Chapter 30

Clearing the air

Air pollution in the U.S. has been as much a problem of industrial emissions as it has been a consumer problem. While power, chemical and manufacturing plants emitted tons of hazardous chemicals from their exhaust stacks, consumers filled the skies in urban areas with fumes from their automobiles. Over the course of the 20th century, both problems were addressed with mixed success. Government regulators have had to contend with new industrial manufacturing processes and new types of pollutants, while manufacturers exerted political influence on legislative and executive branches of government to ease up on restrictions. Pollution cases were taken to court, but that process was far too slow to keep up with rapid growth and change in the U.S. industrial sector. For aluminum producers, fluoride regulation was left up to the states until studies could be conducted and standards be established. Oftentimes, the aluminum industry had a hand in developing standards based on what was believed to be the best available technology for control of emissions.

One of the founders of the U.S. aluminum industry had an interest in seeing cleaner skies. On July 31, 1888, a group of entrepreneurs from the steel industry met in the Pittsburgh home of Alfred E. Hunt to discuss Charles Martin Hall's discovery of a commercial way to produce aluminum. The group founded the Pittsburgh Reduction Co. that later became Alcoa. By the 1880s, Pittsburgh was a center for industrial activity, with a reputation as a tough and dirty city. [1] Hunt was a renowned industrialist who influenced an effort to purify the public water supply in Pittsburgh. He also served on a city commission tasked with finding a remedy for the smoke nuisance in the city. [2]

An important case in the regulation of air pollution in the U.S. mining and metals processing industry came on June 10, 1904, when U.S. District Court Judge John A. Marshall ruled against the Highland Boy Smelter, a copper smelter built near Salt Lake City in 1899, the first in Utah. By summer 1903, "smelter smut" had been blown across the valley and deposited on agricultural lands by rain. Sulfur dioxide fumes in the smoke mixed with water to create sulfuric acid, damaging crops. After local farmers demanded an investigation, authorities turned to John A. Widtsoe at the Utah State Agricultural College. The farmers demanded a complete and immediate stop to the pollution, but negotiations broke down when the smelting company asked for time to study the problem. A total of 419 farmers brought a case against five different smelters. In James Godfrey v. American Smelting and Refining Company, Marshall granted the farmers an injunction requiring that the smelters process ore with no more than 10% sulfur content. [3] In the past, mining companies had used the common law nuisance defense, arguing that providing jobs outweighed damage to livestock or crops caused by smelter fumes. Marshall rejected that defense by pointing out, “If correct, the property of the poor is held by uncertain tenure, and the constitutional provisions forbidding the taking of property for private use would be of no avail.” The decision effectively shut down the smelter industry in Salt Lake City with the exception of ASARCO’s Murray smelter, which paid $60,000 to local farmers in exchange for a modification of a decree allowing the smelter to continue operating. [4]

U.S. fluoride emissions

One of the most notorious industrial air pollution incidents in U.S. history occurred on Halloween night, Oct. 31, 1948, in Donora, Pa. Considered the worst recorded case of industrial air pollution to date in the U.S., emissions from U.S. Steel’s nearby smelters blanketed the town as a weather inversion held down the fumes. Twenty residents died, but a doctor said the number could have been 1,000 if the deadly smog had lasted another evening. In 1998, the Earth Island Institute reported it had uncovered a conspiracy between the U.S. Public Health Service and U.S. Steel to cover up the role fluoride played in the deaths. In 1949, the Public Health Service issued a report stating that no single substance could be blamed for the deaths. The agency that oversaw the Public Health Service, the Federal Security Agency, was headed up by a former top lawyer for Alcoa. Despite the alleged government cover-up, the Dec. 13, 1948, issue of Chemical and Engineering News reported that the blood of dead residents contained fluorine levels 12 to 25 times normal. In a 1994 Ph.D. dissertation, Lynne Page Snyder of the University of Pennsylvania reported that residents in the area had recognized air pollution problems three decades earlier in 1918. The residents took legal action against the Donora Zinc Works in the 1920s, and regular air sampling began in 1926 but stopped in 1935. Walter Winchell broadcast news of the disaster on his national radio show, and the Donora Death Fog incident was credited with influencing the passage of the 1955 Clean Air Act, which began modern efforts to control air pollution. [5]

An effective way to estimate the increase in fluoride emissions by aluminum smelters in the U.S. is to correlate fluoride emissions to the overall increase in aluminum production in the U.S. Government regulators recognized this link by the 1970s, when they began to set limits for fluoride emissions by aluminum smelters in terms of pounds of fluoride emitted per ton of aluminum produced. In 1893, the total annual output of primary aluminum in the U.S. was 100 tons. That increased to 250 tons the next year, 500 tons in 1896 and 2,550 tons by 1900. In 1940, on the eve of World War II, total annual production of primary aluminum in the U.S. was 206,300 tons – more than two thousand times the amount produced at the start of the U.S. aluminum industry. That figure increased to 309,050 tons the next year and then rapidly increased as the U.S.

war effort picked up. More than 521,000 tons were produced in 1942, about 776,000 tons in 1943 and 920,000 tons in 1944. Production started to decline in the last year of the war, dropping to 495,000 tons in 1945. Total annual production increased 150% from 1941 to 1944, the high point for the war. [6]

In 1945, with World War II ending in Europe in April and in Japan in August, total annual production of primary aluminum in the U.S. sharply declined, reaching 409,000 tons in 1946, before starting a nearly continuous climb through the 1950s. Production reached 571,500 tons in 1947, about 718,500 tons in 1950, about 1.5 million tons in 1955 and more than 2 million tons in 1960 – more than doubling the wartime high. Production declined by 1.8% from 1956 to 1957 and by 4.9% from 1957 to 1958, but total annual production in the U.S. tripled from 1945 to 1960. Thirteen aluminum companies operated 30 aluminum reduction plants in the U.S. in 1971, distributed around the Pacific Northwest, Gulf Coast, Midwest and East Coast. The primary aluminum industry had grown by 877% since 1946 and reached 4 million tons per year by 1970, accounting for about 46.6% of the world's total. At the time, economic projections called for the primary aluminum industry to continue growing and to double or even triple by 2000. [7]

Fluoride impacts came from a variety of industries across the U.S. In Polk County, Fla., ranchers blamed fluoride emissions from a nearby phosphate plant for the decline in the cattle industry from 120,000 head in 1954 to 30,000 in 1965. Fluoride levels in local pastures had reached 1,800 ppm in grass and other forage when the official allowable maximum was 40 ppm. [8] By the late 1960s, the U.S. Environmental Protection Agency estimated 155,000 tons of fluoride, measured as hydrogen fluoride gas, were emitted each year into the U.S. atmosphere from aluminum smelters, phosphate processing plants, coal-burning facilities, and manufacturers of steel, brick and glass. This fluoride pollution impacted certain vulnerable species of conifers at an ambient concentration of only 1 part per billion, and because fluoride did not break down, it accumulated in the environment. [9]

By 1971, the National Research Council was issuing warnings that fluoride pollution from U.S. industry in ambient concentrations as low as 1 ppb had caused damage to vegetation and posed a threat to livestock in areas as far as 20 miles downwind from emission sources. In some cases, grasses consumed by livestock were found to contain 200,000 times more fluoride than existed in the ambient air. Grasses containing 30 ppm to 40 ppm of fluoride were considered toxic to cattle. Fluoride effects on industrial workers included osteosclerosis, ossification of ligamentous attachments, sinus trouble, perforation of the nasal septum, chest pains, coughs, thyroid disorders, anemia, dizziness, weakness and nausea. In a 1973 report in the Journal of Environmental Studies, researchers identified fluoride as a "highly unpublicized pollutant" and noted that the President’s Science Advisory Committee had once classified fluoride as a “highest priority” pollutant. Plants that emitted fluoride had once been built in isolated areas with wide exclusion zones, but these facilities had proliferated by 1973 and become more closely concentrated, the researchers reported. [10] In January 1986, the EPA reported that coal combustion accounted for about 78% of the hydrogen fluoride emitted in the U.S., primary aluminum production accounted for about 15%, with fertilizer and other chemical plants accounting for the remainder. [11]

Early air pollution regulation

Federal air pollution control efforts in the U.S. took a serious step forward in 1955 when the National Air Pollution Control Administration (NAPCA) was founded in reaction to a number of alarming events and conditions – including a suffocating smog that blanketed Los Angeles, the 1948 inversion in Donora and a 1952 “fog” in London that killed about 4,000 people over a four-day period. NAPCA began as a research body with no regulatory powers over interstate air pollution problems. In 1963, Congress passed a Clean Air Act that gave NAPCA limited enforcement powers. The act was amended in 1965 to allow NAPCA to set pollution standards for automobile emissions. Little use was made of NAPCA’s enforcement powers, and they were further diluted by the 1967 Air Quality Act, which re-emphasized the principle of state and local control over air pollution. [12] In December 1963, the U.S. Senate’s Public Works Committee approved a bill authorizing the federal government to enforce abatement of air pollution problems not being addressed by local or state governments. The bill authorized the appropriation of $182 million over the next five years to be used for research and grants to municipal and regional air pollution control agencies. Similar parallel federal authority already existed for water pollution problems. Montana Sen. Lee Metcalf was a member of the Senate’s Air and Water Pollution Control Subcommittee that initiated the legislation, and Montana Sen. Mike Mansfield co-sponsored the legislation. The U.S. House had earlier approved a similar bill. Metcalf and Mansfield had good reasons to support federal air pollution legislation – Montana’s air pollution laws were considered too weak to deal with hazardous emissions in Butte, Anaconda, Great Falls and Missoula. [13]

The Environmental Protection Agency was established by Congress on Dec. 2, 1970, following a growing national awareness of a need for the federal government to step in and help control air and water pollution. This growing awareness had reached “rumbling” proportions by May 1969 when President Richard Nixon set up a Cabinet-level Environmental Quality Council as well as a Citizen’s Advisory Committee on Environmental Quality, according to a 1985 history of the EPA by Jack Lewis. Critics, however, charged that the two groups were largely ceremonial bodies with no real power. Reacting to these charges, Nixon appointed a committee in December 1969 headed by Roy L. Ash to investigate the need to reorganize the government in order to create a new agency to protect the environment. [14] On July 9, 1970, Nixon submitted to Congress his Reorganization Plan No. 3 of 1970 that sought to establish two new agencies – the EPA and the National Oceanic and Atmospheric Administration. “Our national government today is not structured to make a coordinated attack on the pollutants which debase the air we breathe,” Nixon said. “Despite its complexity, for pollution control purposes the environment must be perceived as a single, interrelated system.” Nixon called for uniting the functions of various government bodies under the EPA, which would be responsible for research and setting standards for air, water, pesticides and radiation pollution. [15]

When Congress passed the National Environmental Policy Act in 1969, it also created the Council on Environmental Quality to advise the President and review environmental impact statements, which by that time were required by all federal agencies planning projects with significant environmental ramifications. While the public was ideologically divided on many other public issues, especially the Vietnam War, it seemed to be united on the need for a bill like the National Environmental Policy Act, and Nixon chose to sign the bill on New Year’s Day 1970, marking the beginning of what many called “the year of the environment.” On Jan. 22, Nixon called for action in protecting the environment in his State of the Union address, and on April 22, twenty million Americans took part in the first Earth Day celebration. On July 9, Nixon submitted his reorganization plan that created the EPA – a “strong, independent agency” to watch over the nation’s environment. The “year of the environment” concluded with the passage of the Clean Air Act on Dec. 31, 1970. [16]

A comprehensive federal law that regulated emissions from area, stationary and mobile sources, the Clean Air Act authorized the EPA to establish national ambient air quality standards to protect public health and the environment. The Act called for establishing air quality standards in every state by 1975, coupled with the development of state implementation plans applicable to appropriate industrial sources in each state. The Act was amended in 1977 primarily to set new goals and dates for achieving attainment of the national air quality standards, as many areas in the U.S. had failed to meet the deadlines. The Act was amended again in 1990 in large part to meet unaddressed or insufficiently addressed problems, including acid rain caused by coal-burning power plants, ground-level ozone primarily caused by automobile emissions, stratospheric ozone depletion and air toxics. [17] The Act gave the EPA the authority to list and regulate air toxics which the agency considered hazardous. By 1990, the agency had listed and established regulations for seven different chemicals. [18]

While the EPA became the government watchdog agency for environmental pollution, the Occupational Safety and Health Administration began operating in 1971 with the mandate to “assure so far as possible every working man and woman in the nation safe and healthful working conditions.” The agency adopted permissible exposure limits for about 400 different chemicals based on limits developed by the American Conference of Governmental Industrial Hygienists in 1968. Through the 1970s, OSHA added standards for nine additional substances. In 1980, the U.S. Supreme Court struck down an OSHA standard that had greatly reduced the permissible level for benzene. The court said OSHA needed to prove that its regulation would prevent a “significant risk of harm.” The court did not define “significant risk” but suggested that one additional death per one thousand workers was probably significant, whereas one in a one billion was not. Since then, OSHA utilized the one-in-one thousand risk as the strictest possible standard. In 1987, OSHA undertook a sweeping update of its limits for air contaminants, and less than two years later, it issued permissible exposure limits for 376 chemicals. More than half of those limits were stricter standards for chemicals already on the 1971 list. Industry and labor challenged the law, and in 1992 an appellate court threw out the new standards, ordering OSHA to carry out a separate rule-making procedure for each substance. OSHA never carried out the expensive and time-consuming separate rule-making procedures, but the American Conference of Governmental Industrial Hygienists continued to produce voluntary exposure limits known as threshold limit values at the rate of 20 to 40 per year. By 2008, the professional group had produced standards for more than 700 substances, compared to the 400 or so that OSHA regulated. [19]

U.S. aluminum regulations

The relationship between the EPA and the aluminum industry was close from the start when it came to developing new standards for fluoride and other emissions, according to William H. Rodgers’ 1973 book “Corporate Country: A State Shaped to Suit Technology.” In 1970, the EPA’s Air Pollution Control Office asked the National Academy of Sciences to provide scientific evidence to support air quality criteria for airborne fluorides. Among the nine members of the National Academy of Science’s panel handling the request were Leonard Weinstein and Delbert McCune from the Boyce Institute on Plant Research, a contract research firm that often worked for aluminum companies as expert witnesses in air pollution cases; Frank A. Smith, the co-author of an Aluminum Association publication on the effects of fluoride on human health; and John W. Suttie, who wrote a report for the Aluminum Association on air quality criteria to protect livestock from fluoride toxicity. Suttie’s work for the National Academy of Sciences depended heavily on the work he had already done for the aluminum industry. The EPA also hired Singmaster & Breyer, an engineering consulting firm that had worked for aluminum companies for many years, to conduct an extensive industry-wide study.

As the panel continued to cast doubt on the capabilities of state-of-the-art air pollution control by the end of 1970, Singmaster & Breyer grew impatient at companies that did not return questionnaires or left gaps in reporting data, according to Rodgers. Then, with the report nearly completed, the aluminum companies deluged Singmaster & Breyer with data. The contracting firm requested more funding, and by 1972 the report had still not been completed. [20]

On Jan. 26, 1976, the EPA published guidelines to state governments to be incorporated into federal law for air pollution control in the U.S. primary aluminum industry. The standards grew out of a section in the 1970 Clean Air Act that required the EPA to establish procedures under which the states could submit plans for the control of designated air pollution sources. The new law required the states adopt fluoride emission standards for existing primary aluminum plants. The EPA was required to publish a guideline document for the states that specified emission guidelines, times for compliance, a discussion of the pollutant's effects on human health and welfare, and a description of control techniques and their effectiveness and costs. After publication of the EPA guidelines, the states were given nine months to develop and submit plans for control of fluoride emissions. If the plans did not meet EPA approval, the EPA would submit its own plan for implementation. The EPA distinguished between "health-related pollutants" that created adverse health problems for humans and "welfare-related pollutants" that had not been proven to pose adverse health problems for humans. In the case of welfare-related pollutants, state governments were given the flexibility to balance the emission guidelines, compliance schedules and other information against other factors of public concern –particularly economic concerns. [21]

The EPA had determined that while fluoride emissions could endanger the public welfare, adverse effects on human health had not been demonstrated. The daily intake of fluoride from normal ambient air was typically a few hundredths of a milligram. If the air contained eight micrograms of fluoride per cubic meter, such as might be found in the vicinity of a primary aluminum plant with only moderate air pollution control, the daily intake might reach 150 micrograms. This intake was considered low when compared to the estimated daily intake of about 1,200 micrograms of fluoride from food, water and other sources for the average person. The EPA also found that the intake of fluoride indirectly through the food chain was insignificant. On the other hand, fluoride emissions were found to cause damage to livestock and vegetation in the vicinity of aluminum smelters. Ingestion of fluorides by livestock from hay or forage caused bone lesions, lameness and impairment of appetite that could lead to decreased weight gain or diminished milk yields. Fluoride ingestion could cause abnormal growth in the teeth of young animals and damage plant growth. Fluoride emissions were therefore classified as a welfare-related pollutant, and the EPA emphasized technical and economic concerns in developing guidelines for the control of fluoride emissions during its field trips to nine different primary aluminum plants. [22]

The Clean Air Act of 1977 subjected fluoride-emitting sources to regulatory review and permitting, but amendments made in August 1980 stated that any new or modified air pollution source that exceeded specified regulatory emission potential was subject to a pre-construction review process. This included aluminum smelters, hydrofluoric acid plants and phosphate-rock processing plants. States were required to develop their own air quality implementation plans, and if approved by the EPA, they could be used for pre-construction review. At the time, the U.S. had no national fluoride standards, but particulate fluoride was subject to regulation for total suspended particulates. Twelve states had specific fluoride standards in 1980 – Montana, Idaho, Kentucky, Maryland, New Hampshire, New York, Pennsylvania, South Carolina, Tennessee, Texas, Wyoming and Washington. Nine of those had forage standards for fluoride, including Montana. Ten had ambient air quality standards for fluoride, not including Montana. The forage standard for fluoride was 40 ppm as a maximum annual average and 80 ppm as a maximum monthly average for vegetation based on dry weight. The forage standards were developed to protect an economic resource – livestock, not wildlife. J.R. Newman commented on the impact of this policy in the Journal of the International Society for Fluoride Research in 1984. “Fluorosis in wildlife has been reported even when compliance with state forage standards has been met,” he said. The primary route for fluoride was through ingestion of contaminated food or water. Fluoride was known to be more toxic to younger animals and animals that were stressed. Newman called for modeling and monitoring, not just setting standards, to protect wildlife. [23]

The Clean Air Act was amended by Congress again in 1990. The amendments significantly changed how the EPA would attempt to control air pollution. Section 112 of the Act included a list of 189 hazardous air pollutants that were selected by Congress on the basis of potential health and/or environmental hazards, especially carcinogenic chemicals. The EPA was expected to regulate those 189 chemicals, but to do that the EPA needed to identify categories of sources for the 189 pollutants. The EPA’s regulations were expected to be technologically based. In some cases, the EPA might have to specify exactly how pollution could be reduced, but in general companies were given the flexibility to choose how they would reduce pollution. In any case, companies were expected to employ maximum available control technology (MACT), a very high level of pollution control. The EPA was directed by Congress to begin by issuing regulations for major pollution sources, such as large industrial plants, and then work its way down to smaller and smaller sources of pollutants. [24]

The idea behind MACT was that the EPA would study a particular source category for a particular type of hazardous air pollutant and determine what technology existed that could best control emissions of that particular pollutant. The EPA then would set an emission standard on the basis of that particular technology. Different criteria were used by the EPA for new versus existing sources. The 1990 Clean Air Act Amendments also described how individual states could implement National Emissions Standards for Hazardous Air Pollutants (NESHAP) programs with authority while allowing states to demonstrate that their programs were equivalent in effect to NESHAP. [25] The intent of Congress was based on a bureaucratic process – first list dangerous chemicals; next establish an initial list of source categories for these chemicals; and then establish technology-based emission standards for these source categories in order to regulate companies that emitted the chemicals. "Major sources" under the 1990 Clean Air Act Amendments were defined as contiguous areas under common control, such as an industrial plant, which either emitted or had the potential to emit 10 tons per year of any listed hazardous air pollutant, or a combination of listed hazardous air pollutants of 25 tons or more. [26]

Alcoa deals with emissions

The U.S. aluminum industry began with the Pittsburgh Reduction Co. in the late 19th century. The company was producing about 1,000 pounds of aluminum per day in New Kensington, Pa., when the availability of cheaper power near Niagara Falls, N.Y., presented an opportunity for a major expansion. By 1895, the company that grew into Alcoa had an aluminum smelter operating in Niagara Falls designed for doubling of capacity as the market grew. The aluminum company was the first in a wave of major metals and chemicals companies to relocate at Niagara Falls between 1895 and 1910, and the move required a large investment by the company. By 1907, the Pittsburgh Reduction Co.'s Niagara Falls plant had grown to three large potlines. [27] Alcoa's first fluoride emissions "control equipment" was installed in the Niagara Falls smelter in 1896. The "equipment" amounted to the design of the potline building itself, which provided for natural draft ventilation for the benefit of the potmen. The design added little to the cost of the plant, but fluoride emissions simply drafted out of the building into the surrounding atmosphere. Alcoa learned of significant negative environmental impacts caused by fluoride emissions from its aluminum smelters in the early 1940s when complaints were received at Vancouver and East Tennessee. Alcoa's investigations confirmed suspicions that fluoride from the smelters had ended up in vegetation eaten by livestock. Major modifications made to the plants at Vancouver and East Tennessee included pot hooding, duct work and fans to collect pot gases and the use of wet scrubbers to remove hydrogen fluoride from the exhaust gases. Hydrogen fluoride captured by the wet scrubbers was either discarded or neutralized with lime, creating a low value calcium fluoride. [28]

One of the oldest Alcoa smelters was located in the town that gave the company its new name – Alcoa, Tenn. The aluminum company began operating a smelter there in 1914 using reduction pots originally designed by Charles Martin Hall. On Feb. 4, 1952, the last of the Hall reduction pots at the plant were shut down for the first time since being put into operation in 1888. [29] As part of the World War II aluminum expansion program, the Tennessee plant's capacity was increased by 50,000 tons per year. By 1998, the plant's capacity was rated at 125,000 tons of aluminum per year. [30] Alcoa, Tenn., was a company town, with company-owned housing, stores, utilities, schools and amenities, but the company wasn't controlling its smelter fumes, according to George Waldbott's 1978 book "Fluoridation: The Great Dilemma." On Jan. 1, 1953, a lawsuit was filed in Blount County alleging that fluoride emissions from the smelter had damaged farmlands and injured registered cattle. By that time, Alcoa had not yet settled earlier claims by 141 other farmers and cattle ranchers. [31]

The complaints were taken to a higher level on July 29, 1955, when a lawsuit was filed in federal court by 157 county residents representing 84 farms seeking $2.8 million in damages from Alcoa. The lawsuit alleged that poisonous fumes emitted from the company's plant, especially fluoride compounds, damaged farmlands and injured registered cattle to the extent that they were not marketable. The plaintiffs claimed that the damage was acknowledged by Alcoa in a compensation agreement they had made with Alcoa that ran to Jan. 1, 1953. Under the earlier agreement, Alcoa had made up the loss of income incurred by farmers and cattle ranchers. The plaintiffs in the new lawsuit claimed that Alcoa refused to continue payments after Jan. 1, 1953. According to the new lawsuit, gases and fumes from the Alcoa plant were "heavier than air and settle on the ground, adhering to growing crops, trees and shrubs, thus causing damage." The lawsuit further claimed that the fumes caused "premature deterioration of teeth," along with "stiffness of joints, knots on ribs, loss of appetite and the general retarding of growth." Individual damages up to $150,000 were claimed by the farm owners. R.O. Davis, who owned a 215-acre farm adjacent to the Alcoa plant, was seeking the most in damages. The plaintiffs also asked that Alcoa cease releasing fluoride compounds. Thomas Stephenson, manager of Alcoa operations in Tennessee, told the media he had no comment to make at that time. [32]

After three hours of deliberation, the jury announced in a packed courtroom on May 6, 1958, that harmful fluoride fumes had been emitted by Alcoa's smelter until August 1955, at which time the company installed electrostatic precipitators to remove minute chemical particles from pot gases. Alcoa earlier had installed what it considered a complete fume elimination system in 1952. Prior to that time, the company had settled with all but 23 of the 164 plaintiffs. Alcoa then refused further payments to 141 other plaintiffs after 1952. Alcoa said it installed the electrostatic precipitators at the smelter and fabricating plant in 1955 only as an additional precaution, saying it believed the emissions by that time were already harmless. The jury's decision meant the 164 Blount County plaintiffs were entitled to damages from 1952 to 1955 but not to permanent damages. The plaintiffs claimed fluoride compounds accumulated on grass and poisoned their cattle and were seeking $2 million, claiming temporary and permanent damage, the latter due to an alleged permanent stigma attached to their real estate as a result of the continual air pollution. [33]

The Tennessee case was set to continue under U.S. District Court Judge Robert L. Taylor with the same jury to hold hearing trials for each of the 164 farmers – with each required to show to what extent their cattle were damaged, if at all. The first phase, which determined if Alcoa was liable, lasted 22 days. Attorneys expected the second phase to last up to two months. Attorneys and the judge were considering joining four or five individual plaintiffs from a common neighborhood to present their cases together. Elimination of the permanent-damage liability was expected to shorten the length of the second phase of the trial, as there would be no need to put real estate appraisers on the stand. Judge Taylor presented the jury with three questions: 1) Has Alcoa maintained a nuisance that damaged the famers since May 18, 1949? The jury answered yes. 2) Has the nuisance been stopped? The jury answered yes. 3) When was the nuisance stopped? The jury answered Aug. 17, 1955. Plaintiff J.P. Anderson said he was "well pleased" with the outcome and that he believed other farmers felt the same way. "The way I figure it, we can come in here again in 1959 and sue the company again," he said. "We could just try to prove then that the nuisance wasn't stopped in 1955 at all." [34]

By turning to coal-fired generating plants for its smelters in the 1950s instead of hydroelectric power, Alcoa found itself contending with a new set of air pollution problems in addition to those caused by aluminum reduction. In 1952, Alcoa began operating an aluminum smelter in Rockdale, Texas, that by 2000 was one of the largest aluminum smelters in North America. The smelter was powered by four coal-fired generating plants that burned lignite coal from a nearby Alcoa-owned strip mine. According to one account, the coal was "considered so poor that it has been compared to burning dirt." The Rockdale plant was located on 7,000 acres and discharged about 104,000 tons of pollutants per year, including 60,000 tons of sulfur dioxide which were "grandfathered in" beginning with the 1971 Texas Clean Air Act. In 1979, when Alcoa began mining a higher-sulfur content coal, the state environmental agency provided a special deal to Alcoa that allowed it to discharge more sulfur dioxide than any other plant in the state. In 1992, the Texas environmental agency reinforced Alcoa's previous deal by allowing "fossil-fuel fired steam generators located in Milam County which begun operation prior to 1955" to exceed sulfur dioxide emission standards. Only one industrial facility matched that description – Alcoa's Rockdale plant, according to the Texas Public Employees for Environmental Responsibility. [35]

In 1999, Gov. George W. Bush signed the Texas Clean Air Responsibility Enterprise act that allowed non-utility grandfathered polluters to "volunteer" to reduce emissions. The volunteer companies were not required to reduce emissions or use state-of-the-art pollution control equipment. But in 1999, under public pressure, the Texas Legislature passed a bill requiring the grandfathered power plants to reduce nitrogen dioxide emissions by 50% and the sulfur dioxide emissions by 25%. According to the Texas Public Employees for Environmental Responsibility, Alcoa was able to evade the new requirement with the assistance of its law firm's connections to President George W. Bush's re-election campaign at that time. Alcoa proposed reducing nitrogen dioxide emissions, but the company proposed reducing the 100,000 tons of sulfur dioxide it emitted by only 6,000 tons per year. Alcoa publicly said that if it was forced to comply with stricter emission standards, it would be forced to shut down the Rockdale smelter. But in 1999, Alcoa made $1 billion in profits and acquired Alumax for $3.8 billion, the watchdog organization noted. Alcoa also announced plans to strip mine an additional 15,000 acres south of its existing coal mine. [36] In April 2003, Alcoa agreed to spend about $330 million to install a new coal-fired power plant with state-of-the-art pollution controls at the Rockdale facility. Alcoa had not installed necessary pollution control equipment earlier when it overhauled the smelter's power plant, and it had not obtained the proper permits, so the company was not in compliance with the federal Clean Air Act. [37] In the end, it was all for naught – Alcoa announced on Jan. 6, 2012, that it was permanently closing the Rockdale smelter. The move was designed to reduce the company's capacity after aluminum prices dropped by more than a quarter in 2011. [38]

Alcoa also built a large aluminum smelter in the Ohio River region that relied on coal-fired power generation. On April 17, 1956, the company announced plans to build a 150,000 ton-per-year aluminum smelter and a 375-megawatt power plant near Evansville in Warrick County, Ind. First metal was poured on June 9, 1960. Construction followed for adjacent rolling mills, and the first fabricated products were produced at the Warrick Operations facility in 1964. By 2015, the 9,000-acre facility included a 742-megawatt power plant operated by Alcoa Generating Corp. that could power a city of 200,000. At full capacity, the smelter could produce 330,000 tons per year. Billions of aluminum cans were recycled at the Warrick plant. At full capacity, the Warrick ingot plant was the largest in the world, casting 30-foot long 40,000-pound ingots. [39] On March 25, 2016, Alcoa marked the final day of aluminum manufacturing at Warrick. The company had announced in January that the smelter would be closed because it wasn't competitive with the drop in aluminum prices. [40]

In 2008, Indiana ranked eighth out of 48 states for hydrogen fluoride releases with 1,320 tons, according to the EPA's Toxic Release Inventory. No. 2 on the list for Indiana was Alcoa's Warrick smelter with 162 tons. Eighteen of the top 20 emitters of hydrogen fluoride in Indiana were coal-fired generating plants, ranging from five tons to 200 tons per year, totaling 1,100 tons. [41] According to the Warrick plant's state operating permit, the smelter and power plant were at one location and owned by the same company so they were regulated as a single source. Alumina was brought to the plant by barge, truck and rail where it was processed in six potlines using center-worked prebake reduction pots. Pot gas was treated by fluidized-bed dry scrubbers. The facility's green anode plant manufactured prebake anodes using coal tar pitch mixed with petroleum coke and a ring furnace to bake the anodes. According to the state permit, "Alcoa shall use the lowest sulfur content pitch commercially available" and not exceed 0.8%, with provisions for unavailability. Sulfur dioxide, total fluoride and polycyclic organic matter limits were governed under federal regulations. Polycyclic organic matter emitted from the ring furnace was limited to 0.2 pounds per ton of prebake anodes produced. [42] In February 2016, the Sierra Club criticized the Indiana Department of Environmental Management's emission standards for coal-fired generating plants, saying they were "based on flawed modeling that will not assure that the concentration of air pollution stays below the health standard." The Sierra Club cited the Warrick plan as an example of a major source of sulfur dioxide. [43]

Water and air pollution can become more commonplace during wartime emergencies, as regulations tend to be relaxed, regulators are sent to other assignments and the overall drive for defense production becomes the main focus of government. One such case was the Riverbank, Calif., smelter that Alcoa operated from 1942 through 1944. Financing for construction of the aluminum smelter by the U.S. Defense Plant Corporation was approved on Aug. 19, 1941. Alcoa designed and built the smelter. The site was chosen for its proximity to a rail line and the Hetch Hetchy power transmission line. The facility had 27 buildings, including a rod plant and six pot rooms containing 384 reduction cells capable of producing 48,000 tons of aluminum per year. The plant was similar in layout to Alcoa's smelter in Vancouver, Wash. Because of the wartime shortage of copper, the buss bars connecting the reduction pots were made from silver on loan from the U.S. Mint. The Riverbank plant was phased out of production in August 1944, by which time most of the World War II air fleet had been constructed and the war in Europe was nearing an end. Another factor in shutting down the plant was a damage lawsuit brought in 1944 by nearby farmers who claimed fluoride emissions had damaged crops and adversely affected their livestock. [44]

According to a 1971 company report on the development of new pollution control technology, Alcoa managers at Riverbank became aware of complaints by nearby farmers about damage caused by fluoride emissions from the smelter in 1943. The plant was not built with air pollution control equipment, according to the published report, and trade winds blew fluoride onto downwind pasture lands for about 10 months of the year. Alcoa began to install wet scrubbers to control fluoride emissions at Riverbank, but the end of World War II seemed imminent and the pollution control equipment was moved instead to Alcoa's smelter in Vancouver, and the Riverbank plant was eventually shut down. Alcoa next became aware of fluoride problems at its smelter in Alcoa, Tenn., in 1946, when farmers complained about damages to cattle. Pollution control equipment was installed there, and testing procedures were implemented. Alcoa also looked at ways to control emissions from both Soderberg and prebake pots at the Tennessee plant. In the late 1940s, Alcoa converted its horizontal-stud Soderberg pots to vertical-stud pots in an effort to control fluoride emissions. [45]

The expanding aluminum industry

In 1950, as the U.S. faced a deficit of aluminum for military purposes during the Korean War, the federal government encouraged U.S. companies to construct additional aluminum reduction facilities. Kaiser Aluminum was already in an expansion mode and proposed a greenfield smelter plant with four potlines and 100,000 ton-per-year capacity in the Pacific Northwest using power from the Bonneville Power Administration. However, Interior Secretary Oscar Chapman, along with the Federal Munitions Board, opposed locating a new aluminum plant in the Pacific Northwest, citing a shortage of electrical power and because regional Congressmen wanted an industrial operation that provided more jobs per consumed kilowatt-hour than another aluminum smelter. Chapman "somewhat forcefully" "suggested" that a new aluminum smelter plant be built in the Texas or Louisiana coastal region, where a plentiful supply of natural gas was available to generate electricity, according to George Binczewski's 2002 account. The federal government wielded considerable leverage because it offered a five-year amortization of loans and a guarantee that it would purchase all the smelter's surplus aluminum production, over what the general market would not absorb, and put it in a government stockpile. [46]

Kaiser began construction of an aluminum smelter at Chalmette, La., about seven miles downstream from New Orleans, in February 1951. Construction proceeded quickly, and first metal was tapped 10 months later on Dec. 11, 1951. Plans for a 100,000 ton-per-year, four-potline plant soon doubled to 200,000 tons and then further increased to 275,000 tons and nine potlines before the original construction was completed. The Chalmette plant utilized Soderberg anode technology, a decision Kaiser later lamented.

In the 1950s, Alcoa and Reynolds were still building Soderberg reduction pots, and Alcan had installed vertical-stud Soderberg cells in 1954 at its new Kitimat, British Columbia, smelter. According to one account, the Soderberg cells at Chalmette emitted “copious fumes,” and in 1956 Kaiser installed a $6 million pollution control system with a 559-foot tall smokestack to collect and disperse fumes. By 1976, the stack had become obsolete and was replaced by a dry scrubber system that cost $32 million. The plant produced its own electricity from the beginning – the first two potlines were powered by burning natural gas in 11-cylinder Nordberg radial engines that became available during the early mobilization days of the Korean War. Additional potlines were powered by gas-fired boilers and steam turbines. The plant had a favorable 30-year natural gas contract that helped the plant survive the 1970s energy crisis, but the contract’s expiration date came during an economic recession in the early 1980s, and Kaiser decided to close the plant in 1983. [47]

Shortly after the Anaconda Company became the fourth U.S. aluminum producer with its smelter in Columbia Falls, Mont., the Olin Mathieson Chemical Corporation entered into a $285 million joint venture with Revere Copper & Brass Inc. to form a new company called Ormet. The 1958 joint venture called for construction of a $110 million 180,000 ton-per-year aluminum reduction plant in Hannibal, Ohio, and a $175 million 350,000 ton-per-year alumina refinery at Burnside, La. [48] During the smelter plant’s time operating along the Ohio River, complaints were made of crippled cows at dairy operations near Hannibal. [49] The Ormet plant also faced regulators over emissions from the coal-fired generating plant that powered the smelter. On Nov. 15, 1994, a settlement was announced by the U.S. Department of Justice, the EPA and Ohio Power Plant, the owner and operator of the Kammer Power Plant, a coal-fired electrical power plant in Moundsville, W.Va. The Kammer plant provided electric power primarily to a single customer – the Ormet aluminum smelter in Hannibal. The power company agreed to reduce its sulfur dioxide emissions to compliance levels in less than one year. The EPA had estimated that the power plant’s three coal-fired boilers annually discharged about 80,000 to 100,000 tons of sulfur dioxide above the West Virginia State Implementation Plan’s emission limits since at least 1976.[50]

In addition to Niagara, the Pacific Northwest, the Gulf Coast region and the Ohio Valley area, two smelter plants were built along the Atlantic Coast. In 1967, Alumax, Howmet and Pechiney teamed up to build an aluminum smelter in Frederick County, Md., near Buckeystown. The Eastalco plant began operating in 1970 on 350 acres of a 1,900-acre site, a portion of which was farmed by the company. According to court testimony in a 1978 fluoride pollution case, the site was chosen because of its nearness to the port in Baltimore and access to relatively cheap electricity. The smelter produced 175,000 tons per year and employed about 1,025 workers in 1978. [51] Patricia Zimmerman, who lived on a 110-acre farm near the Eastalco smelter, began a lawsuit against the smelter in 1972. She claimed her cows “started acting up” and she suspected fluoride emitted by the plant was the cause. [52] On July 17, 1976, The Frederick Post published a front-page story about a $60,000 air monitoring station that was being set up by the state of Maryland to determine pollution levels caused by the Eastalco aluminum smelter along with a nearby lime kiln and power plant. [53]

One year later, The Morning Herald Tri State News reported on its front page that Montana university professor Clancy Gordon had strongly criticized efforts by the state of Maryland to protect farmers from fluoride pollution by the Eastalco plant. In a 73-page report, Gordon said the state’s standards did not protect farmers. “In language uncommon to scientists, Dr. Gordon says the people carrying out the testing program around the Eastalco plant ‘are totally incompetent to carry out a serious fluoride investigation,’” the newspaper story said. “The Montana scientist said ‘almost every aspect of the air monitoring and forage studies were set up to benefit the interests of the Eastalco Aluminum Company management.’” The newspaper story said neighboring property owners had complained about damages over the past few years, but the Eastalco plant was operating for the most part within state limits. [54]

On Feb. 11, 1980, Lennart Krook, a professor of pathology at the New York State College of Veterinary Medicine at Cornell University, sent a 10-page report to Gordon on the impacts of fluoride from the Eastalco plant on the Zimmermans’ farm about two miles north of the smelter. Krook referred to an earlier report by Gordon and T.G. Tourangeau titled “The impact of fluoride on the farmlands of Buckeystown, Maryland, caused by the Eastalco aluminum smelter.” Krook wrote that the Zimmermans had 48 cows in November 1979 of which 40 were milking and eight were dry, in addition to 17 younger cows. The cows were fed clover and timothy grown at the farm or nearby that contained about 12.57 ppm fluoride. The fluoride levels in the hay were below state standards. Krook described some dental abnormalities but little evidence of dental fluorosis. The cows were expected to produce about 15,000 pounds of milk per cow per year but only produced 9,000 pounds. In general, Krook did not find evidence that could conclusively prove damage to the Zimmerman farm by fluorides from the smelter. [55]
Thirty-two years after Zimmerman began her fight, in July 2004, officials at the smelter contested EPA’s pollution figures. According to the EPA’s Toxics Release Inventory, the Eastalco plant’s annual hydrogen fluoride emissions increased from 297 tons in 2001 to more than 1,250 tons in 2002, but the company claimed that only 451 tons of the fluoride was emitted in the air, with the remaining amount going into fluoride sludge stored at a landfill on the site. [56] The sludge was likely produced by wet scrubber air pollution control equipment.

In 1968, Southwire went into partnership with National Steel to build and operate an aluminum smelter at Hawesville, Ky. By 1980, the smelter was rated at 180,000 tons per year and was considered the producer of the world's purest commercial aluminum. [57] In the late 1980s, National Steel-Southwire sued the EPA after the agency said Southwire could not turn off its wet scrubbers as the company planned. According to court records, when the smelter was constructed in 1969, before passage of the 1970 Clean Air Amendments, the company equipped the plant with wet scrubbers to control emissions of gaseous fluoride. After passage of the Clean Air Amendments, the EPA determined that fluoride pollution presented a serious threat to public welfare because it damaged natural vegetation, herbivorous animals and agricultural crops. The EPA determined that the de minimis level for fluoride emissions at the Southwire smelter was three tons per year, and that emissions in excess of that amount could cause damage to vegetation. On Oct. 23, 1974, EPA issued "new source performance standards" for fluoride emissions from new and modified primary aluminum reduction plants. Kentucky was required to adopt state standards limiting fluoride emissions from existing, unmodified plants, which it did in 1981. These standards had the effect of preventing any increase in the emission of gaseous fluorides from Southwire's plant but did not require the company to reduce those emissions. [58]

In 1982, during a routine maintenance-related shutdown of the wet scrubbers, Southwire observed that its ambient air monitors did not detect any appreciable change in ambient fluoride levels as a result of not scrubbing the exhaust gases. Because of the substantial cost of operating the wet scrubbers, the company sought and obtained from Kentucky a relaxation of the state's standard by a factor of thirteen – from 1 pound of fluoride per ton of aluminum produced to 290 pounds of fluoride emitted per hour, the equivalent of 13.18 pounds of fluoride per ton of aluminum. This action would have increased gaseous fluoride emissions from the plant by 1,174 tons per year, but the relaxation of state standards needed approval from the EPA. Kentucky submitted a proposed draft of its relaxed standard to the EPA for comment on March 22, 1985. The proposal included a stipulation that if Southwire turned off the wet scrubbers to take advantage of the relaxed standard, the change would not be considered a "modification" that would render the plant subject to the "new source performance standards" limits. The EPA, however, informed Kentucky that the latter provision would not be approved. On Sept. 22, 1986, the EPA rejected Southwire's contention that the wet scrubbers were not part of the stationary source and stated that turning off the wet scrubbers would be a modification under the "new source performance standards" rules. The EPA reasoned that the exclusion of pollution control equipment from the definition of "stationary source" would be "contrary to the plain words of the definition" and that "inclusion of air pollution control equipment as part of a stationary source is essential if the Administrator is to implement" the 1970 Clean Air Act. [59]

Southwire sought review of the EPA decision in the U.S. Court of Appeals for the Sixth Circuit, which sustained the agency's decision. The appeals court first rejected Southwire's contention that a "stationary source" encompassed only pollution-generating equipment – such as reduction pots – and not an emission control system. The court reasoned that although the statutory definition of the term "stationary source" did not specifically mention pre-existing pollution control equipment, such equipment was not excluded from the definition's sweep. The appeals court also noted that the EPA had concluded that pollution control equipment were part of a stationary source when it amended the applicable regulations in 1975. The appeals court next addressed whether turning off the wet scrubbers was excluded from "new source performance standards" rules as an exception under the "modification" criteria. The appeals court stressed that the exception did not apply to the "removal" of a pollution control system – even the replacement of one pollution-control system with another constituted a modification if the EPA determined that the replacement would be less environmentally beneficial, the court said. Southwire's proposal "would leave gaseous fluorides virtually uncontrolled," the appeals court said. [60]

Southwire also had argued that the EPA's decision was contrary to the legislative intent of the Clean Air Amendments of 1970 because the Act gave the individual states primary responsibility to regulate emissions from existing sources of pollution. The court disagreed, stating that "it is clear that Congress intended that federal enforcement of federal air pollution standards governing new or modified stationary sources not be controlled by the states." The appeals court ruled that Southwire would either need to restart its wet scrubbers or install a new pollution control system. [61] The smelter continued operating but ran into trouble with the EPA a quarter century later. On July 23, 2009, the EPA announced that Southwire had agreed to pay a total of $337,500 in civil penalties to the U.S. and Kentucky to address alleged noncompliance in testing, operational, monitoring and record-keeping requirements of the Clean Air Act in response to a Feb. 20, 2006, notice of violation from the Kentucky Energy and Environmental Cabinet Department of Air Quality. In August 2007, the state environmental department confirmed that air pollutant levels had met industry standards established by the MACT rule, so no further action needed to be taken. [62]

In 1968, Noranda Mines Inc. of Canada formed Noranda Aluminum Inc. as the company acquired several aluminum-fabricating businesses. In 1971, the company completed construction of a 70,000 ton-per-year aluminum smelter in New Madrid, Mo., which was expanded to 140,000 tons per year in 1974. [63] By 1998, under Noranda Aluminum ownership, the plant was producing 253,000 tons per year of aluminum. The Noranda and National Steel-Southwire plants were among the few smelters in the U.S. producing high-purity aluminum. [64] On Aug. 4, 2010, the Missouri Air Conservation Commission issued a construction permit to Noranda allowing the company to increase aluminum production at New Madrid to 325,000 tons per year. Under the "best available control technology" limit for sulfur dioxide, Noranda was limited to 6,077 tons per year for entire New Madrid facility, including three carbon-bake furnaces. The company was required to use coal tar pitch with no more than 0.8% sulfur and coke with no more than 3% sulfur. In addition to "best available control technology" limits, the carbon-bake furnace was limited to 0.11 pounds of sulfuric acid emitted per ton of baked anode produced and 11.33 tons of polycyclic organic matter for the entire plant over 12 months. Limits for the aluminum production expansion were set for particulates, carbon monoxide and fluorides. The fluoride limit was 1.9 pounds per ton of aluminum produced. The plant used dry scrubbers for pot gas and had hooded reduction pots that were required to capture secondary emissions to assure 96% efficiency plant-wide. [65]

The company's expansion plans, however, didn't match market conditions. With $1 billion in debt, Noranda Aluminum filed for bankruptcy protection on Feb. 15, 2016, and announced plans to idle remaining operations at its New Madrid smelter in March. An electric rate cut wouldn't be enough to save the smelter from at least a temporary shutdown – low commodity prices caused by a global slowdown in emerging economies such as China had hurt aluminum producers, reducing the number of operating U.S. smelters to just a handful from 23 in 2000. [66] On Sept. 30, 2016, Noranda Aluminum announced court approval for the sale of the company's aluminum smelter and facilities in New Madrid to ARG International for $13.7 million. The court approval followed an auction on Sept. 28. Noranda's alumina refinery in Gramercy, La., and the company's bauxite mining operation in St. Ann, Jamaica, were not included in the auction. [67]

The Gramercy alumina refinery also had environmental problems. Kaiser announced plans to build the refinery at Gramercy with a capacity of 430,000 tons per year in December 1955. The Anaconda Aluminum Co. was an early customer, signing a 15-year contract to be supplied a minimum of 850,000 tons of alumina from the refinery at the rate of 130,000 tons per year. [68] On July 5, 1999, an explosion at the refinery injured 15 workers and sent a fine red powder containing bauxite and sodium hydroxide up to 1 ½ miles away. [69] Kaiser officials were not sure when the plant would restart. One official said multiple explosions had destroyed 10 flash tanks in a part of the refinery where high temperatures and pressures existed. [70] Gramercy was Kaiser's only U.S.-based alumina refinery, and all the facility's production went to third parties. Kaiser officials said the explosion occurred near the digester operation, where bauxite was mixed with liquid sodium hydroxide, and there was no evidence of sabotage by striking Steelworkers at the plant. Metals traders reported an excess of alumina in the market, so prices would be unaffected by the blast despite the large amount of alumina lost to production. Early estimates for repairs to the plant ran to $80 million, while construction costs for an entirely new plant ran to $1 billion. About 5,000 local residents filed a class-action lawsuit against Kaiser for physical harm and property damage. About 60% of the bauxite sent to the Gramercy refinery came from Jamaica's Discovery Bay, which expected a loss in export earnings of $17 million. [71] In February 2000, the U.S. Mine Safety and Health Administration cited Kaiser for the explosion and said it expected to fine Kaiser within the next 45 days. By then, Kaiser had already obtained a state environmental operating permit and had started construction on a new digester for the plant. [72]

The Gramercy refinery later was investigated for emitting mercury after it had been returned to operation. In February 2015, Louisiana Department of Environmental Quality officials ordered Noranda Alumina, which acquired the refinery from Kaiser in 2009, to conduct modeling after company officials acknowledged in 2014 that mercury emissions to the atmosphere had been occurring, possibly for years, without a permit. The state environmental department relaxed its order in April, saying the company would not be required to do the modeling. At Noranda's request, the department instead ordered the company to identify possible mercury sources and figure out how much was coming from those sources. Noranda had told the state on March 17 that the refinery emitted far less mercury than company had first thought, and the emissions were likely less than 25 pounds per year. State law viewed mercury emissions below that rate as insignificant and the state could choose on a case-by-case basis not to require a permit. [73] On Feb. 1, 2016, the Louisiana Environmental Action Network notified Noranda that it planned to file a federal lawsuit over mercury emissions that the watchdog group claimed were polluting nearby wetlands which drained into the Blind River and nearby groundwater sources. Noranda was violating federal and state hazardous waste laws, the group said. Louisiana officials had advised the public for years to limit consumption of fish caught in the Blind River because of mercury contamination, the group said. Mercury was a human poison that could affect the functioning of the brain and cause birth defects, and it could combine with organic compounds in the environment to form methyl mercury, a chemical that could bio-accumulate in the food chain. [74]

The intent-to-sue notice was also sent to Kaiser, with the watchdog group claiming the emissions were ongoing since the plant began operations. "Noranda admits it and prior owner Kaiser have likely been releasing mercury into the air, without a permit, for nearly six decades," Louisiana Environmental Action Network Executive Director Marylee Orr said. "Yet the company has utterly failed to take any concrete steps to contain, reduce or clean up the mess it has created here in Louisiana. As a result, there is a significant risk to human health, the environment and our food chain." Noranda called the charges "misplaced and unwarranted." The company told state Department of Environmental Quality officials that the amounts of “elemental mercury” being released were well below levels posing health or environmental risks. “We have worked constructively with LDEQ on this matter from the time in March 2014 that we identified trace amounts of elemental mercury within facility process equipment at our refinery and self-reported those findings,” Noranda spokesman John Parker said. “Based on the sampling and other activities we have conducted to date, as well the LDEQ’s own air monitoring in the area, we are not aware of any potential exceedances of applicable ambient air quality standards.” [75]

The last major aluminum smelter built in the U.S. also emitted fluoride that impacted its surrounding environment. On June 20, 1980, Alumax began producing aluminum at its new $340 million 197,000 ton-per-year Mt. Holly aluminum smelter in South Carolina. [76] According to a study of white-tailed deer that inhabited the land around the plant, concentrations of skeletal fluoride in the deer collected at the Mount Holly Plantation increased approximately five-fold three years after the smelter began operating. Less than two-fold increases in skeletal fluoride were observed in deer obtained from the Medway Plantation, which had its nearest boundary about one mile from the smelter site. No dental fluorosis was observed in deer collected at the Medway Plantation, but mild dental fluorosis was observed in a significant number of deer collected at the Mount Holly Plantation. The observed dental fluorosis was not associated with incisor wear or with fluoride-induced molar wear. Osteofluorosis of mandibles or metacarpals was not observed in any of the deer obtained from either plantation. The data obtained from the study indicated that the presence of a modern aluminum smelter caused a detectable increase in concentration of skeletal fluoride in the resident population of white-tailed deer, but that no adverse health effects were seen. [77]

New technologies, new regulations

Aluminum producers were constantly looking for ways to improve the Hall-Heroult reduction process. By the 1950s, it took on average about 21 kilowatt-hours of electricity to produce 2.2 pounds of aluminum in a modern smelter. By 1999, that figure had improved to 15.7 kilowatt-hours. Aluminum formed in the reduction pots at 1,652 degrees Fahrenheit, but it had a melting point of only 1,220 degrees. Recycling aluminum required only 5% of the energy required to make new metal from alumina. Blending recycled aluminum with new metal allowed considerable energy savings with no change in quality or properties of the product, according to the World Aluminium Organization in 1999. Most smelters produced aluminum at 99.7% purity, which was adequate for most applications. By 1996, about 10.3% of smelters continued to use horizontal-stud Soderberg pots, 19.4% used vertical-stud Soderberg pots, 9.8% used side-worked prebake pots and 60.3% used center-worked prebake pots. The latest in smelting technology was the center-worked prebake system that used computer-controlled multiple point-feeders located near the center of the pot between the prebake anode blocks. The center-worked prebake system produced much lower emissions in the potrooms, and all pot gas went through a common ductwork to an efficient scrubber system. Computer technology could reduce anode effects, a source of perfluorocarbon emissions, a potent greenhouse gas. [78]

Alcoa first tested point-feeding technology at its Wenatchee smelter in Washington in 1958. Small holes were punched in the crust that formed between the anode and the cathode at two to six different positions using iron rods driven by fast-acting pressurized air cylinders. Small amounts of alumina were then fed into the holes, which reduced the amount of sludge that could form in the center of the cell. That sludge could reduce efficiency and cell life. By 1961, the technology was in use at Alcoa's Rockdale smelter. Point-feeder technology was developed at Alcoa's laboratory in New Kensington, Pa., in an attempt to reduce labor costs. As the technology improved over time, it became apparent that point feeders could make aluminum reduction cells more efficient and more environmentally friendly. Point-feeder technology was considered one of the most important breakthroughs for the aluminum industry and eventually went into use in every smelter in the world. [79]

New rules and regulations for U.S. primary aluminum producers were published in the Federal Register on Oct. 7, 1997. Commonly referred to as Primary Aluminum NESHAP Subpart LL, the rules and regulations were created under the umbrella of the 1990 Clean Air Act, which had directed the EPA to investigate U.S. industries and develop standards and regulations. The EPA's study found that the most significant hazardous air pollutants emitted by primary aluminum smelters were hydrogen fluoride, measured as total fluoride, and polycyclic organic matter. Every primary aluminum smelter using the electrolytic reduction process was subject to these rules with no exception. Different rules were being developed for secondary aluminum processing facilities that melted scrap or recycled consumer products such as beverage cans. Emission levels for each plant were established according to the type of reduction cells used by a smelter – Soderberg or prebake, horizontal or vertical stud, side-break or center-break – but total fluoride and polycyclic organic matter emission standards were established for all reduction cells. All primary aluminum smelters in the U.S. were ordered to comply with these standards by Oct. 7, 1999. The rules established that the Columbia Falls Aluminum Co. smelter in Montana, for example, operated a vertical-stud Soderberg Type 2 facility, and limits were set at 2.7 pounds total fluoride per ton of aluminum produced and 3.6 pounds polycyclic organic matter per ton of aluminum produced for each individual potline, or slightly greater amounts when averaging from two to five of the potlines together.[80]

According to the EPA explanation that accompanied the 1997 rules, short-term inhalation exposure to gaseous hydrogen fluoride and related fluoride compounds could cause severe respiratory damage in humans. Long-term inhalation exposure to low levels of hydrogen fluoride by humans had been reported to result in "irritation and congestion of the nose, throat, and bronchi while damage to liver, kidney, and lungs has been observed in animals." Polycyclic organic matter according to the EPA included a combination of polycyclic aromatic hydrocarbons such as anthracene, benzo(a)pyrene, and naphthalene, among others. Several of the polycyclic aromatic hydrocarbons compounds, including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene, "are probable human carcinogens, and cancer is the major concern from exposure to these polycyclic aromatic hydrocarbons," the EPA said. [81]

The source of polycyclic organic matter emissions was the pitch used to make anode paste. Pitch was derived as a byproduct at plants which distilled coal to produce coke. Polycyclic organic matter emissions took place whenever the pitch was heated to a liquid state, as in storage tanks and in paste plants, where anode briquettes for Soderberg anodes were produced. The new federal rules ordered plants to enclose these emission points and evacuate the emissions to a dry coke scrubber or similar pollution control device. Polycyclic organic matter emissions also took place in Soderberg potlines as the anode paste was baked in situ in the reduction cell. In contrast, polycyclic organic matter emissions were eliminated in smelters using prebake cells because the paste was baked in an anode furnace to create hard carbon blocks for use as replacement carbon in reduction cell anodes. Most fluoride emissions came from reduction cells as opposed to unloading and storage facilities, the EPA said. [82]

To meet compliance, according to the EPA, primary aluminum-producing companies had two options – meet the emission limits for each individual potline, or average the emissions from multiple existing potlines. Special rules were created for newly built potlines versus existing ones, for modified potlines, and for plants with a combination of Soderberg and prebake facilities. The rules specified the type of monitoring required, including monthly measurements of total fluoride as secondary emissions, annual measurements of total fluoride as primary emissions, quarterly monitoring of polycyclic organic matter as secondary emissions, annual measurements of polycyclic organic matter as primary emissions, continuous parameter monitoring of emission-control devices, monitoring of daily weights of aluminum produced and daily visual inspections of exhaust stacks. [83]

Primary emissions were exhaust gases and particulates collected from the reduction cells and treated through a scrubber system. Secondary emissions were exhaust gases and particulates which escaped the reduction cells and were vented through the roofs, windows or doors of the potrooms. According to the EPA, “The pots are large heat sources; consequently, the potrooms are ventilated to maintain reasonable working conditions and to help with proper pot operation. Usually this ventilation air enters at the sides of a potroom and exits through roof vents (roof monitor). This ventilation is the major source of potroom fugitive emissions.” Primary emissions of fluoride by the 1990s were controlled at most plants by dry scrubber systems using alumina. Some plants had wet scrubbers mounted on potroom roofs to handle secondary emissions. The new federal rules ordered plants to initiate corrective actions within one hour if a primary control device measured an operating parameter outside the established limits. Primary control devices were not to exceed the limits more than six times in a semi-annual reporting period. [84]

Climate change concerns

In June 2003, the International Aluminium Institute uploaded data to its website describing smelter emissions. Most smelters worldwide removed 96% to 99% of pot gas fluoride and recycled it into the alumina reduction process through a dry scrubber, emitting only 2.4 pounds of fluoride per ton of aluminum produced for older plants and 1.1 pounds for newer plants. The two main types of fluoride emissions included the inorganic fluorides, including sodium fluoride, aluminum fluoride and sodium aluminum fluoride as particulates and hydrogen fluoride as a gas, and the organic fluorides, including two perfluorocarbons, tetrafluoromethane and hexafluoroethane, as gases. Research showed that vegetation near smelters “quickly recovered when fluoride emissions were reduced to current levels,” the institute reported. But as a precaution, “Most aluminium smelters are surrounded by environmental control zones, normally farmland, and the environment in these is closely monitored.” For inorganic fluoride emissions, the institute divided the history of existing aluminum smelters into three generations – during the first, from 1940 to 1955, smelters produced 26 to 33 pounds of fluoride per ton of aluminum produced; the second, from 1955 to 1975, saw 4.4 to 13 pounds per ton; and the third, from 1975 to 2003, saw 0.66 to 2.2 pounds per ton. [85]

Perfluorocarbons were “chemically inert” but had a high global-warming potential, the International Aluminium Institute said. Perfluorocarbons were created by aluminum reduction pots during anode effects, when the alumina concentration in the cryolite bath was insufficient and the anode reacted directly with the fluoride in the cryolite bath. “It is clear that the more efficiently the electrolytic process can be run, the lower the generation of perfluorocarbons,” the institute said. Polycyclic aromatic hydrocarbons were produced by the manufacturing of prebake anodes or by the consumption of Soderberg anodes. Emissions of polycyclic aromatic hydrocarbons was

0.11 pounds per ton of aluminum produced by prebake smelters and 0.55 pounds per ton for Soderberg plants, with the most modern prebake smelters emitting only 0.02 pounds per ton. The institute noted that polycyclic aromatic hydrocarbons emissions in Soderberg plants "have been dramatically reduced" by the introduction of dry anode technology, by process improvements and by altering the types of raw materials used to make carbon briquettes. [86]

Sulfur dioxide emissions resulted predominantly from electrical generation by fossil fuel-fired plants or by use of fossil fuels for production, the institute said, including steam generation in alumina refineries and heating furnaces to create prebake anodes. Sulfur dioxide was also produced by anode consumption in reduction pots. The remedy was to use low-sulfur fuel for generating electricity or low-sulfur coke for producing anodes and to use wet scrubbers to catch emissions, the Institute said. Carbon dioxide emission, however, "is a feature of all metal processes which produce metal from ores containing oxides," the institute said. Carbon in the anode combined with the oxygen in the raw material and was "therefore an unavoidable byproduct of the aluminium smelting process." In the past 10 years, carbon dioxide emission had been reduced by 10% through better production techniques, the institute said. [87]

Carbon dioxide emissions from aluminum smelters were believed to contribute to global warming, but worse were perfluorocarbons created by the interaction of fluoride in the bath with carbon in the anodes. On Feb. 15, 1998, scientists participating in the Voluntary Aluminum Industrial Partnership presented the results from monitoring perfluorocarbon emissions at several aluminum smelters in the Pacific Northwest. Perfluorocarbons were long-lasting in the atmosphere and produced a significantly larger effect on global warming. One ton of tetrafluoromethane had the same global-warming potential as 6,500 tons of carbon dioxide, and one ton of hexafluoroethane had the same global-warming potential as 9,200 tons of carbon dioxide. Both gases were characterized by "strong infrared radiation absorption and relative inertness in the atmosphere." As byproducts emitted during anode effects at aluminum smelters, the EPA estimated the annual output of perfluorocarbons from U.S. aluminum plants in 1990 at about 2,700 tons – equivalent to about 18 million tons of carbon dioxide. [88]

Scientists participating in the Voluntary Aluminum Industrial Partnership study monitored the perfluorocarbon emissions at exhaust stacks from primary treatment scrubbers and at potroom rooftop vents, typically using EPA Method 14 monitoring station collectors. The Northwest Aluminum plant at The Dalles, Ore., and the Goldendale Aluminum plant at Goldendale, Wash., had scrubber systems on the potroom roofs. The study found that fugitive emissions from rooftops accounted for 10% to 33% of perfluorocarbon exhaust emissions for smelters with vertical-stud

Soderberg pots. The study also compared perfluorocarbon output with anode effects. The Columbia Falls Aluminum Co. smelter averaged 9.78 anode-effect minutes per cell-day compared with 5.37 at The Dalles and 2.54 at Goldendale. All three used vertical-stud Soderberg pots. The third lowest was Tacoma, which used horizontal-stud Soderberg pots, at 2.82. Among the plants with prebake pots, Vanalco at Vancouver had 2.97 anode-effect minutes per cell-day and Kaiser at Spokane had 1.42. The amount of tetrafluoromethane and hexafluoroethane produced at the plants varied proportionately to the number of anode effects, and CFAC scored the highest on output of these two perfluorocarbons. Vertical-stud Soderberg pots were opened to the potroom atmosphere when the crust was broken to extinguish an anode effect. CFAC also scored significantly higher in the number of anode effects per cell day – 3.43 compared to 1.92 for The Dalles. The average for prebakes was 0.87. CFAC scored lower for average duration of anode effects but scored significantly higher for weight of tetrafluoromethane or hexafluoroethane per ton of aluminum produced. CFAC also scored significantly higher for the ratio of tetrafluoromethane to hexafluoroethane produced. [89]

In June 2003, the World Resources Institute published a set of tools for primary aluminum producers to calculate the amount of greenhouse gases – carbon dioxide and perfluorocarbons – emitted per ton of aluminum produced. The formula and default values were developed after the institute surveyed plants around the world from 1990 through 2000. The tools provided in the institute's report did not address greenhouse gas emissions by upstream operations in the aluminum-producing industry, such as bauxite mining or alumina refining, or by downstream operations, such as ingot casting and fabrication mills. Carbon dioxide produced from burning fossil fuels to generate the energy used to produce aluminum was calculated from a separate set of institute tools. The typical value for net carbon consumption in tons of carbon per ton of aluminum produced in prebake plants was 0.40. For Soderberg plants, the typical value for net paste consumption in tons of carbon per ton of aluminum produced was 0.51. For prebake plants, the institute's default value was 1.7 tons of carbon dioxide emitted per ton of aluminum produced. For Soderberg plants, the default value was 1.6 tons of carbon dioxide per ton of aluminum produced. The default values for tetrafluoromethane emissions improved during the 1990 to 2000 survey period. The values for the years 1998 to 2000 in kilograms of tetrafluoromethane per ton of aluminum produced were 0.2 for plants with center-worked prebake reduction pots; 0.08 for point-fed prebake pots; 1.4 for side-worked prebake pots; 0.4 for vertical-stud Soderberg pots; and 0.6 for horizontal-stud Soderberg pots. The calculation for hexafluoroethane was based on a multiplier factor. The factor for center-worked prebake pots was 0.17; for point-fed prebake pots was 0.17; for side-worked prebake pots was 0.24; for vertical stud Soderberg pots was 0.06; and for horizontal stud Soderberg pots was 0.09. [90]

In 2013, the International Aluminium Association estimated perfluorocarbon emissions by the world's aluminum smelters to be about 32 million tons of carbon dioxide-equivalent global-warming potential, a significant decrease from about 100 million tons in 1990. During the same time period, global primary aluminum production more than doubled from less than 20 million tons in 1990 to more than 50 million tons in 2013. Perfluorocarbon emissions decreased by about 35% from 2006 to 2013 in carbon dioxide-equivalent tons. The estimates came from voluntary self-reported data on anode effects from 218 smelters and potlines around the world, representing about 20 million tons of primary aluminum production. The results utilized estimates of perfluorocarbon emissions from the other 30 million tons produced in the world, mostly from China, using models based on historic sampling or other means. The International Aluminium Association categorized the collected data based on the type of reduction pot, including vertical-stud or horizontal-stud Soderberg pots, and center-worked, side-worked or point-feeder prebake pots. [91]

The irony of fluoride use in the 20th century was that while it was considered harmful when emitted to the atmosphere by industrial plants, cities and towns added fluoride to their drinking water supplies to improve dental health. But some investigations have shown a link between the promotion of fluoridation of drinking water and the U.S. aluminum industry. One investigation began with Andrew and Richard Mellon, who were founders of Alcoa and the Mellon Institute of Pittsburgh, Pa. The Mellon Institute was an "intellectual holding company and a laboratory for applied science open to the U.S. businessman" which looked at all kinds of subjects, from shaving to smoking, Life Magazine reported on May 9, 1937. "When a manufacturer is in trouble, for example, he finds the market for his goods is shrinking, he goes to the Institute," Life reported. "For $6,000 or more, he gets a fellowship entitling him to employ a scientist for a year and use laboratory facilities. When the research is satisfactorily completed, all discoveries are turned over to the manufacturer exclusively." One of the Mellon Institute's scientists, Gerald Cox, a biochemist, played a key role in promoting the use of fluoride in public drinking water to promote dental health. [92]

The investigation also turned to the Kettering Laboratory in Cincinnati, an institute founded in 1930 which received 90% of its funding from industry. Kettering Laboratory's first director, Robert Kehoe, later played an important role in promoting fluoridation of drinking water. According to a contract between Alcoa and Kettering, information from the lab should be disseminated to the public, but "before the issuance of public reports or scientific publications, the manuscripts thereof will be submitted to the Donor for criticism and suggestions. Confidential information obtained from the Donor shall not be published without permission of said Donor." Another scientist at Kettering, E.J. Largent, who later went to work as a consultant for Reynolds, later wrote a book called "Fluorosis: The health aspects of fluorine compounds" which, as the jacket copy said, was intended to "aid industry in lawsuits arising from fluoride damage." [93]

In an article titled "Water boom for fluorides," the July 7, 1951, issue of Chemical Week reported that the U.S. Public Health Service was encouraging public water system operators across the U.S. to put fluoride in water to improve dental health. The article noted that the trend "adds up to a nice piece of business on all sides, and many firms are cheering the USPHS and similar groups as they plump for increasing adoption of fluoridation." Among the firms named as beneficiaries of this trend was Alcoa. According to George Waldbott's 1978 book, the aluminum industry lost huge amounts of fluoride to the atmosphere and left sodium fluoride accumulating in the bath, which was not used in the reduction process. Waldbott reported that Alcoa was fined in 1950 for dumping sodium fluoride into the Columbia River at its Vancouver plant. Alcoa needed a use for the many tons of leftover sodium fluoride it possessed, and in 1950 an advertisement promoting the use of Alcoa's sodium fluoride product in drinking water appeared in the Journal of the American Water Works Association. [94]

The irony of the atmospheric fluoride problem versus the drinking water fluoride benefit led to an editorial in the Hungry Horse News on Jan. 21, 1972. While the Montana Department of Health was calling for reducing fluoride emissions at the AAC smelter in Columbia Falls, the department was calling for increasing the amount of fluoride in the city's drinking water supply. The department wanted the aluminum plant to reduce fluoride emissions from 2,500 pounds per day to 864 pounds, but it also claimed that fluoride levels in the Columbia Falls drinking water were the lowest in the state, and that there was a higher incidence of cavities in children's teeth as a result. [95]

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