

## 7. Recommendations for Cleaning Machines for the use of Chlorinated Solvents in dry cleaning and surface cleaning

### ***Recommendations for Cleaning Machines for the use of Chlorinated Solvents in Dry Cleaning and Surface Cleaning***

#### ***The benefit to use modern closed cleaning machines***

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

Over the last decades, since the mid 1980ies, cleaning machines have undergone a huge evolution from simple very basic equipment with high emissions to highly sophisticated, closed or sealed equipment as commercialized today. Modern machines are incorporating many innovations like

- equipment internal closed loop air flows with solvent abatement and regeneration
- continuous solvent recycling
- the use of vacuum technology in surface cleaning.

The use of modern cleaning machines has lead to a very strong decrease of 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 are heavily supporting 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 to fully use the advantages of such equipment leading to a strongly extended life time of the solvent in the equipment. E.g. in surface cleaning, the life time of a machine filling with solvent could be extended from less than a month in simple equipment to up to 2 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 heavily increases the eco-efficiency of the chlorinated solvents.

ECSCA strongly recommends the use of modern closed equipment of Best Available Technology (BAT). It is recommended to use at least 4<sup>th</sup> -Generation or higher for dry cleaning equipment. And it is recommended to use machines of at least type III or higher for surface cleaning<sup>6</sup>. 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 reach legal compliance but also ensure the sustainable use of solvents in surface or textile cleaning by minimizing 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 manufacturer of machines for surface or dry cleaning.

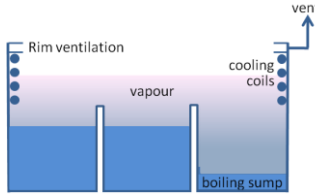
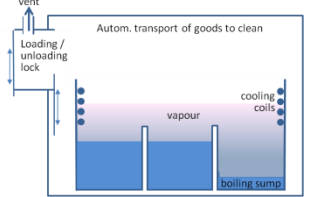
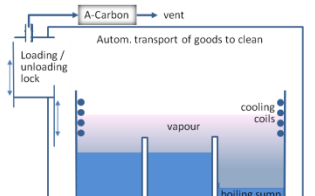
### ***Review and description of the different cleaning machine generations and types***

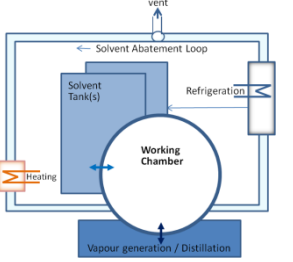
The development of the machines used in surface cleaning and dry cleaning is summarized in the following tables 1 and 2. The tables describe the different machine types / generations. The nomenclature follows for surface cleaning the nomenclature adopted by ECSCA in 2001 and for dry cleaning the nomenclature adopted by the Leonardo da Vinci E-DryClean training program ([www.cinet-online.net/edryclean/](http://www.cinet-online.net/edryclean/)), which has been prepared in partnership with ECSCA. Both tables give cross-references / equivalences to different nomenclature used in other documents.

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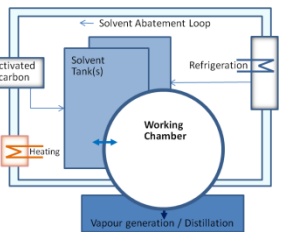
<sup>6</sup> For the use of Trichloroethylene (TRI) in surface cleaning confirmation of use in machines of type III or higher is a pre-condition for delivery. This voluntary commitment is fixed in the **ECSCA TRI Charter for the safe use of Trichloroethylene** (<http://www.eurochlor.org/index.asp?page=813>) which has been signed by producers and importer of TRI.

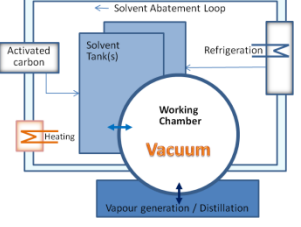
**Table 1: Types / Generations of Surface Cleaning Machines**

Current ECSA Nomen- clature <sup>1)</sup>	Schematic Drawing	Key characteristic (Key improvement in red)	Legal compliance	Nomenclature Reference /equivalence in European Standard EN 12921-4 <sup>3)</sup>	Nomenclature Reference /equivalence in J.von Grote, ETH Diss. #15067 of 2003 <sup>4)</sup>
<b>Type I</b> Open Top		<ul style="list-style-type: none"> <li>• Open Top</li> <li>• Rim ventilation</li> <li>• Cooling with water or Refrigerated cooling (2°C).</li> <li>• Typical air emission: between 1-16 kg/h, average 4.7 kg/h</li> </ul>		As “ <b>Open top tank</b> ” in Figure A.4 of Appendix A.	<p>Water cooling: As <b>Type I</b> “open top water cooled”</p> <hr/> <p>Refrigerated cooling: As <b>Type II</b> “open top electro- cooled”</p>
<b>Type IIa</b> enclosed (vented directly to atmosphere)		<ul style="list-style-type: none"> <li>• <b>Encased</b> (all side closed)</li> <li>• <b>Vented Air lock</b> for loading / unloading of goods</li> <li>• Refrigerated cooling</li> <li>• <b>Automatic transport of goods</b></li> <li>• Typical air emission: 2.0 kg/h</li> </ul>		As “ <b>Type II – enclosed open cleaning machine</b> ” in Figure A.3 of appendix A.	As <b>Type III</b> “ <b>encased machines</b> ”
<b>Type IIb</b> Enclosed & abatement (vented through external A- Carbon filter)		<ul style="list-style-type: none"> <li>• As type IIa but with additional external A-carbon filter for solvent abatement from exhaust air.</li> <li>• Typical air emission: 1.0 kg/h</li> </ul>	<ul style="list-style-type: none"> <li>• May fulfil German Emiss. Directive “2.BImSchV” in old Version of 1986</li> <li>• May enable the fulfilment of limits set by EU-SED<sup>2)</sup> directive</li> </ul>		

<p><b>Type III</b> Closed with internal air cleaning prior to opening</p>		<ul style="list-style-type: none"> <li>• Closed <b>single chamber</b> or use of a collection chamber (air-lock to seal against solvent bathe(s))</li> <li>• <b>Solvent abatement loop</b> with refrigeration (&lt;-20°C) to clean air prior to opening (&lt;2g/m2)</li> <li>• Typical air emission: 155g/h</li> </ul>	<ul style="list-style-type: none"> <li>• Generally fulfils requirements of German Emiss. Directive "2.BImSchV" .</li> <li>• Designed to comply with SED limits.</li> </ul>	<p><b>Type I – sealed cleaning machines</b> differentiated by  <b>Type Ia – Collection chamber systems</b>  Fig. A.1 of Appendix A. and  <b>Type Ib – Single chamber cleaning machine</b>  Fig. A.2 of Appendix A.</p>	<p>As <b>Type IV</b> "one chamber" machines</p>
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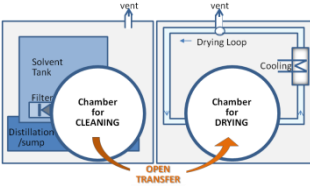
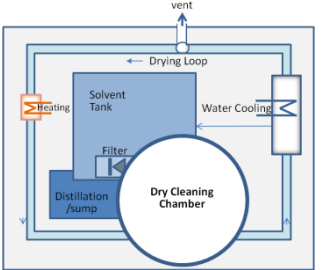
**Table 1 (cont.): Types / Generations of Surface Cleaning Machines**

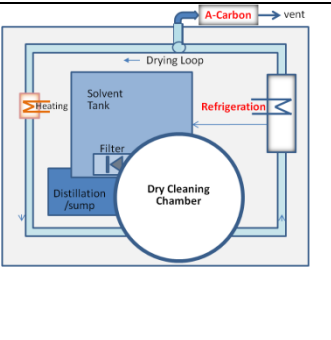
Current ECSA Nomenclature <sup>1)</sup>	Schematic Drawing	Key characteristic (Key improvement in red)	Legal compliance	Nomenclature Reference /equivalence in European Standard EN 12921-4 <sup>3)</sup>	Nomenclature Reference /equivalence in J. von Grote <sup>4)</sup>
<p><b>Type IV</b> Closed with closed loop air drying without vent</p>		<ul style="list-style-type: none"> <li>• <b>No exhaust air</b> (Fully closed air loops)</li> <li>• <b>Equipm. Internal A- carbon</b> in addition to refrigeration.</li> <li>• Better drying also of goods with difficult shapes.</li> <li>• Typical air emission: 1-100 g/h, average about 38 g/h</li> </ul>	<ul style="list-style-type: none"> <li>• Generally fulfils requirements of German Emiss. Directive "2.BImSchV" .</li> <li>• Designed to comply with SED limits.</li> </ul>	<p>Not yet known to EN 12921-4</p>	<p>As <b>Type V</b> "closed loop drying one chamber" machines</p>
<p><b>Type V</b> Closed without vent</p>		<ul style="list-style-type: none"> <li>• As type IV but with</li> <li>• <b>Vacuum technology</b>, keeping the working chamber and distillation</li> </ul>	<ul style="list-style-type: none"> <li>• Generally fulfils requirements of German Emiss. Directive</li> </ul>	<p>Not yet known to EN 12921-4</p>	<p>Was not yet known to the thesis</p>

<p>and operation under vacuum</p>		<p>under reduced pressure during operation</p> <ul style="list-style-type: none"> <li>• Improved drying</li> <li>• Reduced emissions</li> <li>• Reduced waste</li> <li>• Increased solvent life time (because of lower temperature)</li> </ul>	<p>“2.BImSchV” .</p> <ul style="list-style-type: none"> <li>• Designed to comply with SED limits.</li> </ul>		
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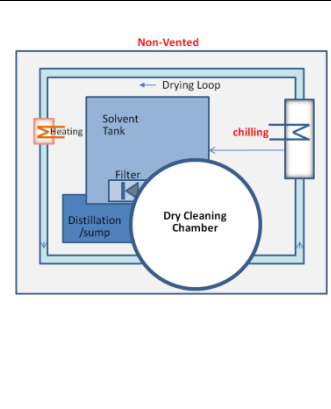
- 1) first time used in ECSA publication: “Annex to Perchloroethylene Risk Assessment Report, ECSA Response to UK Environment Agency regarding Perchloroethylene Emission Reduction from the Solvent Emissions Directive (1999/13/EC), 30 April 2001”
- 2) EU Solvent Emission Directive (COUNCIL DIRECTIVE 1999/13/EC) also referenced sometimes as EU VOC Directive
- 3) EN 12921-4 “Machines for surface cleaning and pre-treatment of industrial items using liquids or vapours - Part 4: Safety of machines using halogenated solvents”
- 4) 4J. 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

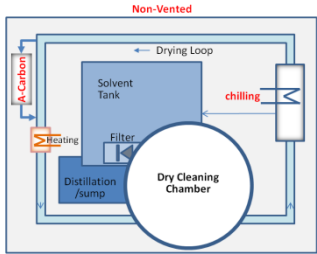
**Table 2: Types / Generations of Dry Cleaning Machines**

Current ECSA Nomenclature	Schematic Drawing	Key characteristic (Key improvement in red)	Legal compliance	Nomenclature Leonardo da Vinci E-DryClean Training program <sup>3)</sup>	Nomenclature Reference /equivalence in in ETH Dissertation of Julia van Grote <sup>4)</sup>
<p><b>1<sup>st</sup> Gen.</b> Transfer Machines</p>		<ul style="list-style-type: none"> <li>• Separate equipment for cleaning and drying.</li> <li>• Open transfer of wet garments</li> <li>• Typical total PER consumption: ab. 300 to 500 g / kg textiles <sup>3)</sup></li> </ul>		<p>Same as current ECSA Nomenclature: <b>1<sup>st</sup> Generation</b> machines</p>	<p>Same as current ECSA Nomenclature: <b>1<sup>st</sup> Generation</b> machines</p>
<p><b>2<sup>nd</sup> Gen.</b> dry-to-dry vented machines with water cooling</p>		<ul style="list-style-type: none"> <li>• <b>Single equipment machines</b> combining cleaning and drying in one equipment</li> <li>• Water cooling (15°C) in drying loop</li> <li>• Vented to atmosphere</li> <li>• Typical total Per consumption: ab. 100 to 150 g / kg textiles <sup>3)</sup></li> <li>• Introduced in the late 1950s <sup>3)</sup></li> </ul>		<p>Same as current ECSA Nomenclature: <b>2<sup>nd</sup> Generation</b> machines</p>	<p>Same as current ECSA Nomenclature: <b>2<sup>nd</sup> Generation</b> machines</p>
<p><b>3<sup>rd</sup> Gen.</b> Dry-to-dry vented machines</p>		<ul style="list-style-type: none"> <li>• As Generation II, but with</li> <li>• <b>external activated carbon filter</b> for post cleaning of</li> </ul>		<p>Same as current ECSA Nomenclature:</p>	<p>Same as current ECSA</p>

<p>with refrigerated cooling and external activated carbon filter</p>		<p>vented air</p> <ul style="list-style-type: none"> <li>• Water and later <b>refrigerated cooling (ca.-15°C) in the Drying loop</b> and</li> <li>• Typical total Per consumption: ab. 40 to 80 g / kg textiles <sup>3)</sup></li> <li>• Introduced in the late 1960s, <sup>3)</sup></li> </ul>		<p><b>3<sup>rd</sup> Generation machines</b></p>	<p>Nomenclature: <b>3<sup>rd</sup> Generation machines</b></p>
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**Table 2 (cont.): Generations of Dry Cleaning Machines**

<p><b>Current ECSA Nomenclature</b></p>	<p><b>Schematic Drawing</b></p>	<p><b>Key characteristic (Key improvement in red)</b></p>	<p><b>Legal compliance</b></p>	<p><b>Nomenclature Leonardo da Vinci E-DryClean Training program <sup>3)</sup></b></p>	<p><b>Nomenclature Reference /equivalence in in ETH Dissertation of Julia van Grote <sup>4)</sup></b></p>
<p><b>4<sup>th</sup> Gen.</b> Single equip., not vented, closed loop drying machines with chilling system for cooling</p>		<ul style="list-style-type: none"> <li>• Single equipment</li> <li>• <b>Closed loop drying loop</b></li> <li>• <b>No vent</b></li> <li>• <b>Chilled cooling (-20°C) in drying loop</b></li> <li>• Typical total Per consumption: 20 to 40 g / kg textiles <sup>3)</sup></li> <li>• Introduced in the early 1980s <sup>3)</sup></li> </ul>	<p>Designed to enable user to achieve emission limits set by the EU-SED <sup>1)</sup></p>	<p>Same as current ECSA Nomenclature: <b>4<sup>th</sup> Generation machines</b></p>	<p>Same as current ECSA Nomenclature: <b>4<sup>th</sup> Generation machines</b></p>
<p><b>5<sup>th</sup> Gen.</b> single equip., un- vented,</p>		<ul style="list-style-type: none"> <li>• As Generation IV with in addition</li> </ul>	<p>Designed to comply with the 2<sup>nd</sup></p>		

<p>closed loop drying machines with chilling system + integrated A-carbon.</p>		<ul style="list-style-type: none"> <li>• <b>Activated carbon integrated in drying loop</b> (to efficiently achieve residual concentration of 2g/m<sup>3</sup> after drying required by 2.BImSchV of 1990)</li> <li>• Typical total Per consumption: &lt; 10 g / kg textiles<sup>3)</sup></li> <li>• Developed in the late 1980s and introduced in the early 1990s<sup>3)</sup></li> </ul>	<p>BImSchV (German Emission Directive) of 1990<sup>2)</sup></p> <p>Designed to enable user to achieve emission limits set by the EU-SED<sup>1)</sup></p>	<p>Same as current ECSA Nomenclature: <b>5<sup>th</sup> Generation</b> machines</p>	<p>Same as current ECSA Nomenclature: <b>5<sup>th</sup> Generation</b> machines</p>
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- 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 Emissionsbegrenzung 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





## ECSA – The European Chlorinated Solvent Association

ECSA represents the interests of the producers of chlorinated solvents in the EU that are organized under Euro Chlor.

Euro Chlor is the Brussels based business association representing chlor-alkali producers in the EU and EFTA regions, employing 39,000 people at nearly 70 manufacturing sites. Almost 2,000,000 jobs in Europe are related to chlorine and its co-product caustic soda. These two key chemical building blocks underpin 55% of the European chemical industry turnover. More than 90% of the European drinking water is made safe with chlorine and about 85 % of all medicines are synthesized using chlorine chemistry.

Euro Chlor is an affiliate of Cefic – the European Chemical Industry Council.

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