Save Article Instructions

Close

Manual Fridge Recycling Could be 100 X More Damaging to the Environment

London
8 February 2011

Manually stripping ozone-depleting substances from refrigeration equipment results in an unacceptable release of CFCs, about 100 times greater than emissions when encapsulated shredders are used, finds recent research by the Öko-Institut.

In response to global climate protection initiatives many countries are setting up or planning to establish take-back schemes for end-of-life refrigeration equipment containing ozone-depleting substances (ODS).

But one key issue raised by these initiatives is how to extract the ODS-containing insulating foam material from the refrigerator itself, and then how to separate the chlorofluorocarbons (CFCs) from that foam.

The two options are foam extraction and foam degassing within an encapsulated airtight processing facility, or manual dismantling of the appliance and removal of the foam by hand.

Manual dismantling and foam stripping was adopted in Europe at the end of the 1980s. Indeed, if initial investment costs had remained the sole determiner in the European fridge recycling sector, the plants and processes in use at the end of the 1980s would probably still be operating today.

But there was a radical change in the fridge recycling landscape in the early 1990s leading to the introduction of hermetically sealed recycling procedures.

Manual stripping vs sealed procedures

From a purely economic point of view, manual foam stripping would seem to be the method of choice. As the investments required for manual disassembly of waste fridges are not excessive, if labour costs also happen to be low, then manual disassembly of the waste appliances would initially seem to be the cheapest and easiest option.

The environmental impact of manual fridge dismantling has only recently undergone scientific study. German environmental research organisation Öko-Institut e.V. has now investigated the topic in its recently published 'Study of the ozone depletion and global warming potentials associated with fridge recycling operations that involve the manual stripping of polyurethane insulation foam'.

Current state-of-the-art recycling of waste refrigeration appliances involves treatment in fully encapsulated plants, in which the appliances are broken apart and shredded, the secondary raw materials are individually recovered, and harmful components or substances are separated for disposal or destruction, according to the study.

If recycling is carried out in accordance with the RAL quality assurance specifications (RAL GZ-728 Quality Assurance and Test Specifications), more than 90% of the particularly harmful CFCs are separated and safely destroyed.

But some countries that are considering the introduction of a systematic fridge recycling scheme have proposed dispensing with such fully mechanised treatment. Under this approach, refrigerant would first be removed from the cooling circuit of the waste appliance, which would then be manually disassembled, with insulating foam stripped out and then incinerated or treated in a special degassing facility in which the CFCs are extracted and liquefied.

But the Öko-Institut points out that no detailed plans or practical implementations of this processing channel exist at present.

Working on behalf of the RAL Quality Assurance Association for the Demanufacture of Refrigeration Equipment, Öko-Institut e.V produced a Life Cycle Assessment (LCA) study in 2007 to calculate and evaluate the relatively low levels of CFC emissions associated with state-of-the-art fridge recycling.

The 2007 study found that state-of-the-art processing resulted in CFC emissions of about 0.45g per appliance (expressed in R11 equivalents) for an average refrigeration appliance (An average unit weighed 40 kg under the study and 80% of its sample units were CFC-containing.)

The main source of emissions was identified as the residual CFC still trapped in the degassed polyurethane (PU) foam, which was partially released when the foam was subjected to further processing.

Investigating manual disassembly

In its latest study, the Öko-Institut determined the average emissions associated with the manual disassembly of refrigeration appliances solely during the manual dismantling phase.

The tests were carried out at a recycling centre operated by GAB mbH in Limburg, Austria. The manual dismantling of the appliances was carried out by trained GAB personnel, while weighing and data recording was done by Öko-Institut staff.

The initial steps of the manual dismantling work were carried out, as is the case in the USA, using professional power tools, such as a high-quality electric all-purpose saw that can easily cut through the metal and plastic cabinets. Special lever irons and crow bars were also used. A special tool was used to scrape off the PU foam. Tools that would have produced significant quantities of dust, such as angle grinders, were not deployed.

But the authors of the study question whether, when carried out as a part of commercial recycling activities, manual dismantling can be conducted as cleanly as was possible in the 'model environment' offered at GAB.

Around 20 refrigeration units of varying sizes were supplied by GAB, and subjected to stage I processing (vacuum extraction/removal of the CFC and the compressor oil from the cooling circuit and removal of any glass, capacitors, mercury switches, compressors, covers and any loose plastic parts).

The doors were unscrewed and removed. The subsequent tests were carried out on these empty appliance cabinets and their separated doors.

Only units that had PU foam insulation in both the cabinet and the door were used for testing purposes, any units containing polystyrene were not. This left nine units for testing. The cabinets and the doors were dismantled and stripped of their foam. The dismantling process yielded three fractions: a metal and plastics fraction with some residual PU foam still attached; large coarse chunks of PU foam; and a fine fraction made up of metal and plastic chippings.

Each fraction was weighed. The residual foam sticking to the units was then removed using a bevel-edged chisel, and the scrapings weighed. The PU foam fractions removed from seven of the nine appliances were stored in open sacks and weighed for a second time after 24 hours, and four of the sacks weighed for a third time after two weeks.

The resulting data was analysed to determine how much CFC escapes into the atmosphere when PU insulating foam is manually stripped; how much CFC remains in the adhered residue; and how much CFC is lost during the subsequent storage of the PU fraction.

For the purposes of the analysis, the average mass of CFC in the PU foam was assumed to be 8.5% for all appliances, and that any loss of mass arose solely from the CFC degassing into the atmosphere.

Study results

When the results from both the cabinets and the doors are combined, the average mass of the appliance carcasses tested was 23.7kg. The lightest carcass had a mass of 13.8kg, while the heaviest weighed 41.4kg. The appliance carcasses tested contained between 1.9kg and 13.3kg of PU foam; the average amount was 5.1kg of PU foam per carcass.

The calculated total amount of CFC R11 originally present in the appliances prior to testing ranged from 160g to 1134g per carcass, with a mean average value of 432 g.

The Öko-Institut concluded that CFC losses from manual foam stripping of the carcasses - cabinets plus doors - were between 18g and 232g, with an average value of 88 g.

Between 7g and 19g of CFC were lost - an average of 11 per carcass - through CFC still present in the residual PU foam adhering to the dismantled appliance carcass.

The total loss of CFC per carcass during manual dismantling (including CFC retained in adhered PU foam residues) ranged from 25g to 245g with the average value being 98.6g per appliance carcass.

These figures correspond to%age losses of between 16% and 30%, with an average of 23%. On average, the manual foam stripping process is responsible for about 89% of total CFC losses.

In analysing the results, the authors of the study considered several sources of possible error:

- It is conceivable that the PU foam takes up moisture from the air during testing
- It is conceivable that the PU foam released moisture to the air during testing
- The original CFC content in the PU foam, which was assumed to be 8.5%, is not constant for all CFC-blown foams and can vary within a range that cannot be defined exactly
- The CFC of the residual foam adhering to the carcass was estimated to be 50% of the foam's original CFC content;
- The linearity of the weighing equipment was plus/minus 5g
- A further source of test data uncertainty can arise from the loss of fine dust-like abraded material or from the input of dust from the surrounding work environment. The amount of fine material swept up and collected after manually stripping foam from the cabinets was between 5 g and 77 g, with an average value of 28g. A further 12g was collected by re-sweeping the floor area after completing all tests on the first day of testing.

'No alternative' to encapsulated shredding

To allow for a fair comparison with the results it obtained in its 2007 study into state-of-the-art fridge recycling, the Öko-Institut took only the results from the six smaller units tested in this study.

Results from the earlier study were also adjusted to compensate for the study's input mix of 80% of refrigeration units containing CFC, and 20% without.
The 2007 LCA's average CFC emission level of 0.45 g (expressed as R11 equivalents) for a refrigeration unit recycled in a state-of-the-art facility conforming to the RAL quality standard was revised to 0.54 g for a fair comparison.

According to the study, the manual dismantling of the six smaller appliances produced average emissions of 55g of CFC per appliance - about 100 times greater than the emissions expected if the appliance had been treated in a state-of-the-art fridge recycling plant. The ODS losses associated with manual stripping average 1.1 tonnes CO2 per fridge.

"The ODS emissions identified in the tests and the ozone depletion and global warming potential of these emissions lead us to conclude that manual dismantling of ODS containing refrigeration appliances to recover PU insulating foams cannot be recommended," reads the report's summary of its findings.

"In our view, there is no alternative but to shred the entire appliance carcasses (cabinet + door) in encapsulated shredders."

To access this Article, go to:
http://www.waste-management-world.com/wmw/en-us/index/display/article-display.articles.waste-management-world.recycling.2011.02.Manual_Fridge_Recycling_Could_be_100_X_More_Damaging_to_the_Environment.htmlhtml