RECOMMENDATIONS FOR CLEANING MACHINES FOR THE USE OF CHLORINATED SOLVENTS IN DRY CLEANING AND SURFACE CLEANING

The benefit of using modern closed cleaning machines

Chlorinated solvents (**Perchloroethylene** (PER), **Trichloroethylene** (TRI) and **Dichloromethane** (DCM)) have been used for many decades as cleaning solvents in metal or more generally speaking surface cleaning. Perchloroethylene, specifically, has also been used for many decades as the major cleaning solvent in the dry cleaning of textiles.

Over the last decades, since the mid-1980s, cleaning machines have undergone a huge evolution from simple very basic equipment with high emissions to highly sophisticated, closed or sealed equipment as commercialised today.

Modern machines are incorporating many innovations like:

- Equipment for internal closed loop air flows with solvent abatement and regeneration
- Continuous solvent recycling
- Use of vacuum technology in surface cleaning. The use of modern cleaning machines has led to a very strong decrease in emissions from over 150g of perchloroethylene per kg of garments to less than 10g/kg in dry cleaning and from over 10kg/h to less than 20g/h in surface cleaning.

ECSA and its member companies strongly support the development and market introduction of **modern cleaning machines** and have developed adequate solvent formulations and stabilisation packages to fit the requirements of modern machines. This allows the advantages of such equipment to be fully exploited, leading to an extensively extended lifetime of the solvent in the equipment. For example, in surface cleaning, the lifetime of a machine filling with solvent could be extended from less than a month in simple equipment to up to two years of solvent performance and up to even more in modern equipment. This means that the **cleaning efficiency of a solvent molecule could be increased by a factor of 20 and more**. The cleaning efficiency of chlorinated solvents used in modern equipment is currently unmatched because of the unique recycling properties of chlorinated solvents. This greatly increases the eco-efficiency of the chlorinated solvents.

ECSA strongly recommends the use of modern closed equipment of Best Available Technology (BAT). **Recommended are 5th generation machines** (at least 4th generation should be minimum standard) **for dry cleaning equipment**. And it is recommended to use machines of at least type III or higher for surface cleaning.

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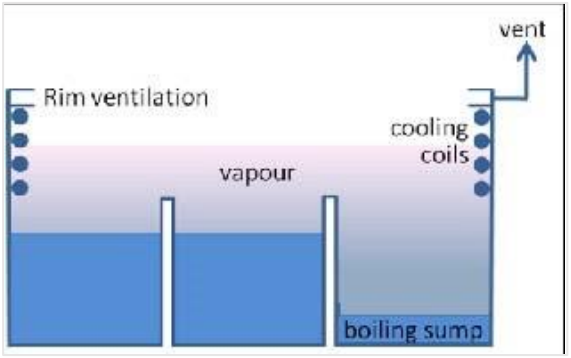
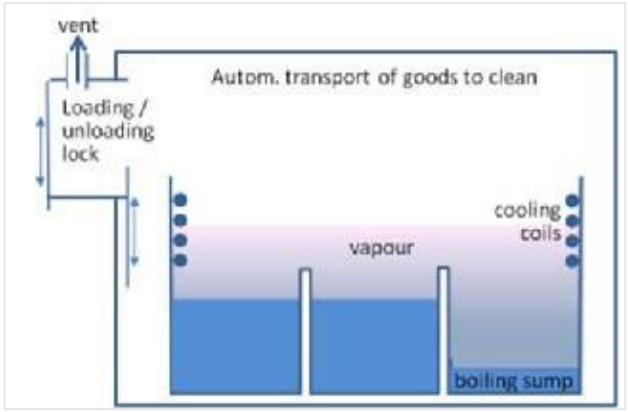
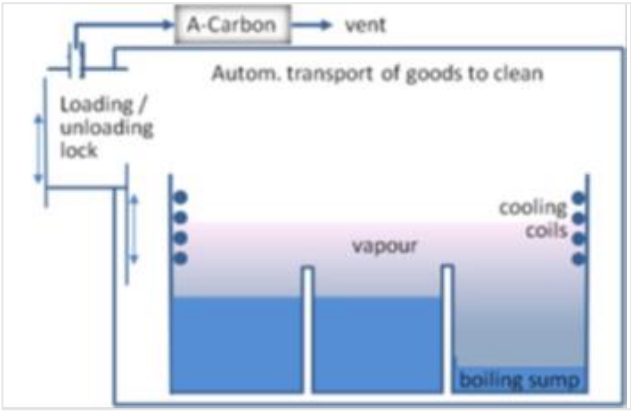
These modern machines are designed to fulfil the emission requirements of the European VOC directive. Higher machine generations (dry cleaning) or machine types (surface cleaning) will not only contribute to reaching legal compliance, but also ensure the sustainable use of solvents in surface or textile cleaning by minimising emissions and ensuring the safe handling, transfer and take-back of the solvent. The machines can easily be equipped for an emission-free solvent transfer in combination with emission-free delivery and take-back containers (closed loop safety containers). Modern BAT cleaning machines are available from all leading manufacturers of machines for surface or dry cleaning.

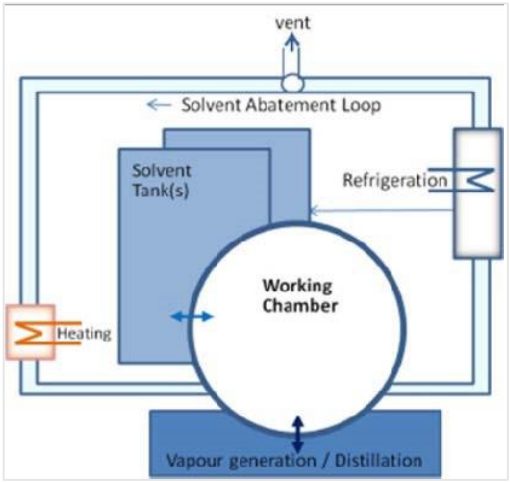
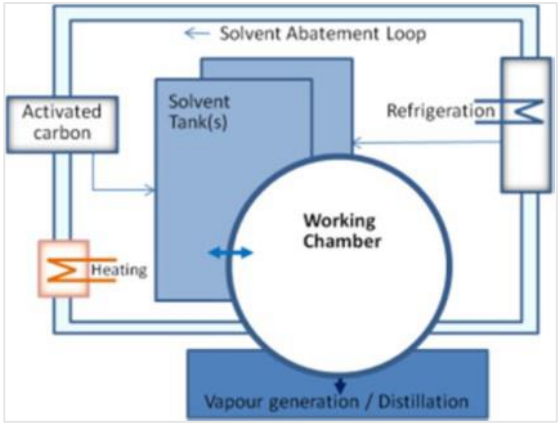
Review and description of the different cleaning machine generations and types

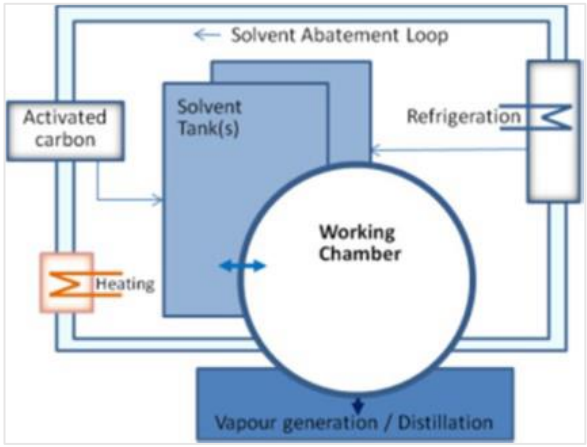
The development of machines used in surface cleaning and dry cleaning is summarised in the following tables 1 and 2. The tables describe the different machine types / generations. The nomenclature follows for surface cleaning the nomenclature adopted by ECSA in 2001 and for dry cleaning the nomenclature adopted by the Leonardo da Vinci E-DryClean training programme, which has been prepared in partnership with ECSA. Both tables give cross-references / equivalences to different nomenclature used in other documents. For the use of Trichloroethylene (TRI) in surface cleaning, confirmation of use in machines of type III or higher is a pre-condition for delivery. This voluntary commitment is fixed in the **ECSA TRI Charter for the safe use of Trichloroethylene,** which has been signed by producers and importezr of TRI.

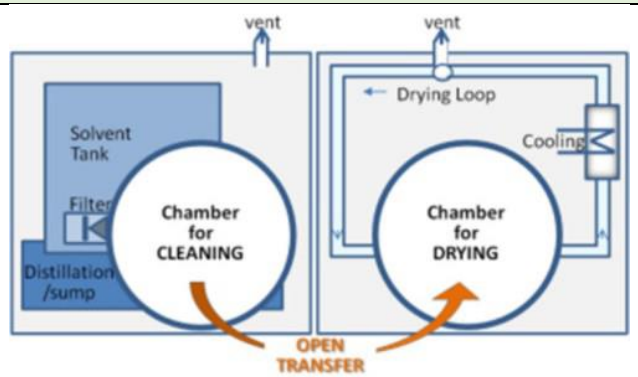
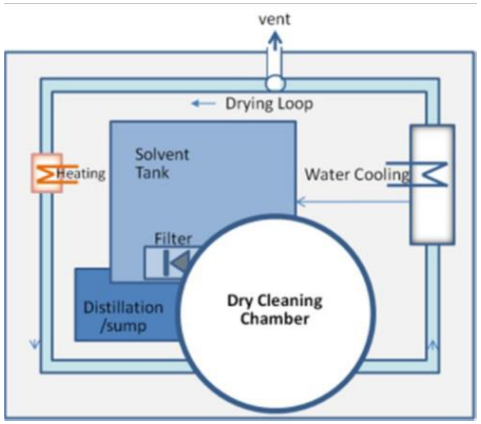
Table 1: Types / Generations of Surface Cleaning Machines

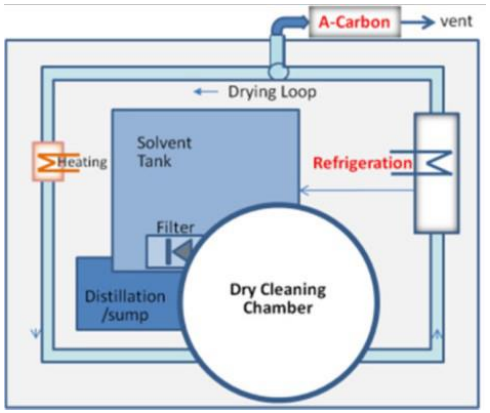
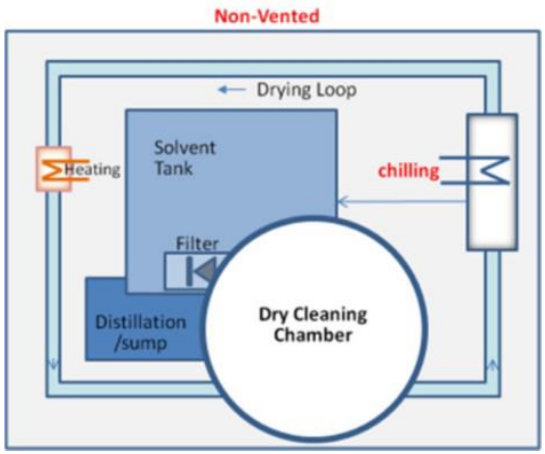
Current ECSA Nomenclature [1]	Schematic Drawing	Key characteristic (Key improvement in red)	Legal compliance	Nomenclature Reference/ Equivalence in EU Standard 12921-4[3]	Nomenclature Reference/equivalence in J. von Grote, ETH Diss. #15067 of 2003[4]
Type I **Open Top**		• Open top • Rim ventilation • Cooling with water or refrigerated cooling (2°C) • Typical air emission: between 1-16kg/h, average 4.7kg/h		As "Open top tank" in figure A.4 of Appendix A.	• Water cooling: as Type I "open topwater cooled" • Refrigerated cooling: as Type II "open top electro-cooled"

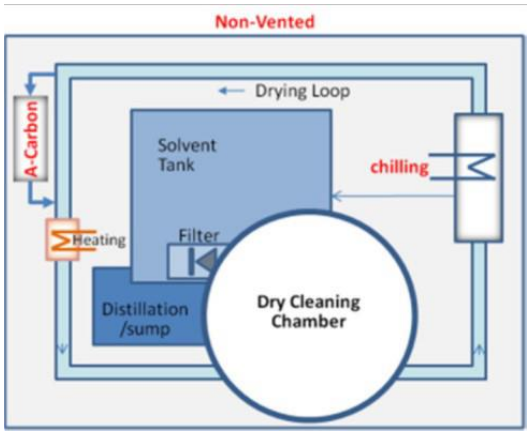
Type IIa **Enclosed (vented directly to atmosphere)**		• Encased (all side closed) • Vented air lock for loading/unloading of goods • Refrigerated cooling • Automatic transport of goods • Typical air emission: 2.0 kg/h		As "Type II enclosed"	
Type IIb **Enclosed & abatement** (vented through external A-Carbon filter)		• As type IIa but with additional external A-carbon filter for solvent abatement from exhaust air • Typical air emission: 1.0 kg/h	• May fulfil German Emission Directive "2. BimSchV" in old version of 1986 • May enable the fulfilment of limits set by EU-SED directive[1]		

Type III **Closed with internal air cleaning prior to opening**		• Closed single chamber or use of a collection chamber (airlock to seal against solvent bathe(s)) • Solvent abatement loop with refrigeration (<-20°C) to clean air prior to opening (<2g/m³) • Typical air emission: 155 g/h	• Generally, fulfils requirement of Ger-man Emission Directive "2. BImSchV" • Designed to comply with SED limits	• Type I – sealed cleaning machines differentiated by Type Ia – Collection chamber systems Fig. A.1 of Appendix A. • Type Ib – Single chamber cleaning machine Fig. A.2 of Appendix A.	As Type IV "one chamber "machines
Type IV **Closed with closed loop air drying without vent**		• No exhaust air (Fully closed air loops) • Equipm. Internal A-carbon in addition to refrigeration • Better drying also of goods with difficult shapes • Typical air emission: 1-100 g/h, average about 38 g/h	• Generally, fulfils requirement of Ger-man Emission Directive "2. BImSchV" • Designed to comply with SED limits	Not yet know to EN 12921-4	As Type V "closed loop drying one chamber "machines

Type V **Closed without vent and operation under vacuum**		• As type IV but with Vacuum technology, keeping the working chamber and distillation under reduced pressure during operation • Improved drying • Reduced emissions • Reduced waste • Increased solvent lifetime (because of lower temperature)	• Generally, fulfils requirement of German Emission Directive "2. BImSchV" • Designed to comply with SED limits	Not yet know to EN 12921-4	Was not yet known to the thesis

Current ECSA Nomenclature[1]	Schematic Drawing	Key characteristic (Key improvement in red)	Legal compliance	Nomenclature Leonardo da Vinci E-DryClean Training program[3]	Nomenclature Reference/equivalence in J. von Grote[4]
1st Gen. Transfer Machines		• Separate equipment for cleaning and drying • Open transfer of wet garments • Typical total PER consumption: ab. 300 to 500 g/kg textiles[3]		Same as current ECSA Nomenclature: 1st Generation machines	Same as current ECSA Nomenclature: 1st Generation machines
2nd Gen. **Dry-to-dry vented machines with water cooling**		• Single equipment machines combining cleaning and drying in one equipment • Water cooling (15°C) in drying loop • Vented to atmosphere • Typical total PER consumption: ab. 100 to 150 g / kg textiles[3] • Introduced in the late 1950s[3]		Same as current ECSA Nomenclature: 2nd Generation machines	Same as current ECSA Nomenclature: 2nd Generation machines

3rd Gen. **Dry-to-dry vented machines with refrigerated cooling and external activated carbon filter**		• As Generation II, but with external activated carbon filter for post cleaning of vented air • Water and later refrigerated cooling (ca.-15°C) in the Drying loop • Typical total Per consumption: ab. 40 to 80 g / kg textiles[3] • Introduced in the late 1960s[3]	• May fulfil German Emiss. Directive "2. BimSchV" in old version of 1986 • May enable the fulfilment of limits set by EU-SED directive[2]	Same as current ECSA Nomenclature: 3rd Generation machines	Same as current ECSA Nomenclature: 3rd Generation machines
4th Gen. **4th Gen. Single equip., not vented, closed loop drying machines with chilling system for cooling**		• Single equipment • Closed loop drying loop • No vent • Chilled cooling (-20°C) in drying loop • Typical total Per consumption: 20 to 40 g / kg textiles[3] • Introduced in the early 1980s[3]	• Designed to enable user to achieve emission limits set by the EU-SED[1]	Same as current ECSA Nomenclature: 1st Gene-ration machines	Same as current ECSA Nomenclature: 1st Generation machines

5th Gen. **Single equip., unvented, closed loop drying machines with chilling system + integrated A-carbon**		• Activated carbon integrated in drying loop (to efficiently achieve residual concentration of 2g/m 3 after dying required by 2. BImSchVof 1990) • Typical total Per consumption: < 10 g / kg textiles[3] • Developed in the late 1980s and introduced in the early 1990s[3]	• Designed to comply with the 2nd BImSchV (German Emission Directive) of 1990[2] • Designed to enable user to achieve emission limits set by the EU-SED[1]	Same as current ECSA Nomenclature: 2nd Gene-ration machines	Same as current ECSA Nomenclature: 2nd Generation machines

References

1) EU Solvent Emission Directive (COUNCIL DIRECTIVE 1999/13/EC) also referenced sometimes as EU VOC Directive

2) German 2nd Federal Immission Protection Directive (2.BImSchV, Zweite Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes, Verordnung zur Emis-sionsbegrenzung von leichtflüchtigen Halogenkohlenwasserstoffen) of 10.Dezember 1990.

3) Module 5 of "E-DryClean, Sustainable dry cleaning processing", a training program in six modules having as objective to improve and adapt the educational level of entrepreneurs and employees working in dry cleaning sectors across the European Union, CINET (Comité International de L'Entretien du Textile)

4) J. von Grote, Occupational Exposure Assessment in Metal Degreasing and Dry Cleaning – Influences of Technology Innovation and Legislation, Dissertation (no 15067), ETH Swiss Federal Institute of Technology Zurich, Zurich, Switzerland, 2003

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