Responsible Care – Product Stewardship for Refrigerants

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1 ABSTRACT

Product stewardship summarizes the concept of following products beyond their production and through their complete lifetime all the way to environmentally benign recycling, destruction or disposal. The concept has found wide acceptance throughout various manufacturing segments including the chemical industry.

This paper describes a European manufacturer's approach for applying the concept to fluorinated refrigerants. Even though the producer of the substances fulfils essential tasks within the concept, it requires co-operation with others who are involved during the product's lifetime. The paper will describe the responsibilities of different parties. Even though regulations and legal requirements do apply to ensure proper use of fluorinated refrigerants, many aspects rely on voluntary measures within the industry.

The paper will further focus on **primary recycling** of refrigerants, meaning to process used refrigerants to fresh product specifications. **Secondary recycling** refers to product that for different reasons cannot be processed into fresh material quality. The paper further describes a thermal separation unit, that provides secondary recycling to hydrofluoric acid and hydrochloric acid: substances that are widely used both in the chemical industry and in other industries.

The described concept is targeted at providing a closed cycle of the materials involved.

2 INTRODUCTION

The environmental impact of direct refrigerant emissions has been reduced significantly over recent years. Driving forces for these improvements are the reduced impact of the refrigerants themselves on important environmental characteristics such as ozone depletion and global warming impact. Reduced emissions caused by better handling of the products and tighter systems further account for reduced overall direct emissions. The handling of used refrigerants whose quality is no longer sufficient for use in refrigerating systems is another important factor which has seen substantial improvements over the last years. It must be stated that discovering the CFC's contribution to the destruction of the ozone layer has significantly improved industry's awareness towards environmental matters. Special recycling and incinerating facilities were built as a consequence of the findings mentioned above. Europe now provides a wide network of these facilities which are operated either by

governmental bodies, private institutions or by the chemical industry as part of the production facilities.

The content of this paper reflects the strategies and procedures of the author's company. This company will be referred to as the PRODUCER within the text. Even though the legal background is applicable to the whole industry of the discussed region, competitors may have alternate strategies to fulfil the task.

3 USED REFRIGERANTS

Product stewardships become more complex with increasing number of parties that are involved during the product's lifetime. The following chapter will focus on the field of commercial and industrial refrigeration since this field of the industry involves a number of parties that have to share responsibilities within the concept.

3.1 Logistics

The sequence of the recycling system implemented by the PRODUCER and its partners is best described using figure 1.

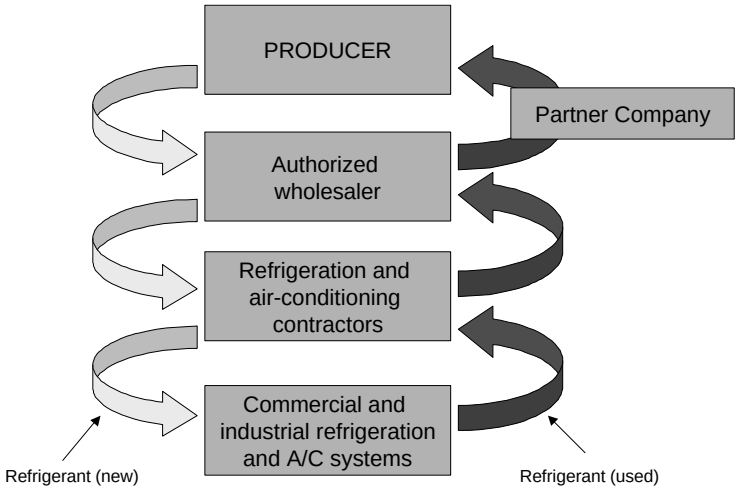

Figure 1: Recycling system for commercial and industrial applications

The PRODUCER produces refrigerants and supplies these via authorised distributors to the market. Refrigeration contractors use them to charge and service their refrigeration and air conditioning systems. If a plant is shut down or converted (retrofitted), the refrigerant must be properly removed and recycled. In the field of commercial and industrial refrigeration, the recycling system is compromised of the following substeps in particular

- Removal of the refrigerant from the equipment
- Transport to an authorised refrigerant distributor
- Refrigerant analysis
- Refilling into bulk containers (0,9 m^3) at the distributors site
- Transport of the bulk containers to the recycling partner
- Analysis of the container's content and decision regarding how to proceed
    - A) Recycling
    - B) Waste disposal via a partner company with final treatment at the PRODUCER'S separation unit

In case of A) primary recycling

- Environmentally safe removal of contaminants such as oil and water by a partner company
- Transportation of product in container or road tanker to the PRODUCER
- Primary recycling at the production site (only for refrigerants that are in production) or
- Secondary recycling of used CFC refrigerants (see section 3.3.2)

In case of B) waste disposal via partner company with final treatment in the separation unit at the production facility

- Disposal of non-processable and non-utilisable refrigerants / refrigerant blends (see section 3.3.2)

The PRODUCER by this means offers the customer the opportunity to **remove waste** either by **reutilization** or by **disposal**. Within this system a significant share of the duties is taken over by the partner company as described in figure 2.

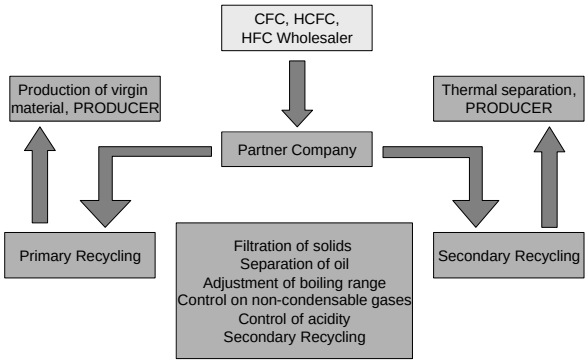

Figure 2: Role of the partner company within the recycling system

3.2 Responsibilities

Various parties are involved during the refrigerant's lifetime. Responsibilities are unavoidably shared among those parties with respect to an environmentally friendly life cycle of the product. This challenge is not unique to the product refrigerant, however a successful implementation of product stewardship concepts requires detailed knowledge of the applications and markets. The following chapter will demonstrate the shared responsibilities of parties other than the PRODUCER in the field of commercial and industrial refrigeration and air-conditioning.

3.2.1 Contractors

The contractor fulfils one of the most important duties within the described process.

He is responsible for the proper, emission-free removal of refrigerants from the plants that he services, keeping each type of refrigerant separate.

The technical procedure to remove refrigerants remains the same for all refrigerants and concerns all available types (CFCs, HCFCs and HFCs).

If a refrigeration or air conditioning system is shut down or converted to alternative refrigerants, proper refrigerant removal must proceed according to the following principle: For refrigerant removal from plants, special recycling equipment is available, which must comply with ISO/DIS 11650 or similar standards. The equipment primarily consists of a condensing unit with an air cooled condenser and a liquid pump.

The liquid phase of the refrigerant may be filled directly into the recycling cylinder using the liquid pump. Refrigerant vapour must then be removed from the equipment via the condensing unit of the recovery system into the recycling cylinder. Using appropriate level controls, it must be ensured that a filling factor of 0.75 kg per litre container volume is not exceeded. This filling factor applies for all commonly used HFC, HCFC, and CFC refrigerants: R12, R22, R502, R134a, R12 Drop-in Blends, R404A, R507, R407C, R410A, etc.. To avoid mixing, a separate and appropriately labelled recycling cylinder shall be used for each type of refrigerant. This especially applies to all new HFC types. Since many of these

types are blends, a successful primary recycling is only possible when different types are recovered separately.

3.2.2 Authorised Distributor

The authorised wholesaler of refrigerants – and normally of refrigeration and air-conditioning components as well – fulfils an important distribution function by selling new refrigerants. Within the recycling system, the distributor also contributes fundamentally to the functioning of the logistics.

- He provides recycling cylinders to the contractor or other involved parties
- He offers recovery equipment and accessories without which the emission-free and separate collection of refrigerants would not be possible
- He acts as a collection, control and distribution point within the concept

The PRODUCER assists the authorised distributor by providing information material and by conducting seminars to increase the end users awareness.

3.3 Recycling Procedures

3.3.1 Primary Recycling

‘Primary recycling’ of refrigerant on a large scale means processing used refrigerant back to original specification quality.

Primary recycling is performed for HFC refrigerants, and –based on national regulations- for HCFC and CFC refrigerants. The Procedure described in this paper does not include primary recycling of CFC refrigerant types.

Primary recycling of blends of different refrigerants is not possible in most cases. Additional contaminants which are not typically found in refrigerants after their use make processing more difficult and mean considerable additional expense.

The quality of reprocessed refrigerants is monitored by analysis. For all criteria they must meet the PRODUCER’S requirements for newly produced refrigerant:

- Compliance with the boiling range
- Content of high boiling residue
- Content of non-condensable gases
- Moisture content
- Acidity
- Impurities including other refrigerants

The relevant standards must be observed. By employing this method, the PRODUCER ensures that only one established and high quality standard for refrigerant products is offered to the customer.

HCFC and HFC quantities which are treated by primary recycling are afterwards integrated into the production process of the PRODUCER for new refrigerants.

A process that came to be known as ‘internal recycling’ or ‘reclaim’ has established itself within the industry and must be differentiated from the described large-scale primary recycling. Internal recycling refers to cleaning of refrigerants on site by using mobile recycling or recovery equipment. The refrigerants recovered in this way do not generally conform to the strict quality requirements of the PRODUCER or to those of internationally accepted standards. A European standard (EN 378-4) defines, that refrigerant quantities which are by those means treated shall only be used in the system from which they were recovered.

3.3.2 Secondary Recycling

The PRODUCER guarantees to take back and reutilize used single component refrigerants, commercial blends and mixtures of different refrigerants which cannot be economically reprocessed to meet new product specifications. The applied procedure is called secondary recycling. Within this procedure valuable raw materials for the chemical industry (hydrofluoric acid and hydrochloric acid) are reprocessed from either CFC, HCFC or HFC refrigerants by thermal separation. These substances will be reused as raw materials in chemical production or other applications.

The separation products are reused in other processes, while solid wastes for landfill disposal and toxic waste gases are avoided.

Figure 2 outlines the procedure.

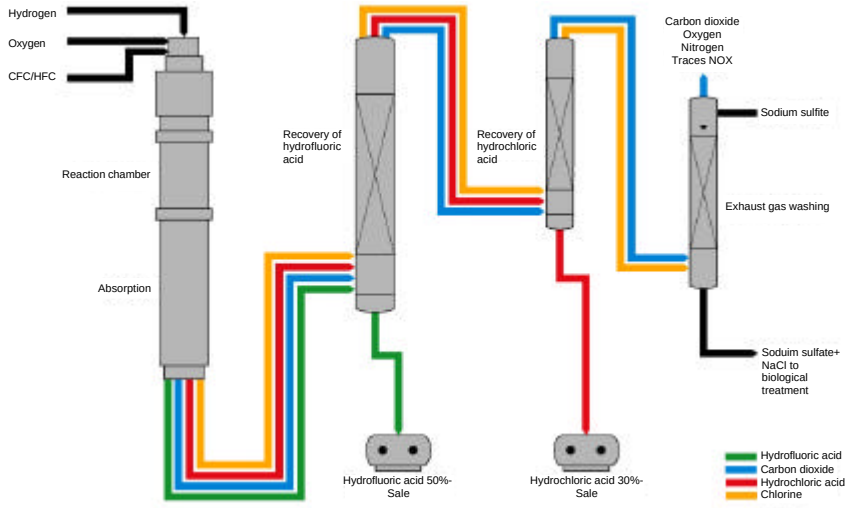

Figure 2: Secondary recycling by thermal separation

Within the heart of the process, a H_2/O_2 flame with a temperature of 2000°C is employed to thermally decompose CFCs, HCFCs and HFCs. The degree of separation under the given

conditions was found to be greater than 99,99%. Using O_2 instead of air to feed the flame avoids additional formation of nitrous oxides.

4 CONCLUSION

The described logistical and technical processes form the basis for a current Europe wide system for the responsible use of HCFC and HFC refrigerant as well as for an environmentally benign disposal of CFCs. The system requires awareness and co-operation of all involved parties to be successful. The concept further demands additional handling efforts as well as cost commitments from all involved parties. The cost of recycled refrigerant quantities may in certain cases be higher than the cost of newly produced material.

However the cost for incineration of used refrigerant has to be included in this calculation as well. In most cases the comparison then probably will result in at least equal costs. In any way in order to protect the environment and to have a responsible way of working with refrigerants additional efforts must be made.