Low Temperature Thermal Desorption: An Innovative and Environmentally Sound Means for Remediation of Hydrocarbon Contaminated Soil

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Outline

- Background
- Process overview and description
- Factors for success
- Case Study
- Benefits

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Nelson Overview

- Nelson Environmental Remediation is an Alberta based environmental solutions corporation
- Nelson Environmental Remediation (NER) has been offering Mobile Low Temperature Thermal Desorption soil remediation services for over 20 years
- Nelson owns and operates the largest fleet of mobile Low Temperature Thermal Desorption units in North America.
- NER provides Soil Thermal Systems Consulting and Site Remediation & Reclamation Technologies around the globe

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What is Thermal Desorption?

- The EPA currently defines thermal desorption as “a physical separation process - it is not a form of incineration.”
- Thermal desorption is an Ex-Situ means of physically separating volatile and semi volatile organic contaminants from the soils through application of heat, incorporating sound environmental practices.
- Thermal desorption is applicable to organic contaminants and generally is not used for treating metals and other inorganics.

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Thermal process overview

- Soils impacted organic compounds are placed in a rotary drum desorber, and heated (up to 500C) to volatilize the organics. Typical organic compounds removed:
  - Hydrocarbons, VOC's, SVOC's, pesticides, coal tar and creosote
  - flux of volatilized soil H2O assists contaminant removal through non-equilibrium molecular. entrainment
- The process gases are sent through a bag house to remove particulate
  - The vapourized contaminants of concern are transferred to a thermal oxidizer and destroyed at 870C converting them into carbon dioxide and water.
- Remediated soil is quenched with water spray to that cool and rehydrate the soil.

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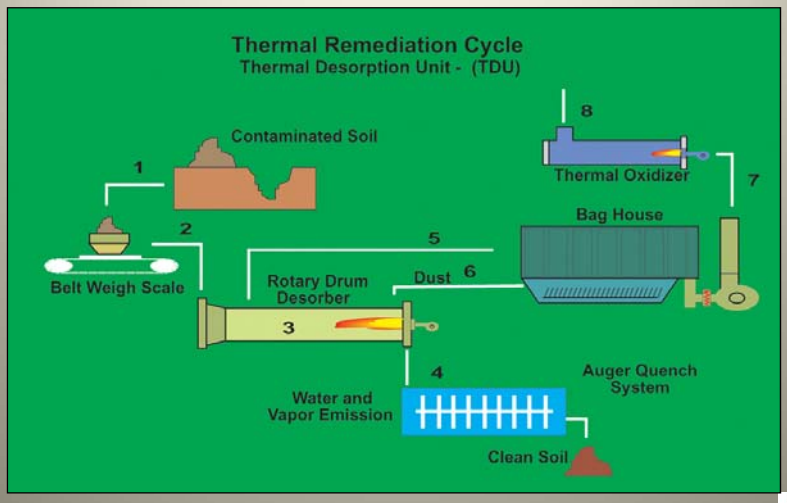
Thermal process overview



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Process Overview

TDU Excavation overview

- **Value added support services to enhance your project efficiencies**
- Full service, turnkey operations for excavation, remediation and reclamation
- Nelson owns our own full line of heavy equipment
- Over 40 years of earth moving, soil handling and environmental construction experience

TDU Excavation overview

- Excavations for the thermal process need to managed differently than for a dig and dump
- Process efficiency is optimized by stockpiling soil to achieve homogenized contaminant and moisture levels
- Excavated material is pre-screened to remove rocks and other large debris, typically using a Trommel screen and/or Allu bucket if required

Soil Remediation – Rotary Kiln

Weigh scale belt **measures tonnage and feeds kiln**
→ Soil heated to **200 – 500 °C** (400-900 °F) in kiln
→ Remediation by gasification of contaminants
→ *Soil cooled, re-hydrated, discharged & stockpiled*

Emission Particulate Control

Gasified contaminants flow to Bag House
→ Dust particulate filtered and returned to soil stream

Contaminant Destruction by Thermal

→*Contaminants heated to* ***870+°C*** *(1600°F),* O_2 *then added*
→ *1 second chamber retention time yields d destruction efficiency >* ***99.99%***
→ *Stack Emissions: 83 - 85%* N_2*; 7 - 8%* O_2*; 7 - 9%* CO_2

Treated Soil Characteristics

- The clean recycled soil is re-hydrated to between 8 to 10% moisture
- Uniformity of post-treatment particle sizing
  - provides for smooth backfilling and excellent compaction.
  - Rehydrated and cooled soil can be utilized to backfill the excavation at the site.

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Factors for Success

- Location and regulatory issues
- Site specifics
- Utilities available
- Soil type and volume
- Contaminant Characteristics

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Location and Regulatory

- Soil remediation criteria.
- Air emission guidelines.
- Employee visas, health, safety, translation, accommodation, transportation etc.
- Administrative, contractual, legal, financial, asset security, insurance, taxation, import/export, licensing, permitting, registrations etc.
- Local labour capability, much of the staff requirement in long-term projects can be hired locally and trained,
- Local supplier capability, heavy equipment (Caterpillar etc.), equipment parts and repairs,
- Mobilization and demobilization logistics, costs and timing.

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Site Specific Criteria

- Size and shape, preferably a 100m x 100m pad but less can work if site specifics allow.
  - The more room the better in order to allow preparation of the feedstock and permit stockpiling of processed soil in 200 Tonne increments while awaiting lab results, lab turnaround time is critical, ideally 24 hours.
- Distance to neighbours, residential or industrial. 24-hour / 7-day operation is critical to minimize costs.
- Site security.
- Access for services, utilities, deliveries etc.
- Compaction for plant footing, site drainage, etc.
- Weather, altitude, humidity etc. can affect TDU settings and subsequent production.
- Ground water table?

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Site Layout

Utilities Availability

- Burner fuel can be natural gas, propane, diesel etc. (require 30-70 MMbtu/hour equivalent depending on TDU spec).
- Diesel is always required for peripheral soil handling equipment. (approx. 700-1500 Litre/day).
- Electricity is required at 480 volt 250-700 amp (generator provided if power not available).
- Clean water is required for soil rehydration. (aprox. 200 Liter/Tonne of soil processed)

Soil Type and Volume

- Clay versus sand dictates equipment selection for soil handling as well as TDU configurations and desorption rates.
- Sands and coarse grained materials desorb more easily than fine grained soils.
  - Some contaminants have the capacity to be adsorbed by soils more easily than others
  - Clay versus sand dictates equipment selection for soil handling as well as TDU configurations and desorption rates.
- High organic soils may contribute combustibles and energy
- Moisture content. Directly affects throughput, fuel consumption and soil handling requirements
  - Additional site room to allow drying of soil may create major savings of time and fuel.
  - Costs increase as moisture content level increases due to reduction of production rate. Preferred ceiling is 25%,
- Frost and frozen ground conditions

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Contaminant Characteristics

- The concentration of contaminant versus remedial criteria affects process.
- Wide range of hydrocarbons or refined product with narrow spectrum?
  - Distribution of the carbon chains C11-C100+ has a large affect on process.
  - Carbon chains beyond C60require special operating parameters
- Is there potential for compounds present that lab analytical missed?
  - Asphaltenes, tars, etc. that the lab misses in the extraction process may have a major affect on the TDU
  - This is sometimes evidenced only by energy values or carbon loading of the soil.
  - This is most notorious at MGP sites, flare pits, coal tar facilities Most of these compounds are best treated by thermal desorption, but the acceptable soil levels will be project specific depending on the variables.
- Do chlorinated compounds exist? Sites with downstream petrochemical activity may require additional gas scrubbing equipment.
- Do non-organic contaminants exist that can react to the thermal process? (mercury, lead, magnesium, sulphur etc.)

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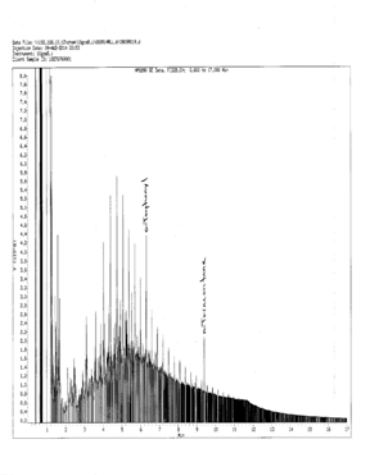
Soil Limits

Soil limits are usually set as follows in order to achieve safe TDU operating parameters:

- Total hydrocarbons less than 50,000 mg/kg combined.
- Asphaltene component less than 10,000 mg/kg.
- Energy value of soil less than 2,500 kj/kg.
- Moisture content of soil less than 20% bdw (higher levels can be accommodated, but costs increase).
- Chlorinated compounds less than 1000 mg/kg (higher values may necessitate acid gas scrubber).

Treated stockpile confirmation sampling and reinstatement/backfilling



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Site Visit

- NER personnel would normally conduct a site visit to plan logistics and collect samples. Samples will be sent to Canadian labs for the following analysis:
  - Total petroleum hydrocarbons. Including up to C100+
  - Polynuclear aromatic hydrocarbons
  - Oil and Grease by DCM
  - Calorific energy value
  - Loss on ignition
  - Total carbon
  - Moisture content
  - Soil classification
  - Metals
  - Halogens (if suspected)

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Benefits of Using Thermal Desorption

- Thermal desorption safely recycles contaminated soil from liability to valuable asset for reuse.
- Cradle to Grave Site management
- Dramatically increased safety through elimination of trucking, and lowers analytical cotss
- Original soil from site is preserved, while eliminating liabilities of transportation , long term disposal and backfill importation.
- Enhanced Community relations

Benefits of thermally-treated soils

Removal of organic contaminants from the soil:

- flux of volatilized soil $H_2O(g,l)$ assists contaminant removal (non-equilibrium molecular entrainment)
- the treatment temperature can be dialed-up to 500 °C (cf. higher Tbpt compounds).

Uniformity of post-treatment particle sizing:

- rotary quench drum guides particle aggregation (i.e., fines as a temporary 'glue')

Uniformity provides for smooth backfilling and excellent compaction.

Boosting of inorganic nutrient availabilities post-treatment:

- thermal exfoliation of clay mineral crystal structures exposes basal-plane ions;