

HFC containment has already failed

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1 Summary: HFC containment has already failed

Since the late 1980s the refrigeration and air-conditioning (RAC) industry has instituted a policy of *containment* in response to concerns over ozone depletion and global warming. Its main aim was to prevent leakage of hydrofluorocarbons (HFCs) from RAC systems; this was to be achieved through both design and operational measures.

Containment was to have reduced leak rates massively – by half or even more – during the 1990s and the early ‘00s in both North America and Europe. This has been claimed again and again over the past ten years by the RAC industry, both beforehand as predictions and afterwards as estimates. The UK government has supported these claims since at least 1995. In 2002 the government reported massive leak-rate declines to the UNFCCC, and in July 2003 it published a compendium of containment reductions.

However, containment of HFCs has not occurred. Research published in February 2003 by the fluorocarbons industry completely refutes the claims of containment as applied to HFC-134a, which accounts for about two-thirds of all HFCs in use. The study’s results, which have been verified by atmospheric monitoring agencies, show that leak rates of HFC-134a over the period 1990-2000 are the same as they were for its predecessor, CFC-12, in the mid-1980s.

This remarkable finding of containment’s failure appears not to have been noticed by the European Climate Change Programme (perhaps because it was first published just as most of the ECCP’s deliberations were winding up). Then again, most previous criticisms of containment – which have been made for years now – have been ignored as well.

For this paper we have independently reviewed the fluorocarbon industry’s research by conducting a similar exercise, i.e. testing both ‘non-containment’ and ‘containment’ leak rates against an HFC-134a market model. In our work, the fit of the data strongly suggest the validity of the ‘non-containment’ leak rates, thereby lending support to the fluorocarbon industry’s finding.

These findings of containment’s failure should be particularly useful in the current debate over regulation of HFCs.

2 Introduction

Refrigerant fluids traditionally were viewed as consumables [1], but since chlorofluorocarbons (CFCs) were linked to stratospheric ozone depletion, this attitude has changed. For CFCs and halons, the policy answer was to ban production and most uses under the Montreal Protocol [2]. Hydrochlorofluorocarbons (HCFCs) have also been banned, on a slower schedule.

For hydrofluorocarbons (HFCs) in refrigeration and air-conditioning (RAC), however, a policy has been instituted of *containment*. As the word suggests, its main aim is to prevent fluid leakage from RAC systems; this is to be achieved through both design and operational measures.

Containment as policy has been much debated, most recently under the auspices of the European Climate Change Programme [3]. Proponents in industry and government [for example, 4] contend that containment already has cut refrigerant leakage substantially. Others, including this author [for instance, 5], argue that leak-rate reductions have been overstated and under-verified.

This latter view was confirmed in 2003 by fluorocarbon producers themselves [6]. Their research showed that ‘emission functions’^A derived in the mid-1980s for CFC-12 [7] “adequately describe the relationship between the quantities in use, the atmospheric lifetime...[of] 14.6 years and the extent of release into the atmosphere” of HFC-134a. “The relative rate of loss has remained similar” for CFC-12 and HFC-134a.

The findings of the fluorocarbon producers tie up well with atmospheric monitoring studies [6, 8, 9], which show that atmospheric concentrations of HFC-134a have soared [10, 11]. Not surprisingly, related research also shows that HFC-134a leaks are under-reported to the UNFCCC [12].

In other words, leak rates have not been reduced. Containment has failed. .

For this paper, we have tested the ‘non-containment’ leak-rates reported in [6] against an HFC-134a market model that was developed from public information. We have also tested ‘containment’ leak-rates. We conclude that the former leak-rates describe the market much more accurately than do the latter ones. Put more precisely, if a 25%-30% MAC operating leak rate is assumed, the data fit is good. At the 15%-10% rates presumed under containment, the fit is poor.

This analysis is presented in three sections:

- The promise of containment and its rebuttal
- Was HFC-134a contained as claimed?
- The failure of containment, and a look to the future

3 The promise of containment and its refutation

The idea of containing fluorocarbons (as opposed to banning them) dates back to at least the early 1990s [13, 14]. Today, containment is no longer just something of the future. It is claimed to have delivered major leak-reductions already in the 1990s.

Critics have for years disputed both the predictions and estimates of containment. In 2003 the fluorocarbons industry supported this case by refuting thoroughly containment estimates for HFC-134a. This refutation appears not to have been noticed by the European Climate Change Programme; we find no mention of it as of mid-February 2004 [3].

3.1 Predictions and historic estimates of containment

There have been many predictions and historic estimates of containment. We present a sample of those here (Table 3-1) just to show this very well known concept, not to document it exhaustively.

^A —

Containment is meant to have happened already, starting in the early-mid 1990s. For instance in the MAC sector, in 1999 an air-conditioning manufacturer reported that “reasonable emission reduction options have been provided to optimize both current HFC-134a systems and the capability of the service industry to minimize loss of refrigerant to the atmosphere. Most, if not all, options presented are currently being implemented by A/C system suppliers.” The manufacturer further said that then-current estimates of 8-10% leak rates “may overestimate actual emissions.” [15]

Table 3-1: Predictions and historic estimates of containment

Emission source	Operating leak trend*	Time frame	Location	Date of Prediction /Estimate	Predictor	Reference
Chillers	9%-3% pa	1980's-2002	USA	Jan-02	FC industry (EPEE)	16
MAC	35%-12% pa	1980's-2002	USA	Jan-02	FC industry (EPEE)	16
Supermarket	35%-15% pa	1980's-2002	USA	Jan-02	FC industry (EPEE)	16
Unit A/C	10%-5% pa	1980's-2002	USA	Jan-02	FC industry (EPEE)	16
Supermarket	30%-17% pa	1995-2000	UK	1995	RAC industry and UK Dept of Environment	17
MAC	15%-10% pa	1995-2000	UK	Jul-03	RAC industry and UK Dept of Environment	4
MAC	15%-6% pa	1995-2020	UK	Jul-03	RAC industry and UK Dept of Environment	4
MAC	8-10% to 4-5% pa	1998-future	USA	1999	RAC Industry	15
MAC	30%-10.5% pa	pre 1993-post 1993	Global	1999	RAC Industry	18

*Leak as percent of installed capacity

Also in 1999 a refrigerant producer noted that his estimated reduction in leaks from 30% to 10.5% pa occurred as part of the conversion from CFC-12 to HFC-134a MAC systems in 1993-94. “The conversion from R12 to R134a systems was accompanied by significant system improvements concerning hose permeability, hose couplings, fittings, service valves, compressor shaft sealings and charge reduction in order to reduce refrigerant losses during operation and service.” [18]

Clearly, containment of MAC emissions was said to have occurred in the world’s three centres of automobile manufacturing: North America, Western Europe and Japan. Especially in this sector, containment was said to be global. [4, 15,19]

3.2 Refutation of containment claims

The most powerful refutation of containment (such as expressed in Table 3-1) comes from peer-reviewed research done on behalf of fluorocarbons producers [6], which found that the observable leak rates of HFC-134a are similar to those for CFC-12 of some 30 years ago [7]. For non-hermetic refrigeration this averages 25% a year; for hermetic applications it averages just above 8% pa. The authors [6] note that their finding disproves containment: “This would seem to ignore the technical developments that have been made in the design of systems.”

This refutation was extraordinarily powerful, because it comes from the fluorocarbon industry^B. This industry has a clear interest in promoting containment over, say, bans, and it traditionally has claimed that containment works and is working (Table 3-1).

Powerful as it is, this was not the first rebuttal. For years the claims of containment have been disputed [for instance, 5]. In 2003 the critics won a round: a dispute over MAC leak rates concluded with the EU raising its estimates 40% above previous estimates by the ECCP working group [20].

However, this author's experience is that many regulators routinely accept containment estimates, even though "real measurements actually proving the lowered refrigerant emission rates are not available" [21], while at the same time simply dismissing criticisms^C. For instance in 1999 the UK government [22] stated: "New [fire extinguishing] systems can be expected to have average annual emission rates in the range of 1% to 3% of system charge." Even after it was pointed out in consultation that this range goes below that required to extinguish fires, the estimate was not changed.

4 Was HFC-134a contained as claimed?

Whichever leak rates prevailed in the 1990s – either 'containment' ones of Table 3-1 or 'non-containment' ones [6, 7] – these should have been reflected in HFC markets. An inspection of market data, therefore, should suggest what leak rate levels actually were.

Of course this inspection is just what the authors of [6] did. For this paper we have independently reviewed their work using public data, and we come to the same conclusion: HFC-134a leak rates did not decline as was claimed. The following three subsections explain our review.

4.1 HFC-134a is the best 'marker' for containment

Ideally, containment could be proved or disproved by a market-analysis of all HFCs produced in commercial quantities. Unfortunately, market data available publicly is too sparse to allow this for most of the HFCs^D.

Fortunately, this analysis is possible for HFC-134a. This, plus three other reasons make it a 'marker' for containment:

- HFC-134a is the predominant HFC, accounting for about two-thirds of all HFCs in use [23],
- About two-thirds of HFC-134a consumption is in the MAC sector [23, 24], which can be modelled independently and has claimed major leak-reductions (Table 3-1) on a global basis,
- Audited global production statistics for HFC-134a are available publicly from AFEAS [25], a group convened by the fluorocarbons industry.

^B One or more of the authors of [6] are authors or co-authors of 12 of the 13 references on fluorocarbon emissions cited by AFEAS at http://www.afeas.org/production_and_sales.html. Two of the three authors previously were employed by fluorocarbons manufacturers.

^C Like the fluorocarbon industry, some governments have an interest in believing in containment. Containment makes it easier for them to claim that they have achieved emission-reduction targets.

^D ...

4.2 How we modelled the HFC-134a market

The global HFC-134a market (all applications) was modelled from 1992-2001 using data independent from leak-rates (Table 4-1) with one exception: the refill of MAC units, which of course depends on leakage.

Table 4-1: Main inputs to the HFC-134a market model

Input	Sources
Light vehicle sales	[26, 27]
A/C installed	[26, 28]
Average HFC-134a A/C charge	[4]
Production/sales of HFC-134a	[23, 25]
HFC-134a consumption in:	
RAC	[23]
Aerosol/solvent	[23]
Foam blowing	[23]

Two basic scenarios were applied for leak rates:

- ‘Containment’ operating leak rates – these decline from 15% pa in 1995 to 10% in 2000, as estimated by the UK government in 2003 [4].
- ‘Non-containment’ operating leak rates – this is 25% pa [7].

In both scenarios it was assumed that MAC leakage starts in the calendar year after installation.

4.3 Market model points to ‘non-containment’ leak rates in two ways

The market model conforms to the ‘non-containment’ leak scenarios much better than to the ‘containment’ leak scenarios in two ways: calculated consumptions match reported ones more closely; and so do calculated emissions.

Consumption fits are twofold:

- With ‘non-containment’ leak rates, the market model comes within 4% and 5%, respectively in 1996 and 1999, of HFC-134a production reported by AFEAS [25]. With ‘containment’ leak rates, the market model is off by 14% and 23%, respectively. Interpolation and extrapolation of the detailed data generates similar results for the years 1997, 1998, 2000 and 2001.
- With ‘non-containment’ leak rates, the model calculates the North American refill market for HFC-134a in 1999 at 40 million lbs, which correlates well to an estimate made early that year of 45-50 million lbs [29]. With containment leak rates, the model calculates the North American refill market for HFC-134a in 1999 at less than 20 million lbs.

The market model was then inverted to estimate emissions. MAC emissions were simply equal to refill rates, and all other emission rates were set at levels reported by the fluorocarbons industry [6, 7]. Using the ‘non-containment’ scenario, the market model comes within 9% and 3%, respectively in 1996 and 1999, of HFC-134a production reported by AFEAS [25]. With ‘containment’ leak rates, the market model is off by 34% and 32%, respectively. Again, interpolation and extrapolation of the detailed data would generate similar results for the years 1997, 1998, 2000 and 2001.

To double-check we also ran the market model at 30% pa MAC leak rates, which are implied in [6]. The data-fit was slightly better than at 25% leak rates.

5 The failure of containment, and a look to the future

Clearly, HFC containment has failed, and this after so much promotion for many years. This is of particular importance if, as projected by a recent study [30], global HFC demand increases to 600 kilotonnes pa by 2007. This is about 3 times the market size in 2001.

Most importantly, this paper calls into question the use of containment as a policy tool for controlling HFC emissions.

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