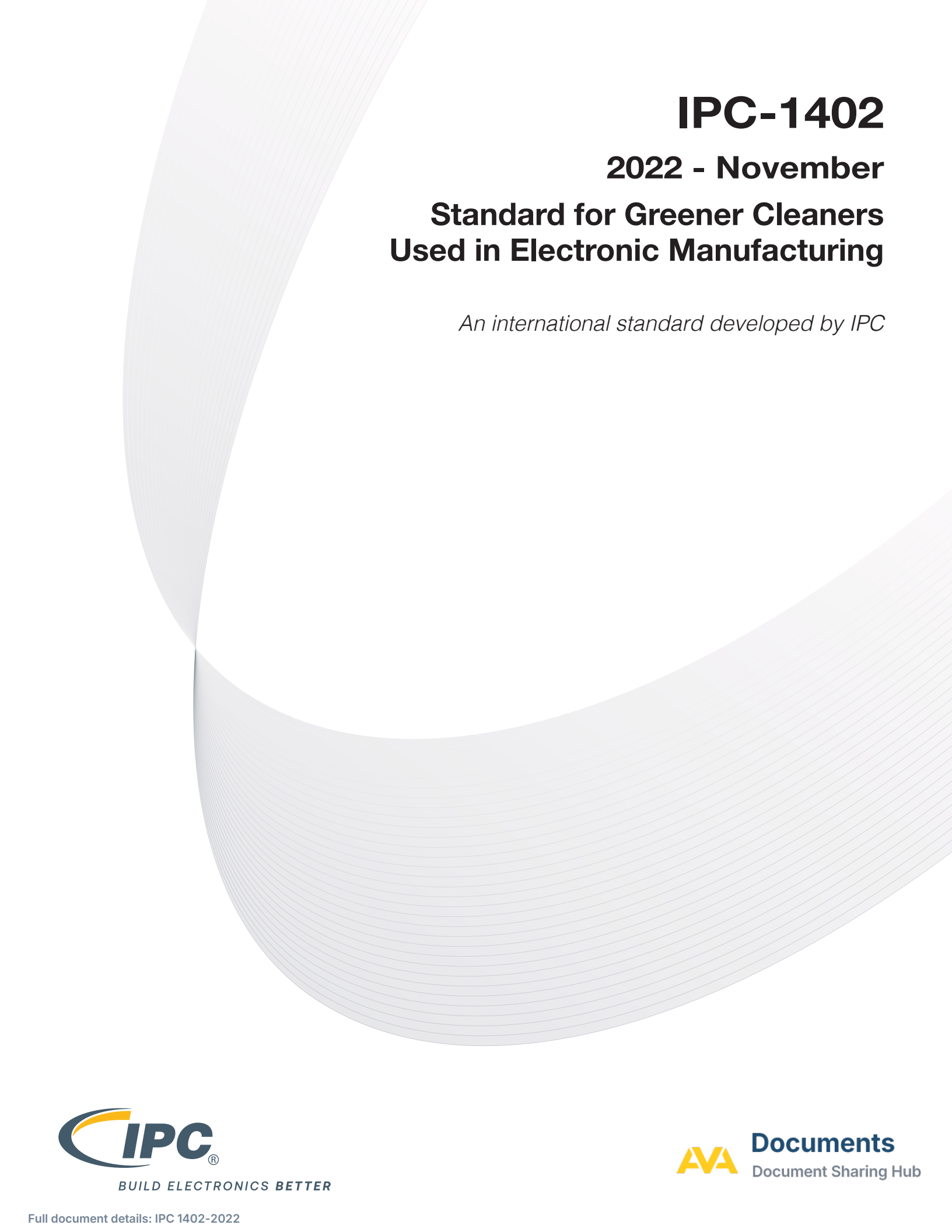




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2022 - November

Standard for Greener Cleaners Used in Electronic Manufacturing

An international standard developed by IPC



BUILD ELECTRONICS BETTER



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IPC-1402

Standard for Greener Cleaners Used in Electronic Manufacturing

Developed by the Green Cleaners in Manufacturing Task Group (5-26a) of
the Assembly & Joining Committee (5-20) of IPC

Users of this publication are encouraged to
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Standard for Greener Cleaners Used in Electronic Manufacturing

1.0 SCOPE

This standard applies to cleaning products used in the Electronics Manufacturing, including but not limited to original equipment manufacturers, electronics manufacturing services companies, board manufactures, cable and wire harness manufacturers and electronics industry suppliers.

This standard applies to direct use chemicals to clean products or components, as well as to clean manufacturing machines or tooling during operation and maintenance.

Cleaning product categories that are in scope of this document include but are not limited to:

- Removing solder and flux residuals from PCBs, components
- Cleaning of the contaminated surfaces inside reflow ovens
- Cleaning the flux residual on stencil, carrier, and frames
- Cleaning adhesive dispensing needles
- Screen wiping
- Optical lens cleaning
- Packaging printer cleaning
- De-bonding solutions for re-work or recycle
- Degreasing tooling and machine parts
- Stripping of coatings

Product categories that are out of scope of this document include but are not limited to:

- Demolding solutions
- Cleaners used in non-manufacturing activities (e.g., laboratory, office housekeeping, and maintenance unrelated to manufacturing)
- Surface treatment agents used to promote adhesion, etching and post etching operations, and chemical mechanical planarization (CMP process).

This standard is focused on reducing the human health and environmental impacts and improving the safety of cleaning products used during the manufacturing process. This standard does not include or assess the performance of cleaning products.

This standard is targeted to define greener cleaners and does not replace the risk assessment associated with cleaning application under various working conditions.

1.1 Purpose The purpose of this standard is to set pragmatic, minimum criteria for greener cleaning products used in electronics manufacturing that can be feasibly and efficiently applied by decision-makers to protect workers and the environment. The minimum criteria are based on a foundational set of scientifically defensible environmental, health and safety requirements using a combination of list-based data sources, information found on Safety Data Sheets (SDSs) and analytical testing results. Additional guidance is included to facilitate continuous improvement in formulating safer cleaning products.

1.1.1 Users This standard is intended to be used by chemists, EHS professionals, and engineers working at companies formulating cleaning products or manufacturing electronics. It can also be used by purchasers and other stakeholders interested in evaluating use of safer cleaning products by suppliers.

1.1.2 Value Electronic manufacturers can demonstrate their commitment to protection of workers and the environment by specifying use of this standard for selecting cleaning products. Cleaning product formulators can demonstrate their commitment to providing greener and safer products to the market by formulating products to meet this standard, and following the included guidance to continually improve their formulations.

1.1.3 Limitations This standard is intended to be an important initial step in identifying greener cleaners that avoid known problematic chemicals using list-based data sources and analytical testing results. This standard is intended to work in harmony with more detailed hazard and alternatives analyses, or independent product certification schemes requiring a comprehensive review of all available data and information that goes well beyond the data requirements of this standard. Since the data used to

demonstrate how a cleaning product meets this standard have a significant impact on the results, a reviewer may come to a different conclusion regarding the product after conducting a more comprehensive chemical hazard assessment.

1.2 Definition of Requirements The words **shall** or **shall not** are used in the text of this document wherever there is a requirement for materials, preparation, process control or acceptance.

The word “should” reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

Line drawings and illustrations are depicted herein to assist in the interpretation of the written requirements of this Standard. The text takes precedence over the figures.

1.3 Order of Precedence The contract **shall** take precedence over this Standard, referenced standards and drawings. In the event of conflict, the following order of precedence applies:

- 1) Procurement as agreed and documented between customer and supplier.
- 2) Master drawing reflecting the customer’s detailed requirements.
- 3) When invoked by the customer or per contractual agreement, this standard.

When documents other than this standard are cited, the order of precedence **shall** be defined in the procurement documents. The User has the opportunity to specify alternate acceptance criteria.

1.3.1 Conflict In the event of conflict between the requirements of this standard and the applicable drawing(s) and documentation, the applicable user-approved drawing(s) and documentation govern.

Some examples of documentation include the contract, purchase order, technical data package, engineering specification or performance specification. In the event of a conflict between the text of this standard and the applicable documents cited herein, the text of this standard takes precedence. In the event of conflict between the requirements of this standard and drawing(s) and documentation that has not been user approved, this standard governs.

1.3.2 Clause References When a clause in this document is referenced its subordinate clauses apply, unless the requirement references specific subordinate clauses.

1.3.3 Appendices Appendices to this standard are not binding requirements unless separately and specifically required by this standard, the applicable contracts, assembly drawing(s), documentation or purchase orders.

1.4 Abbreviations and Acronyms Periodic table elements are abbreviated in the standard. See the list below for full spellings of abbreviations (including elements) and acronyms used in this standard.

1.4.1 CAS RN Chemical Abstract Service Registry Number

1.4.2 GHG Greenhouse Gasses

1.4.3 GWP Global Warming Potential

1.4.4 ODS Ozone Depleting Substances

1.4.5 VOC Volatile Organic Compounds

1.4.6 CEPN Clean Electronics Production Network

1.4.7 ACI American Cleaning Institute

1.4.8 AISE International Association for Soaps, Detergents and Maintenance Products

1.4.9 ISO International Standard for Organization

1.4.10 EU European Union

1.4.11 ECHA European Chemicals Agency

1.4.12 IPCC International Panel on Climate Change

1.4.13 PHA Process Hazard Evaluation

1.4.14 CFC Chlorofluorocarbons

1.4.15 HCFC Hydrochlorofluorocarbons

1.4.16 CH₃Br Methyl bromide

1.4.17 CCl₄ Carbon tetrachloride

1.4.18 CH₃ CCl₃ Methyl chloroform

1.4.19 HBFC Hydrobromofluorocarbons

1.4.20 CH₂BrCl Bromochloromethane

1.4.21 PBT Persistent, Bioaccumulative and Toxic

1.4.22 HFO Hydrofluoroolefin

1.4.23 RSL Restricted Substance List

1.4.24 IARC International Agency for Research on Cancer

1.4.25 GHS Globally Harmonized System

1.4.26 PPE Personal Protection Equipment

1.4.27 SDS Safety Data Sheet

1.4.28 PVD Physical Vapor Deposition

1.5 Terms and Definitions Other than those terms listed below, the definitions of terms used in this standard are in accordance with IPC-T-50.

1.5.1 CAS RN – Chemical Abstract Service Registry Number An internationally recognized number to uniquely identify a chemical.

1.5.2 Chemical/Chemical Compound A molecule (or molecular entity) composed of atoms of more than one element held together by chemical bonds and typically identified by a CAS RN. Synonyms used in this guidance include “chemical” or “compound.”

1.5.3 Cleaners Chemicals and chemical mixtures used to remove contaminants, unwanted materials (unwanted ink, coating PVD, adhesives, etc.) and/or manufacturing processing residues (e.g., lubricants, adhesives, solder flux residues, plastic residue, mold releases, etc.) from:

- Individual parts, subcomponents, assemblies, process substrates and/or final assembled products.
- Manufacturing equipment to manufacture individual components or final product
- The cleaner may be in any form, such as liquid, powder, gas, vapor, paste, bar, cake, molded piece, shape, etc.

1.5.4 Greener Cleaners Cleaners meeting the minimum criteria for a greener cleaner as defined in section 5.3.

1.5.5 Enclosed Process Enclosed production, or processes with equivalent containment conditions, without likelihood of exposure. The enclosed transfers inherent to the process, including sampling, are included. Unenclosed transfers to charge/discharge the process are not included. (Adapted from EU PROC 1) (CEPN Definition)

1.5.6 Hazard Determination One of three levels, High, Moderate or Low, assigned to a cleaning agent:

- High: Chemicals with significant safety health or environmental hazards.
- Moderate: Potential hazards have been identified for these chemicals.
- Low: Hazards of this chemical agent are relatively low.

1.5.7 Greenhouse Gasses (GHG) A gas in the atmosphere such as water vapor, carbon dioxide, methane and nitrous oxide that can absorb infrared radiation, trapping heat in the atmosphere. This greenhouse effect means that emissions of greenhouse gases due to human activity cause global warming.

1.5.8 Global Warming Potential (GWP) The cumulative direct and indirect warming impacts integrated over a period of time from the emission of a unit of mass of gas relative to carbon dioxide, which is assigned a value of 1. Each greenhouse gas (GHG) has a global warming potential value; these values are indexed to the climate effects associated with carbon dioxide. Global warming potential values provide a comparison for same mass of carbon dioxide (CO₂). This number is calculated by the Intergovernmental Panel on Climate Change (IPCC), based on the intensity of infrared absorption by each GHG and how long emissions remain in the atmosphere. GWPs are calculated using a set time horizon. All GWPs used for GHG inventory purposes are considered over a 100-yr timeframe. GWPs are updated periodically with improvements to the underlying science. (reference: <https://ww2.arb.ca.gov/ghg-gwps#:~:text=This%20number%20is%20calculated%20by%20the%20Intergovernmental%20Panel,inventory%20purposes%20are%20considered%20over%20a%20100-yr%20timeframe>)

1.5.9 Ozone Depleting Substances (ODS) “Substances known to deplete the stratospheric ozone layer. The ODS controlled under the Montreal Protocol and its Amendments are chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC), halons, methyl bromide (CH₃Br), carbon tetrachloride (CCl₄), methyl chloroform (CH₃CCl₃), hydrobromofluorocarbons (HBFC) and bromochloromethane (CH₂BrCl).” (California Air Resources Board). Refer to the newest version of “Montreal Protocol” for the detailed substance list.

1.5.10 Volatile Organic Compounds (VOC) Local and Regional Governments have adopted considerably different VOC definitions and may also have special material or use case exemptions. Therefore, the end user should always check their local definition when evaluating greener cleaning options. The following are examples and references of how VOCs are determined based on locality:

- **China:** GB 38508-2020 – Organic compounds that will undergo atmospheric photochemical reaction at standard atmospheric pressure of 101.3 kPa and initial boiling point less than or equal to 250 °C, or those determined according to relevant regulations.
- **European Union (EU):** Industrial Emissions Directive (Directive 2010/75/EU) – ‘Volatile Organic Compound’ means any organic compound as well as the fraction of creosote, having at 293.15 K a vapor pressure of 0.01 kPa or more, or having a corresponding volatility under the particular conditions of use.
- **United States (US):** The Environmental Protection Agency (EPA) definition of a VOC in non-consumer applications is any compound of carbon excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate and excluding compounds that have negligible photochemical reactivity such as: ethane, methane, methylene chloride, perchloroethylene, and acetone. For other compounds, see 40 Code of Federal Regulations Section 51.100(s). Please also check with state and local governments as they may be more restrictive than the definition above.

1.6 Organizations The following organizations of the revision in effect at the time of order form a part of this document to the extent specified herein.

1.6.1 Clean Electronics Production Network (CEPN) CEPN Main Index – Green America Center for Sustainability Solutions Title; <https://www.cleaninginstitute.org/understanding-products/how-read-labels/glossary-cleaning-product-terminology>

1.6.2 American Cleaning Institute (ACI) <https://www.cleaninginstitute.org/understanding-products/ingredients/ingredient-glossary>

1.6.3 International Association for Soaps, Detergents and Maintenance Products (AISE) https://www.aise.eu/documents/document/20180125164634-aise_detergents_guidelines_final_22_november_2017_with_correct_links_to_ec.pdf

1.6.4 International Standard for Organization (ISO) <https://www.iso.org/obp/ui/#iso:std:iso:862:ed-1:v1:en>

1.6.5 European Union (EU) <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02004R0648-20150601&from=LV>

1.6.6 European Chemicals Agency (ECHA) <https://echa.europa.eu/home>

2.0 APPLICABLE DOCUMENTS

The following specifications of the revision in effect at the time of order form a part of this document to the extent specified herein. If a conflict of requirements exists between this specification and the listed applicable documents, this specification **shall** take precedence.

2.1 Regulatory Documents

- GB 38508-2020 Limits for Volatile Organic Compounds Content in Cleaning Agents
- EU Directive 2004/42/CE
- EE Semi Comprehensive Reference on Semiconductor Manufacturing: <https://www.eesemi.com/wafer-cleaning.htm>
- EPA’s Carcinogen Risk Assessment Guidelines: U.S. EPA. 2005. Guidelines for Carcinogen Risk Assessment. 70 FR 17765-17817; U.S. EPA. 1986. Guidelines for Carcinogen Risk Assessment. 51 FR 33992-34003
- EU Directive 2010/75/EU

2.2 Other Industry Standards

- OECD, LISTS OF PFOS, PFAS, PFOA, PFCA, RELATED COMPOUNDS AND CHEMICALS THAT MAY DEGRADE TO PFCA: [https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/jm/mono\(2006\)15](https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/jm/mono(2006)15)

3.0 CLEANER OVERVIEW

The purpose of the Cleaner Overview section is to provide background information and perspective to the user of this standard. This section is used for reference only.

3.1 Cleaning Process A cleaning process is achieved by exploiting cleaning energy from two items, first there is chemical energy (this is the cleaner) and secondly, mechanical energy (this is the cleaning equipment). If no mechanical energy is provided, an item is considered to be “soaking” in the cleaner. Here, we consider the cleaner.

3.1.1 Cleaner Based on Chemistry A cleaning product in the broadest sense of the definition is a product used to lift residues from a surface. Pertaining to this documentation, focus is given to cleaning products that are both employed by and of interest to the electronic cleaning industry. For this reason, we focus on defining the cleaner, its role and attributes in terms of the electronic cleaning industry.

3.1.2 Role of the Cleaner and General Contamination Being Cleaned The core job of a cleaner is to clean and while this role may be static, the contamination will differ as well as how the cleaner is utilized. Additionally, human exposure to the product will differ depending upon how the product is used and cleaning equipment utilized. It is not within the scope of this document to differentiate between different potential exposure levels or consider engineering controls that may reduce or eliminate exposure to the cleaner. It is instead the goal of this document to focus solely on the cleaning product itself, independently of usage. However, that being said, background for the purpose of context and understanding is important.

Cleaners in general fall into two broad categories, Machine cleaner and Product cleaner. Although there can be overlap between the two.

- 1) **Machine cleaner** Machine cleaners are those cleaners which have been specifically designed for use in a piece of industrial equipment. Cleaners are then tailored to various types of equipment and cleaning needs. Electronic cleaning equipment types can range from (but is not limited to): spray in air, spray under immersion, ultra-sonic, centrifugal, dipping, vapor defluxing and vacuum cleaning. A typical process will involve 3 steps: cleaning, rinsing, and drying. When cleaning equipment is employed, potential human exposure to concentrated chemistry occurs primarily during the loading phase of the chemistry into the instrument.
- 2) **Product cleaner** Product cleaners are those cleaners which have been developed with the understanding that the mechanical power required for cleaning will for most applications be supplied by a human input or via cleaning equipment, which has been specifically developed to use a product cleaner. Typically, this type of cleaning is found in (but not limited to) maintenance cleaning and touch up work. When mechanical energy is being provided by human input, exposure to the chemical by the human is constant while cleaning takes place. Regarding product cleaning machines, such as equipment which is developed for whole product cleaning or automatic repairing, risk further extends past human exposure and as with most equipment, flammability becomes a concern again.
- 3) **Contamination** As the cleaner's job is to remove residues from a given surface, the type of contamination under consideration can be virtually limitless. Many solder pastes and fluxes will contain items such as heavy metals, organic acids, and flammable solvents. It is important to note this standard pertains to a cleaning product and not to a cleaner contaminated from use. We also note that this standard is not intended to describe the cleaning process or to provide guidance as to what should be considered clean. Readers who are instead seeking a reference as to what should be considered an acceptable cleaning level should look to IPC J-STD-001.

3.1.3 Cleaner Classification During the design of a cleaning agent, a specific residue type is targeted for removal and then a choice is made as to if the cleaner will be an aqueous based cleaner or a neat solvent-based product.

Cleaners as the finished product are formulated in one of two ways.

- 1) A cleaner can be designed and formulated in such a way that the product is intended to be diluted before use
or
 - 2) The product can be intended for next use. Additionally, when an employed formula encounters problems, additives may be sold which are intended for use in a cleaner to endow the cleaner with additional abilities (such as inhibition packages, defoaming, etc.).
- a. Aqueous Based Cleaning Products** When a cleaner is intended for dilution in water before use, the cleaner is considered an aqueous cleaner and typically sold as a concentrate. These cleaners will have a dilution recommendation provided by the manufacturer and the bulk of the cleaning solution then becomes water after dilution. This leads to a situation where, after dilution, the cleaner typically becomes somewhat safer because of the large volume of water that is present. Due to sub-standard water quality, aqueous cleaners may be procured ready-to-use in their diluted state. For ready to use products, the manufacturer supplies prediluted products to the customer. As the goal of this document is to provide a greener cleaner standard as it relates to the product being supplied to the customer, inevitably if a ready to use product is provided of a concentrated product, a situation does exist where a single product can have two separate assessments. The reasoning behind this is because the overall maximum solution that a worker could be exposed to is different in each instance, one is a concentrated chemistry and the other (ready to use product) is majority water. So, we note here that products which are sold prediluted in water, **shall** have some type of nomenclature to distinguish their difference from their concentrated counterpart. To this point we stress that assessments are given to products as sold and not necessarily to products as used.

- b. Solvent Based Cleaning Products** Solvent based cleaners are those cleaners being sold for direct use without dilution in water by the user or predilution by the manufacturer. Solvent based cleaners use formula bases that are primarily composed of organic and or halogenated solvents and in general are defluxing cleaners that will not be diluted in water.
- c. Applications and Residue to be Removed** The job of a cleaner is to remove a given residue from a specified surface (as previously indicated, this document focuses upon cleaners found within the electronic industry). With consideration to this, it is useful to indicate potential applications and residues to which this document may be applied. The following list describes potential applications, see Table 3-1, in which a cleaner in the electronic industry may be employed and notes the residue that will likely be removed for an application of this type. Although the listing is not all inclusive, the listing serves as a general guide to cleaning in the electronic industry.

Table 3-1 Potential Applications List

Applications	Impurity for Removal	Examples
Post soldering PCBA and DCB - Cleaning - Defluxing - Flux removal	PCBA and DCB defluxing - solvent based - water based	Flux residual removal from PCBs, DCBs, and etc. after soldering has taken place. Includes repair/retouch flux removal.
Precision Parts Cleaning	Removal of any process contaminant from a desired substrate	Removal of conductive adhesives from dispensing needles
Optical Module Cleaning	Grease, dust, particle, etc. removal from optical module	Cleaning of fiber optic connectors
Screen Wiping	Removal of dirt, fingerprint, oil, and particles from screen	Wiping of the LCD display
Metal & Plastic Cleaning	Removal of oil, grease, or stains from metal & plastic parts.	Cleaning of a metal surface before metal bonding takes place
Printing Machine cleaning	Removal of inks and unsoldered jet printed solder pastes	Removing inks from jet printers
Semi-Conductor Cleaning	Silicon wafers photoresist cleaning	Manual cleaning with cups and automatic cleaning with wafers
Stencil/squeegee/tooling/misprint cleaning/etc.	Removal of uncured solder paste and uncured adhesives	Stencil cleaning and the cleaning of misprinted PCBs.
Maintenance Cleaning	Removal of flux and residue from equipment	Cleaning: reflow oven, SMT & PTH & testing equipment, pick and place nozzle, testing probes, auxiliary equipment such as router and lead-trimming machine, etc.
Conformal coating removal and De-bonding	Removal of conformal coating/ultrathin coating and adhesive removal	Pallet cleaning and adhesive removal

3.2 Raw Material Groupings for the Cleaner The standard provided here within is for the final cleaning product as a whole. Regarding the composition of a cleaning product, a cleaner is composed of solvents and surfactants to solubilize residues, followed by a host of supporting molecules to provide desired attributes to the cleaner. Supporting molecules can then encompass any of the broad chemical groupings (polymers, non pH neutral components, and salts).

3.2.1 Solvent Solvents play a key role in formula development when it comes to cleaners. Solvents provide the necessary chemical energy to solvate residues for removal and play an active role in micelle formation. Solvents broadly fall into one of three categories: non-halogenated organic, inorganic, and halogenated. The category of a given solvent is less important in terms of its ability to solvate an impurity and instead various solubility parameters give a better view into how a solvent will behave. Organic solvents are widely employed in both solvent based and aqueous cleaners while halogenated solvents are commonly found in vapor defluxing. Inorganic solvents are less used within the industry with the one exception being water. All solvents have a melting point, boiling point, and vapor pressure. The lower the boiling point and higher the vapor pressure, the easier it is for a given solvent molecule to escape the bulk liquid phase and enter the gas phase; this can then factor into items such as flammability, VOC, and the quantity of the solvent found within the surrounding air.

3.2.2 Surfactant Surfactants are like solvents in many ways as their key role in a cleaner is to solvate impurities. They are surface activate agents and their molecular structure is normally composed of both a hydrophilic and hydrophobic segment. As it relates to physical properties, the primary difference in a solvent and surfactant is that surfactants typically have a much higher boiling point than solvents and in a similar manner, they have a much higher viscosity. In fact, many surfactants will have a boiling point

enough and vapor pressure low enough that many of the raw materials falling into this grouping will have a negligible quantity of the material in the vapor phase at any given time. In regard to the role of a surfactant, surfactants are agents that help reduce surface tension between two states (liquid-liquid, liquid-gas, or liquid-solid) and can potentially provide a means to micelle formation when in solution. Additionally, surfactants can be either ionic or nonionic in nature. As ionic species can be problematic in the electronic industry, ionic surfactants are typically avoided for electronic cleaners.

3.2.3 Polymers Polymers are class of organic compounds that consist of repeating monomers covalently bound together. They can be soluble or insoluble, and vary in size, composition, and chain length.

3.2.4 Acids and Bases Alkalinity can play a large role in the development of a cleaner, this can easily be seen by the wide range of alkaline cleaners that are commercially available on the market for the electronic industry. Conversely acids are less seen in electronic cleaners and more frequently found in solder pastes and fluxes, the one exception being when they are used for adjusting the pH of a given product. When acids or bases are used as a pH adjuster, they act to provide a more desirable pH to the overall product. It is notable to state that when an acid or base is used for neutralization, after the neutralization process is complete, the resulting mixture will lose any corrosivity (as related to human health and skin assessments) that were a result of the acidic or alkaline nature of the initial solutions. Additionally, it should be noted that all acids and bases are at least partially ionized at all pH values, this in turn can contribute to the conductivity of a solution.

3.2.5 Salts A salt is the inevitable outcome of combining an acid and base or formed during some Oxidation/Reduction reactions. Although specific acid/base reactions can be highly depended upon a given pH, these types of reactions can take place throughout the entire pH range. Ionic in nature, a salt compound will typically exhibit a reasonable solubility in water and in some instances can be employed as a buffer for a cleaning solution. Salts left behind on an electronic part will have the potential to be detrimental to the long-term reliability of the part. As a salt is composed of both a cation and anion, salt compounds are responsible for ionic contamination.

3.3 Cleaning Process A cleaning process is achieved by exploiting cleaning energy from two items, first there is solvency (this is the cleaner) and secondly there is mechanical energy. If no mechanical energy is provided, an item is considered to be “soaking” in the cleaner. If cleaning energy from any one item is reduced, it **shall** be compensated by the other to achieve a similar cleaning result. As previously stated in other sections, it is outside of the scope of this document to consider equipment or engineering controls that can reduce chemical exposure, however, background on the cleaning method should be provided for the sake of context.

3.3.1 Manual Cleaning Manual cleaning is cleaning in which the mechanical power required for cleaning is supplied by a human. As a human provides mechanical energy for this type of cleaning, human exposure to the chemistry is constant while cleaning takes place. Additionally, cleaners sold for this express purpose are defined in this document to be a “Product Cleaner”.

- 1) **Typical Cleaning Methodology** Typically this type of cleaning is found in (but not limited to) maintenance cleaning and touch up work. Cleaning of this type is normally achieved through a human using a tool such as a brush or cloth to provide a scrubbing action upon the desired surface to be cleaned. As the physical ability of most humans are somewhat different, manual cleaning is somewhat difficult to standardize because the input of mechanical energy for the cleaning process can vary greatly.

3.3.2 Equipment Cleaning As there is a wide diversity of parts and residues which require cleaning in the electronic industry, many different types of equipment exist for cleaning parts. In general, a cleaner can be used to clean a part via spraying action of the cleaner, submerging in the cleaner or with hot vapors from the cleaner. Additionally, cleaners sold for this express purpose are defined in this document to be a “machine cleaner”.

- 1) **Typical Cleaning Methodology** This type of cleaning methodology uses cleaning equipment to provide a standardized amount of mechanical energy to allow a cleaning process to be uniform. The level of mechanical energy offered to the cleaning process can range from mild to non for items such as dip tanks to great amounts of mechanical energy for items such as Ultra-Sonic and Spray-in-Air equipment.

3.3.3 Different Types Other types of cleaning process are discussed below.

3.3.3.1 Spray-in-Air Spray-in-Air equipment uses a high-pressure spraying action of a cleaning solution to remove desired residues from a part. Frequently equipment of this type can reach pressures of up to 90 – 100 psi and have the ability to heat the cleaning solution to an elevated temperature. As noted in the name Spray-in-Air, the cleaner is generally sprayed into an oxygen rich environment, the air. For this reason, many cleaners used in Spray-in-Air equipment are either aqueous cleaners that have been significantly diluted with water or explosion proof equipment is employed when using solvent based cleaning products, if the flash point is low enough to be a concern. Spray-in-Air equipment is typically found in two different variety types, either a conveyor driven inline process or a sequential batch process. An inline process places a part on a conveyor where it is carried through