A Case of Nerves.

(A report from the Tooele Army Depot chemical-weapons incineration facility in Utah)

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For a brief moment, as he stands at the edge of a vast, open valley beneath the bright Utah sun, t enormity of the task that confronts Timothy Thomas is mirrored perfectly by the landscape around him. He is flanked by massive monuments to the ingenuity of human destructiveness. And they each make Thomas seem very small by comparison. A few hundred yards in front of him, carved into the valley in neat rows that stretch for more than a mile, are hundreds of cement bunkers, called igloos, that contain almost half the U.S. Army's stockpile of chemical weapons. Stored here are more than one million aging rockets, bombs, shells, and mines, each designed to disperse deadly mustard gas or nerve gas. There are enough poisons stored here, in fact, to kill every human being on the planet handily, if the lethal doses could somehow be effectively administered. Thomas's prodigious task is to destroy these weapons safely before they can cause harm--accidental or otherwise.

Thomas's response to the deadly stockpile before him towers at his side: a brand-new hulking industrial complex of high-temperature furnaces, remote-control machines, and room-size banks of carbon filters. Thomas is the project manager for the Army's chemical weapons incinerator here at the Tooele (pronounced too-WIL-ah) Army Depot, 30 miles southwest of Salt Lake City. It is the first facility of its kind in the continental United States, and its long-anticipated completion has stirred worldwide interest, concern, and fear. Now in a lengthy test phase, the facility is slated to begin full-scale operations in February 1995.

Eight years ago Congress and the public stood deeply divided over the Pentagon's appeal for a new generation of chemical weapons; on three separate occasions, then--vice president George Bush cast a tie-breaking vote in the Senate to allow the United States to proceed with a controversial program calling for small-scale testing and production. In contrast, there was near unanimous agreement on another part of the program: the part that called for the Army to destroy its oldest chemical munitions. As the Army had known for years, many of its World War II--era chemical weapons were leaking their lethal contents and endangering the very people they were designed to protect.

Despite congressional approval, the chemical weapons production program never got off the ground. One reason was that in the late 1980s the perceived need for new chemical weapons began to wane. Another was that the program was stalled, oddly enough, by the major multinational chemical firms. In response to pressure from foreign governments and environmental groups alike, the companies had adopted policies that prohibited them from producing the lethal substances unless explicitly ordered to do so by the U.S. government. The final blow to the program came in the spring of 1990, when the Americans and the Soviets signed a historic agreement to destroy the vast majority of their chemical stockpiles. Spurred by this superpower agreement, 148 nations have since signed the landmark Chemical Weapons Convention, which prohibits the United States, Russia, and other signatory nations from amassing any new chemical weapons and allows for onsite inspections to ensure that none are developed. (Several countries did not sign, however, including Iraq, Syria, Libya, and Egypt.) The agreement gives all signatory nations just ten years to destroy completely their existing arsenals.

Thus the completion of the Tooele incinerator this summer marked a critical passage: for the first time, the technology that has brought generation after generation of ever more potent chemicals to the service of war may be reversed.

Chemical warfare has a long, if ignoble, history. Poison arrows, after all, have been used as weapons almost since the beginnings of human history, and the Romans fouled the wells of their adversaries more than 2,000 years ago. The first systematic effort in modern times to deploy poison on the battlefield, though, occurred near the Belgian town of Ypres during World War I. On April 22, 1915, German soldiers released 6,000 canisters of chlorine gas and promptly killed 5,000 French and Algerian soldiers. By the end of the war, more than 100,000 tons of poison gas had been let loose, killing some 91,000 people and injuring more than one million.

The horror of gas warfare persuaded most of the world's nations to sign the Geneva Protocol of 1925, which outlawed the first use of chemical weapons. But countries reserved the right to respond in kind to a gas attack. During World War III the Allied and Axis powers were both poised to unleash massive gas attacks, but each side refrained and no chemical weapons were used. Nevertheless, the chemical arms race continued after the war, this time with the United States and the Soviet Union as the leading contenders. Today the U.S. arsenal reportedly contains millions of weapons and a total of approximately 30,000 tons of chemicals (the exact amount remains classified); the Russian arsenal contains about 40,000 tons. Fortunately, since the 1925 accord these chemical superpowers have never used their weaponry. Some countries with smaller arsenals, though, may have--notably Iraq, which reportedly used mustard gas against its own Kurdish population in the late 1980s.

The vast U.S. stockpile is stored at eight sites around the country--too volatile, politically and otherwise, to move. The Army is now committed to destroying (or in Army parlance "demilitarizing") these weapons where they are, by an elaborate process that will dismantle and then incinerate them, leaving as residues contaminated brines and ash, which will be buried in hazardous-waste landfills, and decontaminated metal parts from the weapons' casings, which will also be buried or possibly sold as scrap. If all goes according to the current plan, the Army will ultimately construct a total of seven other facilities like the one now being tested in Tooele. But as the Army Chemical Demilitarization Program's manager, civilian Charles Baronian, notes, the task will not be easy: "These munitions were not made to be demilitarized; they were made to be used. And there was very little consideration given to what would happen if they weren't."

No one is more aware of the difficulty of the task than Timothy Thomas. Until the past few years, much of Thomas's work as an engineer was devoted to designing the Army's first chemical weapons incineration plant, on the exceedingly remote Johnston Island in the Pacific--a facility known in Army-speak as JACADS, the Johnston Atoll Chemical Agent Disposal System. The JACADS facility, some 750 miles southwest of Hawaii, has been testing incineration procedures for the Army since 1990; the experience there has taught Thomas and many others that the goal of destroying the arsenal is easier to espouse than to accomplish. "Clearly," he says, smiling with an engineer's enthusiasm, "it is more complicated taking these weapons apart than it ever was putting them together."

The new plant Thomas oversees--the Tooele Chemical Disposal Facility--is a mind-numbing paean to this simple statement, replete with 840 miles of electrical wire, 33 miles of pipes, and 16,000 valves and instruments--not to mention some 2,000 pieces of equipment designed to be operated and monitored by remote control. The complexity of the plant matches the diversity of the arsenal it was built to destroy. The United States has amassed a number of different chemical "agents," including several varieties of nerve and mustard gases, and the plant must be adjusted differently for each type. Worse yet, the various agents are packed into weapons of all shapes and sizes--from long, slender missiles to squat land mines--each requiring tailor-made destruction machinery.

Overriding all other concerns, though, is simply that all the chemical munitions contain poisons that, in minute quantities, are specifically designed to kill humans. The mustard gas stored at Tooele, part of the Army's family of "blister agents," kills by irritating the lungs so violently that they fill with fluid; the victim literally drowns. The stockpile's newer nerve agents, primarily two compounds called GB and VX, work faster--almost instantly--clenching the body's muscles and heart in an unyielding death grip. (The difference between the two is that GB was designed to kill when inhaled; it disperses in a cloud that dissipates in just a few hours. VX, in contrast, settles onto the ground or vegetation with a consistency more like motor off; it kills not only by being inhaled but also by contact, and it retains its lethal properties for weeks.) For Thomas and his co-workers, the implication is inescapable: the lethal power of the chemicals leaves the Tooele incinerator frighteningly little room for error. Already, accidents at Tooele and other storage depots have left workers hospitalized, although no one, perhaps remarkably, has died.

A few strong whiffs of the nerve gas VX will incapacitate a victim within seconds and kill in less than a minute; in liquid form (normally all these chemicals are stored as liquids but dispersed in vapor form), a drop no larger than a pinhead on the skin is also fatal, if slower to act; a teaspoon of the substance contains enough lethal doses potentially to annihilate the plant's entire construction crew of close to a thousand workers. There is no telling what carnage the accidental detonation of a single one of the depot's nearby munitions could cause. A lone bomb, if it exploded, could cause fatalities ten miles away. And such a dire scenario is not at all farfetched in an arsenal of weapons dating back all the way to World War II.

In fact, none of the weapons stored at Tooele is less than 25 years old. Army officials say that 1,221 of them are "leakers," and many of these are M55 rockets made during the 1960s and filled with GB; the leakage is being caused by the reaction of the agent with the aluminum in the warhead. Colonel David

Emling, the Tooele Army Depot base commander until late this summer, says accidents have largely been prevented by monitors, installed in the igloos, that can detect leaking chemical vapors at very low levels. The tripping of a monitor is the signal for workers to suit up, then seal the leaking weapon in an airtight container and isolate it in a designated storage igloo. Most of the leakers exude only small amounts of vapor, the Army says, so small that you'd have to be standing next to one in an igloo to be harmed.

But obviously, even a small event could have serious consequences. Says Brigadier General Walter Busbee, commander of the Army's Chemical Materiel Destruction Agency, "Every time we've studied the issue of what to do with the stockpile, continued storage always presents the greatest risk of any alternative." Even though the chances of a serious accident are slim, he says, the risk is there every minute until the weapons are destroyed. "We can only thank goodness we have never faced a catastrophic, act-of-god event that released a substantial amount of chemical agents," he says grimly.

The key ingredient in the nerve gases is phosphorus, a poison in its own right. When combined with oxygen to form phosphate and bonded with organic compounds, its effect can be extraordinarily lethal. These "organophosphates" lead to a fatal buildup of acetylcholine, a chemical compound the body uses as a neurotransmitter to send signals among nerves, organs, and muscles. When released, acetylcholine triggers nerves to fire, glands to secrete, muscles to contract. This message is cleared, allowing the muscles to relax, only when the acetylcholine is split into the compounds acetic acid and choline.

The enzyme that breaks apart acetylcholine--called acetylcholinesterase--is "the fastest enzyme we know of," says Alexander Karczmar, a neuropharmacologist at Loyola University in Chicago. A single enzyme molecule can break down 300 acetylcholine molecules in a thousandth of a second, allowing continuous control of the body's muscles. The phosphorus atom in nerve agents, Karczmar explains, is strongly attracted to one particular site on the enzyme--where the amino acid serine is located. The phosphorus combines with the serine, thereby "clogging" the enzyme and preventing its function. Since the body uses only infinitesimal amounts of acetylcholinesterase, commensurately small quantities of nerve agents can have a tremendous impact.

The synapses relying on acetylcholine include those in strategic areas in the brain that control the body's respiratory and cardiovascular systems; they also connect nerves to some of the body's most critical muscles, such as the diaphragm and the heart. Within seconds after inhaling an imperceptible breath of a nerve agent like GB, a victim experiences difficulty in breathing. Cramps, involuntary urination and defecation, drooling, vomiting, and twitching follow as the victim loses control over muscles. Simultaneously, the brain loses its ability to control blood supply and respiration, leaving the heart and lungs disabled. The result, within minutes, is death due to respiratory failure. "It's a major disaster," Karczmar says, groping to describe the gruesome progression.

The massive new incinerator sits on a 22-acre concrete staging area. Many components still lie scattered on the site: crates filled with heavy-gauge valves; wooden pallets laden with chains, ducts, and hoses; enormous spools wound with electrical cable nearly as thick as a wrist. From all directions carpenters, pipe fitters, and electricians wearing hard hats and goggles stride past. The group could almost pass for a construction crew anywhere, except that everyone on the site, including Thomas, carries an additional piece of equipment: a green canvas bag slung from the shoulder or strapped at the waist. The bag, the Army's standard issue chemical weapons protection kit, contains an M9 gas mask and three small Mark I self-injecting canister kits designed to treat the effects of nerve gas.

Entering the incinerator complex, Thomas leads the way along the twisted route designed for the chemical weapons themselves, venturing deep into parts of the plant that will be virtually off-limits to humans once it goes on-line. The first stop is a cavernous room the Army descriptively calls the unpack area. As the munitions are taken by suited workers from the igloss nearby, they will be sealed inside thick steel drums ("overpack containers") and stored in an adjacent building to await processing. After monitoring these containers to assure that the weapons inside have not begun to leak during transportation and storage, plant workers will cart them here by hand.

The three heavy steel conveyors look strangely like armor-plated supermarket checkout counters. Workers here, with gas masks at the ready, will lift the weapons and place them on a track of metal rollers that will draw the munitions toward a door--the gateway to their automated, incendiary journey. Thomas pats the machine heartily. "This is the last point at which we will manually handle the munitions. Once past this explosion-proof barrier," he says, motioning to the two-foot-thick reinforced concrete wall behind him, "everything will be done automatically."

Beyond the wall is a Level A contamination area--the highest grade. The panoply of industrial machines there will perform the intricate tasks of dismantling the weapons--tasks deemed too dangerous for direct human contact not only because of the levels of chemical agents but also because of the danger of explosion. Should people be required to enter this sealed area once the plant is running--and they will do so only for infrequent maintenance or in the event of what Thomas euphemistically calls an "upset condition"--they will need to don the Army's highest grade of protective clothing, an airtight, one-time-use white plastic suit that constitutes part of what the Army calls its Demilitarization Protective Ensemble. The suit is part moon suit, part Pillsbury Doughboy costume, inflated with an umbilical cord--like a long garden hose--that pipes uncontaminated air from a pump and filtration machine located in a safely removed area. Before undertaking an assignment in such life-treatening conditions, workers will be heat-sealed into the outfit.

Even if the suit gets punctured--as it has on numerous occasions during maintenance work at the Army's JACADS plant--positive air pressure provides an outward flow of air that keeps any ambient lethal gases away from the worker inside. If this pumped air also fails, workers are equipped with an auxiliary tank of emergency oxygen designed to switch on automatically in the event of a loss of pressure.

The Army developed these dispossable suits in the 1970s specifically for use in environments contaminated with chemical agents; they're intended to be a first line of defense against accidental splashes or stray fumes. However, each is designed to endure reliably only two hours of use in such dangerous territory. Furthermore, despite years of research and testing, the suits are still vulnerable to unexpected accidents. In one case, a worker at the JACADS plant inadvertenly blocked the exhaust valve on his partner's suit; pressure built up and the suit popped. (Fortunately the worker suffered no exposure to agents.)

The chemical munitions enter this area on the conveyor belt, via double-door air locks. Their first stop here is the Explosive Containment Room. This room works like a factory running in reverse: whole munitions go in and constituent parts leave. Each style of rocket, mortar shell, or projectile proceeds through a disassembly line that has been tailored to its needs.

The 105-millimeter mortar projectile, for example, rides the conveyor belt into the Explosive Containment Room and has its nose removed by a remote-control arm. The conveyor then shuttles the projectile to a large table that revolves like a lazy Susan; sitting upright, the projectile moves around to a series of stations. At station 2 a remote-control machine unscrews the fuse, removes it, and sends it off to a separate kiln for explosives, know as the deactivation furnace. At station3 small explosive devices called boosters are removed and sent off to be incinerated. The boosters sit underneath the fuse and help set off the "burster," which is a solid explosive that runs down the center of the weapon; when detonated by the fuse (and boosters), it explodes, blowing liquid chemicals into aerosols, the better to disperse their deadly contents. At station 4 the burster is sucked out by pressurized air and sent over to the Rocket Shear Area, where it is chopped into little pieces lest it detonate while being incinerated. Then these pieces, too, are fed to the deactivation furnace.

At the fifth and final station the projectile--which still contains the liquid chemical--is placed by a robot into an "eggcrate tray" for its journey into the Munitions Processing Bay. There a machine removes the burster well--a steel tube that holds the burster. Removing the well exposes the chemical agent at last. A tube is inserted and the agent is sucked out. The burster will is crushed by yet another machine, then returned to the projectile. Now free of explosives and poisons, the projectile is sent for final incineration to a furnace for metal parts.

The liquid poisons, meanwhile, are pumped to the heart of the Tooele complex--the room that holds its two-story liquid incinerator. Here they are sprayed into a cyclone burning at 2700 degrees. At this searing temperature, the chemical bonds of these compounds are readily broken and the once-stable molecules destroyed. The now-gaseous agents spend less than two seconds inside the furnace, where they are sundered and combined with oxygen in the air stoking the furnace to form simpler, less toxic molecules, such as nitrogen dioxide, hydrochloric acid, hydrofluoric acid, and sulfur dioxide.

Their next stop is a slightly lower temperature furnace called in afterburner, designed to provide added "residence time" to ensure that all the chemicals have been thoroughly incinerated before entering the plant's elaborate filtration system. Thomas says that between the afterburner and the filters, virtually all of the by-products generated in the incineration process will be removed from the exhaust, leaving only carbon dioxide, nitrogen, unburned oxygen, nitrous oxide, and water vapor, the normal combustion products of natural gas, which fuels the plant.

Despite Thomas's upbeat presentation, the complexity and variety of the processes involved make the prospect of flawless execution dubious. Mishaps at the JACADS plant don't necessarily inspire confidence, either. In January of this year, for example, a fire broke out in the Explosive Containment Room there, causing the facility to shut down. According to the Army, no chemicals were released into the environment during this incident, but operators found themselves largely helpless for more than three hours against a blaze that broke out in a corner of the plant that--because of the Army's oversight--lacked sufficient fire suppression or sprinkler systems.

The room where the fire occurred, like other Level A contamination areas, is designed to be held at a negative air pressure relative to surrounding, presumably less contaminated areas so that any releases will not circulate to other parts of the plant. In essence, the whole incinerator complex functions like a giant vacuum cleaner, drawing clean ambient air into the heart of its most contaminated areas and drawing potentially contaminated air through banks of carbon filters to the atmosphere outside.

During the JACADS fire, however, operators had to override the plant's vaunted ventilation system to prevent this "safety device" from fanning the flames. Unfortunately, this caused the room to fill with opaque smoke that rendered its video monitors so ineffective that the operators couldn't tell if the blaze was spreading and threatening to detonate partly dismantled munitions nearby. Two suited-up workers ultimately had to enter the room and put the fire out by hand. The Army dismisses the importance of this incident. (By the time the workers arrived, the Army says, the flame had shrunk to the size of a softball, so they were able to extinguish it with damp cloths.)

Despite the consideration given to the possibility of an explosion, it seems plant designers had not considered the possibility of a fire. An investigative team speculated that the accident occurred when the "booster removal machine" malfunctioned, pinching the "booster cap," which became wedged between the discharge chute and the belt of the conveyor, causing a spark. Still, the Army is unsure of exactly what caused the fire.

Even a cursory look at project managers' logs reveals that JACADS has been plagued from the first by broken meters, dogged burners, faulty circuit breakers, and blocked pipes. Pieces of the contaminated metal casings from the weapons, melted into blobs by the furnace, stuck to a conveyor belt, cooled, dropped off, and dogged a chute. A minor explosion in the deactivation furnace--caused by a piece of burster that exploded--blew a hand-size hole in the furnace wall. (No agent was detected, and a thicker wall was installed.) During yet another incident, a small amount of the nerve agent GB was released during a furnace shutdown, apparently because of improper procedures. Fortunately, the release--well documented by the plant's air monitors--went alarms blaring and forced roughly a thousand workers to don gas masks. The concentration of the agent was low enough not to require reporting, and in the end no one was injured.

The question is: Has the Tooele incinerator benefited from the mishaps at JACADS? Or is it destined to repeat the same mistakes--perhaps with devastating results? A failure of the filtration system at Tooele, after all, would not send a lethal cloud harmlessly out to sea; the city of Tooele, Utah (population 13,887), is only 17 miles from the plant, and several smaller communities, like the town of Rush Valley, lie even closer. The Army's own risk assessments estimate that as many as 20,000 fatalities beyond the plant's perimeter could result if an accident such as the detonation of a shell during a forklift collision or a fire occurred. This worst-case scenario would require an unlikely combination of mishaps and meteorological conditions--slow winds and stable weather that would allow the cloud to stay intact while drifting over the most populated areas. Still, program manager Barorian acknowledges that in such circumstances a cloud could travel up to 30 miles before dissipating.

Not surprisingly, Thomas says that his incinerator will profit from the JACADS mistakes. But thousands of design changes--some minor, others more substantial--have been made to incorporate the lessons learned from the operations there. With so many changes, state regulator's are requiring that any new procedures and equipment be fully tested before being incorporated into the Tooele operation.

Yet local activists like Chip Ward remain skeptical of the Army's ability to handle the project. "If you haven't lived next to the Army, you have no idea what waste and incompetence is," says Ward. "Anybody around here can tell you stories. A worker at Tooele recently even sent a vial of nerve gas in his lab coat to the cleaners." The Army says the vial contained only a diluted amount of an agent that was being used to calibrate instruments and that it was discovered en route to a special Army laundromat before it could do any harm. But such incidents don't inspire confidence.

Most troubling of all to some, perhaps, is that even in destroying the weapons, the incineration process will yield emissions that could, under the right conditions, be highly toxic. It matters little that the quantities of these pollutants will be minuscule. "The more I've learned, the more concerned I am," says Ward, the leader of the local opposition. He argues that the plant will produce significant amounts of dioxins, highly toxic chemical compounds that work their way into the food chain and accumulate in human tissue. A recent National Academy of Sciences report on JACADS, however, showed toxic emissions to be well below the standards set for municipal waste incinerators. Ward is not swayed: "We could be creating problems at the Tooele incinerator that will be the curse of the next generation."

Even Thomas acknowledges that minute quantities of dioxins are released by the plant (and perhaps even infinitesimal quantities of chemical agents, although--if there--they are below detectable levels). While the Army stresses that dioxin is produced at only "background levels"--the same as produced in burning fossil fuels--environmentalists say that even these levels are unnecessary and that the Army has not adequately considered alternatives to incineration. According to Craig Williams, a spokesperson for the Chemical Weapons Working Group, an international coalition of citizens opposed to the Army's plan, "When the Army made the decision to incinerate, they got on the wrong train. Until they get on a different train, every stop is going to be wrong.

In fact, between 1973 and 1976, the Army actually destroyed 4,000 tons of the nerve gas GB through a process called neutralization, by chemically mixing it with a solution of the common alkaline compound sodium hydroxide to make it ineffective. But this process was abandoned in 1982, according to the Army, because of the large amount of liquid waste it produced and because there was some concern (later found to be unwarranted) that the agent was not completely destroyed. Moreover, remaining metal parts and explosives still needed to be burned in some fashion. And during the 1980s incineration seemed to be the method of choice for disposing of everything from hazardous waste to municipal trash.

In the years since, however, environmentalists have grown increasingly skeptical of the technology's safety. Although the process is simple in principle, the experience at JACADS once again raises concerns. The liquid incinerator there frequently failed to reach the temperature required to assure complete incineration of the deadly chemicals.

Ross Vincent, an activist with the Sierra Club who lives in Pueblo, Colorado (home of the Pueblo Army depot, where thousands of projectiles and cartridges filled with mustard gas are stored), calls incineration an "obsolete technology" with "unacceptable environmental and public health risks." Vincent, trained as a chemical engineer, says the Army should abandon its incinerator plans in favor of some alternative form of destruction. His suggestion gained considerable credibility last summer when the National Academy of Sciences issued a report examining dozens of alternative technologies for destroying the arsenal. John Longwell, the MIT chemical engineer who chaired the academy committee, said the group's research showed that there are numerous technologies that "could potentially be used to replace or augment incineration."

Theoretically some of these alternatives would produce smaller volumes of waste gases. Two such possibilities are molten metal pyrolysis, in which agents are mixed with a molten metal such as iron, and plasma arc destruction, in which agents are annihilated in the scorching arc between two electrodes. Other methods, such as neutralization, produce no gaseous emissions at all.

Furthermore, no matter how safely the plant runs, the program's success is far from guaranteed. One issue is cost. In 1985 the Army estimated for Congress that the chemical demilitarization program would cost a total of $1.7 billion. The estimate now stands at $7.9 billion, nearly five times more.

A related problem is delays. Incinerating a test run of GB rockets at JACADS took exactly twice as long as planned, and even then the Army did not incinerate anywhere near all the GB weapons it had initially scheduled. After the completion of the "GB campaign," the staff took more than five months to repair the plant and ready it to handle VX shells.

Environmental concerns have strengthened local opposition at sites slated for chemical weapons incinerators around the country, creating additional hurdles. Already Kentucky, home to a prospective incinerator at the Blue Grass Army Depot, has swung into action. The state has passed legislation requiring the Army to "prove" that incineration poses less risk than any alternative method that could be developed--a daunting and most likely impossible task.

But then, the stakes are high. If successful, the Tooele incinerator will probably become the model not only for the rest of the U.S. disposal program but also for the Russian program, which, despite treaty obligations, is barely under way. Should it fail, however--if the incinerator malfunctions, releases unacceptable emissions, or, worse yet, causes a catastrophic accident--the consequences will reverberate dramatically, jeopardizing domestic plans to incinerate the fragile and possibly even rattling the fragile worldwide consensus that has demanded the swift elimination of the scourge of chemical weapons.

"The facility at Tooele is absolutely pivotal to gaining public acceptance of this technology," Brigadier General Busbee says. "We won't have the kind of credibility we need until we operate at Tooele safely and effectively with full public disclosure throughout the process. And we still have a long way to go."