HEEP – A Program for Tracking Fire Protection Emissions of HFCs and PFCs

by

Tom Cortina
Halon Alternatives Research Corp
2111 Wilson Blvd, Suite 850
Arlington, VA 22201
cortina@alcalde-fay.com

Joseph A. Senecal
Kidde-Fenwal, Inc.
90 Brook Street
Holliston, MA 01746 USA
joseph.senecal@kidde-fenwal.com

Abstract. Hydrofluorocarbons (HFCs) are widely used as alternatives to halons in fire protection applications. Since HFCs are greenhouse gases there is interest in keeping the emissions of these chemicals to the lowest levels necessary to meet the needs of fire protection applications where clean gaseous agents offer important technical and commercial advantages. The HFC Emissions Estimating Program (HEEP) is a vehicle to simply, economically and accurately determine annually the quantities of HFCs (and perfluorocarbons, or PFCs) that are discharged to the atmosphere when used for fire protection purposes. A prime motivation to implement HEEP derives from the fire protection industry's Voluntary Code of Practice (VCOP). The VCOP had its inception in 1999 and was adopted in 2001 by the segment of the fire protection industry that employs HFCs as alternatives to halons. In developing the VCOP it became quickly apparent that merely stating a goal to limit emissions of fluorocarbons in fire protection applications would have little meaning if there was not a means to quantify emissions. The HEEP program was launched in 2002 as a means of collecting and reporting emissions data in a manner that was both informative and considerate of industry needs for confidentiality. Thus far fire industry emissions data has been collected for the years 2002 and 2003. Data for 2004 and 2005 are now being collected. This paper summarizes the background of HEEP, its implementation, the results obtained to date, and the value these results serve in support of industry goals under the VCOP and as a model to other industry segments on how to monitor HFC emissions.

Introduction. Shortly prior to the phase-out of the production of halons a serious industry effort was undertaken to discover alternative fire extinguishing agents for use in total flooding and streaming applications. A number of innovative products were shortly introduced to the market including HCFCs, HFC,s PFCs [1], and inert gases to serve the range of application requirements. Thus, ozone depleting halons have been replaced by products with different features both in terms of fire extinguishing effectiveness and physical properties. The development of HFCs and PFCs for use in fire and explosion protection applications has been instrumental in achieving the accelerated halon production phase-out mandated by the Montreal Protocol on Substances that Deplete the Ozone Layer. At the same time, the use of these classes of chemicals carries with it some environmental concern and, therefore, the need to minimize emissions.

While HFCs and PFCs are not ozone-depleting substances, they have been identified by the

[1] HCFC, hydrochlorofluorocarbon; HFC, hydrofluorocarbons; PFC, perfluorocarbons

Intergovernmental Panel on Climate Change as potent greenhouse gases (GHGs) with long atmospheric lifetimes and are part of the basket of six gases included in the Kyoto Protocol to the United Nations Framework Convention on Climate Change. Emissions of SF_6, HFCs and PFCs currently represent less than 3% of total greenhouse gas emissions. Emissions of HFCs and PFCs from fire protection are estimated at less than 1% of total HFC and PFC emissions from all sources. Nevertheless, because of their significant atmospheric impacts once released, careful management of these gases is an essential component of U.S. climate protection and stratospheric ozone goals.

The U.S. fire protection industry fully supports the goal of minimizing non-fire emissions of fire protection agents, and is committed to continuing to contribute to both ozone layer and climate change protection. The overriding concern of the fire protection industry, however, is the reduction of risk to people and property from the threat of fire through the use of products and systems proven to be effective. With the aim of ensuring that both of these goals are achieved, the fire protection industry has developed a voluntary code of practice that is intended to focus the industry's efforts on minimizing emissions of HFC and PFC fire protection agents. The Voluntary Code of Practice for the Reduction of Emissions of HFC & PFC Fire Protection Agents (VCOP) is a partnership of the U.S. Environmental Protection Agency (EPA), Fire Equipment Manufacturers Association (FEMA), Fire Suppression Systems Association (FSSA), Halon Alternatives Research Corporation (HARC) and National Association of Fire Equipment Distributors (NAFED).

Accurate, credible record keeping and reporting is central to meeting the goals of the Voluntary Code of Practice[2] (VCOP). Successful implementation of the elements of the VCOP must necessarily rely on a verifiable baseline of HFC emissions. The HFC Emissions Estimating Program (HEEP), described in more detail below, provides a format to help industry minimize emissions by setting benchmarks, by providing the incentives to make improvements to current standards and practices, by documenting the industry's commitment to safety and responsible use, and by providing data to support these substitutes for halon systems.

HEEP – Development of a consensus data gathering process. The HEEP concept arose from discussions within HARC in early 2001 as a logical outcome of the process of developing the VCOP which at the time had been a work-in-progress for about two years. The basic notion was that data on emissions of HFCs and PFCs from fire protection systems would serve as an important measure for the fire protection industry to gauge success in reducing non-fire discharges or other emissions of these chemicals. There were several challenges.
The HEEP program methodology would have to be acceptable to industry with regard to guarding confidential business information. The type of data required had to be readily and universally available to the participating companies. Administration of the program had to be simple and inexpensive. The results had to be meaningful. Funding needed to be found to cover the administrative expenses.

In order to obtain consensus support form the fire protection industry a presentation was made to the Board of Directors of FSSA in June of 2001. The FSSA endorsed the HEEP concept and charged the FSSA Technical Committee to provide support. An FSSA technical working group (WG) of six was

[2] The VCOP was announced at a press briefing jointly by (Stephen Summerill of Kidde representing the fire protection industry) and Jeff Cohen (representing the EPA) at the Earth Technologies Forum on March 25, 2002.

formed to consider and develop a preliminary structure for the HEEP program. The WG represented four fire protection systems manufacturers and two systems installers. The outcome of the WG effort was a proposal that a meaningful metric representing emissions of HFC and PFC agents was the amount sold for the purposes of recharging fire extinguishing system cylinders. Two basic assumptions underpinned this approach. First, agent sold for recharge of cylinders was assumed to be replacing agent that had been discharged or otherwise emitted. Second, the HFC and PFC agents are costly and, as such, it was deemed unlikely that system cylinders removed from service (decommissioned) would be vented but would most likely be sold to an agent recycler.

Data on agent sales was certainly on file in the databases at each level of the business - agent manufacturers, fire suppression systems manufacturers, and systems distributors / installers. The number of agent and systems manufacturers is small (fewer than 10) but the number of distributor / installers is large (hundreds). A successful program had to reduce the number of data collection points to a manageable level. Additionally, the data collection process had to be able differentiate between agent installed in OEM equipment on a first-fill basis and that sold for the purposes of refilling discharged equipment.

Three features of the agent sales process were important in arriving at the data collection plan adopted. First agent manufacturers have simplified their sales management process by selling, with some exceptions, to a small number of OEM systems manufacturers. Systems manufacturers fill new equipment, may provide refill services, and sell agent to distributors who primarily provide refill services but may also do first fill on OEM equipment. Second, the HEEP data collection process needed to track only sales of agent used for refill purposes. Thus a simple classification of agent users is helpful:

Business Type	Agent Sales Activities
A.	**Agent manufacturer** that sells only to OEM systems manufacturers
B.	Case (A) and also sells to parties that only do refill
C.	**Systems manufacturer** that only fills OEM cylinders
D.	Case (C) and also refills discharged cylinders
E.	Case (C or D) and sells agent to distributors who do refill
F.	Case (C, D, or E) and sells agent to distributors who do both refill and 1st Fill of OEM cylinders
G.	**Distributor** that only performs refill services
H.	Case (G) that also performs first fill on OEM equipment.

Reporting companies need only be those that meet the following criteria:
1. Sells agent to another company that in turn performs refill only.
2. Performs first fill and refill operations

Based on these criteria the classification of "reporting parties" would be as follows:

Business Type	Reporting Party	Agent Reported
A.	No	
B.	Yes	Sold for refill only
C.	No	
D.	Yes	Used for refill
E.	Yes	Used for refill and sold to refill-only distributors
F.	Yes	Used for refill and sold to refill-only distributors but not to "First Fill" distributors
G.	No	
H.	Yes	Used for refill

The number of companies representing potential Reporting Parties is small.

Third, businesses use databases to keep track of agent sales. Inquiries indicated that businesses generally employ several agent part numbers depending on where it was used. One part number is used for agent allocated their production departments that filled OEM cylinders. Agent sold to the in-house service department (for refill of returned cylinders) is assigned a different part number. Agent sold to a manufacturer's distributor, often drop-shipped from the agent manufacturer, is handled on yet one or more different part numbers. Agent sales databases, therefore, contained internal accounting tags that allowed a simple basis of sorting first-fill from recharge agent.

The FSSA working group approved the data gathering model and aided in developing a list of companies to whom an letter could be sent explaining the HEEP program and the value of participation. An important remaining issue was assuring confidentiality of business data supplied by Reporting Parties.

In order to assure the confidentiality business data the it was proposed that an Independent Third Party (ITP) be employed to receive data, convert the raw numbers and combine into a single measure of industry emission of GHGs expressed as an equivalent quantity of carbon dioxide.

Additionally, in order to keep the HEEP process free of bias the administration and publishing of HEEP data should be by a respected independent agent. HARC, as an industry trade association, is both a respected and fair representative of the industry and was asked to take on this role. Thus, the ITP would make its report to HARC who would then publish it broadly.

To summarize, the essential elements of the HEEP are as follows:

- "Emission" for the purposes of the HEEP is defined as the quantity of agent sold for the purpose of "recharge" of fire suppression containers. This approach is deemed reasonable as recharge is only required after agent has been discharged, emitted, from equipment.
- Collection and submission of data from reporting parties in industry that are in a position to make relevant measurement.

- Not all fire equipment companies need to be reporting parties in order for data collection to be substantially complete. Only the following need be reporting parties:
  - Equipment manufacturers or distributors that perform 1st Fill of original equipment and also recharge equipment.
  - Agent suppliers or equipment manufacturers that sell to distributors that only perform recharge.
- Distributors who recharge cylinders but do not fill original equipment – most distributors – do not need to report as their agent use would be reported by their supplier.
- An independent 3rd Party will collect industry reports of emissions by agent type, convert the values to equivalent emissions of carbon dioxide, and report only aggregate results annually back to industry through its trade association, HARC.

Data Collection. In August 2002 a survey was distributed to a list of companies previously identified as possible reporting parties and to the members of FEMA, FSSA, HARC, and NAFED. The purpose of the survey was to identify all of the companies in the U.S. that were likely to be HEEP reporting parties based on the criteria outlined above. By distributing the survey to the members of the four major fire protection associations, it was felt that all of the appropriate companies would be reached. Based on the response to the survey and additional input from industry experts, a final list of 24 reporting parties was identified.

In March 2003 and June 2004, a guidance letter and data collection form were sent to the 24 reporting parties asking for pounds of HFC/PFC fire protection agents sold for recharge in 2002 and 2003, respectively. A list of the agents for which data was requested along with the global warming potentials (GWPs) used to calculate carbon dioxide (CO2) equivalence for each agent are shown below.

Table 1
HFCs and PFCs Used in Fire Extinguishing Products

Agent	Chemical Formula	GWP IPCC 1996	Fire Extinguishing System Type	
			Fixed Systems Total Flooding	Portable Units Streaming
HFC 23	CHF_3	11,700	X	
PFC 14	CF_4	6,500		X
HFC 125	C_2HF_5	2,800	X	
HFC 134a	$C_2H_2F_4$	1,300	X	
HFC 227ea	CF_3-CHF-CF_3	2,900	X	X
HFC 236fa	CF_3-CH_2-CF_3	6,300	X	X
PFC 3-1-10	C_4F_{10}	7,000	X	

Results

2002. Data for 2002 sales of agent used for refill purposes was reported by 22 of the 24 companies originally identified as reporting parties. Data was reported for five gases: HFC-23, HFC-125, HFC-236fa, HFC-227ea, and PFC 3-1-10. The total amount reported for each gas type was multiplied by

its GWP thereby converting the actual gas quantity to an equivalent amount of CO_2. The CO_2 equivalents for the several gases agent were then combined to obtain an industry wide emission expressed as en equivalent CO_2 emission.

Based on the results of final HEEP reporting, 1,165,818,500 pounds, 0.529 million metric tons - MMT, of CO_2 equivalent emissions of the above 5 agents were sold for recharge in the United States in 2002 by the 22 reporting companies. The traditional reporting format for greenhouse gases is in the units of million metric tons of carbon equivalent (MMTCE). The MMTCE emission is equal to 0.273 times metric ton equivalent of CO_2. The 2002 industry emission, therefore, was 0.144 MMTCE.

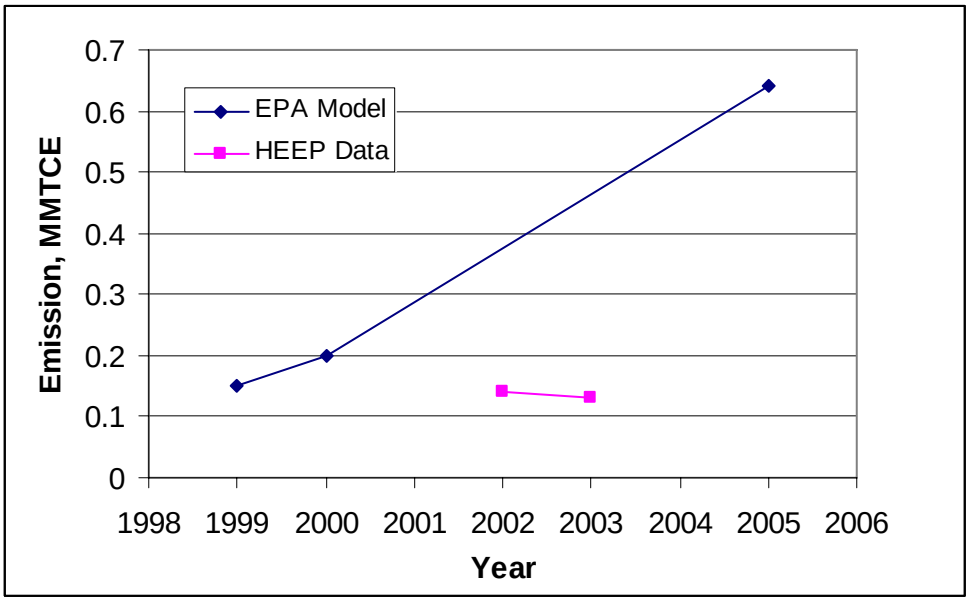
2003. Industry data for 2003 was reported by 18 of the 22 companies that reported data for 2002. Data was reported for the same five gases: HFC-23, HFC-125, HFC-236fa, HFC-227ea, and PFC 3-1-10. Based on the results of HEEP reporting process 1,075,252,400 pounds, 0.488 MMT, of CO_2 equivalent industry emissions in the United States was reported for 2003 by the 18 reporting companies, or 0.133 MMTCE.

Discussion of Results.

Industry response to HEEP. The overall response of those deemed to be potential "reporting parties" has to be viewed as very good. In the first year 22 of the 24 companies contacted, or 91.6%, voluntarily reported HFC sales data. The two companies that did not participate are believed to represent relatively small HFC sales for recharge use. Thus, the response is believed to be significantly greater than 92% on the basis of agent sold for recharge use.

Industry emission level. It is useful to put some perspective on the reported emission numbers. First, the reported emissions can be compared to estimates of emissions of HFC/PFC for fire protection and non-fire protection uses and based on modeling. The EPA vintaging model is a source for estimating emissions of greenhouse gases used as substitutes for ozone depleting substances. It tracks chemical consumption and emissions by making detailed calculations in over 40 end-uses of the quantity of equipment or products sold, serviced, and retired each year, what chemical(s) are being used, and the amount of chemical required to manufacture and/or maintain the equipment.

EPA model estimates of emissions of HFCs/PFCs for fire protection are 0.15 MMTCE in 1999, 0.20 MMTCE in 2000, and 0.64 MMTCE in 2005. This compares with reported emissions of the order of 0.14 MMTCE in 2002. Thus, the estimated emissions of HFC/PFC chemicals exceed apparent actual values by a factor of about 2.5 to 3. This suggests that in the case of the fire protection industry the emissions model is overestimating agent leakage.



EPA estimates of HFC/PFC emissions for other applications for 1999 are as follows: 11.0 MMTCE from refrigeration and air conditioning, 8.3 MMTCE from HCFC-22 production, 2.7 MMTCE from aluminum smelting, and 2.1 MMTCE from solvent cleaning. The total 1999 estimated emissions from these four categories of uses is 24.1 MMTCE, or 160 times the estimated emissions for fire protection uses.

Rationalizing results of uneven reporting. In order to better compare the 2002 and 2003 data sets it is necessary to make an adjustment data to account for the difference in the number of companies that reported in 2002 and 2003, 22 vs. 18. The amount of emissions reported in 2002 by the four companies that did not report in 2003 is 126,886,600 pounds of CO2 equivalent emissions, or 0.0157 MMTCE. If this amount is subtracted from the originally reported 2002 data then the result is directly comparable to the total emissions reported for 2003.

Year	Emissions As Reported, lb	Emissions As Reported, MMTCE	Emissions on 2003 basis MMTCE	% Change from 2002
2002	1,165,818,500	0.144	0.128	-
2003	1.075,252,400	0.133	0.133	+3.7%

Interpretation. Taken at face value, there was a modest increase in HFC/PFC emissions over a one year period.

In setting up this program the hope was that over time emissions of HFCs and PFCs from fire protection uses would decrease with the implementation by the industry of the Voluntary Code of Practice. But something that needs to be considered as data from subsequent years is collected and analyzed is that there is no adjustment being made from year to year for the increase in the size of the bank of HFCs and PFCs. As more and more extinguishers and systems are put in service, overall

emissions would be expected to increase even if the emission rate stays the same. Depending on the number of new extinguishers and systems that are added to the bank each year, it may be that overall emissions might increase even if a small decrease in emission rate has occurred.

Another consideration when analyzing this data is that the mix of agents that are being sold for fire protection is changing. Because the data for each agent is multiplied by its GWP and the GWP of each of these agents is different, the total number of pounds of all agents that are released could decrease but the total CO2 equivalent emissions could increase if more agents with higher GWPs are being emitted than in previous years.

Thus, for several reasons it is difficult to tell, based on data for only two reporting years, what the year-on-year change means over the long term.

Next steps. The HEEP process has had a successful beginning. Emissions data for 2004 is being collected and processed but is not yet finalized. A request for 2005 data will be made shortly by HARC. In order for the HEEP process to yield significant value it will be necessary for the participating parties to continue to support data measurement and reporting for several years. As with many initiatives, an initially high level of enthusiasm often flags with time resulting in extra effort to keep participants actively engaged.

Value of HEEP. HEEP was set up as an outgrowth of the fire protection industry's Voluntary Code of Practice. The goal was to provide a measure of whether emissions of HFC/PFC agents are being effectively controlled and limited. Its value to that end remains to be determined pending collection and validation of additional data.

An additional value of HEEP is to serve as a model for self monitoring for other applications sectors. Both the small relative size and operational structure of the fire protection industry lent itself well to creating a simple measurement and reporting structure. Other industry segments will have different operating strategies that need to be understood in order to devise an emissions model.

Conclusions. In response to the needs of the fire protection industry's Voluntary Code of Practice on the emissions of HFCs and PFS a measuring tool was devised to allow the industry to use built in business operating features to easily measure and report sales of HFC and PFC agents that are used for the purpose of refilling discharged product containers. Such sales are a one-for-one measure of emissions of these chemicals. Thus born the HFC Emissions Estimating program, or HEEP, has been used to collect data on HFC and PFC emissions for 2002 and 2004. Data collection is ongoing for 2004 and soon for 2005. Conclusions on emissions trends from the initial data are limited but initial indications are that emission rates are effectively constant over the two year period. The precision of the HEEP annual measurement is unknown and year-on-year variability in the emission measurement remains to be determined.