Overview

Founded in 2008, Heartland Water Technology ("HT") has patented and commercialized novel technology for treating difficult-to-treat industrial waste waters.

The Heartland Concentrator is a direct contact evaporator that sets new benchmarks for reliability, ease of use and cost to treat.

Proven technology with tier 1 customers in key applications:

- Landfill Leachate
- Flu Gas Desulfurization
- Produced Water
- Enhanced Pond Evaporation

Commercially Sensitive
Leachate Management

Survey: Raise your hand if you dispose of your leachate at a local POTW

Source: Environmental Research & Education Foundation. “State of Practice of Landfill Leachate Management and Treatment in the U.S.” Staley and Bolyard. 04/18
Survey: Raise you hand if you discharge directly to the sewer?

- Direct Discharge to Sewer: 62%
- Trucking: 38%

Source: Environmental Research & Education Foundation. “State of Practice of Landfill Leachate Management and Treatment in the U.S.” Staley and Bolyard. 04/18

How Big a Problem…?

- 1,500,000,000 gallons disposed in 2016
- $97,000,000 increase in leachate costs in 2016
- 500% increase in leachate disposal costs in the past 6 years

Source: Darnell Waste Expo 2017
Source: GWI CTO Magazine Dec 2017
Source: Shaner Waste Expo 2017
What Customers Say Regarding Leachate Management
“It just keeps coming!”

Trends Impacting Leachate Management
- Rising cost of leachate management
- More uncertainty than ever before (regulatory, technical, community)
- More POTW risk than ever before
  - Tightening POTW regulation
  - Leachate impact on POTW treatment (visibility, strength, ammonia)
  - Emerging contaminants of concern
- Continued diligent regulator enforcement
- Less recirculation / more dewatering
- Solid waste characteristics changing impacting leachate quality and volume
- Continued demand for renewable energy and CHP
- Increasing environmental concern
- Managing in conditions of uncertainty

Typical POTW Concerns
- TDS/Chlorides (e.g. deflocculation, pass through into effluent)
- Refractory dissolved organic nitrogen (rDON)
- UV transmittance (POTW issue)
- Ammonia removal inhibition
- Biological treatment upset
- Metals (e.g., arsenic)
- Color
- Non-degradable COD
- Odors
- Foaming
- Sulfate (sewer odor)
## Leachate Management Economics...

<table>
<thead>
<tr>
<th>Type of Treatment</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Site (n=9)</td>
<td>$0.054</td>
<td>$0.010</td>
<td>$0.20</td>
</tr>
<tr>
<td>POTW (Sewer) (n=41)</td>
<td>$0.039</td>
<td>$0.0015</td>
<td>$0.50</td>
</tr>
<tr>
<td>POTW (Trucking) (n=31)</td>
<td>$0.11</td>
<td>$0.0015</td>
<td>$0.80</td>
</tr>
</tbody>
</table>

**On-Site Treatment** is 1.4 times higher than POTW without trucking. **Discharge to POTW by Trucking** is 2.8 times higher than direct discharge.

Source: Environmental Research & Education Foundation. “State of Practice of Landfill Leachate Management and Treatment in the U.S.” Staley and Bolyard. 04/18

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## Leachate Management Economics...

Broad range of costs dependent on multiple factors:
- Proximity to POTW
- Site specific infrastructure
- Leachate chemistry
- Available disposal / treatment options
- Local regulations
- Volume
- Seasonality
- Available on-site storage
- Transportation market competitiveness

### Value Imperatives

- Low total cost to treat
- Solution reliability with ability to adapt to changing feed conditions
- Future-Proofing ... ability control your own destiny
- Wide operating range to address leachate variability
- Maximize LFG Value

**Total Cost-to-Treat Including Transportation and Disposal** $0.04 - $0.30+ per Gallon
On-site Technologies

Thermal Evaporators
Spray Dryers (Power Industry Only)
Reverse Osmosis (RO)
Forward Osmosis (FO)
Evaporation Ponds
Deep Well Injections
Enhanced Evaporation

Evaporators
Dryers
RO
FO
Ponds
Deep Well
Heartland

CAPEX
OPEX
ZLD
Ease of Use
Fouling Potential
Maintainability
Uptime
Environmental Challenges

Solution

Heartland Water Technology
The Heartland Concentrator™ is a rugged and cost-effective solution that can concentrate the widest range of challenging wastewaters all the way to zero liquid discharge (ZLD) in one-unit operation.

The Heartland Concentrator is a ‘direct-contact evaporator’ – where hot gases are mixed directly with feedwaters in Heartland’s proprietary Low-Momentum, High-Turbulence (LM-HT) process.

With only 2 moving parts, no heat exchangers or membranes to foul, low-cost materials of construction, little-to-no pre-treatment required, and ease of operation, Heartland can deliver zero liquid discharge (ZLD) in a single unit operation – with no crystallizer required.

**Heartland Concentrator™ Process Flow**

**Flare Configuration**

**Cogeneration Configuration**

---

**LM-HT® Heartland Concentrator**

**LM-HT Low Momentum – High Turbulence**

1. **Heat Source**
2. **Concentrator Section**
3. **Feed and Recirculation**
4. **Droplet Separator**
5. **Sump**
6. **Exhaust**

- **Sizes**: 12K to 144K gpd per unit
- **Applications**: MSW, Brine Ponds, O&G, FGD, Purge Water, Other
- **Delivery**: 6-9 months; Fully skidded, Modular and re-deployable
- **Flex-Heat**: Flare, Recip Engine Exhaust, Recip Engine Jacket, GT, Hybrid
- **Value Added Solutions**: Plume Suppression; Ammonia Management
- **Lifespan**: 20+ years

---

Left: Process fluids as they exit the concentrator. Right: Solids accumulating in a settling tank. Liquid recycled back to the concentrator.
**Thermal Heat Source Flexibility**

While economical running on natural gas, Heartland’s Concentrator delivers the industry’s lowest cost to treat when utilizing unconventional waste heat.

<table>
<thead>
<tr>
<th>IC Engine Exhaust</th>
<th>Flue Gas</th>
<th>Flare Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT Exhaust</td>
<td>Electric Heater (pilot)</td>
<td>Biogas</td>
</tr>
</tbody>
</table>

**Cogeneration for Industrial Wastewater Evaporation (CoVAP)**

**A New Category of Cogeneration Application**

Traditional
1. Additional Power Generations
2. Industrial Steam
3. Hot Water
4. Refrigeration
and now...

New
5. CoVAP

**Benefits of CoVAP™:**

1. Distributed, reliable renewable power
2. Energy efficient use of waste heat
3. Reliable and cost-effective wastewater treatment
4. Easy and reliable integration
5. Simple to retrofit into simple cycle
6. Rapid deployment
CoVAP™ Significantly Increases Thermal Efficiency

**Simple Cycle**

- Engine: 30%
- Loss - After Cooler: 4%
- Loss - Salon: 10%
- Loss - Radiant: 28%
- Loss - Atmosphere: 9%

**CoVAP**

- Engine: 30%
- 5000 GPD Evaporation Rate
- 5000 GPD Evaporation Rate
- 8400 GPD Evaporation Rate
- Heartland Water Technology

1. Minimize field installation complexity – often in remote areas
2. Factory-tested to ensure seamless start-up and commissioning
3. Lower total cost-of-delivery
CoVAP™ Case Example 1

Virginia Landfill

8000 tons per day of solid waste

100K gpd of leachate
Simple and Safe Integration
Case Example 2
(Hybrid Solution)

Three Rivers Solid Waste Authority Regional Landfill

- Landfill Gas
  - Average dry methane concentration 54%
    - Flare can work below 40%
    - Flare capacity 320SCFM
- Waste Heat
  - 1MW Generator – IC Engine
- Leachate
  - 4.5M gal/year
  - Projected Daily Leachate volume - 12K gal/day growing to 20K gal/day over 20 years
Three Rivers Solid Waste Authority Regional Landfill

- Evaporation
  - 25K capacity concentrator
  - Primary source – Landfill Gas
  - 5,000 gal/day capacity from IC engine exhaust

- Residual
  - Estimated 96% volume reduction
  - 5,000 gal/week residual
  -Returned to the landfill

Three Rivers Solid Waste Authority Regional Landfill

- Flare and Exhaust Heat
- Building enclosure
  - 35’x40’x37’ footprint
Case Example 3
(LFG Flare Only)

Alaska Landfill

- Municipal Landfill Heartland Unit: 12,000 GPD.
- Located in Alaska
- Challenging climate - equipment located in custom designed building and heat traced.
- Load-out door for transferring residuals
- 100% of Thermal Energy Supplied by Flare Exhaust
- Flexibility: Ability to Operate on Natural Gas or LFG
- Installed & operating since 2014.
Volume Reduction Capability

Achievable volume reduction is a function of the starting point (or "strength") of the raw feed to the Concentrator, as well as the 'mode' of operation. This strength is approximated by the Total Dissolved Solids (TDS) of the liquid.

- Standard raw leachate typically has a TDS of 5,000-15,000 mg/L. At these levels, the Heartland Concentrator can achieve 95-98+% volume reduction.
- RO Concentrate typically has a TDS of 30,000-50,000 mg/L. At these levels, the Heartland Concentrator can achieve 80-95% volume reduction.

The environmental challenges of treating industrial waste waters and the related costs are increasing rapidly.
Concentration Ranges for Different Technologies

- **Concentration Ranges** for various technologies:
  - **Reverse Osmosis**
  - **Advanced Membranes**
  - **Falling Film Evaporators**
  - **Crystallizers**
  - **Spray Dryer**
  - **HF Concentrator**

Legend:
- % Solids in Feed
- % Solids in Effluent
- Concentration Range
- Brine Saturation (Typical for mixed saltes)

Heartland Water Technology

Proven Application for O&G Frac Water

- **Owl’s Nest Pilot Facility** (2008-2010):
  - Thermal energy from 100% well-head gas and 100% compressor exhaust proven.
  - ZLD solids to conventional landfill (meeting TCLP, Paint Filter and RAD requirements).
  - Produced custom tailored heavy brine for drilling.

- **Cherry Flats Compressor Station** (2012-Present):
  - Proven Solution for Produced Water

US Produced Water

- Low oil prices shining light on water management.
- Slow down in drilling bringing forward the produced water management cost.
- Increased regulatory focus on deep well injections – wells are harder to permit, and are being closed.
- Need for close proximity (well head) volume reduction.
- Earthquakes from Deep Well Injection could challenge continued use of saltwater disposal wells.

Heartland Water Technology
Summary

Heartland Water Technology

Heartland Concentrator

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Liquid Discharge</td>
<td>- Single unit operation&lt;br&gt;- Future proof (POTW, Regulations)</td>
</tr>
<tr>
<td>Flex-Heat Solution</td>
<td>- Enable/Leverage LFG-to-Energy&lt;br&gt;- Access CHP Incentives&lt;br&gt;- Hybrid Configuration maximizes electricity sales; gas utilization</td>
</tr>
<tr>
<td>LM-HT Process</td>
<td>- No Heat Exchangers or Membrane&lt;br&gt;- Low risk of corrosion or fouling&lt;br&gt;- Ability to handle widest range of waste streams, including chlorides, suspended solids</td>
</tr>
<tr>
<td>Highly reliable</td>
<td>- Only two moving parts&lt;br&gt;- No water chemistry experience req’d</td>
</tr>
<tr>
<td>Materials of Construction</td>
<td>- Low cost&lt;br&gt;- Highly corrosion resistant&lt;br&gt;- Long-lived (20+ years)</td>
</tr>
</tbody>
</table>

Safe, Simple, Rugged, Reliable and Cost Effective<br>Built by Operators for Operators
THANK YOU
www.HeartlandTech.com
(800) 759-1758
Casey Cammann
(603) 490-9203
cammann@heartlandtech.com

Heartland Values
Heartland Values

Values are the enduring beliefs that form the basis of our culture. Our values guide us in making those daily decisions, both large and small, that over time determine our achievement.

Safety
In valuing safety, we acknowledge that the well-being of our team members, partners and customers is always our first and foremost priority.

Customer First
In order to help our customers, we must first understand at a deep level what they value, and how they succeed. Only then can we develop and deliver appropriate solutions for them.

Service
Service is a mindset that says we care for those around us more than we do ourselves. The abundance we create for ourselves is a multiplier of how much we give of ourselves to others.

Solving Important Problems
We work hard. With the time we have available in our careers, we want to work on problems that will help sustain our planet and society for our next generations.

Winning as a Team
The best teams win, not the best collection of athletes. To be an effective team we must perform our jobs at the highest levels, trust in individuals around us, practice and train like professionals, and execute with a quiet confidence. Our ability to play as a team is the cornerstone of our success.

How we Behave

The foundation of all good teams is Trust. How we behave determines the level of trust we build collectively.

\[
\text{Trust} = f(\text{Integrity, Respect, and Candor})
\]

In addition to Trust, great teams have an intangible quality of always achieving more than management practice would deem possible.

\[
\text{Impact Multipliers} = \text{Optimism} + \text{Initiative}
\]

Integrity
Integrity means always doing what is right ... even when no one is watching.

Respect
It is through respect that we acknowledge the value and worth of those around us. We show respect for others in how we communicate, how we listen, how we deliver on commitments, and how we own up to our mistakes.

Optimism
Optimism is a force multiplier. Optimistic teams are not bounded by the conventional wisdom of what is possible, and as a result, consistently achieve more ... and have more fun along the way!

Initiative
Great teams and great team members do not wait around for direction. They seek to understand strategy and business intent, they “see around corners” to identify opportunities and threats, and move proactively to drive impact.
What we do

Over and above our Values and Behaviors, our habits are the things we do each and every day irrespective of the goals and strategy of the company. Our habits, applied over time, are how we win.

We Win by:
- Creating Value for our Customers
- Having a Passion for Process Improvement
- Simplifying the Complex
- Being Insatiable Learners
- Operationalizing Metrics and Scorecards
- Embracing Problems and Challenges
- Recognizing and Rewarding Impact

Intellectual Property

- Heartland maintains a comprehensive IP management program.

- Heartland currently owns 108 active US and foreign patents and patent applications, including:
  - 25 issued US patents, and
  - 26 issued foreign patents

- The HTP IP is generally directed to and covers various aspects of HTP’s technology, which includes:
  - Low momentum, high temperature (LM-HT) evaporative technology, and
  - The basic configuration and construction of the LM-HT evaporator, and
  - The use of the LM-HT evaporator with different types of fuel sources and at different temperatures, including low temperatures.
  - The result: unmatched, proprietary ability to assist clients in solving their wastewater treatment needs using a broad range of previously ‘wasted’ thermal energy sources.
Glossary of Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOC</td>
<td>Build, Own, Operate. A contract structure Heartland utilizes with clients (often used interchangeably with ‘DBBO’ below.</td>
</tr>
<tr>
<td>DBBO</td>
<td>Design, Build, Own, Operate. A contract structure Heartland utilizes with clients (often used interchangeably with ‘BOO’ above.</td>
</tr>
<tr>
<td>Entrainment Separator</td>
<td>Often known as a mist eliminator; entrainment separators are essential in many process operations for the removal of entrained material in vapor flows.</td>
</tr>
<tr>
<td>Flare</td>
<td>A gas flare, alternatively known as a flare stack, is a gas combustion device used in industrial plants such as petroleum refineries, chemical plants, natural gas processing plants as well as at oil or gas production sites having oil wells, gas wells, offshore oil and gas rigs and landfills.</td>
</tr>
<tr>
<td>FO</td>
<td>Forward osmosis (FO) is a cationic process that, like reverse osmosis (RO), uses a semi-permeable membrane to effect separation of water from dissolved solutes.</td>
</tr>
<tr>
<td>GT</td>
<td>Gas Turbine (GT) as in exhaust from a gas turbine engine.</td>
</tr>
<tr>
<td>IC</td>
<td>Internal Combustion (IC) as in an internal combustion engine.</td>
</tr>
<tr>
<td>Leachate</td>
<td>Leachate is the liquid that drains or ‘leaches’ from a landfill. It varies widely in composition regarding the age of the landfill and the type of waste that it contains. It usually contains both dissolved and suspended material.</td>
</tr>
<tr>
<td>LM-HT</td>
<td>Abbreviation for Low Momentum, High Turbulence (LM-HT) evaporative technology; a useful and trademarked description of the Heartland Technology Concentrator.</td>
</tr>
<tr>
<td>RAD</td>
<td>Abbreviation for Radiation. In the context of HTP, it refers to the ability of stabilized solids to pass local radiation requirements for disposal at a Subtitle D landfill.</td>
</tr>
<tr>
<td>RO</td>
<td>Reverse Osmosis (RO) is a liquid filtering process in which a contaminated (more concentrated) liquid is forced to pass through a semi-permeable membrane that block dissolved or suspended contaminants.</td>
</tr>
<tr>
<td>Stabilized solids</td>
<td>The end product of a process allowing for the disposal of process residuals containing a variety of 'bad actors' (e.g. barium, radium, mercury, arsenic, selenium) in a non-hazardous Subtitle D landfill.</td>
</tr>
<tr>
<td>Subtitle D landfill</td>
<td>A non-hazardous, municipal solid waste (MSW) landfill as defined by the United States Environmental Protection Agency (USEPA) Resource Conservation and Recovery Act (RCRA) Subtitle D regulations.</td>
</tr>
<tr>
<td>T&amp;D</td>
<td>Transportation &amp; Disposal.</td>
</tr>
<tr>
<td>TCLP</td>
<td>Toxicity characteristic leaching procedure (TCLP) is a soil sample extraction method for chemical analysis employed as an analytical method to simulate leaching through a landfill. The testing methodology is used to determine if a waste is characteristically hazardous (D-List).</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solids.</td>
</tr>
<tr>
<td>TS</td>
<td>Total Solids.</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids.</td>
</tr>
<tr>
<td>WEF</td>
<td>World Economic Forum.</td>
</tr>
<tr>
<td>ZLD</td>
<td>Zero Liquid Discharge.</td>
</tr>
</tbody>
</table>

Intellectual Property

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  - The basic configuration and construction of the LM-HT evaporator, and
  - The use of the LM-HT evaporator with different types of fuel sources and at different temperatures, including low temperatures.
  - The result: unmatched, proprietary ability to assist clients in solving their wastewater treatment needs using a broad range of previously ‘wasted’ thermal energy sources.
Integrated Solution for Onsite Landfill Leachate Management

- **Reverse Osmosis**
  - Used if large leachate volumes or thermal limitations (heat capacity or cost)
  - Use raw leachate or employ limited pre-treatment
  - Easy to "chase" higher recovery of pre-treatment. Adds cost/complexity
  - Need to manage permeate

- **Liquids Pre-treatment**
  - Oxidation used on raw leachate or RO concentrate
  - Primary targets are H2S and Mercaptans, and others
  - Can be treated to low concentrations or to non-detect
  - Oxidant recipe is modified if other odor causing compounds are prevalent

- **Vapor Post-treatment**
  - Most commonly, no vapor-phase post-treatment required
  - Ammonia absorbed in Concentrator exhaust, and produces a marketable 30% liquid ammonium sulfate (LAS), or dilute form for sewer disposal
  - Secondary treatment, such as caustic scrubbers or condensers, can attack other odor causing compounds and/or mitigate the visible plume

- **Residual Management**
  - Residual safely returned to the landfill
  - 95%+ volume reduction
  - Thermal process kills biologics
  - Optional sludge thickening provided if no liquid residual to the landfill is allowed

---

Comparative Leachate Characteristics (Not dissimilar from other high strength industrial wastewaters)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Domestic Sewage</th>
<th>Landfill Leachate</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weak/Medium</td>
<td>Strong (≤3/4 yrs)</td>
<td>Old (&gt;38 - 20 yrs)</td>
</tr>
<tr>
<td>BOD5</td>
<td>mg/l</td>
<td>110 - 190</td>
<td>2,000 - 30,000</td>
<td>100 - 1,000</td>
</tr>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>250 - 450</td>
<td>3,000 - 60,000</td>
<td>100 - 500</td>
</tr>
<tr>
<td>NH₃-N</td>
<td>mg/l</td>
<td>12 - 25</td>
<td>10 - 800</td>
<td>20 - 40</td>
</tr>
<tr>
<td>Total P</td>
<td>mg/l</td>
<td>4 - 7</td>
<td>5 - 100</td>
<td>5 - 10</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/l</td>
<td>120 - 210</td>
<td>200 - 2,000</td>
<td>160 - 400</td>
</tr>
</tbody>
</table>

**Notes**
1. Adapted from Table 3-15 from Metcalfe & Eddy, 4th Edition.
2. Leachate collected from onsite storage tanks.
## Comparison of Common Effluent Limitations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Monthly/Daily Concentration Limits (Mass limits may also apply)</th>
<th>Typical POTW Pretreatment*</th>
<th>Direct Discharge†</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average</td>
<td>Average</td>
<td>Maximum</td>
</tr>
<tr>
<td>BOD&lt;sub&gt;5&lt;/sub&gt;</td>
<td>mg/L</td>
<td>200 - 500</td>
<td>37</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>100 - 1,000</td>
<td>27</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Ammonia&lt;sup&gt;±&lt;/sup&gt;</td>
<td>mg/L</td>
<td>25 - 300</td>
<td>4.9 to &lt;1.0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/L</td>
<td>Site specific</td>
<td>0.11</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Alpha Tensio</td>
<td>mg/L</td>
<td>Site specific</td>
<td>0.016</td>
<td>0.033</td>
<td></td>
</tr>
<tr>
<td>Dimethyl Acet</td>
<td>mg/L</td>
<td>Site specific</td>
<td>0.071</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>p-Cresol</td>
<td>mg/L</td>
<td>Site specific</td>
<td>0.014</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Phenol</td>
<td>mg/L</td>
<td>Site specific</td>
<td>0.015</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>unit</td>
<td>6.0 - 9.0</td>
<td>6.0 - 9.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. General range of POTW is compiled based on project experience
2. Table 2-2: Non-Hazardous Landfill Subcategory, EPA-821-R.99-019
3. TSS limits as low as 6 mg/L have been imposed for direct discharges and 50-100 mg/L for Pretreatment
4. Site specific discharge permits will likely require additional parameter monitoring and/or impose additional parameter limitations

Direct >10X more stringent and Broader than indirect