Voluntary Aluminum Industrial Partnership

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Abstract
A very successful record of emissions reduction has been achieved through a voluntary program developed between U.S. primary aluminum producers and the U.S. Environmental Protection Agency (EPA). The program is currently in the final year of the first agreement period, and work is under way to develop a new memorandum of understanding to achieve future reductions. Primary aluminum producers working through the U.S. Aluminum Association (AA) have developed an effective communications channel to work with EPA. Aluminum producers have worked cooperatively with EPA to develop a better understanding of emissions of perfluorinated carbon (PFC) compounds, to make measurements of these compounds in normal production, and to develop good inventories of these compounds.

VAIP Background
In the early 1990s, the focus on global warming and climate change grew rapidly. At the same time, U.S. primary aluminum producers recognized the role of PFCs as a significant contributor to anthropogenic greenhouse gases [1]. Two perfluorocarbon compounds are produced as by-products in the production of primary aluminum. These two PFC compounds, tetrafluoromethane and hexafluoroethane, are potent greenhouse gases. Both are strong infrared absorbers and are quite stable in the atmosphere, with a lifetime in excess of 50,000 years [2]. Reports indicate that natural sources account for approximately one-half the total accumulated CF_4 content of the atmosphere, but anthropogenic sources are vastly predominating new contributions to the atmosphere [3]. The two PFC compounds are formed in primary aluminum production when a condition known as "anode effect" occurs. Anode effects typically occur less than 0.05% of the total production time. During these anode effects, the electrolysis of aluminum oxide—the raw material for production of aluminum—is partially interrupted and PFC gases are produced simultaneously with aluminum. Although the fact that PFC gases are produced from anode effects has been recognized for some time, the specific mechanism of how anode effects were initiated or how they are eliminated after initiation were unknown at that time. Also, little information was available on what production parameters were important in determining PFC emission rates, beyond the fact that PFCs were produced only when the electrolysis cells were on anode effect.

As part of the U.S. government's Climate Change Action Plan of October 1993, EPA initiated meetings with aluminum producers through the AA in Washington, D.C., to discuss the possibility of the industry making a commitment to reduce emissions of PFC compounds. The aluminum industry responded by forming a PFC task force within AA to consider what was known at that time about PFC emissions and the possibility of reductions of these emissions. EPA worked cooperatively with the PFC task force to develop language that provided the aluminum industry with flexibility in how emissions would be reduced and still achieve the targeted

emissions reductions. The agreement became known as the Voluntary Aluminum Industrial Partnership, or VAIP.

VAIP Agreement Structure

The VAIP agreement that was developed between EPA and primary aluminum producers consisted of two parts. The first part of the agreement contained a preamble, common agreements and principles, the EPA's responsibilities under the agreement and, finally, the partner's broad responsibilities under the agreement. The second part of the agreement contained the specific commitments made by each member partner. The agreement called for an ambitious reduction of PFC emissions by the aluminum industry of 30% to 60% by 2000 and defined the base year for the program as 1990. The voluntary nature of the program was reaffirmed, and the agreement specifically called only for those reductions that were technically feasible and cost-effective. Furthermore, the language recognized that there were no agreed-upon measurement methods for PFCs from aluminum production at that time and that the development of these measurement methods and emission factors were critical to the overall success of the partnership.

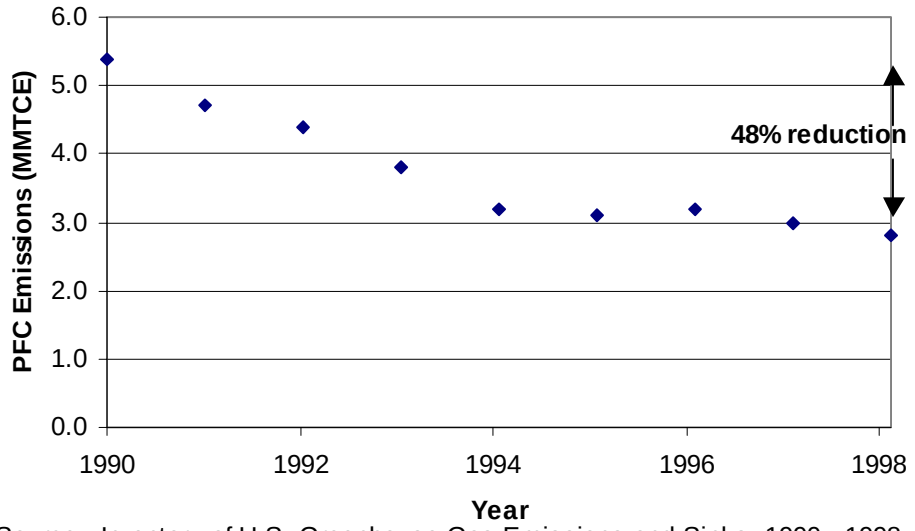
There are a number of different technological variations on the basic Hall/Heroult process that involves electrolysis of alumina in a molten salt bath employed in the U.S. and worldwide for the production of primary aluminum. The agreement recognized these differences and that there would be different potentials for emissions reductions based on the particular mix of technologies employed by each producer. Flexibility was built into the agreement to allow each partner to take into account unique facility characteristics. The language further stated that there should be no expectation of zero emissions of PFCs from primary aluminum production.

EPA agreed to facilitate development of knowledge about PFCs from aluminum production and share this knowledge with partners. EPA also agreed to encourage other aluminum-producing countries to include PFCs in their plans for greenhouse gas emissions reductions. Other responsibilities of EPA outlined in the VAIP agreement included providing appropriate publicity concerning the program and, importantly, to respect the privacy of information deemed to be confidential by participants. The industrial partners agreed to provide appropriate data to track reductions of PFCs and to provide emission inventories for PFCs beginning with 1990, the baseline year for the program. Because there were no internationally accepted methods for inventorying PFCs at the time of the development of the agreement, it was agreed that the emission inventories might change as new information linking process data with PFC emissions became available. Finally, industrial partners signed individual, tailored agreements with EPA for specific and measurable reductions based on the analysis each had done to determine what they felt their potential for reduction might be. The level of each company's commitment was confidential and was not shared among participants. For each company, an individual liaison was identified to work with a corresponding single point of contact named by EPA.

Program Results

The VAIP program is a success [4]. The initial VAIP program is nearing the end of the measurement period of 1999 to 2000. Overall PFC emissions reduction results for U.S. aluminum producers are shown in Figure 1 in million metric tons of carbon equivalent (MMTCE) from 1990 to 1998.

Figure 1 - PFC Emissions Reductions from U.S. Primary Aluminum Producers [5]

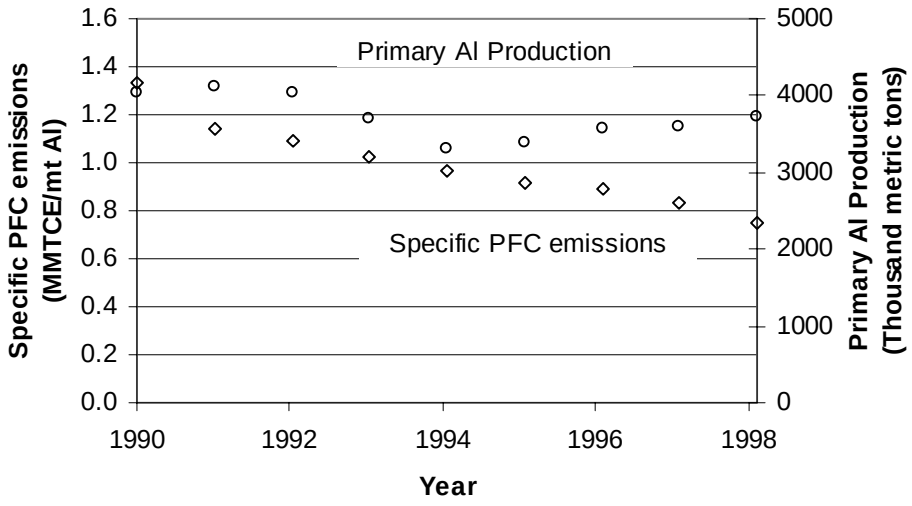


Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 1998

U.S. primary aluminum producers committed through the VAIP to reduce PFC emissions by slightly more than 40% from 1990 levels by 2000. Results through 1998 show a reduction of about 48%. Figure 2 shows annual trends in both U.S. primary aluminum production and for specific emissions of PFCs. Total primary aluminum production in the U.S. has decreased by about 8% from 1990 to 1998, accounting for some of the overall reduction in PFC emissions. However, the data show a 43.5% reduction in PFC emissions per ton of primary aluminum produced, illustrating that the reductions in PFC emissions are substantial and real.

The reductions in PFC emissions were achieved through improvements in operating performance on anode effect frequency and shortening the duration of anode effects. The results are noteworthy not only with regard to the positive environmental impact, but also for the improvements in the economics of aluminum production. Reducing anode effects reduces the power consumed per unit of aluminum produced, increases overall current efficiency, and has the potential to reduce labor cost for dealing with anode effects that cannot be extinguished by the process computer control system.

Figure 2 – Trends in Specific PFC Emission Rates and U.S. Primary Aluminum Production



Benefits of VAIP Program for Producers

Certainly some of the benefits achieved during VAIP may have been achieved in the absence of the program. However, there is no doubt that the program added value and focus to the reduction effort. Leadership in the form of a clear and ambitious goal stimulated a deeper level of thought about how anode effect reduction might be achieved. The dialogue established between the primary aluminum industry and EPA in developing the agreement allowed an understanding of the capabilities and limitations of the industry by EPA that would have been difficult to achieve by other means. Another valuable element of the program was the workshops, both formal and informal, that EPA sponsored to share nonproprietary information on PFC measurements and reduction efforts.

Measurements of PFC emissions were key to understanding emission mechanisms and in improving emissions inventories. EPA sponsored two major measurement campaigns in which PFC emissions measurements were made at member company locations during typical production operations [6,7]. These measurements were invaluable in adding to the understanding of the specifics of PFC emissions and how reductions might be most effectively pursued. An important part of the measurement effort was EPA's funding of an effort at the National Institute of Standards and Technology that resulted in the production of three PFC reference gases for calibration of measurement instrumentation [8]. The measurement work funded by EPA has had an international impact in that the standards and measurement protocols developed for the U.S. measurements have been used for a series of Canadian measurements.

A fundamental research program was co-funded by EPA and member companies of AA at MIT. The MIT effort was aimed at understanding the fundamental electrochemistry of PFC production from aluminum reduction. Several publications resulted from the work, and the benefits of increased fundamental understanding developed in laboratory scale experiments are being investigated in commercial cells [9-11]. As with many fundamental studies, the benefits of the knowledge gained from these efforts continues to be realized through heightened understanding of the results from commercial cells after the fundamental work is completed.

Future Direction

As the initial VAIP nears the end of its final year, both the industrial partners and EPA are beginning to consider where the program should go next. When the first VAIP agreement was drafted in the mid-1990s, there was still active debate about whether climate change was real. Today, most legitimate climate change scientists agree on the reality of climate change, and the discussion has turned to magnitude and timing of climate change. Participants are actively negotiating the details of the Framework Convention on Climate Change and the Kyoto Protocol. The next negotiating session, COP-6, is scheduled to begin in mid-November in The Hague, Netherlands.

Details of the complex issues being discussed in these negotiating sessions involving emissions trading, joint implementation, and the clean development mechanism, give a new impetus to reducing uncertainty in greenhouse gas emissions inventories and to emissions reduction, as real economic value is tied to emissions with the potential to impact all industry including the aluminum industry. Maintaining open channels of communication between the industrial sectors and U.S. negotiators is important so that informed negotiating decisions can be made. Continuing the VAIP program offers one path for such a dialogue.

A next-phase VAIP agreement offers the opportunity to incorporate developments in international accepted standards for emissions inventorying. Recommended good practices have been developed for inventorying greenhouse gases from the industrial sector and include PFCs from the aluminum industry [12]. An updated agreement offers the opportunity to incorporate these good practices in reporting emissions. Annual reductions in PFC emissions have tailed off in recent years, with smaller reductions than in the first years after the 1990 baseline year. Those emission reductions most easily obtained have been realized, and further reductions will require a more detailed approach. However, opportunities still remain from incorporation of good management practices. The most recent international survey on anode effects and perfluorocarbon compound emissions shows a wide range of performance among aluminum producers operating with similar technologies [13]. Finally, technology offers future emissions reduction opportunities with the possibility of completely eliminating PFC emissions if inert anode technology can be brought to fruition. In the nearer term, improved computer process control and raw materials control might offer a path to lower PFC emissions.

In summary, the VAIP program has, I believe, accelerated the pace of PFC emissions reduction beyond what would have been achieved in the absence of the program. The structure of the program has given the flexibility to all U.S.-based producers to work toward emission reduction in the manner that best suits their particular mix of technologies. The reporting system allows EPA to track emissions reductions and to produce the national inventory data needed to comply with the Framework Climate Convention. The measurements conducted as part of the program have added a new level of understanding of the mechanism of PFC emissions. The fundamental research cosponsored by EPA and AA provides the background to better interpret the measurement data and to improve emissions predictions based on process data. The database constructed to track PFC emissions from 1990 to 2000 may well take on added importance as international negotiations proceed on political and economic aspects of climate change. The experience developed in the VAIP program between EPA and the U.S. aluminum industry might well serve as a model for consideration by other industrial sectors as they look at how climate change issues will affect them in the future.

References:

1. Tabereaux, A.T., Anode Effects, PFCs, Global Warming, and the Aluminum Industry, Journal of Metals, 1994, pp 30–34.
2. Zander, R., Solomon, S., Mahieu, E., Goldman, A., Rinsland, C.P., Gunson, M.R., Abrams, M.C., Chang, A.Y., Salawitch, R.J., Michelsen, H.A., Newchurch, M.J., and Stiller, G.P., Increase of stratospheric carbon tetrafluoride (CF_4) based on ATMOS observations from space, Geophysical Research Letters, Vol. 23, No. 17, 1996, pp 2353–2356.
3. Harnish, J. and Eisenhauer, A., Natural CF_4 and SF_6 on Earth, Geophysical Research Letters, Vol 25, No. 13, 1998, pp 2401–2404.
4. Dolin, E.J., EPA's Voluntary Aluminum Industrial Partnership, Environmental Technology, July/August 1998, pp 40–43.
5. U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–1998, EPA 236-R-00-001, 2000, pp 3-26–3-27.
6. Leber, B.P., Tabereaux, A.T., Marks, J., Lamb, B., Howard, R. Kantamaneni, Gibbs, M., Bakshi, V., and Dolin, E., Perfluorocarbon (PFC) Generation at Primary Aluminium Smelters, Light Metals 1998, 277–287.
7. Marks, J., Roberts, R., Bakshi, V., Dolin, E., Perfluorocarbon (PFC) Generation during Primary Aluminum Production, Light Metals, 2000, 365–371.
8. Rhoderick, G.C., Chu, P.M., Dolin, E.J., Marks, J.Y., Howard, T., Lytle, M.C., McKenzie, L.G., Altman, D., Perfluorocarbon (PFC) Primary Standards Development for Aluminum Production Emissions Monitoring, In Press.
9. Nissen, S.S. and Sadoway, D.R., Perfluorocarbon (PFC) Generation in Laboratory-Scale Aluminium Reduction Cells, Light Metals 1997, pp 159–164.
10. Zhu, H. and Sadoway, D., The Electrode Kinetics of Perfluorocarbon (PFC) Generation, Light Metals 1999, 241–246.
11. Zhu, H. and Sadoway, D., An Electroanalytical Study of Electrode Reactions on Carbon Anodes During Electrolytic Production of Aluminum, Light Metals 2000, pp 257–263.
12. IPCC (International Panel on Climate Change), "Good Practice in Inventory Preparation for Industrial Processes and the New Gases," Draft Report, Intergovernmental Panel on Climate Change, Washington, D.C., 1999.
13. International Aluminium Institute, Anode Effect Survey 1994–1997 and Perfluorocarbon Compounds Emissions Survey 1990–1997.