Rust: The Longest War

Finalist for the Los Angeles Times Book Prize ** A Wall Street Journal Best Book of the Year

It has been called "the great destroyer" and "the evil." The Pentagon refers to it as "the pervasive menace." It destroys cars, fells bridges, sinks ships, sparks house fires, and nearly brought down the Statue of Liberty. Rust costs America more than $400 billion per year-more than all other natural disasters combined.

In a thrilling drama of man versus nature, journalist Jonathan Waldman travels from Key West, Florida, to Prudhoe Bay, Alaska, to meet the colorful and often reclusive people who are fighting our mightiest and unlikeliest enemy. He sneaks into an abandoned steelworks with a brave artist, and then he nearly gets kicked out of Ball Corporation's Can School. Across the Arctic, he follows a massive high-tech robot that hunts for rust in the Alaska pipeline. On a Florida film set he meets the Defense Department's rust ambassador, who reveals that the navy's number one foe isn't a foreign country but oxidation itself. At Home Depot's mother ship in Atlanta, he hunts unsuccessfully for rust products with the store's rust-products buyer-and then tracks down some snake-oil salesmen whose potions are not for sale at the Rust Store. Along the way, Waldman encounters flying pigs, Trekkies, decapitations, exploding Coke cans, rust boogers, and nerdy superheroes.

The result is a fresh and often funny account of an overlooked engineering endeavor that is as compelling as it is grand, illuminating a hidden phenomenon that shapes the modern world. Rust affects everything from the design of our currency to the composition of our tap water, and it will determine the legacy we leave on this planet. This exploration of corrosion, and the incredible lengths we go to fight it, is narrative nonfiction at its very best-a fascinating and important subject, delivered with energy and wit.
Jonathan Waldman studied writing at Dartmouth and Boston University's Knight Center for Science Journalism, and worked in print, radio, and TV before landing in books. His first book, Rust: The Longest War, was a finalist for the Los Angeles Times Book Prize and winner of the Colorado Book Award. His writing has otherwise appeared in The New York Times and McSweeney's. Visit him at JonnyWaldman.com or email him at JonnyWaldman@gmail.com.Rust INTRODUCTION: THE PERVASIVE MENACE

Rust has knocked down bridges, killing dozens. It's killed at least a handful of people at nuclear power plants, nearly caused reactor meltdowns, and challenged those storing nuclear waste. At the height of the Cold War, it turned our most powerful nukes into duds. Dealing with it has shut down the nation's largest oil pipeline, bringing about negotiations with OPEC. It's rendered military jets and ships unfit for service, caused the crash of an F-16 and a Huey, and torn apart the fuselage of a commercial plane midflight. In the 1970s, it was implicated in a number of house fires, when, as copper prices shot up, electricians resorted to aluminum wires. More recently, in the "typhoid Mary of corrosion," furnaces in Virginia houses failed as a result of Chinese drywall that contained strontium sulfide. They rusted out in two years. One hundred fifty years after massive ten-inch cast iron guns attacked Fort Sumter, rust is counterattacking. Union forces have mobilized with marine-grade epoxy and humidity sensors. Rust slows down container ships before stopping them

entirely by aiding in the untimely removal of their propellers. It causes hundreds of explosions in manholes, blows up washing machines, and launches water heaters through the roof, sky high. It clogs the nozzles of fire sprinkler heads: a double whammy for oxidation. It damages fuel tanks and then engines. It seizes up weapons, manhandles mufflers, destroys highway guardrails, and spreads like a cancer in concrete. It's opened up crypts.

Twenty-five miles northeast of San Francisco, one of the country's largest rust headaches bobs at anchor in Suisun Bay, and puts Syzygy to shame. Fittingly, the National Defense Reserve Fleet belongs to the US Department of Transportation, an agency that nearly plays God in its attempt to placate the needs of man and machine. Scores of people inspect on a daily basis as many old merchant ships that, in earlier extralegal times, would have been scuttled offshore. Now, the ships are too fragile to be hauled out and repainted, and not worth towing to Texas to be scrapped. Lacking other options, to Texas they've gone. Confounding matters, the US Coast Guard insisted in 2006 that the hulls of the ships be cleaned of invasive mussels before being moved, while the California Water Quality Control Board demanded that the bay not be polluted during said cleaning, and threatened to fine the Maritime Administration $25,000 a day until it came up with a plan. Environmental groups sued, demanding studies. While ten biologists, ecologists, toxicologists, statisticians, modelers, and mapping experts collected clams and mussels and took hundreds of sediment samples, the ships went on rusting. Big surprise: they contaminated the bay. At least twenty-one tons of lead, zinc, barium, copper, and other toxic metals have fallen off of the ships. What to do about the Reserve Fleet conundrum is such a touchy question that Senator Dianne Feinstein, who has a position on every environmental issue in California, officially has no position on the matter.

On the other coast, two dozen flip-flop-wearing employees of the US Naval Research Lab fill their time studying corrosion-resisting paints under palm trees at Naval Air Station Key West. Long before the place was an air station, in 1883, the Naval Advisory Board tested anticorrosive concoctions there, because rust was plaguing the navy. Today's paints self-heal, or can be applied underwater, or change color when exposed to rust-and still, rust plagues the navy. Rust, in fact, poses the number one threat to the most powerful navy on earth. By many measures, and according to many admirals (who sound as if they're employed by the DOT), the most powerful navy on earth is losing the fight. The name of one of the department's annual maintenance conferences: Mega Rust. The motto of that Florida lab: "In rust we trust."

As with boats, they say a lot of things about cars. About one brand of American car, they used to say this: "On a quiet night you can hear a Ford rust." In Ohio, since rust used to lighten automobiles by about ten pounds every year, that was half an ounce of metallic music to your ears nightly.1 The symptoms extend beyond the rust belt, and express themselves in more than just Fords. Since 1972, the National Highway Traffic Safety Administration has had Volkswagen recall three-quarters of a million Sciroccos, Dashers, Rabbits, and Jettas with rusting fuel pumps and nearly as many cars with rusting brake lines. At NHTSA's insistence, Mazda recalled more than a million cars with rusting idler arms, and Honda recalled nearly a million vehicles with rusting frames. Chrysler recalled half a

million cars with rusting front suspensions and Subaru recalled as many with rust problems in the other end. Ford recalled nearly a million Explorers with rusty hood latches and nearly a million Mercurys and Tauruses with rust-prone springs, and in the fifth-largest recall in history, almost four million SUVs and pickups because corroding cruise-control switches could cause parked vehicles to catch fire. You'd hear that day or night. Rust, attacking rocker panels, door hinges, door latches, floor pans, frames, fuel lines, airbag sensors, brakes, bearings, ball joints, shift cables, engine computers, and hydraulic hoses, has led to steering loss, wheel loss, shifting loss, fuel tank loss, brake failure, airbag failure, wiper failure, axle failure, engine failure, and hoods flying open at speed. DeLorean made its bodies out of stainless steel, old Land Rovers had galvanized chassis, and some 1965 Rolls-Royces had galvanized underbodies, but few automobile companies have steered clear of corrosion. Hyundai, Nissan, Jeep, Toyota, GM, Isuzu, Suzuki, Mercedes, Fiat, Peugeot, Lexus, and Cadillac have all recalled automobiles because of rust. More than once, Firestone has recalled millions of steel-belted radials on account of rust. Of NHTSA, the president of the consumer rights advocacy organization Public Citizen, Joan Claybrook, had this to say in 2003: "They've made up more names for recalls than Carter has liver pills." NHTSA never made up names for rust, though. It's always just corrosion. The godfather of American corrosion studies, a metallurgical engineer named Mars Fontana, once joked that in addition to the eight forms of corrosion he had defined, an additional form was "automobile corrosion."

In the twenty-one states that the DOT calls the "salt belt states"-the upper right quadrant of the contiguous United States, everywhere north and east of Kansas City, Missouri-it's not hard to suffer from the malady. In postwar suburbia, state departments of transportation resorted to salt (sodium chloride or calcium chloride) like addicts, doubling their use on highways every five years until 1970. By then, the country used about ten million tons of salt a year. It's fluctuated mildly since. Salt is bad news because chlorine is as reactive as oxygen, and more persistent. By 1990, the total bill for nationwide salting was half a billion dollars; Robert Baboian, a straight-talking corrosion engineer with much experience in public and private consulting, contributed to a Transportation Research Board study on the matter. No use in cutting back now, he wrote-the salt had long since begun reacting with the steel in bridges, such that the chloride ions were embedded like trillions of ticks. Salting has much to do with the deficient condition of the country's bridges, but at least you can spin your steel-belted radials on wet pavement on a snowy day. The cost of maintaining those bridges also had much to do with the DOT's funding of the 2001 study of the nationwide cost of corrosion, which made the cost of salt look like peanuts.

Thanks to better design (eliminating areas that hold mud and moisture), galvanized parts, improved primers and paints, and tests in salt mist facilities-giant steam ovens for cars-auto manufacturers got a handle on corrosion more or less around Y2K. Bridges haven't caught up. As a result, few other agencies are pulled in directions so opposite with such force as the DOT. Yet there are limits to how far it may be stretched. A new car, the agency figures, you can afford; a new plane, it figures, you cannot. At airports, the Federal Aviation Administration prohibits the use of standard chloride-containing highway salts. Instead, airports rely on deicing alternatives like acetates, formates, and urea. The most common, calcium magnesium acetate, is one-fifth as corrosive as salt on steel and one-tenth as

corrosive on aluminum. It also costs twelve times as much as salt. To deice planes, airports rely on glycols. If you really want your car to last, drive exclusively down runways.

Beyond the domain of the FAA, rust troubles us almost everywhere. Oil rig designers put one extra inch of steel on the bottom of offshore oil platforms, calling it a "corrosion allowance." Some engineers mitigate "urine splash" in bathroom fixtures; others design bridges with corrosive pigeon poop in mind. More than a few engineers ensure that corrosion doesn't ruin your can of Coke before you get to it. Relying on corrosion tests (developed by Baboian), the US Mint designed new pennies and dollar coins. The government does not want, literally, to lose money. Cloud Gate, the sixty-foot, hundred-ton bean-like sculpture in Chicago, was made of a low-sulfur stainless steel so that it would remain shiny, and so that it would endure for a thousand years the road salt deposited by Chicago's other godlike agency. Engine oil, gasoline, and coolant all contain corrosion inhibitors-in concentrations from a few parts per million to a thousand times that. In gasoline, the inhibitors protect not just your car's fuel tank, but the gas station's underground storage tank, and the pipeline through which the gasoline was delivered. To protect water mains, tap water contains a corrosion inhibitor. Where I live, twenty-five miles east of the continental divide in Colorado, it's lime (calcium hydroxide), though other municipalities use sodium hydroxide or phosphates. Engineers in my town add the stuff from a fifty-thousand-pound tank, much like a flour sifter, to counteract the acidity that results from processing water. The clearest, safest, cleanest water just happens to be slightly acidic. As such, it's corrosive. They add lime to make the water slightly basic. As water flows from the Rockies to the Mississippi, and gets successively treated by more municipalities, it grows laden with calcium and magnesium, becoming what most people call hard. It's not like utilities are trying to make the water hard. They're trying to load it up with positive ions and make it less corrosive. City governments see water mains as the DOT sees planes: worth keeping operational as long as possible. Showerheads and faucets: clogged with minerals, they're as repairable or replaceable as Fords.

Only a small portion of Fortune 500 companies-those in finance, insurance, or banking-are privileged enough not to overtly deal with corrosion. Of course, corrosion is a major concern where their servers are stored. To inhibit rust in server rooms, companies use dehumidifiers and gas filters that remove ozone, hydrogen fluoride, hydrogen sulfide, chlorine, sulfur dioxide, and ammonia to minute (less than a few parts per billion) levels. On the Principality of Sealand-a tiny platform in the North Sea-server rooms are filled with nitrogen, so that anyone entering needs to put on scuba gear. This anoxic environment provides a certain type of security, and ensures against corrosion.

Rust is so prevalent that regarding it the Bible offers a sense of defeatism. "Lay not up for yourselves treasures upon earth, where moth and rust doth corrupt, and where thieves break through and steal," says Matthew 6:19. Why improve thy lot if nature will unimprove your work while others plot to take it? A Yiddish proverb suggests the same inevitability: "Trouble is to man what rust is to iron." Rust has been such a mainstay that the British admiralty, in 1810, refused to hear a proposal on using iron rather than wood for ships. The Royal Navy figured that "iron doesn't swim." Lloyd's, too, wouldn't insure oceangoing metal ships for more than two decades after such things began moving cargo.

In industrializing America, where one author called rust "the great destroyer" and another simply referred to it as "the evil," corrosion seemed such a threat that urban critics considered it folly to build skyscrapers with steel. In Chicago in 1902, engineers debating corrosion rates predicted that the city's first steel structures would fall down in three years. In New York that same year, when one of the city's earliest skyscrapers, the eight-story Pabst Building, was eliminated (to make room for Adolph Ochs's twenty-five-story Times Tower), it was disassembled beam by beam, bolt by bolt, so that engineers could examine the effect of the damp climate on the steel. Many had said that erecting such buildings so near the coast was ridiculous.

By the end of the twentieth century, judicial opinion well recognized that rust was both inevitable and dangerous. Judge Linda Chezem, of the Indiana Court of Appeals, addressed corrosion in a case involving a leaking underground storage tank (UST) at a gas station halfway between Indianapolis and Chicago, smack in the middle of the rust belt. She wrote:

Evidence was presented that Shell and Union understood that steel USTs are subject to corrosion; that steel USTs eventually leak; that leaks were impossible to prevent (prior to 1980s technology); that slow leaks were virtually impossible for the on-site gas station employees to detect (with the primitive dipstick method); that the solution to the problem required significant engineering knowledge and resources beyond the limits of most gas station owners; and that small amounts of gasoline leaking into groundwater over a long time can pollute an entire community's drinking water with benzene, a human carcinogen.

In other words: Oh, steel: that stuff's unreliable. Everybody knows that. Failure is destiny, and if we don't fix it, we'll all get cancer because of it.

There's even rust in outer space, on account of atomic (rather than molecular) oxygen-no small challenge for NASA. Rust is ubiquitous. It's why cast-iron skillets are oiled, why copper wires are sheathed, why lightbulbs contain no oxygen, why spark plug electrodes are made of metals such as yttrium, iridium, platinum, or palladium, and why serious dental work costs an arm and a leg. The highest-ranked rust official in the country calls it "the pervasive menace."

Almost every metal is vulnerable to corrosion. Rust inflicts visible scars, turning calcium white, copper green, scandium pink, strontium yellow, terbium maroon, thallium blue, and thorium gray, then black. It's turned Mars red. On Earth, it gives the Grand Canyon, bricks, Mexican tile, and blood their hue. A ruthless enemy, it never sleeps, reminding us constantly that metals, just like us, are mortal. Were Mad Men's Don Draper to pitch metal, he'd say it's like a maiden: rare, unrivaled in beauty, and impossibly alluring; but also demanding of constant attention, best watched carefully, quick to age, and intrinsically unfaithful. This of modern society's most important material!2

Yet rust sneaks below the radar. Because it's more sluggish than hurricanes, tornadoes, wildfires, blizzards, and floods, rust ranks dead last in drama. There's no rust channel. But rust is costlier than all other natural disasters combined, amounting to 3 percent of GDP, or $437 billion annually, more th...

Other Books

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