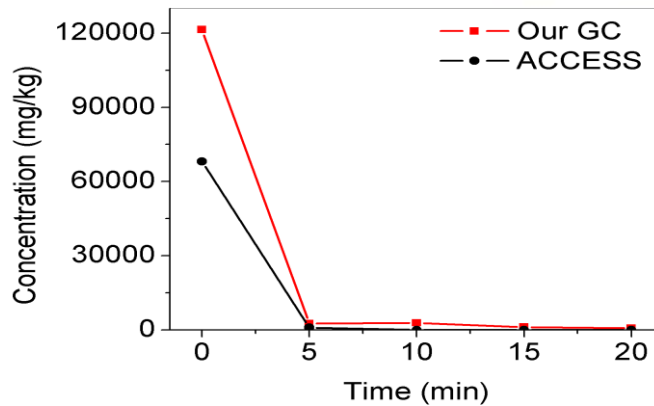
Condition	Treatments		Residual Conc. F2 (C10-16) + F3 (C16-32) (mg/kg)	Removal rate (%)
	T-Rex composite	Time (min)		
0	0	0	74327	100
1	0	15	22098	70.3
2	0	20	16309	78.1
3	Composite I	15	7559	89.8
4	Composite II	15	7208	90.3
5	Composite III	15	5417	92.7
6	Composite IV	15	2914	96.1
7	Composite V	20	5558	92.5
8	Composite VI	20	1978	97.3
9	Composite VII	20	1665	97.8
10	Composite VIII	20	2399	96.8



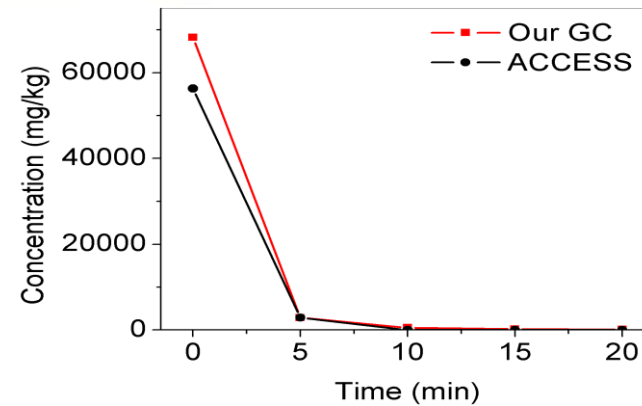
Concept Performance

■ Diesel

Fraction 2
(C10-C16)

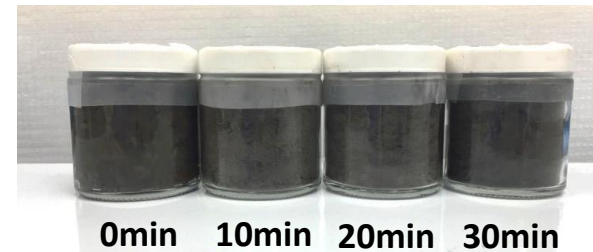


Fraction 3
(C16-C32)

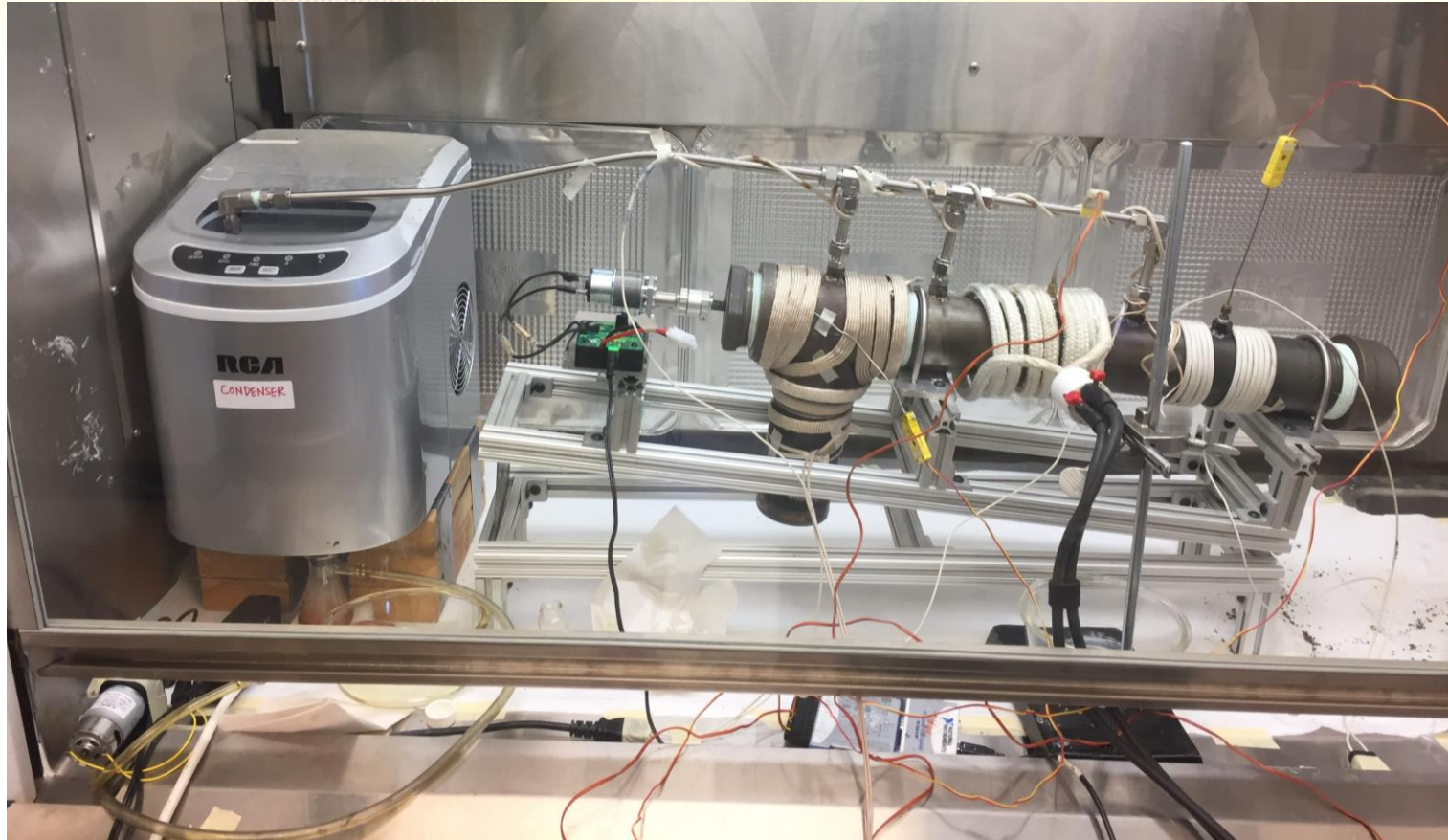


■ Total Organic Carbon

- Before = 6.3%
- After = 5.7%



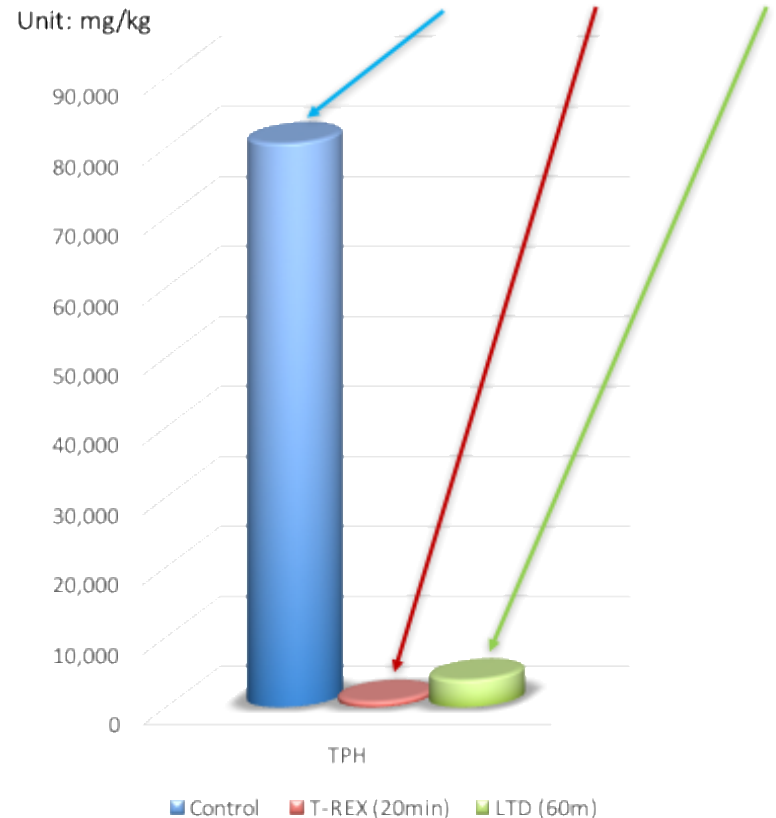
Lab Prototype



Prototype Performance

- High concentration process comparison
- Refining process parameters
 - Retention time
 - Pressure
 - Temperature
 - Vapour capture

Parameter	Control	T-REX (20min)	LTD (60m)
Batch Processing Time (min)	0	20	60
TPH	80,597	815	3,896



Vapour Recovery

- Vapour Recovery

- >50% by wt. recovery

- Opportunity for improvement

10% Diesel in Sand / 300 °C				
Description	Component	Concentration (mg/kg)	Total Concentration (mg/kg)	Removal Percentage (%)
Before treatment	F2	67174	110334	0
	F3	43160		
After treatment	F2	4634	6831	93.8
	F3	2197		



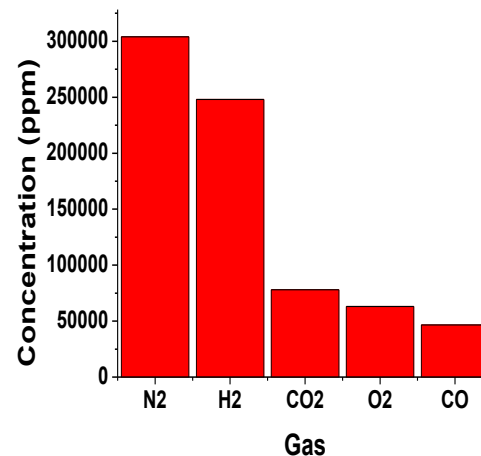
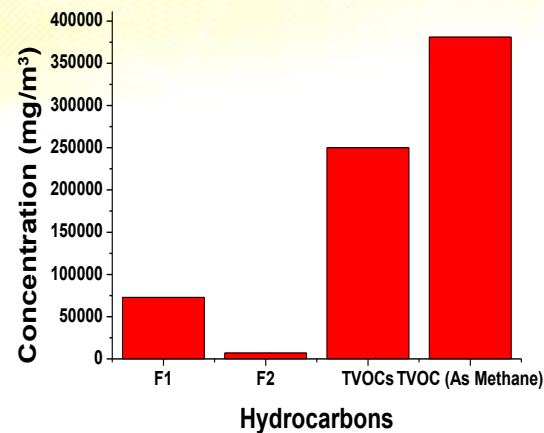
Vapour Characterization

Table 1. Volatile Organic Compounds (Air)

Benzene	2650	ppm(V)
Ethylbenzene	451	ppm(V)
Toluene	2580	ppm(V)
Xylenes	1460	ppm(V)
F1-BTEX	72800	mg/m3
F2	7050	mg/m3
Sum	86991	

Table 2. TVOCs amounts

TVOCs	250000	mg/m3
TVOC (As Methane)	381000	ppm(V)



Field Prototype - S. Korea



Field Prototype Test Parameters

- 0.5 Ton/hour
- <20 min SRT
- 1% Diesel and 4% Lube Oil Tests



Field Prototype Observations

- $>200^{\circ}\text{C}$ activation increase, audible
- No visible difference with control in diesel test
- Significant removal difference in lube oil test
 - Visible in control, not in T-REX.
 - Sample results pending



Future Development Scope

- Patent filed September 2016
- Currently operating field system to establish engineering and economics aspects
 - Additional tests conducted for considerations for efficiency / metallurgical / heat transmission in a large scale operations
 - Lower temperature activation
 - Vapour collection
 - Commercialization in 2017
- Lab scale process testing & design of in-situ T-REX treatment

Acknowledgement

- National Research Council, Industrial Research Assistance Program (NRC-IRAP)
- MEDAL, Mechanical & Manufacturing Engineering, University of Calgary
- Korea Soil Remediation Company (KSR)
- Alberta Innovates Technology Futures
- Can Export
- CETAC-West

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