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Norwegian fridge recycling put to the test: Hvitevareretur commissions RAL to audit all plants in Norway

As waste refrigerators and freezers often contain climatically harmful chlorofluorocarbons (CFCs), they are unique among recyclable end-of-life electrical goods. In 1997 Norway was one of the first countries in Europe to introduce a nationwide system for collecting waste refrigeration equipment via local and municipal waste collection facilities. Two years ago, working in collaboration with Norwegian local authorities, the national Norwegian take-back-and-treat initiative for white goods *Hvitevareretur* extended and developed the collection system into a scheme that, in the opinion of many experts, can act as a model for WEEE implementation throughout the EU. The waste refrigerator and freezer appliances are sent to three recycling companies that are under contract to *Hvitevareretur*. The recycling plants operated by these companies all differ in terms of their engineering principles and design. In June, the RAL Quality Assurance Association for the Demanufacture of Refrigeration Equipment Containing CFCs was awarded a contract to test and assess the entire collection system and the efficiency of the recycling technology being used in Norway. The results are now available and are currently being discussed with the parties involved.

The test procedure was agreed between RAL and *Hvitevareretur* and involved testing not only the recycling plants themselves, but also the entire waste handling infrastructure including the reception of end-of-life appliances at the collection sites, collection logistics, interim storage of waste appliances at the recycling plant sites, and the general handling of these easily damaged goods.

The test procedure and the results can be summarized as follows:

A. Collection and transport of waste refrigeration equipment:

The collection system in Norway for white goods comprises a network of about 4000 collection sites. Waste refrigerators and other white goods can be taken to civic amenity sites run by local and municipal authorities, or can be returned to retail outlets where larger electrical appliances are sold. No charge is made for these services. Other waste electrical equipment can also be returned to these sites for recycling. As auditing all the sites within Norway's very extensive collection network would have been beyond the scope of the test, a total of thirty local-authority and retail-trade collection sites were sampled at random. This ensured that the test's objective of achieving a representative assessment of the quality of the collection infrastructure and of the way in which end-of-life fridges and freezers are handled at these locations could be met. As part of its audit, RAL paid close attention to the technical equipment and facilities available at the collection sites, the visual impression made by the sites, and other important features such as opening hours, availability of oil binders, and the way in which waste appliances were stored and handled.

The RAL Quality Assurance Association sees the geographical density of the collection sites in Norway as both unique and exemplary in Europe. According to Christoph Becker, Secretary to the RAL Quality Assurance Association, who was in Norway for the tests: '*Hvitevareretur has created a highly effective infrastructure that serves local communities well and that can be regarded as a real role model in this area. The RAL Quality Assurance Association welcomes the fact that retailers have been incorporated into the take-back scheme, as this ensures a high level of collection efficiency.'*

However, despite an ideal underlying infrastructure, the RAL tests showed that there was room for improvement at many of the collection sites. *'When one considers that some appliances, and therefore some of the cooling circuits, are over 25 years old and severely rusted, it is clear that these appliances are highly susceptible to damage. It is therefore all the more important that everyone involved in the processing chain – from the private household to the treatment plant – exercises extreme caution when handling and working with waste refrigeration equipment,'* said Becker. While many of the sites inspected were up to standard, at a number of collection facilities, an inadequate level of care was used when handling waste fridges. Commenting on the results of the RAL audit, the Technical Director of *Hvitevareretur,* Thor Christian Wiik Svendsen said: *'Oil and CFC emissions are avoidable environmental burdens, which result when waste fridges and freezers are knocked or incorrectly stored, for instance when they are laid on their cooling coils. Another fact that we have learned from the RAL audit is that many of the collection sites make a poor visual impression because of the disorderly way in which waste goods are stored.'*



(Left and centre: Examples of good storage practice / Right: Example of poor storage conditions)

The constructive criticism offered by RAL will be used in the near future by *Hvitevareretur* to improve conditions at the collection sites.

RAL levied similar criticisms at personnel working at the interim storage stations and to a lesser extent at the recycling plants. Here too, RAL found individual cases where environmentally sensitive waste fridges were treated with inadequate care. In the opinion of the Quality Assurance Association, conducting intensive training schemes and one-to-one discussions with those involved should enable current bad practice to be remedied rapidly.

B. Examining the performance levels of the three fridge recycling plants

The core of the RAL audit was the testing of the three Norwegian recycling plants, which receive their waste appliances from the *Hvitevareretur* collection network. The independent body commissioned by RAL with the plant audit was SGS-TÜV Saarland GmbH, which, as a result of its collaborative work with RAL over many years, has extensive experience in the accreditation of fridge recycling plants throughout Europe.

A major component of the audit was a performance test carried out under identical conditions on all three recycling plants. The RAL performance test is part of the RAL GZ 728 quality assurance scheme and has been used for a number of years to get an independent assessment of CFC recovery levels from fridge recycling plants.

To test the performance of the step I plants, a simple but highly significant test was performed. The test involved subjecting 100 undamaged waste appliances to step I treatment. The 100 appliances were made up of 20 small domestic units, 70 domestic fridge-freezers and 10 domestic chest freezers and upright freezers. The CFC extracted under vacuum from the units was weighed (free of oil and other contaminants) and the weight divided by 100. The resulting value expressed in grams per appliance is a representative measure of the quality of the step I plant.

A similar procedure was used to assess step II performance. In this case, each of the three plants processed 1000 domestic waste fridges and freezers, and once again the test lot reflected the typical fractions of appliance types found in the Norwegian market (20% small domestic refrigerators – type 1 appliances, 70% fridge-freezer combination units – type 2 appliances, and 10% upright and chest freezers – type 3 appliances).

The CFC recovered was weighed (and corrected for any water that might be present) and the resulting weight divided by the number of waste appliances used in the test.

In addition to the performance testing, the audit also involved comprehensive monitoring by the operator of all plant input and output streams. To be able to compare the data from the three plants, monitoring information was recorded on the plant monitoring report form developed by RAL.

Results for step I

Two of the three plants met the RAL criteria for recovering CFC from the cooling circuit (**plant A: 122 g R 12 per appliance / plant B: 121 g R 12 per appliance**), even though one of these plants just failed to achieve the RAL minimum recovery levels (**minimum of 115 g CFC per appliance**) during the monitoring phase. The third plant (C) recovered only **90 g per appliance** and therefore failed to achieve the minimum R 12 recovery rate specified by RAL. According to the RAL audit, checks must now be made to determine whether the third plant reflects current best available technology or whether incorrect plant operation was the cause of the lower CFC yield. The operation of plant C certainly requires optimization.

The residual quantities of R 12 in the refrigeration oil recovered from all three step I plants was too high (**maximum value permitted by RAL: 0.1% w/w**). According to RAL, the plants should be improved in this respect if the refrigeration oil recovered is to be mechanically recycled.

RAL also recommended that annual plant audits should be carried out on the basis of its RAL GZ-728 quality assurance and test specifications so that any improvements or any deterioration in plant performance can be recognized immediately.

Results for step II

In step II of the demanufacturing process, two of the three plants were able to meet the RAL requirements (**plant A: 322 g R 11 per appliance / plant B: 390 g R 11 per appliance**). On the basis of the appliance mix used in the testing, recycling plants should be able to recover a minimum average quantity of 312 g per appliance. The third plant (C) recovered only 279 g of R 11 per appliance on average and here too failed to meet RAL quality specifications.

If one equates the highest recovery level (390 g of R 11 per appliance) with a percentage recovery rate of 90%, the other plants are operating at percentage recovery rates of about 75% and 63% respectively. Although equating actual recovery levels and percentage recovery rates is only theoretical, it appears both expedient and necessary to optimize the other two plants (A and C).

Two of the three plants (A and C) also need to be optimized with respect to the residual quantity of R 11 in the polyurethane (RAL standard: <0.2% w/w of R 11 in PU foam), while one of the plants (A) requires definite optimization in terms of the amount of polyurethane foam still adhering to the metal (ferrous and non-ferrous) and plastics output streams. The RAL specification of less than 0.5% w/w of PU foam residue was exceeded many times over by Plant B. Plant A must also ensure that major improvements are made in future with respect to the residual quantity of R 11 in the plant's exhaust air flow.

As plant C, which had the lowest recovery levels of the three plants tested, had only been in operation for just over nine months when the audit was carried out, and as improvements might result from increased practical experience with the plant, RAL recommended that step II plant testing based on the RAL GZ 728 test specifications should be conducted annually. An

important finding, not only from the current test series in Norway, but from all the more than one hundred plant audits carried out by RAL over the last five years, is that the training and experience of the personnel operating the fridge recycling plants has an influence on CFC recovery levels that should not be underestimated.

The RAL Quality Assurance Association for the Demanufacture of Refrigeration Equipment Containing CFCs believes that *Hvitevareretur* has established an outstanding system for collecting end-of-life fridges and freezers. Nevertheless, there is a need for optimization at all stages of the processing chain. Both *Hvitevareretur* and RAL are convinced that comprehensive training and education programmes must be used to optimize those areas of the collection and transport logistics that require improvement. High-quality plants are available for recycling waste refrigeration appliances in Norway. However, in a number of areas, considerable optimization is needed if the two main objectives of the fridge recycling process are to be achieved: a) maximum recovery of the CFCs contained in the waste appliances, and b) minimum losses of CFCs in process air and waste water streams, in the PU foam and via other loss channels. The national take-back scheme that has been set up in Norway by *Hvitevareretur* has now been complemented by the independent comparative performance testing conducted nationally by RAL. The quality assurance procedures that have for decades been an integral part of the manufacture of electrical equipment, are now becoming an equally important element in the demanufacture of end-of-life equipment.

Summarizing, the Technical Director of *Hvitevareretur*, Thor Christian Wiik Svendsen said: 'As far as quality and quality standards in the recycling process are concerned, this project has made *Hvitevareretur* far better able to deal with the upcoming producer responsibility in the recycling of waste refrigeration equipment. The co-operation with RAL has been constructive and informative and has helped us considerably to improve the design and implementation of our take-back system.'

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