Low Temperature Thermal Desorbtion

by

Darryl Nelson

Low Temperature Thermal Desorbtion

The process is a combination of four separate processes that achieve extraction and destruction of volatile organic compounds from impacted soils.

1) Feedstock preparation

The first stage is the preparation of the contaminated feedstock. This is usually the most overlooked facet of the process and can often be the most challenging aspect. Foreign debris and large rock must be removed which can be a difficult procedure with cohesive soils that will not pass conventional screening systems. If the soil has a high clay component an aggressive system for shredding soil is required.

The variables present within any soil sample greatly affect the process parameters. Moisture content, hydrocarbon levels and soil types must be homogenized in order for the thermal treatment process to be optimized. Whether these levels are high or low, it is key they become uniform, as each affects the process operation and efficiency. If conditions allow, the moisture content should be reduced prior to processing. With the soil preparation complete the thermal processing can commence.

2) Primary kiln desorber

The contaminated soil is loaded into a feed hopper. This hopper meters the soil onto a belt weigh scale. The belt scale records tonnage as it feeds the contaminated soil into a couterflow rotary drum desorber.

In this primary chamber, a direct firing burner creates the heat required to vaporize volatile compounds and moisture in the soil. The kiln is counterflow in that the soil enters at the opposite end from the burner and travels upstream against the flow of offgas from the burner. Heat transfer to the soil is maximized by the veiling action of lifting flights. The correct slope of the drum is critical to advance the soil at the optimum rate. The soil is veiled for 80% of the kiln length. As the soil is entering the burner combustion zone, the soil stops veiling and instead tumbles along the kiln floor directly beneath the burner flame. This allows the soil to continue heating through radiant energy. As the soil advances through the kiln, soil temperatures elevate to a level that desorbs the targeted volatile organic required to reach criteria. Typically this will be in a range between 300C and 600C. The retention time of the soil will vary from 5 to 15 minutes as the soil passes through the desorber. The point of vapor exit from the counterflow kiln is at the same end of the kiln as soil entry.

The hot clean soil is discharged from the kiln into an auger quench system to cool and rehydrate soil as it exits. The clean soil is moved to cells while lab analysis is performed to verify successful remediation.

3) Baghouse dust filtration

The second stage of the process begins as the vaporized compounds, steam and dust released in the desorbtion process exit the kiln. The induced draft created by an exhaust fan in the baghouse draws the desorbed compounds from the kiln into the baghouse for particulate removal. The first section of the baghouse is a knockout box formed by an expansion chamber that allows velocity reduction. This allows the larger particulate to fall out of the gas stream into the return auger system that runs along the bottom of the baghouse system. After passing the knockout box the gasses enter the second stage of the baghouse consisting of a series of high temperature felt filters. The synthetic felt filtration captures fine dust particulate while allowing the gasses to pass through. The dust is removed from the filters at regular intervals. Cleaning is accomplished by a pulsejet system releasing a burst of compressed air that momentarily reverses the airflow in a section of the filters at a time. As the pulse sequences through the entire filter assembly, the particulate is released from the surface of the filters and drops into the return auger system. The auger collects the dust from the baghouse and returns it to the soil stream. The dust is mixed back into the soil stream directly below the burner flame in the primary kiln insuring full remediation.

4) Oxidation destruction

The gases exiting the baghouse pass through the induction fan and are pushed into the thermal oxidizer. The oxidizer consists of a refractory lined chamber also equipped with a direct firing burner. As the gasses enter the combustion zone of the oxidizer temperature increases drastically. Ambient air is added to raise oxygen level high enough to allow efficient oxidation. Oxidizer design allows more than one-second retention as gasses pass through chamber. Turbidity is crucial to insure mixing of gasses and oxygen so that full destruction will occur. At the exiting end of the oxidizer the temperature will reach a minimum of 870C. This occurs with a minimum level of 7% oxygen. The factors of temperature, time and oxygen create destruction efficiencies that exceed 99.99%. The hydrocarbons are converted to carbon dioxide and water vapor before they exit the stack. The constituents of the exhaust stream will be 70%-80% nitrogen, 7% or more oxygen, 6-9% carbon dioxide and the balance is water vapor. The stack exhaust will exhibit virtually no visible opacity.

Limitations in Application

Any type of volatile or semivolatile organic compound can be extracted and destroyed through thermal desorbtion. The full range of petroleum hydrocarbons, BTEX, polynuclear aromatic hydrocarbons and chlorinated compounds can be treated. In the case of chlorinated compounds, acid gas must be considered. If levels in the soil will create HCl emission above the allowed level then a wet scrubber will be required to neutralize the acid. Typically levels upto 150-200 ppm can be safely treated before the scrubber is required.

Other process limitations relate mainly to energy release and volume flows in the system. Typically hydrocarbon levels up to 50,000 ppm can be safely remediated. Sometimes the energy release will be equivalent to hydrocarbon levels much higher than lab analyticals indicate and therefore may require feedstock contaminant levels to be lower in order not to exceed temperature ranges in the oxidizer. Also in the case of asphaltenes, as the gasses pass through the baghouse there will be a cooling of gas which may allow an excessive level of condensation to build up in the baghouse prematurely blinding the bags and reducing gas flows.

Often lab analysis will miss much of the asphaltene compounds in their extraction process but the thermal desorber will not. A common misconception is that the heavy end hydrocarbons, which often pose little environmental threat, can be left in the soil while removing the lighter components if the temperature is correct. In reality, the entire spectrum of hydrocarbon comes out more or less in a single body. The average boiling points of all the compounds relate to the required temperature for the process. Due to this it is imperative to understand the full range of contaminants.

Moisture levels play a significant role in the throughput and fuel consumption of the process. Any moisture content can be accommodated by the system as long as an even feed rate can be accomplished. However, as the moisture increases, the feed rate will be reduced. This occurs because water expands drastically as it goes into vapor form. The volume of off gas into the baghouse has limitations in order for velocity across the filter surface to remain in the correct range and negative draft maintained. Often this will determine the production threshold, which cannot be exceeded while maintaining proper conditions of airflow.

Summary

Successful operation of thermal desorbtion can occur in any climate but the operators may have to employ different operating parameters to suit the specifics. Thermal desorbtion has successfully remediated all soil types with wide ranges of organic contaminants.

It is important to understand the difference between thermal desorbtion and incineration, which are different processes. The desorbed contaminants do not combust in the primary kiln of a thermal desorber. This is prevented because the desorbtion process occurs in a starved oxygen condition downstream from the combustion of the burner. This allows the thermal process to operate at uniform temperatures that would not be possible if the hydrocarbons were igniting in the primary kiln. This also allows conditions where the temperatures are high enough to desorb contaminants but low enough to have little affect on the physical nature of the soil. The soil is returned in a useful form for backfill in the excavation it originated from or for other uses such as construction material. A common myth has existed that the soil becomes ash, nothing could be further from the truth.

The TDU meets and exceeds stringent emission standards. The process has become a preferred technology in jurisdictions such as California that have a mandate to accomplish destruction and at the same time insure a minimal impact to the environment with.

For the responsible environmental steward that desires liability elimination, thermal desorbtion provides the value that no other technology can.

Case Study of flare pit cleanups.

A typical project begins with a call from a client who realizes a problem of contaminated soil must be solved and desires responsible elimination of liability.

The client normally has assessments outlining the extent of the problem.
The soils may or may not be excavated.
If soil has not been excavated, it can be coupled with the thermal service. Much of the feedstock preparation and homogenization can be done at the same time creating cost savings.

The following is required in order to plan a project:

- Project location in order to determine mobilization costs and applicable regulatory issues.

- Soil volume. Economies of scale reduce unit costs substantially through the first 10-20,000 Tonnes. With flarepit cleanups it is typical to transport soil from a number of sites to a central site that lends itself to the purpose.

- Site layout and utilities available.
    - Fuel can be a major variable. Our sites are often adjacent to a natural gas facility providing fuel.
    - Water is required for soil rehydration.
    - On large-scale projects it may be feasible to connect for electricity otherwise a generator is operated.

- Soil type and moisture content. Alberta gumbo clay means the selection of equipment for soil handling is critical. Moisture content directly affects throughput and fuel consumption.

- Hydrocarbon characteristics and the level of contamination. Is there a wide range of hydrocarbons or is it a refined product with a narrow spectrum. As the boiling points of contaminants increase the process parameters change.

- Remediation criteria target. Depending on the contaminants of concern there is varying criteria that affect process throughputs and fuel consumption.

Generally a project can be planned with these answers.

If the client has a philosophy of responsible liability destruction, thermal desorbtion is often the clear choice.

Notice is given to the appropriate regulatory body.
On Alberta upstream projects this is the EUB. The EUB recognizes registration under the Alberta Environment Code of Practice for Small Incinerators, which covers the issues of air emissions.

Notification is given to residents within a 1-mile radius of the site to inform and educate them on the process.

With approvals in place the project can commence.

Equipment is mobilized to site and within a few days processing can start.
The first processing will entail test runs at various temperatures and retention time settings to determine optimum plant configuration. With this determined full scale operation begins.

The thermal plant operates on a 24/7 basis with downtime for equipment maintenance.
Soil samples will be taken at regular intervals from which composite samples representing 1000 Tonne increments will be submitted for confirmatory analysis.
Soil will normally be stockpiled in 200 Tonne increments as long as site room permits.

After receipt of lab analysis verifying success, the soil can be returned to the excavation or used as the client desires. The processed soils often show enhanced construction attributes making them excellent material for road construction, tank pads, pipeline backfill etc.

Invoicing occurs only after remediation is confirmed.

A toxic liability has been transformed to a beneficial asset.

The client now has "Clean Dirt, No Doubt".

Please see attached lab analysis.

Following are lab results of hydrocarbon contaminated soil from flarepits.
The hydrocarbon spectrum is broad with a significant component above C60.
There are four examples each of preprocess and post process results.
The post process results show the entire spectrum of hydrocarbons being extracted from the soil with the resulting levels being well below the 1000 ppm target in place at that time.

Preprocess
soil results
C11-C60+

Carbon Number	mg/Kg dry wt.	Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
b					
C11	366	1	C36	707	2
C12	539	1	C37	580	2
C13	714	1	C38	576	2
C14	843	1	C39	557	2
C15	857	1	C40	542	2
C16	984	1	C41	533	2
C17	1020	1	C42	531	2
C18	1090	1	C43	423	2
C19	975	1	C44	529	2
C20	1140	1	C45	418	2
C21	928	1	C46	416	2
C22	952	1	C47	414	2
C23	980	1	C48	412	2
C24	977	1	C49	411	2
C25	826	1	C50	513	5
C26	957	1	C51	414	5
C27	850	1	C52	315	5
C28	717	1	C53	319	5
C29	869	1	C54	433	5
C30	858	1	C55	331	5
C31	835	1	C56	450	5
C32	800	1	C57	463	5
C33	763	1	C58	476	5
C34	622	1	C59	244	5
C35	608	1	C60+	12300	5
			Total	44377	

Preprocess
soil results
C11-C60+

Carbon Number	mg/Kg dry wt.	Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
C11	127	1	C36	661	2
C12	252	1	C37	545	2
C13	446	1	C38	547	2
C14	467	1	C39	534	2
C15	559	1	C40	524	2
C16	620	1	C41	521	2
C17	651	1	C42	524	2
C18	737	1	C43	421	2
C19	689	1	C44	530	2
C20	741	1	C45	424	2
C21	682	1	C46	424	2
C22	831	1	C47	530	2
C23	774	1	C48	428	2
C24	680	1	C49	432	2
C25	795	1	C50	434	5
C26	691	1	C51	442	5
C27	842	1	C52	339	5
C28	619	1	C53	345	5
C29	765	1	C54	472	5
C30	892	1	C55	485	5
C31	627	1	C56	374	5
C32	612	1	C57	386	5
C33	813	1	C58	668	5
C34	571	1	C59	277	5
C35	563	1	C60+	14800	5
			Total	42113	

Preprocess
soil results
C11-C60+

Carbon Number	mg/Kg dry wt.	Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
C11	27	1	C36	569	2
C12	101	1	C37	564	2
C13	272	1	C38	562	2
C14	374	1	C39	546	2
C15	530	1	C40	533	2
C16	651	1	C41	525	2
C17	733	1	C42	523	2
C18	861	1	C43	416	2
C19	806	1	C44	519	2
C20	867	1	C45	410	2
C21	796	1	C46	407	2
C22	969	1	C47	403	2
C23	896	1	C48	501	2
C24	897	1	C49	400	2
C25	759	1	C50	399	5
C26	882	1	C51	303	5
C27	787	1	C52	307	5
C28	799	1	C53	521	5
C29	688	1	C54	319	5
C30	812	1	C55	326	5
C31	796	1	C56	443	5
C32	767	1	C57	456	5
C33	734	1	C58	351	5
C34	597	1	C59	484	5
C35	701	1	C60+	12100	5
			Total	39989	

Preprocess
soil results
C11-C60+

Carbon Number	mg/Kg dry wt.	Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
C11	19	1	C36	492	2
C12	59	1	C37	407	2
C13	148	1	C38	407	2
C14	200	1	C39	398	2
C15	287	1	C40	390	2
C16	358	1	C41	388	2
C17	414	1	C42	390	2
C18	495	1	C43	313	2
C19	475	1	C44	393	2
C20	520	1	C45	314	2
C21	560	1	C46	315	2
C22	522	1	C47	393	2
C23	558	1	C48	238	2
C24	573	1	C49	319	2
C25	491	1	C50	401	5
C26	499	1	C51	246	5
C27	610	1	C52	335	5
C28	450	1	C53	257	5
C29	654	1	C54	351	5
C30	562	1	C55	270	5
C31	462	1	C56	370	5
C32	451	1	C57	382	5
C33	520	1	C58	296	5
C34	508	1	C59	409	5
C35	418	1	C60+	10800	5
			Total	30087	

Postprocess
soil results
C11-C60+

Carbon Number	mg/Kg dry wt.	Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
C11	1	1	C36	11	1
C12	5	1	C37	13	1
C13	8	1	C38	8	1
C14	10	1	C39	10	1
C15	11	1	C40	10	1
C16	12	1	C41	8	1
C17	10	1	C42	7	1
C18	9	1	C43	9	1
C19	10	1	C44	8	1
C20	9	1	C45	5	1
C21	6	1	C46	8	1
C22	8	1	C47	6	1
C23	7	1	C48	4	1
C24	8	1	C49	7	1
C25	7	1	C50	5	1
C26	7	1	C51	4	2
C27	6	1	C52	5	2
C28	9	1	C53	4	2
C29	8	1	C54	5	2
C30	8	1	C55	3	2
C31	11	1	C56	5	2
C32	9	1	C57	4	2
C33	10	1	C58	5	2
C34	12	1	C59	4	2
C35	10	1	C60+	136	20
			Total	505	

Postprocess soil results: C11-C60+		Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
C11	<1	1	C36	5	1
C12	1	1	C37	5	1
C13	1	1	C38	5	1
C14	2	1	C39	5	1
C15	2	1	C40	5	1
C16	4	1	C41	4	1
C17	5	1	C42	5	1
C18	5	1	C43	4	1
C19	5	1	C44	5	1
C20	4	1	C45	4	1
C21	4	1	C46	4	1
C22	5	1	C47	3	1
C23	3	1	C48	3	1
C24	4	1	C49	3	1
C25	4	1	C50	2	1
C26	4	1	C51	4	2
C27	4	1	C52	2	2
C28	5	1	C53	2	2
C29	4	1	C54	3	2
C30	5	1	C55	2	2
C31	6	1	C56	2	2
C32	5	1	C57	3	2
C33	5	1	C58	2	2
C34	6	1	C59	3	2
C35	5	1	C60+	116	20
			Total	299	

Postprocess
soil results
C11-C60+

Carbon Number	mg/Kg dry wt.	Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
C11	<1	1	C36	9	1
C12	1	1	C37	8	1
C13	1	1	C38	8	1
C14	2	1	C39	8	1
C15	3	1	C40	7	1
C16	5	1	C41	7	1
C17	5	1	C42	6	1
C18	4	1	C43	6	1
C19	4	1	C44	5	1
C20	3	1	C45	7	1
C21	3	1	C46	5	1
C22	3	1	C47	5	1
C23	3	1	C48	5	1
C24	4	1	C49	3	1
C25	4	1	C50	5	1
C26	4	1	C51	3	2
C27	5	1	C52	4	2
C28	5	1	C53	3	2
C29	5	1	C54	4	2
C30	6	1	C55	3	2
C31	7	1	C56	3	2
C32	6	1	C57	3	2
C33	7	1	C58	4	2
C34	7	1	C59	5	2
C35	7	1	C60+	182	20
			Total	412	

Back
to previous page

Postprocess
soil results
C11-C60+

Carbon Number	mg/Kg dry wt.	Detection Limit	Carbon Number	mg/Kg dry wt.	Detection Limit
C11	<1	1	C36	7	1
C12	1	1	C37	7	1
C13	1	1	C38	7	1
C14	2	1	C39	7	1
C15	3	1	C40	7	1
C16	5	1	C41	6	1
C17	5	1	C42	5	1
C18	5	1	C43	5	1
C19	5	1	C44	5	1
C20	5	1	C45	6	1
C21	4	1	C46	4	1
C22	4	1	C47	4	1
C23	4	1	C48	4	1
C24	4	1	C49	4	1
C25	4	1	C50	4	1
C26	4	1	C51	3	2
C27	5	1	C52	4	2
C28	5	1	C53	3	2
C29	5	1	C54	4	2
C30	6	1	C55	3	2
C31	7	1	C56	3	2
C32	7	1	C57	4	2
C33	7	1	C58	3	2
C34	7	1	C59	4	2
C35	8	1	C60+	132	20
			Total	358	