EQUIPMENT FOR HCFC SOLVENTS

by

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ABSTRACT

The use of the new HCFC solvents involves some design changes for equipment. These changes will achieve emission rates with HCFC solvents similar to those experienced with the present CFC solvents.

New equipment designs are now available for HCFC solvents from several manufacturers. Modifications to existing equipment to allow HCFC solvent use have also proved feasible in many cases and offer another option for HCFC users.

I. INTRODUCTION

The United Nations Environmental Program (UNEP) meeting in November of 1987 resulted in the Historic Agreement to control and in many cases eliminate materials known to be major ozone depleters. This agreement, the now well-known Montreal Protocol, established a preliminary schedule for control and phase out of CFC 113 solvents among others, and called for a resolution for further study to determine the need to add other substances to the list and to monitor the feasibility of accelerating the phase out schedule.

With the ratification of the Montreal Protocol by the member nations, industry awoke to the fact that alternative cleaning processes would have to be studied. The search for the correct alternative method ensued and continues to this day. Corporations have reacted in a variety of ways. Some have opted for a wait-and-see approach; many have created "Task Force" groups to study CFC elimination and alternative processes; numerous corporations have self-imposed schedules for CFC elimination well in advance of Protocol Guidelines.

The enactment of legislation by the United States Congress, taxing CFCs on the basis of ozone depletion potential (ODP) has influenced the search for alternatives. Cost of process has become a major factor in the study of alternatives.

The reconvening of the Montreal Protocol in June of 1990 saw the acceleration of the schedule for phase out of CFC's, as well as the inclusion of Methyl Chloroform and Carbon Tetrachloride. Methyl Chloroform or 1,1,1-trichloroethane (TCA) a chlorinated solvent widely used in metal degreasing, had been considered an alternative for numerous CFC solvent cleaning applications. The inclusion of 1,1,1 trichloroethane (TCA) to the Montreal Protocol with the attendant schedule for total phase out has diminished its attractiveness as an alternative. TCA's attractiveness was in the fact that a large number of vapor degreasing/defluxing equipment in use, might easily be converted from CFC 113 solvent use to TCA solvent use. Schedule for reduction of 1,1,1-trichloroethane under terms of London amendment to Montreal Protocol in Table 1.

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<table>
<thead>
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<td>Jan. 1, 1995  30% Reduction from 1989 levels</td>
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HCFC solvents were deemed essential by the UNEP assessment process if a phaseout of CFC's by 2000 was to be achieved. A declaration of intent to phase out transition compounds in solvent applications by 2015 provided for an acceptable life span for HCFC's enhancing their role as alternative solvents.

HCFC-123 and HCFC-141b, with boiling points between 80°F and 90°F, are viable alternates to CFC 113 in most solvent applications. The lower boiling points suggest that HCFC solvents will exhibit greater volatility than CFC 113 solvents. Due to the higher latent heats of vaporization of HCFC-123 and HCFC-141b however, their evaporation rates are comparable to CFC 113. Table 2 compares these and other values.

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<tr>
<td>Formula</td>
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<tr>
<td>CF₂Cl₂CFCl₂</td>
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<tr>
<td>Normal B.P., °F</td>
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<tr>
<td>Heat of Vaporization, J/G</td>
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<td>Evaporation Rate (ether=1)</td>
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In this paper we shall discuss the suitability of degreasing/defluxing equipment currently in use and the possibility of modification of existent equipment for use with HCFC solvents. We will also discuss new equipment design characteristics desirable when selecting equipment for use with HCFC solvents. We will briefly discuss solvent distillation equipment modification.

II. **Existing Equipment Suitability**

One of the major considerations in the selection of alternative cleaning processes is cost of equipment. The attractiveness of HCFC solvents in this consideration is that modification can make it possible to use existent equipment.
Before cataloging the various modifications it is necessary to review the process of degreasing/defluxing and the theory determining that process.

Upon the introduction of a work load into a degreaser the temperature difference between the load and the vapor allows the condensation of the warmer vapor upon the cooler surface of the load. The greater that difference the greater the condensation of solvent vapor into liquid solvent and thus the greater potential for solubilization of soils. The lower boiling point and vapor temperature of HCFC solvents may not allow adequate condensation to take place. When this condition is encountered it may be possible to achieve adequate cleaning by immersion into liquid solvent sumps or by spraying with solvent distillate drawn from a distillate reservoir.

Due to the fact that poorly conducted distillate spraying practices have proven to be a major factor in solvent loss, and the increasingly stringent air quality standards governing solvent emissions, distillate spraying is largely discouraged. Thus existing equipment with only vapor or vapor spray cycle capability may indicate the requirement for replacement equipment with immersion capability.

Equipment with zinc or galvanized interior coatings or with phenolic or epoxy based linings or coatings are not acceptable candidates for modification. Additionally aluminum racking, baskets or fixtures should be avoided.

Degreasers with only a water jacket or water jacket/helical condensing coil for solvent vapor condensation will be inadequate. We will discuss condensing requirements as one of the modification considerations.

III. Modification Considerations

The increase of freeboard area is basic to the modification of existing equipment if the freeboard ratio is less than 100%. Freeboard is the distance between the top lip of the degreaser (exclusive of ducting or covers) and the true vapor line. There are two types of freeboard. Design freeboard and actual freeboard. Design freeboard and actual freeboard differ when there is a heat transfer imbalance. Inadequate heat input can cause the vapor line to collapse too readily, inadequate condensing temperature can cause the vapor to overcome the condensing system and rise thereby reducing freeboard area. This paper assumes design freeboard in all equipment discussed.

Freeboard ratio is the ratio between the design freeboard and the narrow opening of the degreaser. Thus a degreaser with an open top area of 36" x 24" with a design freeboard dimension of 18" would be said to have 75% freeboard. Present Environmental Protection Agency standards are 75% freeboard ratio. Current design standards suggest a minimum of 100% freeboard ratio.
In laboratory tests freeboard extending collars of various heights were retrofit to 2' x 2' open top vapor degreaser. These tests demonstrated that between 75% and 100% freeboard the solvent loss was reduced considerably during idling. The addition of freeboard to 120% demonstrated only slight additional conservation. Beyond 120% freeboard solvent losses began to increase beyond the losses at 100% freeboard. The studies concluded that a "chimney effect" was created at freeboards over 120% and theorized that in larger opentop degreasers (48" x 30" and larger) freeboard of 120% or greater may be of greater value in controlling solvent emissions. HCFC solvents are generally considered as replacement solvents for CFC 113 based solvents and as such are not likely to be widely used in large open top degreasers. Thus a 100% freeboard is considered to be about the optimum. It should be noted that as freeboard is increased the overall height is increased and access and material handling considerations must be weighed.

The solvent vapor condensing system must be evaluated on existing degreasers. Degreasers with only water jacket areas for condensing will have inadequate surface area even if chilled water is used. Peripheral condensing coils might be installed in addition to or in place of the water jacket design. It should be noted that finned coils provide many times the condensing surface area of smooth tubing. Two passes of 7/8" finned tubing with 7 fins per inch provide equivalent surface area to 20 passes of 1" smooth wall tubing.

The temperature of the condensing system is extremely important. The preferred condensing system will employ direct expansion refrigeration. Depending upon the dew point, the temperature range of the system may be between 20°F and 40°F. Closed loop, chilled water systems may also be employed as long as a maximum 40°F temperature can be maintained. Whichever method is employed the design of the degreaser must be appropriate to the total system. The cost of modification versus replacement with a degreaser of current design standards should be considered.

Automatic covers that close when open top equipment is not being operated, and freeboard chillers that act to control diffusion loss during idling are increasingly required. Freeboard chillers must operate at -15°F to -40°F to achieve significant diffusion loss reduction. Robotic material handling devices can reduce solvent loss by eliminating improper throughput in open top equipment. If control or handling devices are desired or required it will be necessary to determine their compatibility with the equipment on which they will be installed.

V. IN-LINE DEFLUXING EQUIPMENT

The modification of existing In-Line defluxing equipment may not be as easily achievable as with the more basic open top degreaser. While the same basic considerations of freeboard, condensing systems, safety thermostats, materials of construction and structural soundness apply, desired modification or retrofit will likely be more costly. While freeboard chillers may be retrofit at the entrance and exit throats to control solvent loss, it may be necessary to modify belt length, pulley placement, drive motor size and compressor size. Because of potential labor and material cost, and diversity of construction and design, cost of modification vs. replacement must be carefully weighed.
VI. NEW DEGREASING/DEFLUXING EQUIPMENT

New design, low emission vapor degreasing equipment has been available for over a year. Incorporating offset vapor generation, increased freeboard, inverted lip designs and more efficient condensing systems, this new equipment has multi-solvent compatibility. These systems, both Open Top and In-Line types, are capable of using current CFC solvents, methyl chloroform, and the new HCFC solvents. Thermostat set point and refrigeration adjustment capability is provided with these new systems.

Additional conservation devices such as freeboard chillers, automatic covers and robotic material handlers can be factory installed or retrofit as required.

VII. DISTILLATION RECOVERY EQUIPMENT MODIFICATION

Most distillation recovery equipment is of a closed design. Commonly, access to the interior of the still is via gasketed doors or lids. Where the still has a top mounted lid it is advisable to assure that a good seal is achieved by the use of suitable gasketing. Lids on water separators should likewise be gasketed or sealed. Heat balance may require adjustment. Condensing systems will require the same surface area and temperature capabilities as degreasing equipment. Safety thermostats must be calibrated to proper set points. Low liquid level controls might be installed if not included in the original design. In general a "tightening" and thorough maintenance will enable many stills to operate efficiently with HCFC solvents. As with degreasers, materials of construction and structural soundness must be considered.

New, low emission distillation equipment is presently in the engineering and design stage and should be available by the time large scale commercial quantities of HCFC solvents are available.

VII. CONCLUSIONS

In this paper we have shown that modification of existing degreasing/defluxing equipment for use with HCFC solvents is possible. New low emission equipment is available if cost of modification is not justified. Distillation equipment can also be modified and adjusted for HCFC use.

The author would like to acknowledge the contributions of Mr. A. D. Romig in refrigeration system design.