WHITE PAPER

Hydrothermal Alkaline Disposal of Energetic Waste

A closed, non-combustion alternative to open burning and open detonation — validated by the U.S. Army, deployable as a modular on-site system

Applied Extracts, Inc. · July 2026 · appliedextracts.com

Executive Summary

The United States munitions industrial base produces energetic waste faster than it can lawfully dispose of it. Open burning and open detonation (OB/OD) — the default disposal route for decades — is under direct regulatory pressure, replacement incinerators are years behind schedule, and production is ramping. Hydrothermal Alkaline Liquefaction Treatment (HALT) offers a fundamentally different path: a closed, non-combustion chemical process that converts nitrocellulose fines and related energetic wastes into non-energetic products and a methane-rich fuel gas — on site, with no stack, no flame, and no energetic residue. The core chemistry has been validated by the U.S. Army Engineer Research and Development Center (ERDC TR-26-8, 2026). Applied Extracts is engineering HALT as a containerized, transportable skid that turns a facility's most difficult waste stream into recovered energy.

The Problem: Energetic Waste Has Outgrown Its Disposal Options

Every propellant and munitions plant generates energetic process waste — nitrocellulose (NC) fines from purification and dewatering, off-specification propellant, and energetics-contaminated liquids. These materials cannot go to a landfill or a conventional treatment plant: they are reactive hazardous wastes that historically had exactly two exits, open burning and incineration.

Both exits are closing:

- **Regulation.** EPA's proposed revision to RCRA standards for waste explosives (89 FR 19952, March 2024) would require facilities to evaluate and use safe, available alternative technologies in lieu of OB/OD wherever they exist.
- **Consensus science.** The National Academies (Alternatives for the Demilitarization of Conventional Munitions) concluded that safe alternatives already exist for certain explosive wastes — while alternatives for bulk energetics remain a critical gap.
- **Capacity.** Replacement incinerators face permitting resistance, community opposition, emissions liabilities, and multi-year construction delays — while the demilitarization stockpile, already hundreds of thousands of tons, grows every year.
- **Production ramp.** Artillery ammunition production is expanding across the industrial base, multiplying the waste streams at exactly the moment disposal capacity is shrinking.

The result is a compliance and cost problem measured in dollars per ton — and, increasingly, in permits a facility cannot get.

Hydrothermal Alkaline Liquefaction Treatment: How It Works

HALT destroys energetic materials in hot, pressurized water made mildly alkaline with sodium hydroxide. At subcritical hydrothermal conditions (approximately 350 °C in the liquid phase, with dilute 0.5 M NaOH and residence times on the order of thirty minutes), the chemistry does two things at once:

- **Denitration.** The nitrate ester and nitramine functional groups that make the material energetic are cleaved, with nitrogen reporting to benign inorganic species in the aqueous phase.
- **Energy recovery.** The remaining carbon skeleton is depolymerized and reformed into a methane-rich product gas — recoverable on-site energy rather than a disposal cost.

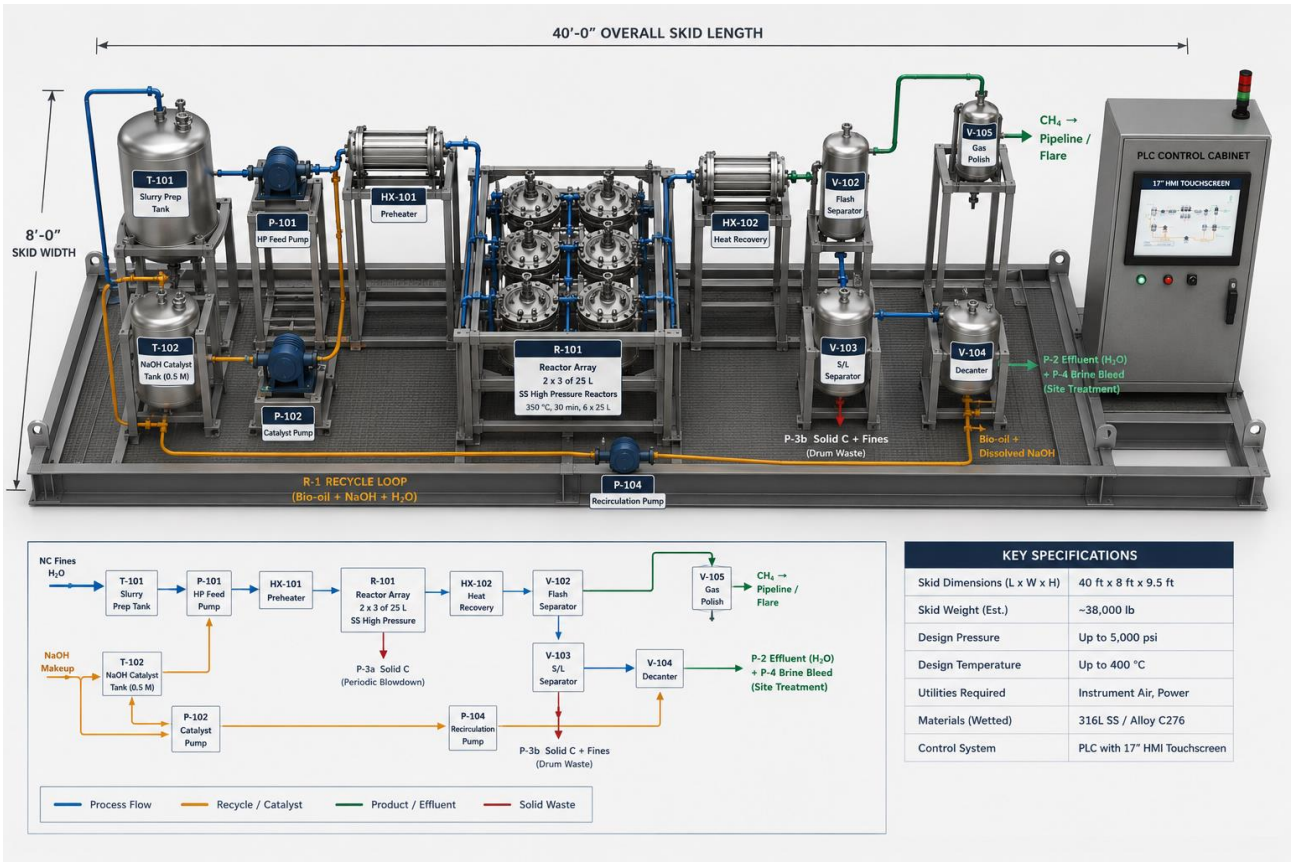
The process is fully closed. Water and alkali recirculate; there is no combustion, no open flame, no stack, and no energetic residue. Because the operating window is subcritical — far milder than supercritical water oxidation — the system is built from standard ASME code-stamped alloy construction rather than exotic-alloy pressure hardware, which is what makes compact, transportable, economically rational systems possible.

Validated by the U.S. Army

The core HALT chemistry was validated in U.S. Army ERDC technical report TR-26-8 (2026), which demonstrated alkaline hydrothermal conversion of nitrocellulose fines to a methane-rich product gas at the conditions described above. Applied Extracts is engaged with ERDC-CERL on demonstration planning to carry that validated chemistry from the bench to a fielded system. The company's process embodiments are the subject of U.S. provisional patent filings (2026) — patent pending.

From Chemistry to Hardware: A Modular, Transportable System

Applied Extracts' deployment concept is a containerized skid — nominally one ton per day of energetic feed per unit — installed at the waste generator's site. Slurry preparation, high-pressure feed, reaction, heat recovery, gas-liquid separation, and gas polishing are integrated on a single frame under PLC control, with the product gas delivered to the site as fuel. Capacity scales by adding skids in parallel, so a facility can start with a single unit and expand as OB/OD permits retire.



KEY SPECIFICATIONS	
Skid Dimensions (L x W x H)	40 ft x 8 ft x 9.5 ft
Skid Weight (Est.)	~38,000 lb
Design Pressure	Up to 5,000 psi
Design Temperature	Up to 400 °C
Utilities Required	Instrument Air, Power
Materials (Wetted)	316L SS / Alloy C276
Control System	PLC with 17″ HMI Touchscreen

Figure 1. HALT process skid (rendering): 40 ft × 8 ft containerized footprint — slurry preparation, high-pressure reactor array, heat recovery, separation, and gas polishing under integrated PLC control.

The Economics: Disposal Cost Becomes Recovered Energy

Where a compliant route exists at all, the cost of disposing of NC fines and related energetic wastes is on an upward trajectory: OB/OD permits are retiring; off-site shipment adds packaging, transport, and receiving-facility surcharges; and compliance costs — monitoring, reporting, and permit defense — compound with each regulatory cycle.

Disposal route	**Cost per ton**	**Permitting burden**	**Timeline to deploy**	**Emissions / liability profile**
OB/OD (where still permitted)	Need to amortize penalties, logistics, and regulatory compliance costs	Existing permits under active regulatory pressure; renewals increasingly contested	In place today; retiring	Uncontrolled air emissions; soil and groundwater liability; community opposition
Off-site incineration / shipment	Hazardous shipping cost premiums	Generator, transport, and receiving-facility permits; constrained third-party capacity	Subject to third-party capacity and backlog	Hazmat transport risk; liability follows the waste off site
On-site incineration (new build)	Capital-dominated: Radford's replacement energetic waste	New air permit; multi-year public	≈5 years from contract award to operations (Radford EWI: 2021 award →	Stack emissions; continuous monitoring burden;

	incinerator is a $145M design-build (2021 award)	process; community opposition	2026 startup), excluding the prior permitting cycle	permanent fixed asset
HALT	Per-ton treatment fee plus a fixed charge for equipment build, installation, and commissioning; host provides utilities and receives the green methane and renewable-fuel credits	Closed treatment unit; no stack or open emission point	~6 months per skid from in-stock pressure components	No combustion, no stack, no energetic residue; recovered fuel gas

The unit economics follow from what HALT displaces. Department of Defense demilitarization disposal has averaged roughly $3,000 per ton in recent program years, and compliant alternatives to OB/OD run from the low thousands to the tens of thousands of dollars per ton once packaging, transport, and receiving-facility surcharges are counted. A single 1-TPD HALT skid displaces that spending on site — on the order of $1 million per year at nameplate utilization — while returning approximately 25 GJ per day of methane-rich fuel gas to the host facility's fuel header — the green methane and any associated renewable-fuel credits accrue to the host. HALT is priced as a per-ton treatment fee plus a fixed charge for equipment build, installation, and commissioning, with the host providing site utilities; terms are finalized against the host facility's engineering standards and utility interfaces.

These economics only improve as OB/OD permits retire: every disposal route that closes raises the marginal cost of the alternatives, while HALT's cost basis is fixed at deployment.

Safety and Permitting: Designed for the Questions That Matter

HALT's safety case begins with the process itself, not with layered mitigation of an inherently violent operation. The energetic feed enters the system as a dilute aqueous slurry and is destroyed in continuous flow, so the energetic inventory in process at any moment is small in the reactor at steady state. Operating temperatures are subcritical, there is no combustion anywhere in the process, and the material ceases to be energetic inside the reactor rather than in a downstream step. The hazard profile is that of a code-stamped pressurized-water system handling a dilute slurry — not that of a burn pan, a detonation ground, or an incinerator.

The same properties define the permitting path. HALT is positioned as a closed treatment unit — precisely the category of safe, available alternative technology that EPA's proposed revision to the RCRA standards for waste explosives (89 FR 19952) would require facilities to evaluate in lieu of OB/OD. Because the process has no stack and no open emission point, the anticipated permit route is a modification to the host facility's existing RCRA Part B permit, with the HALT skid permitted as a miscellaneous treatment unit under 40 CFR Part 264, Subpart X — or, for the initial demonstration campaign, a Research, Development, and Demonstration permit under 40 CFR 270.65, rather than the multi-year air-permit process a new incinerator would face.

The table below summarizes the principal process risks and the engineered safeguards designed against them.

Risk	**Potential consequence**	**Engineered safeguard (design basis)**
Feed line blockage	Upstream pressure rise; interrupted treatment	High-pressure feed pump trips on discharge-pressure deviation via PLC interlock; automated flush sequence

Reactor overpressure	Vessel stress beyond design limits	ASME code-stamped vessels; pressure relief valves and rupture discs; PLC high-pressure interlock with automated shutdown
Exothermic excursion	Temperature excursion beyond operating window	Dilute slurry limits total energy release by design; redundant temperature sensing; PLC high-temperature interlock with automated feed cutoff
Loss of NaOH dosing	Incomplete denitration; off-spec effluent	Inline pH/conductivity monitoring with dosing interlock; effluent held and verified before release
Seal or fitting leak	Release of hot alkaline process fluid	Skid secondary containment; leak detection with remote monitoring; automated depressurization and shutdown
Off-spec feed with elevated energetic content	Energy release above design basis	Feed characterization and slurry-concentration control upstream of the reactor; dilution bounds energy density regardless of feed composition
Product gas handling	Flammable gas accumulation	Continuous delivery to the site fuel header with no bulk storage on the skid; pressure regulation; flame arrestors and LEL monitoring

Built on a Proven High-Pressure Platform

The credibility question deserves a plain answer: the HALT chemistry is Army-validated at bench scale, and the delivery platform is not — but the platform is not new engineering. Applied Extracts has designed, built, and fielded dozens of commercial supercritical-CO_2 extraction production systems and pilot-scale high-pressure biomass-processing systems — the AE-100 series, at TRL 9: continuous high-pressure processing equipment with full PLC/HMI automation, operating commercially today. The HALT skid applies the same engineering discipline: code-stamped pressure vessels, certified welding, factory acceptance testing, and remote monitoring, executed with an ISO 9001, ASME U- and R-stamp fabrication partner. Scale-up risk, in other words, lives in a domain the company has repeatedly executed.

Applied Extracts is partnered with Caribou Biofuels, which fields modular gasification waste-to-energy systems under an active U.S. Army waste-to-energy contract. The combined team brings a track record of fielded waste-to-energy systems and active DoD engagement — not a first customer relationship built from scratch.

The TRL position, stated honestly: the chemistry is validated at bench scale (ERDC TR-26-8); the high-pressure delivery platform is proven at commercial scale (AE-100 series); and the demonstration proposed below is the bridge between them.

Where HALT Applies

Figure 2. AE-100-series high-pressure pilot system: processing columns, separator train, and PLC/HMI control cabinet.

HALT addresses the energetic waste streams a plant actually struggles with:

- **NC fines.** Nitrocellulose fines from propellant manufacturing — the validated anchor application: a wet, fine-particle waste stream poorly suited to burning and ideally suited to slurry-fed hydrothermal treatment.
- **Propellant waste.** Off-specification and obsolete single- and double-base propellants, sized and slurried for continuous feed.
- **Demil streams.** Demilitarization-derived bulk energetics, where closed-disposal capacity is the binding constraint on the national stockpile drawdown.
- **Contaminated liquids.** Energetics-contaminated process waters and washdown streams, treated in the same closed loop.

Delivery is flexible: equipment supply, or treatment-as-a-service — priced as a per-ton treatment fee plus a fixed charge for equipment build, installation, and commissioning; the host provides utilities and receives the green methane and renewable-fuel credits.

Proposed First Engagement: One Skid, One Waste Stream, One Site

Applied Extracts proposes a funded on-site demonstration, scoped deliberately narrow: a single 1-TPD HALT skid operating on a defined NC-fines stream, in a 90-day campaign. Because the skid is built from in-stock pressure components, delivery to site is approximately six months from award.

Applied Extracts provides the system, commissioning, trained operations, and a full data package — feed characterization, destruction efficiency, effluent analysis, gas composition and yield, and operating-cost actuals — suitable for permitting support and for scaling decisions. The host site provides the feedstock, utilities, siting, and permitting support.

The engagement fits existing contracting mechanisms. For primes and munitions plants: cost-plus-fixed-fee NRE with operating services under an IDIQ. For government-funded demonstration: ESTCP or an agency BAA vehicle, for which this white paper is structured to serve as the basis of a submission.

If your facility has an energetic waste stream that is getting harder to dispose of every year, we would like to scope a demonstration against it.

Contact: James White, Ph.D. · Founder & CEO · jwhite@appliedextracts.com · 617-818-3332

About Applied Extracts

Applied Extracts, Inc. (San Mateo, California) is a U.S. small business specializing in supercritical-fluid and hydrothermal process technology for energetic materials — spanning waste destruction, energy recovery, and energetics manufacturing. The company was founded by James White, Ph.D.

Contact: James White, Ph.D. · Founder & CEO · jwhite@appliedextracts.com · 617-818-3332