



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

IPC-SC-60A

Post Solder Solvent Cleaning Handbook

ANSI/IPC-SC-60A

August 1999

A standard developed by IPC

Supersedes IPC-SC-60
April 1987

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Post Solder Solvent Cleaning Handbook

Developed by the Solvent Cleaning Task Group (5-31a) of the
Cleaning and Coating Committee of IPC

APPROVED OCTOBER 20, 1999 BY



AMERICAN NATIONAL STANDARDS INSTITUTE

Users of this standard are encouraged to participate in the
development of future revisions.

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Acknowledgment

Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the Solvent Cleaning Task Group (5-31a) of the Cleaning and Coating Committee are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Post Solder Solvent Cleaning Handbook

1 SCOPE

This handbook addresses solvent cleaning of electrical/electronic assemblies, parts and application tools after soldering.

1.1 Purpose The content of this text is intended to provide a basic understanding of the subject and to serve as a guide to users or prospective users of solvent cleaning technology, allowing selection or improvement of solvent cleaning processes.

Notes:

1. Content of this revision is limited to those solvents that have a wide use in electronic assembly cleaning operations as of date of publication.
2. New solvents or formulations that are developed and then proven effective for this use will be included in a future revision.
3. Since *normal propyl bromide (nPB)* and its formulations are legal for sale and use for electronics cleaning, pending the issuance of a final rule by the U.S. Environmental Protection Agency (EPA) Significant New Alternatives Program (SNAP) office, all references to *nPB* or *brominated* cleaning agents in this document are in italics (see Annex C).
4. Transportation and storage related temperatures and weights are also provided in English units for safety related reasons. It is recognized that certain paragraphs are U.S. specific and other countries will need to substitute equivalent requirements/information.

1.2 Terms and Definitions All terms and definitions used throughout this handbook are in compliance with IPC-T-50. Other basic terms and definitions, essential for the discussion of the subject, are provided below or are defined in appropriate sections of this handbook.

Solvent Cleaning – A cleaning process that uses a solvent medium, instead of water, for washing and rinsing the electronic parts and assemblies. In solvent cleaning, drying is application and equipment dependent. In vapor defluxing, drying is accomplished by evaporating residual liquid solvent on the part being cleaned into the vapor zone generated by the boiling solvent. In all other applications, drying occurs by evaporation of residual solvent into the air, taking care to keep the vapor in air levels within recommended limits.

Wash or Washing – The primary cleaning operation that removes undesirable impurities (contaminants) from surfaces by chemical and physical effects, mainly dissolution of the contaminants.

Rinse or Rinsing – A cleaning operation (usually following the wash step) where fresh solvent replaces - via a dilution mode - any residual contamination, leaving surfaces wet with pure solvent.

Drying – The process of removing any residual liquid solvent on the surface of the washed and rinsed parts. In a vapor defluxing process, drying is accomplished in the vapor zone created by the boiling solvent in the wash zone of the cleaning machine. Drying can be augmented by passing superheated solvent vapor across the surface of the parts, to ensure complete removal of residual liquid solvent. This technique is especially effective with complex geometries that can entrap liquid solvent.

Defluxing (Flux Removal or Post Solder Cleaning) – The cleaning process designed to remove solder flux and by-products. Other objectives are removal of process residues and materials used as production aids, such as solvent soluble maskants. Impurities left by board or component fabrication processes or other operations may be removed during the process, thus the defluxing process widens the process window for assemblers.

1.2.1 Chemical Material Acronym Definitions

HCFC Hydrochlorofluorocarbon
 HFC Hydrofluorocarbon
 HFE Hydrofluoroether
nPB normal Propyl Bromide
 CFC Chlorofluorocarbon
 TCE Trichloroethylene
 PCE Perchloroethylene

2 APPLICABLE DOCUMENTS

This section contains references to industry standards, federal regulations, test methods and vehicles which are applicable to post solder solvent cleaning. Not all of these are cross-referenced in the text. They are listed below for the convenience of the readers.

2.1 Industry Standards

2.1.1 IPC Standards¹

IPC-B-24 Surface Insulation Resistance Test Board

IPC-B-25 Multipurpose Test Board

¹ IPC, 2215 Sanders Road, Northbrook, IL 60062

IPC-B-36 Cleaning Alternatives Test Board**IPC-T-50** Terms and Definitions for Interconnecting and Packaging Electronic Circuits**IPC-SA-61** Post Solder Semi-Aqueous Cleaning Handbook**IPC-AC-62** Post Solder Aqueous Cleaning Handbook**IPC-CH-65** Guidelines for Cleaning of Printed Boards and Assemblies**IPC-CS-70** Guidelines for Chemical Handling Safety in Printed Board Manufacturing**IPC-TP-383** Organic Surface Contamination: Identification, Characterization, Removal Effects on Insulation Resistance and Coating Adhesion**IPC-PE-740** Troubleshooting Guide for Printed Board Manufacture and Assembly**IPC-TM-650** Test Methods Manual

2.3.25 Detection and Measurement of Ionizable Surface Contaminants

2.3.27 Cleanliness Test - Residual Rosin

2.3.27.1 Rosin Flux Residue Analysis - HPLC Method

2.3.28 Ionic Analysis of Circuit Boards, Ion Chromatography Method

2.3.30 Solvent pH Determination in Anhydrous Fluorocarbon Solvents

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2.6.9.1 Test to Determine Sensitivity of Electronic Assemblies to Ultrasonic Energy

2.6.9.2 Test to Determine Sensitivity of Electronic Components to Ultrasonic Energy

2.6.13 Assessment of Susceptibility to Metallic Dendritic Growth : Uncoated Printed Wiring

2.6.14 Resistance to Electrochemical Migration, Polymer Solder Mask

2.1.2 Joint Industry Standards¹**J-STD-001** Requirements for Soldered Electrical and Electronic Assemblies**J-STD-004** Requirements for Soldering Fluxes**J-STD-005** Requirements for Soldering Pastes**J-STD-006** Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications**NOTE:** For additional documents and references related to general cleaning issues (IPC, DOD, EIA, UL, ASTM and ANSI) the reader is referred to the IPC Cleaning Handbook; IPC-CH-65).**2.2 U.S. Federal Regulations²****2.2.1 Federal Laws****CAA** Clean Air Act**CWA** Clean Water Act**RCRA** Resource Conservation and Recovery Act**CERCLA** Comprehensive Environmental Response, Compensation and Liability Act**SARA** Superfund Amendment and Reauthorization Act**2.2.2 Federal Standards****O-A-51** Acetone, Technical**O-E-760** Special Industrial Solvents**O-M-232** Methanol (Methyl Alcohol)**O-T-236** Tetrachloroethylene (Perchloroethylene); Technical**O-T-620** 1,1,1-Trichloroethane, Technical, Inhibited (Methyl Chloroform)**O-T-634** Trichloroethylene, Technical, Inhibited**TT-B-848** Butyl Alcohol, Secondary, For Use in Organic Coatings**TT-I-735** Isopropyl Alcohol**TT-M-261** Methyl Ethyl Ketone**TT-N-95** Naphtha, Aliphatic**TT-N-97** Naphtha, Aromatic**TT-T-548** Toluene Ethyl Alcohol, (Ethanol) Denatured Alcohol, Proprietary Solvents**2.2.3 Department of Defense³****MIL-C-81302** Cleaning Compound, Solvent, Trichlorotrifluoroethane

2. General Services Administration, Federal Supply Service, Bureau Specifications Section (3FBP-W), Suite 8100 470 L'Enfant Plaza SW, Washington, DC 20407

3. Standardization Documents Order Desk, 700 Robbins Avenue, Bldg. 4D, Philadelphia, PA 19111-5094

MIL-C-85447 Cleaning Compounds, Electrical & Electronic Components

MIL-N-15178 Naphtha, Solvent

MIL-T-81533 Trichloroethane 1,1,1 (Methyl Chloroform) Inhibited, Vapor Degreasing

2.2.4 Occupational Safety and Health Administration⁴

OSHA 29 CFR 1910.1000 Air Contaminants

OSHA 29 CFR 1910.134 Respiratory Protection

OSHA 29 CFR 1910.106 Flammable and Combustible Liquids

2.2.5 Environmental Protection Agency⁵

EPA 40 CFR 63 National Emission Standards for Hazardous Air Pollutants for Source Categories

EPA 40 CFR 82 Protection of Stratospheric Ozone

EPA 40 CFR 117.3 Determination of Reportable Quantities for Hazardous Substances

EPA 40 CFR 131.36 Toxic Criteria for those States not Complying with Clean Water Act Section 303(c)(2)(B)

EPA 40 CFR 261 Identification and Listing of Hazardous Waste

EPA 40 CFR 302.4 Designation of Hazardous Substances

EPA 40 CFR 355.30 (b) Emergency Release Notification

EPA 40 CFR 370 Hazardous Chemical Reporting: Community Right To Know

EPA 40 CFR 372 Toxic Chemical Release Reporting: Community Right-to-Know

2.2.6 Department of Transportation⁶

DOT 33 CFR 153.203 Procedure for the Notice of Discharge

2.2.7 American Conference of Governmental Industrial Hygienists (ACGIH)⁷ and National Institute of Occupational Safety and Health (NIOSH)⁸

Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents, and Biological Exposure Indices Published by ACGIH Worldwide.

Permissible Exposure Limit (PEL) (eight hour exposures)
Short Term Exposure Limit (STEL) (typically 15 minutes)

2.3 Other

2.3.1 American Standards for Testing Materials⁹

2.3.1.1 Test Methods

ASTM Method D-56 Flash Point, TAG Closed Cup

ASTM Method D-92 Flash Point, Cleveland Open Cup

ASTM Method D-93 Flash Point, Pensky-Martens Closed Cup

ASTM Method D-1078 Distillation Range of Volatile Organic Liquids.

ASTM Method D-1133 Kauri-Butanol Value for Hydrocarbon solvents

ASTM Method D-1320 Tensile Strength of Paraffin Wax (withdrawn without replacement)

ASTM Method D-2106 Amine Acid Acceptance of Halogenated Organic Solvents

ASTM Method D-2109 Non-Volatile Matter in Halogenated Organic Solvents and Their Admixtures.

ASTM Method D-2111 Specific Gravity of Halogenated Organic Solvents and Their Admixtures

ASTM Method D-2942 Total Acid Acceptance Of Halogenated Organic Solvents

ASTM Method D-2989 Acidity/Alkalinity of Halogenated Organic Solvents and Their Admixtures.

ASTM Method D-3401 Water in Halogenated Organic Solvents and Their Admixtures

ASTM Method D-3443 Chloride in Trichlorotrifluoroethane

2.3.1.2 Standard Specification of Materials

ASTM D 329 Acetone

ASTM D 362 Toluene (Discontinued without replacement)

ASTM D 740 Methyl Ethyl Ketone

ASTM D 1153 Methyl Isobutyl Ketone

4. OSHA, Public Affairs Office - Room: 3647, 200 Constitution Avenue, Washington, DC 20210

5. EPA, 401 Main Street SW, Washington, DC 20460-0003, Telephone: 800-424-8802

6. DOT, 400 Seventh Street SW, Washington, DC 20590

7. ACGIH, 1330 Kemper Meadow Drive, Suite 600, Cincinnati, OH 45240

8. NIOSH, 200 Independence Avenue SW, Room 715H, Washington, DC 20201

9. ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

- ASTM D 1836** Commercial Hexanes
- ASTM D 3622** N-Propyl Alcohol
- ASTM D 4079** Methylene Chloride (Vapor Degreasing Grade)
- ASTM D 4080** Trichloroethylene
- ASTM D 4081** Perchloroethylene (Drycleaning Grade)
- ASTM D 4126** 1,1,1 Trichloroethane
- ASTM D 4376** Perchloroethylene (Vapor Degreasing Grade)
- ASTM D 4701** Methylene Chloride (Technical Grade)
- ASTM D 5309** Cyclohexane 999
- ASTM D 6368** Vapor-Degreasing Grade and General Solvent Grade for *Normal Propyl Bromide*

2.3.2 National Fire Protection Association (NFPA)¹⁰

NFPA 35 Definitions of Flammable & Combustible Substances

2.3.3 Environmental Protection Agency

EPA-453/R-94-081 Guidance Document for the Halogenated Solvent Cleaner NESHAP

3 CLEANING SOLVENTS/SOLUTIONS

A general rule of cleaning is “like dissolves like,” which means that usually nonpolar contaminants are best removed by nonpolar solvents, while polar or ionic contaminants are best removed by polar solvents. Thus a mixed or complex soil will often require a multicomponent solvent cleaning agent formulation to achieve the desired cleaning result in a single cleaning operation. There are several key areas of concern when selecting such cleaning solvents/solutions.

- Effectiveness (See 3.1)
- Stability (See 3.2)
- Safety (See 3.3)
- Environmental (See 3.4)
- Cost (See 3.5)
- Summary (See 3.6)

3.1 Effectiveness To be effective, a cleaner should have the characteristics as defined below:

3.1.1 Wetting Characteristics The cleaning agent should possess good wetting characteristics which ideally should change minimally during the cleaning operation to assure flow and wetting in all areas to dissolve and remove

contaminants. Wetting is generally dependent upon the viscosity and surface tension of the solvent. Solvent formulations possessing low viscosities and low surface tensions will typically have the best wetting characteristics. (Refer to Section 3.1.2)

3.1.2 Solvency Power The cleaner should possess good solvency power (affinity for the contaminant). The cleaner must be capable of dissolving the contaminants present or wetting is of little value other than to mechanically wash away the contaminant. It is difficult to state the solvency power of a cleaner in absolute terms and therefore relative measures are often used. Examples of such relative measures, which are of limited utility, are solubility of contaminant in g/cm³, solution viscosity changes with specific percent loading, Kauri-Butanol value and aniline point number. A much better method is solubility parameter data, which gives the best indication of the ability of a solvent or solvent formulation to remove a soil. Also, it should be noted that solvency can be enhanced by proper choice of cleaning equipment, agitation methods or cleaning cycle.

3.1.3 Multiple Components A cleaner should contain both polar and nonpolar components. The nonpolar portion is needed to efficiently remove nonionic contaminants such as rosin, oils, fingerprint oils, etc., and the polar components for dissolving (solvating) ionic contaminants such as flux activators, plating salt residues, or salts from handling (see Section 5.1). To achieve the polar/nonpolar characteristics, solvent blends and azeotropes are becoming more prominent. The nonpolar component is often a halogenated solvent, either chlorinated, *brominated*, chlorofluorinated or hydrofluorinated. The polar component solvent is typically an alcohol such as methanol, ethanol, 2-propanol or 1-propanol. Other components such as chlorocarbons or hydrocarbons, are often used to adjust the balance of solvent power and compatibility for specific uses. Stabilizers are often added as well to prevent degradation of the solvent formulation during use.

3.1.4 Degradation The cleaner should not, when properly used, degrade hardware or components comprising the electronic assembly. Marking/symbolization should not be removed by the cleaning solvent/solution. (Refer to Section 4.)

3.1.5 Residues The cleaner should not leave detrimental solvent residues after final rinse. Adequate purity of solvents is a very important factor in being able to achieve an acceptable degree of surface cleanliness. Solvent residues/impurities encountered in the cleaning process can be generally attributed to the items in paragraph 3.1.5.1 through 3.1.5.3.

10. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101

3.1.5.1 Suspended Matter (Particulate matter insoluble in the solvent but suspended due to particle size and/or specific gravity.) The probability of this type of impurity being present increases if adequate controls are not implemented on production cleaning equipment or if solvents are initially packaged or repackaged utilizing insufficient controls or inadequate storage containers.

3.1.5.2 Contaminants in Solvents as a Consequence of Manufacture Small fractions of organic compounds distilled over with the solvent during the solvent manufacturing operation are commonly encountered impurities which do not, for practical purposes, interfere with the intended cleaning function or behavior of the solvent. In certain high reliability aerospace applications, where the presence of trace impurities such as sulfur or silicones are considered detrimental, the user will need to have the composition of the solvent certified to ensure end user requirements are met.

3.1.5.3 Dissolved Contaminants (From cleaning operations and codistilled by reclaiming processes.) The use of reclaimed solvent has distinct economical advantages and is the principle behind all vapor phase cleaning equipment. No problem is encountered as long as codistilled contaminants, such as mineral and silicone oils, are not present in the reclaimed solvent (i.e., a controlled/known source is providing the solvent material to be reclaimed). However, reclaimed solvents available at low cost in bulk quantity from commercial reclaimers who coiled solvent scrap from a variety of possibly uncontrolled sources can pose problems if not properly analyzed prior to use. The risk assumed by the user when applying reclaimed solvent can be high if adequate controls (i.e., incoming inspection) are not implemented. Subsequent operations after cleaning, such as conformal coating, can be adversely affected. Often such reclaimed solvent is used upstream for cleaning parts prior to assembly or for maintenance cleaning, reserving the pure material for final assembly cleaning.

Another potential source of contamination in incoming material is repackaging by distributors and/or users. Care must be taken to ensure the plastic coating inside drums or pails (drum liner) is compatible with the solvent formulation. Individual companies must determine their own incoming requirement to minimize product liability.

3.2 Stability The stability (long use life) of the cleaning agent is important from a reliability/cost standpoint. The cleaner should exhibit resistance to both chemical and thermal decomposition.

3.2.1 Resistance to Chemical Decomposition Some halogenated solvents (1,1,1-trichloroethane (no longer produced), trichloroethylene, perchloroethylene, *n-propyl bro-*

mide) are susceptible to chemical decomposition (previously called “going acid,” but more precisely degradation to unwanted or harmful decomposition products) in the presence of heat, moisture, and contact with certain metals. Such decomposition products are acidic and corrosive. Most commercially available cleaning solvents are formulated with stabilizer systems included. Inhibitors and anti-oxidants are present to prevent solvent degradation and acid acceptors are present to neutralize any acidity that might develop. During operation, the stabilizers may become depleted and, therefore periodic testing of the solvent is required. (Refer to Paragraph 8.6 - Solvent Monitoring.)

3.2.2 Resistance to Thermal Decomposition Most halogenated solvents (1,1,1-trichloroethane, trichloroethylene, perchloroethylene, *n-propyl bromide*, HCFCs, HFCs and HFES) are susceptible to thermal decomposition (previously called “going acid,” but more precisely degradation to unwanted or harmful decomposition products) in the presence of elevated sources of heat; such as hot spots on immersion heaters, contact with the heating elements of radiant space heaters (either electrical or gas) or contact with the heat generated by a welding torch. Once the thermal limits of a solvent molecule are exceeded, no stabilizer package can prevent decomposition. The user must take care to ensure that such contact cannot take place.

3.3 Safety Users of solvent cleaners must also evaluate other safety factors such as fire safety considerations, and both the acute and chronic health effects of the specific cleaning solvent chemicals. Users should always make themselves completely knowledgeable on all aspects of all the Material Safety Data Sheets or MSDS (as supplied by the chemical manufacturer) applicable to the materials in use.

Health effects, in addition to potential inhalation hazards, include irritation to, or corrosion of eye and skin tissues. An evaluation of eye and/or face protection requirement should be done. Skin irritation or corrosion may be a potential hazard and it can be prevented by wearing appropriate protective gloves.

For complete safety information, see IPC-CS-70. It should also be noted that, when using any chemical, a current Material Safety Data Sheet must always be reviewed prior to putting the cleaning agent into service.

3.3.1 Fire Safety The halogenated solvents, along with their low percent alcohol blends, are generally nonflammable. Users should be aware that multi-component azeotropes only possess that particular composition at the boiling point. Thus, if the formulation contains a flammable component, the composition could become rich in that component at room temperature, and therefore ignitable.

Other commonly used solvents such as 2-propanol, terpenes, and other hydrocarbons are flammable or combustible and should be handled and stored according to local safety regulations. These materials can all be used safely as long as the precautions recommended by the supplier are rigorously followed.

The flash point test of a liquid or combination of liquids is normally run to determine how the cleaning agent should be packaged and shipped. It was not intended to predict behavior in a vapor defluxer. It is not uncommon for a cleaning agent to have a flammable range, usually expressed as the concentration in the air that can be ignited, but yet not have a flash point.

Factory Mutual (FM) and the National Fire Protection Association (NFPA) regard liquids with a flash point below 140°F to be “flammable,” and liquids whose flash point is above 140°F but below 200°F to be “combustible.” Flammable liquids pose explosion hazards if their vapors are not properly removed by either local or general ventilation. Users of flammable solvent cleaners must also recognize that installations where these liquids are to be used must conform to certain construction standards such as explosion proof wiring, switches, lights, motors, etc., (see NFPA 35 and OSHA 29 CFR 1910.106 for additional information.) Users of flammable liquids should also verify with their local fire department the need for notification and permission of the use of these liquids. Notification may also be required under EPA’s Community Right to Know regulations 40 CFR 355.30(b), 370.20, 370.21 and 370.25 to report storage and usage of certain chemicals to both the local fire department and emergency planning commission.

3.3.2 Workplace Exposure It is important for worker safety that vapors of a chemical used in the manufacturing area be maintained below the maximum threshold limit value (TLV). TLVs are established by the American Conference of Government & Industrial Hygienists (ACGIH). TLVs are generally used by OSHA for determination of compliance with workplace safety standards. Modern closed or sealed equipment can permit the use of materials with low exposure limits (low TLVs), as well as equipment that has been properly retrofitted to comply with modern requirements.

3.3.2.1 PEL/STEL It is a legal requirement to maintain worker exposure to solvent vapors at or below the Permissible Exposure Limit (PEL) for eight-hour exposures, and at or below the Short Term Exposure Limit (STEL) for shorter time periods (typically 15 minutes) as published by OSHA in the air contaminants section of 29 CFR 1910.1000.

It is equally important to maintain worker exposures to solvent chemicals, on which OSHA has not established a PEL or STEL, at or below the Threshold Limit Value

(TLV) for eight-hour exposures as published by the American Conference of Governmental Industrial Hygienists (ACGIH) and/or the National Institute of Occupational Safety and Health (NIOSH) through proper local ventilation or work practices, or both. OSHA requires that engineering controls (i.e., local ventilation) to be the primary method of controlling employee exposure, and requirement to wear personnel protective equipment (PPE) in the form of respirators to be used as a last resort if engineering controls fail to control exposures. Should wearing of respirators be required to adequately protect workers from vapors of cleaning solvents, the user is required to have a written respiratory protection plan (see 29 CFR 1910.134).

3.3.2.2 Workplace Exposure Monitoring Three common methods used for monitoring of solvent concentration in air are the use of air sampling pumps, organic vapor monitor (OVM) badges, and the organic vapor analyzer (OVA). Both the air sampling pump technique and the OVM badges provide a TWA (time weighted average) of a solvent concentration in the air. The organic vapor analyzer (OVA) provides an instantaneous reading of a solvent concentration in air.

Air Sampling Monitor – The method utilizes a sampling pump and a charcoal tube to collect a given volume of air. It is suggested that the air sampling be conducted over an eight hour period. The charcoal tube is sent to a laboratory and then analyzed for the selected solvent concentration.

Organic Vapor Monitor – The organic vapor monitor (OVM) is similar to a sampling pump although without the mechanical pump. One can wear the OVM as a badge by clipping it onto a shirt pocket for a specified time. The main disadvantage of the method is limited selectivity of the solvent being monitored. The OVM will need to be shipped to an analytical lab for analysis.

Organic Vapor Analyzer – The organic vapor analyzer is essentially a portable gas chromatograph using a flame ionization detector. The method provides measurement of trace quantities of hydrocarbons and organics. It is also used to detect leaks from solvent cleaning equipment as well as measure the instantaneous solvent concentrations in air. Laboratory calibration of the equipment is required to select the solvent to be monitored. Additionally, a technically trained operator will be required to conduct the monitoring and interpret the data for determination of solvent concentrations in air.

3.4 Environmental The selection of a solvent cleaning process, including materials and equipment, must incorporate the inherent impact that a given solvent will have on air emissions, water discharges and waste generation from the facility. Each of these three environmental mediums may require a permit depending on the usage rate and existence of other air emissions, water discharges and waste generation at that facility.

Air Emissions – All cleaning solvents have a vapor pressure, and because of this, either local or general ventilation is required to keep employee exposures below acceptable levels. Accordingly, the use of a solvent cleaning process will result in air emissions of the solvent cleaning agent chemical(s) to the atmosphere. Such emissions may be regulated by the state (or other local permitting authority), the Montreal Protocol, or the Clean Air Act (CAA), depending on the type and amount of chemical(s) emitted, and the total chemical emissions at that facility. An air emissions permit may be needed if the emissions threshold for a given chemical is met by the solvent cleaning process, or if the total air emissions of either a given chemical at that facility from all process sources is exceeded, or if the total air emissions of a group of chemicals at a facility is exceeded (such as volatile organic compounds, VOCs at that facility). (Reference Section 9.2 for more detailed considerations.)

ODP – The Ozone Depletion Potential (ODP) of solvents containing chlorine or bromine ranges from near-zero to significant. The ODP is determined by a Scientific Assessment Panel (SAP) which reports to the UN Technology and Economic Assessment Panel (TEAP). Ozone depletion models used by SAP are currently being updated to permit accurate assessment of halogenated solvents with short atmospheric lifetimes.

GWP – The Global Warming Potential (GWP) of a molecule is a function of its atmospheric lifetime. Many halogenated solvents as well as non-halogenated cleaning materials such as carbon dioxide (used in the supercritical CO₂ cleaning process) have atmospheric lifetimes that could contribute to global warming. Various time horizons are used to express GWPs, without universal agreement on one standard scale. While not currently a basis for regulation, GWPs are taken into account during the cleaning agent qualification process.

HAP – Many substances, including some solvents, are regulated as Hazardous Air Pollutants (HAPs) although they may not be regulated on the basis of ODPs or GWPs. HAPs include such common chlorinated solvents as trichloroethylene (TCE) and perchloroethylene (PCE). In some areas, HAP listing can preclude the use of a particular material, or more importantly, provide guidance on the design of proper equipment and proper workplace practices to allow its use.

Handling – All solvents should be handled with care, using the protective equipment and precautions outlined on the MSDS supplied by the manufacturer. In particular with the solvents characterized by high cost per kg or having a low allowable workplace vapor in air level, it is critical to transfer solvent into the cleaning machine below the vapor-air interface using a proper drum transfer pump. In the case of flammable solvents, air driven instead of electrical pumps should be used. Many of the larger cleaning

machines are fitted with transfer pumps as an option, which ensures that solvent is added to and removed from the cleaner properly. Such transfer pumps are often included if the cleaner is fitted with an attached still for recycling the solvent.

Recycling – Nonflammable solvents are readily recycled by use of a relatively simple still. The still can either be piped directly to the cleaner, to multiple cleaners (assuming the same soil is being removed in each cleaner) or a stand-alone unit. If similar soil chemistry is used for manual cleaning operations, including rework and repair, spent solvent from these cleaning operations can be combined with the solvent from the batch or conveyORIZED cleaning units, thus maximizing the solvent that is recycled and reused (see Section 8.5 for details of recycling still design, options, features, operation and maintenance).

Waste Generation – The generation of spent or waste cleaning solvents may be heavily regulated as a hazardous waste. It is imperative that all spent cleaning solvents be analyzed and characterized by someone knowledgeable in the hazardous waste generation, storage and shipment regulations. These regulations may subject a facility to extensive rules on personnel training, recordkeeping, storage and handling requirements. Even if hazardous waste rules are not applicable, local or state rules on solid waste, not regulated as hazardous, may apply (see Section 9.4 for further information).

Water Discharges – The following information is pertinent for users dealing with waste water streams from water separators and water cooling coils. Generally, the discharge of any new wastewater stream, both by total flow and by chemical makeup, will require a permit from the local publicly owned treatment works (POTW) under the Clean Water Act (CWA). In addition, such a permit may also require co-current state approval (and in rare cases, regional EPA approval). Hence, it is imperative that any new or additional wastewater flow from a solvent cleaning process step be reviewed with local POTW officials BEFORE commencing the discharge of wastewater. Such a review may result in the POTW waiving the need for a permit, or in reducing the monitoring requirements of a required permit. If wastewater discharge to an on-site septic disposal system is contemplated, any such groundwater discharges must be reviewed with the facility's state groundwater protection bureau on the need for a groundwater discharge permit. Extreme caution must be exercised in discharging wastewater containing cleaning solvents, as contaminated groundwater and possible soils may result, which can be extremely costly to remediate. Reference 9.3 for additional details.

Community Right-to-Know – In addition to the above considerations regarding air emissions, water discharges, and waste generation, the annual usage or storage amount of certain chemicals will subject a facility to annual reporting

requirements to federal EPA, the state and local emergency planning commissions or fire departments. In addition, spills or leaks of certain chemicals above established thresholds will require self-reporting to federal, state and local agencies (see Section 9.5 for further detailed information).

3.5 Cost The costs (including initial acquisition and reclamation efficiency) must be reasonable. Solvents with low exposure limits, highly volatile, and flammable materials may require sophisticated equipment and controls to prevent excessive material loss and higher than permissible exposure levels. Previously mentioned factors of stability, effectiveness, disposal, work practices and safety, coupled with initial cost of the solvent are all important in determining total process cost based on overall cost per part cleaned.

3.6 Summary The cleaning agent should:

- not be harmful to employees
- possess excellent wetting ability to enable rapid exchange of the working volume of the cleaning agent under components and within blind holes or other entrapment areas
- be able to remove both soluble and particulate contaminants
- be compatible with the product, equipment and work area
- be stable during repeated reuse
- be cost efficient (lowest cost per part cleaned)

4 Properties of Cleaning Solvents

4.1 Introduction Several types of organic solvents are used in the cleaning of printed wiring boards (PWBs) and printed wiring assemblies (PWAs). Solvents are also contained in conformal coatings, which contact the laminate surface. The most common of the solvents are halogenated solvents, aliphatic hydrocarbons, alcohols, ketones, and aromatic solvents (see Tables 1 and 2). Blends of the various solvents are also commonly used. This section contains the following:

- Physical Properties
- Solvency
- Solvent monitoring / stability
- Safety and Environmental properties
- Cleaning processes

Discussion in each section is limited to the most commonly used solvents for cleaning PWAs (see Tables A-2 & A-3, Annex A).

4.2 Physical Properties The physical properties of several families of solvents are listed in the following tables.

Table 1 Physical Properties of Hydrocarbons and Oxygenated Solvents

Table 2 Physical Properties of Allowed and Discontinued Halogenated Solvents

Table A-2 Hydrogenated and Oxygenated Solvent Formulations (Annex A)

Table A-3 Halogenated Solvent Blends and Azeotropes (Annex A)

Note that blends of each of the solvents are available. The various blends and azeotropes do exhibit slightly different physical properties. Properties for a number of such blends are listed in Table A-2 and Table A-3 (Annex A). Individual manufacturers should be contacted for specific information by trade names.

4.3 Solvency Solvency of one material in another can be determined by comparing solubility parameters of the two materials involved. The closer the solubility parameters are, the better the solvency of the two compounds in each other. Obviously solvents or solvent formulations which have a similar solubility parameter as rosin would be best suited for the removal of rosin residues. The solubility parameter for epoxy resin (typical of laminate) is very close to that of methylene chloride, thus, methylene chloride was found to be the cause of resin softening and white spotting when military multilayer PWAs were defluxed with a cleaning solvent containing methylene chloride.

Both the older Hildebrand and modern Hansen solubility parameters which relate the actual soil and the cleaning solvent give a more accurate guide to cleaning efficacy and are therefore preferred for today's complex soils. An older guide used for predicting solvency was the Kauri-Butanol (KB) number per ASTM Method D-1133, which was an indirect measure related to the power of a solvent for dissolving Kauri gum.

It is critical to note here that neither of these solvency tests give a measurement for effectiveness of ionic contamination removal. This must be determined on an individual basis, taking into account the particular soldering materials, components and soldering parameters in the assembly operation. In general, multi-component formulations containing a base solvent and an alcohol are strongly recommended for ionic removal. Contact individual cleaning solvent suppliers for specific product performance capabilities, as they often have comparative laboratory data available for reference.

4.4 Polymer and Marking Compatibility At any temperature, the interactions between polymers (plastics, elastomers, solder resist, and inks used in marking) and solvents depend on a number of factors. Examples are: the chemical properties of the polymer in question, the polymer formulation parameters, the degree of crosslinking (curing or vulcanizing conditions), annealing of molded

Table 1 Physical Properties of Common Hydrocarbons and Oxygenated Solvents

Property	Cyclopentane	Cyclohexane	Toluene	Xylene	Methanol	Ethanol	2-Propanol	1-Propanol	OS-10	OS-20
General Solvent Type	Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon	Alcohol	Alcohol	Alcohol	Alcohol	Methyl Siloxane	Methyl Siloxane
Boiling Point °C (°F)	49 (120)	81 (177)	110 (230)	127-159 (261 - 318)	64 (147)	78 (172)	82 (180)	97 (207)	100 (212)	152 (306)
Flash Point, TCC °C (°F)	-37 (-35)	-18 (-1)	4 (40)	27 (80)	11 (52)	14 (57)	12 (54)	22 (72)	-3 (27)	34 (93)
Flammable Limits - LEL (vol % in air)	1.5									
Flammable Limits - UEL (vol % in air)	8.7									
Vapor Pressure at 20°C, torr	400	78			95	45	33			
Relative Evaporation Rate (butyl acetate = 1)		5.6								
Vapor Density (air = 1.00)										
Liquid Density at 25°C, g/cm ³ (lb/gal)	0.750 (6.30)	0.775 (6.47)	0.867 (7.23)	0.868 (7.24)	0.792 (6.61)	0.765 (6.63)	0.787 (6.57)	0.815 (6.80)		
Surface Tension at 20°C, dyne/cm	22.6	24.6 ¹	28.4	28.9	22.6	22.8	22.6	23.9	15.2	16.5
Viscosity at 20°C, cp	0.50	0.91 ¹	0.59	0.69	0.62	1.22	2.40	2.26	0.65	1.00
Solubility of water in solvent (weight % at 20°C)	Negligible	Negligible	0.04	0.02	∞	∞	∞	∞		
Solubility of solvent in water (weight % at 20°C)	Negligible	Negligible	0.05		∞	∞	∞	∞		
Solubility Parameter (Hansen) (Cal/cm ³) ^{1/2}										
- Nonpolar	8.1	8.2	8.8	8.1	7.4	7.7	7.7			
- Polar	0	0	0.7	3.4	6.0	4.3	3.0			
- Hydrogen bond	0.1	0.1	1.0	1.0	10.9	9.5	8.0			
Solubility Parameter (Hildebrand), (Cal/cm ³) ^{1/2}	8.1	8.2	8.9	8.8	14.5	13.0	11.5	11.9		
Kauri Butanol Value	53	56	94-105	94					17	15
VOC Content, grams/liter	738	775								
Exposure limit, ppm	600									
Atmospheric Lifetime, years									15 days	15 days
Global Warming Potential (CO ₂ = 1) =>100 yr ITH										
Ozone Depletion Potential	0	0	0	0	0	0	0	0	0	0

Notes: ¹Values @ 25°C

1. Blank space indicates data not available.

Table 2 Physical Properties of Allowed and Discontinued Halogenated Solvents

Product Name	Trichloroethylene	Methylene Chloride	Perchloroethylene	trans 1,2-Dichloroethylene	HCFC-225	HFC-43-10	HFE-7100	<i>n</i> -Propyl Bromide*	1,1,1-Trichloroethane	CFC-113	CFC-112	CCl ₄	HCFC-141b
General Solvent Type	Chloro-carbon	Chloro-carbon	Chloro-carbon	Chloro-carbon	HCFC	HFC	HFE	<i>Bromo-carbon</i>	Chloro-carbon	CFC	CFC	Chloro-carbon	HCFC
Boiling Point °C (°F)	87 (189)	40 (104)	121 (250)	48 (118)	54 (129)	55 (130)	60 (148)	71 (160)	74 (165)	48 (118)	93 (199)	77 (171)	32 (90)
Flash Point, TCC °C (°F)	None	None	None	6 (43)	None	None	None	None	None	None	None	None	None
Flammability Limits - LEL (vol % in air)	8.0	12.0	None	10.0				3.0	7.5	None		None	7.6
Flammability Limits - UEL (vol % in air)	10.5	19.0	None	13.0				8.0	15.0	None		None	17.7
Vapor Pressure at 20°C, torr	60	349	14	400		228		98	101	334	46		
Relative Evaporation Rate (butyl acetate = 1)								6.2					
Vapor Density (air = 1.00)	4.53	2.93	5.76	3.30	7.00			4.24	4.55	6.50	7.47	5.30	
Liquid Density at 25°C, g/cm ³ (lb/gal)	1.463 (12.21)	1.307 (10.91)	1.619 (13.51)	1.260 (10.50)	1.550 (12.90)	1.580 (13.20)	1.500 (12.50)	1.330 (11.30)	1.307 (10.91)	1.560 (13.10)	1.645 (13.70)	1.590 (13.30)	1.240 (10.30)
Surface tension at 20°C, dyne/cm	29.2	28.1	32.3	17.0	16.2	14.1	13.6	25.9**	25.9	17.3	23.0	26.3 ¹	19.3
Viscosity at 20°C, cp	0.58	0.43	0.90	0.40	0.59	0.67	0.61	0.49**	0.86	0.69	1.06	0.97	0.43
Solubility of water in solvent (weight % at 20°C)	0.02	0.15	0.01	0.55		0.05	0.01	0.05**	0.03	0.01	0.001	0.01	
Solubility of solvent in water (weight % at 20°C)	0.11	1.38	0.02	0.63	0.02	0.01	<0.0002	0.24**	0.09	0.02	0.01	0.08	0.04
Solubility Parameter (Hansen) (Cal/cm ³) ^{1/2}													
- Nonpolar				8.3				7.8**		7.2			
- Polar				3.3				3.2**		0.8			
- Hydrogen bond				2.2				2.3**		0			
Solubility Parameter (Hildebrand) (Cal/cm ³) ^{1/2}	9.2	9.7	9.3	9.2				8.9**	8.4	7.3	7.9		
Kauri Butanol Value	130	136	90	117	31			125**	125	31	70		56
VOC Content, grams/liter	1450	0	0	1260				1330		0			
Exposure limit, ppm	50	25	25	200	50	200		50-100	350	1000	500		500
Atmospheric Lifetime, years	4.7 days	0.5	0.3	0.9	2.8 - 8.0	20.8	4.1	11 days	5.7	100.0			9.4
Global Warming Potential (CO ₂ = 1) =>100 yr ITH	0.7	9.0	0.5		370	1300.0	500.0	0.3	110.0	5000.0			630.0
Ozone Depletion Potential					0.03	0	0	0.03	0.10	0.80			0.10

Note: ¹Value @ 25°C *Indicates solvent is pending EPA SNAP approval. **Indicates value for pure (as opposed to stabilized) *nPB*; such stabilized formulations contain >93% *nPB*.

1. Blank spaces indicate data not available. 2. Exposure limit of 50-100 ppm suggested by EPA while approval is pending. 3. ODP of 0.026 is the current official ODP for *nPB* from the Scientific Assessment Panel (SAP). 4. Official ODPs are not available for trichloroethylene, methylene chloride, perchloroethylene or trans 1,2-dichloroethylene. 5. 1,1,1-trichloroethane, fluorocarbon 113 and fluorocarbon 112 and HCFC 141b are included for reference only.

plastics, the time of exposure to the solvent, and the level of contamination in the solvent. Because of this, it is very difficult to predict compatibility/incompatibility with absolute accuracy. Therefore, a user should evaluate all parts for compatibility with their defluxing solvent. Short term exposure testing is suitable for PWA materials. Long term exposure testing should be accomplished for materials of construction of cleaning and ancillary equipment.

4.4.1 Compatibility with Conformal Coating Solvents

Conformal coatings often contain solvents that are more aggressive than typical cleaning agents. If the PWAs will be conformal coated, any of the polymers or marking inks previously qualified for compatibility with cleaning solvents per clause 4.4 should also be checked for compatibility with the coating solvent.

4.5 Metals Compatibility and Solvent Stability It is important to note that chlorinated, fluorinated, and *brominated* solvents can react readily with “white metals” (tri and divalent metals such as aluminum, zinc, cadmium, magnesium; and alloys of such metals) and, because of this, inhibitors and/or stabilizers are present in commercial grades to increase their stability. This should be taken into consideration when selecting the materials of construction for solvent cleaning equipment as well as for baskets, fixtures or carriers.

Generally, commercial solvent cleaners with stabilizer packages must be managed when exposed to excess water. In the presence of excess water, the stabilizer can be extracted, which could result in solvent decomposition (previously called “going acid,” but more precisely degradation to unwanted or harmful decomposition products); especially if an acid acceptor type stabilizer is used. Therefore, most users of these solvents test them for acid acceptance per ASTM D2942 on a regular basis.

5 MANUFACTURING RESIDUES

5.1 Introduction For the purpose of this section, there are three general categories of contaminants (residues) to contend with:

Category 1 — “polar” or “ionic”

Category 2 — “nonpolar” or “nonionic”

Category 3 — “particulate”

It should be kept in mind however, that some polar contaminants are nonionic (i.e., metal oxides, etc.) and some nonpolar residues (i.e., organic acids, etc.) are ionic in nature when exposed to specific solvents/solutions. Table 3 lists the more common contaminants in each of the three categories.

From a reliability standpoint, it is mandatory that activated flux residues and fingerprints containing salts/oils be

removed to meet end use requirements. Rosin in an activated flux is noncorrosive and nonionic in nature; however, it may partially encapsulate the ionic activator residues. Such residues can lead to corrosion of conductors, insulation resistance breakdown, malfunction/sticking of component switches, accumulation of dust and moisture resulting in electrical shorts, and adhesion problems with PWA conformal coatings.

5.2 Solvent Classifications and Characteristics The majority of solvents generally used in electronic assembly cleaning fall into the following three groups (see Table 4). The classification in conjunction with the types of soils in Table 3 can be a guide to choosing an appropriate cleaning agent (recall “like dissolves like”). For example, if one needs to clean a single component soil such as a lubricant (nonpolar), a nonpolar solvent such as an aliphatic hydrocarbon may be used. If the soil, such as activated flux, contains more than one component, a blend of polar and nonpolar solvents should be used.

5.2.1 Hydrocarbon Solvents Saturated hydrocarbons such as aliphatics and cycloaliphatics; unsaturated hydrocarbons such as aromatics and terpenes; and oxygenated hydrocarbons such as alcohols, ethers, esters and ketones; although capable of removing solder fluxes and many polar contaminants, are volatile, flammable materials. In some cases they may be incompatible with certain materials of construction. This class is generally used only in small quantities in well-ventilated areas (e.g., touchup). Large quantity use is restricted to properly designed batch or in-line cleaning equipment. Equipment designs should include fire suppression and explosion-proof wiring, plus an isolation zone around the perimeter of the machine per national and local regulations.

5.2.2 Halogenated Solvents Chlorinated and *brominated* solvents are nonflammable and are suitable for use in vapor defluxing equipment that will maintain the vapor level and workplace air concentration below the workplace exposure limits. These solvents are very effective in removing most nonpolar soils such as cutting oils, soldering and handling oils, flux rosin, and organic films. However, their strong solvency characteristics may require compatibility testing with some materials and components used in PWA cleaning.

Partially fluorinated solvents (HCFCs, HFCs, and HFEs) are nonflammable. They are capable of dissolving some oils and fluxes and are suitable for use in vapor defluxing equipment that will maintain the vapor level and workplace air concentration below the workplace exposure limits. Since their solvency characteristics are generally less than those of chlorinated or *brominated* solvents, they are generally combined with other solvents to make blends or azeotropes that provide more effective cleaning performance.

Table 3 Electronic Assembly Contaminants (Residues)

Category 1 (Polar or Ionic)	Category 2 (Nonpolar or Nonionic)	Category 3 (Particulate)
Flux Activators	Flux Resin	Resin and Fiberglass Debris from Drilling and/or Punching Operations
Activator Residues	Flux Rosin	Metal and Plastic Chips from Machining and/or Trimming Operations Dust
Soldering Salts	Oils	Fingerprints (particulate) Lint
Fingerprints (Sodium & Potassium Chlorides)	Grease	Insulation
Residual Plating Salts	Waxes	Hair/Skin
Residual Etching Salts	Synthetic Polymers	
Neutralizers	Soldering Oils	
Ethanolamines	Metal Oxides	
Surfactants (ionic)	Fingerprints (Skin oils)	
	Polyglycol Degradation By Products	
	Hand Creams	
	Lubricants	
	Silicones	
	Surfactants (nonionic)	

Table 4 Solvent Classifications and Characteristics

Solvent Group	Solvent Type
Hydrocarbon Alcohols Ketones Aromatic/Aliphatic Hydrocarbons	Polar Polar Nonpolar
Halogenated Chlorinated Fluorinated Brominated	Nonpolar Nonpolar Nonpolar
Blends & Azeotropes Chlorinated/Alcohol Fluorinated/Alcohol Brominated/Alcohol Aliphatic hydrocarbon/Alcohol	Polar/Nonpolar (Bipolar) Polar/Nonpolar (Bipolar) Polar/Nonpolar (Bipolar) Polar/Nonpolar (Bipolar)

5.2.3 Blends and Azeotropes Several cleaning blends (non-azeotropic) and azeotropic compositions are currently available. They are usually composed of partially fluorinated, chlorinated or *brominated* solvents blended with alcohols. The resulting blends and azeotropes can remove both polar/ionic and nonpolar/nonionic residues. In some cases such azeotropes are further elaborated by blending with a chlorinated solvent component to increase solvency power or blended with a hydrocarbon diluent to reduce solvency power and increase compatibility. In cases of these more complex azeotropes, additional care must be taken by the operator to avoid compositional changes that will result in loss of tight cleaning process control.

5.2.3.1 Co-Solvent Cleaning In this process, a lower boiling partially fluorinated solvent is combined with a higher boiling organic solvent such as a hydrocarbon or ester to generate a homogeneous mixture in the first sump of a multi-sump vapor defluxer. The boiling point of the

mixture is determined by the ratio of the two solvents. The partially fluorinated solvent is used in the remaining sumps to rinse the co-solvent mixture and dissolved soils from the PWAs. Drying is easily accomplished in the vapor zone. This process, with the ability to raise the temperature in the first sump, can be effective in removing stubborn soils.

5.3 Summary Each type of solvent has advantages and disadvantages and the selection of cleaning solvent will depend primarily on the type of contaminant(s) to be removed and the material compositions of the electronic assemblies in question.

Many Category 1 (plating and etching salts, sodium chloride, etc.), Category 2 (nonpolar/nonionic residues such as metal oxides (tin or lead oxides)), and Category 3 (particulate residues, such as machining residues, resin and fiberglass debris, dust, lint, etc.) contaminants are not satisfactorily dissolved by solvent cleaning. However, various combinations of cleaning cycles (i.e., high and/or low pressure spray, flooding, flushing, ultrasonics) are capable of adequately removing insoluble residues in many instances through their inherent physical actions. (In certain cases a rosin-based lacquer has been applied to lead-based residues, cured and then removed by a fluorinated solvent/alcohol blend to wash away both the contaminant and the lacquer. This process should also work with the newer solvent formulations.)

Table 5 contains a listing of typical/potential contaminants with which the assembly cleaning processes must contend and the relative ability of various cleaning solvents to remove them. The list is by no means a complete compilation of all residues possible in an electronic assembly; but

Table 5 Relative Cleaning Effectiveness

Contaminant/Residues	Solvent Groups							
	Chlorinated	Brominated	Fluorinated	Bipolar/ Blend/ Azeotrope	Alcohols	Ketones	Aromatics/ Aliphatics	Check List*
Category 1								
Fingerprint Salts	I	/	I	E	E	E	I	
Rosin Activators	I	/	I	E	E	I	I	
Activator Residues	I	/	I	E	E	I	I	
Cutting Oils (water soluble)	I	/	I	G	G	G	I	
Temporary Solder Masks/ Solder Stops	I	/	I	G	G	I	I	
Soldering Salts	I	/	I	I	I	I	I	
Residual Plating Salts	I	/	I	I	I	I	I	
Residual Etching Salts	I	/	I	I	I	I	I	
Category 2								
Resin Fixative Waxes	E	E	E	E	E	E	G	
Waxes	E	E	G	G	I	G	G	
Soldering Oils	E	E	E	E	E	E	E	
Cutting Oils (solvent soluble)	E	E	E	E	E	E	E	
Fingerprint Oils	E	E	E	E	E	E	E	
Flux Rosin	E	E	E	E	E	E	G	
Markings	E	E	I	G	I	E	E	
Hand Cream	E	E	E	E	G	E	G	
Silicones	G	G	G	I	I	I	I	
Tape Residues	E	E	E	E	E	E	E	
Temporary Solder Masks/ Solder Stops	E	E	E	G	I	I	I	
Organic Solvent Films	E	E	E	G	E	E	E	
Category 3								
Resin & Fiberglass Debris	M	M	M	M	M	M	M	
Metal & Plastic Machining Debris	M	M	M	M	M	M	M	
Dust	M	M	M	M	M	M	M	
Handling Soils	M	M	M	M	M	M	M	
Lint	M	M	M	M	M	M	M	

Legend E = Effective in dissolving contaminant
 I = Ineffective in dissolving contaminant
 G = Gray area (moderately effective)
 M = Mechanical action required.

Note: Blend/Azeotrope column will be applicable to preceding columns for particular solvent groups.

*Check List: Contaminants/residues present in my operation

rather a guide to aid in proper solvent selection for a given category of contaminant/residue.

6 CLEANING AFTER AUTOMATED SOLDERING

6.1 Introduction This selection deals with the most common type of cleaning systems on the market. Each system is covered in three sections: (1) definition, (2) equipment options, and (3) precautions. Equipment features may be required to meet applicable national or local regulations. (See IPC-CH-65A for additional information.)

6.1.1 Automated Soldering Methods and Residues The main methods for automated soldering are reflow soldering (used for surface mount components) and wave soldering (used for through-hole components). The residues from each method are slightly different, which may affect the choice of cleaning parameters. In many cases the surface mount components are reflow soldered, then the through-hole components are wave soldered, and finally the completed PWAs are solvent cleaned. These mixed technology cases can be the most challenging from a cleaning standpoint.

6.1.1.1 Reflow Soldering After placement of the surface mount components, either on a traditional solder paste printed PWB or on a solid solder deposit (SSD) PWB, the board is conveyed through a heated zone to melt the solder paste or the solid solder deposits, thus completing the attachment of the components. The heated zone can be the vapor of a high boiling stable fluid (vapor phase soldering), or infrared heated air or nitrogen. When the heated air or nitrogen systems incorporate added circulation capability, it is called convection reflow. Control of the heated vapor in this manner permits compensation for uneven thermal requirements across the PWA surface mandated by design requirements. The residues from the solder paste used are more complex than the traditional liquid fluxes, since rheology control agents and multiple activator systems are employed. Thus, it is best to clean as soon as possible after reflow. Technical studies have shown that these residues become much harder to clean after two minutes have elapsed between reflow and cleaning, with the difficulty reaching a maximum and plateauing after the interval is fifteen minutes. This effect is more pronounced with extended time at liquidus temperature.

6.1.1.2 Wave Soldering After insertion of the through-hole components, the board is carried over a fluxing station, an excess flux removal station, through a heating zone to evaporate all the flux volatiles and warm all the components and the PWB and then finally over one or two solder waves to complete the attachment process. The flux can be applied by wave, foam or spray method, while the excess flux is removed either by a brush or by an air knife. Pre-heating is accomplished by either radiant plates or Calrod heaters. The heat sources are either below the board or both above and below, depending on the PWB design and thermal mass. Often passive components (resistors and capacitors) are affixed to the solder side of the PWB. In this case, either two solder waves (a rough surface or “chip wave,” followed by a smooth surface or “finish wave”) or a single wave agitated by a oscillating plate systems are used to maximize soldering yields. Standard through-hole components are usually soldered with a traditional single smooth wave or a dual wave system with the chip wave turned off. The residues from wave solder fluxes are simpler to remove than solder paste residues, provided the flux is not overheated during the preheating or actual soldering steps. Rosin based fluxes are most susceptible to unwanted residue formation, since rosin is a natural product of variable composition. Such residues can be prevented by using fluxes that have been pretreated to remove the residue precursors or by using Differential Thermal Analysis (DTA) to eliminate flux that will give such problems in use. Again, cleaning as soon as possible within fifteen minutes of soldering will maximize cleaning success. The usual transit time from solder machine to cleaner will allow the soldered assembly to cool to a temperature below the boiling point

of the solvent, which enhances wetting and dissolution of the residues.

6.2 Batch Vapor Cleaning

6.2.1 Definition and Description of Process Vapor defluxing is by far the most popular method of solvent defluxing. It is a process whereby a solvent specifically formulated for the process is boiled and the vapors are condensed and returned to the boiling tank. When the solvent is boiled, the vapor generated has a lower boiling point than the flux and soils being removed. This results in vapor remaining relatively pure thus providing a continuous source of clean solvent to work with.

When a part such as a printed wiring assembly is lowered into the vapor, the difference in temperature of the part and the solvent vapor causes the vapor to condense on the cooler part flushing away the flux. In actual practice simple vapor condensation on a cooler part is seldom adequate for thorough defluxing, since the heat capacity of the plastic laminate is so much lower than a metal part of the same dimensions. For this reason the vapors that are condensed are channeled into additional tanks and spray reservoirs where the parts to be cleaned receive additional treatment. The tanks and/or spray reservoirs are arranged in such that clean solvent is cascaded from one tank to another and finally back to the boiling tank counter-current to the movement of the parts through the cleaning machine. Also, due to the poor condensation capacity of PWAs, immersion in the boiling solvent is much preferred for rapid dissolution of contaminants.

A common cleaning cycle for defluxing would be a two minute immersion in the boiling tank followed by a one minute immersion in a rinse tank and finally a one minute suspension in the vapors. There are many variations in cleaning cycles and one should work with the solvent and/or equipment manufacturer to optimize the individual system. Vapor degreasers used for defluxing are usually made of stainless steel, electrically heated, and cooled by chilled water or by refrigeration.

6.2.2 Equipment Features (all may not be available on all equipment)

- Low liquid level safety switch
- Hand spray (cold or heated; with heated being much preferred)
- Internal spray
- Particulate filter systems
- Desiccant water removal system
- Ultrasonics (added to a rinse tank)
- Automatic covers
- Automated hoists
- Special solvent control equipment

- Freeboard chiller, carbon absorber
- Solvent recovery still
- Dehumidification coils
- Hot vapor recycle

6.2.3 Precautions

- The user should be aware that if contaminants build up in the boiling sump, there is a potential for contaminating the product during defluxing which could adversely affect subsequent assembly operations, i.e., conformal coating, component bonding, etc. In such cases a separate still or additional offset boiling sump is necessary.
- Avoid locating equipment where drafts are present.
- All state and federal safety agencies require that ingress/egress speeds must not exceed 3.4 meters/minute (11 feet/minute).
- Water is the enemy of vapor defluxing solvents, therefore, water that enters the vapor defluxer by condensation on the cooling coils must be controlled or removed. This is accomplished, in solvents not containing alcohols, by means of a mechanical water separator usually built into the unit. A desiccant or water separator can be used to remove water from solvents and their blends depending on the solvent/blend used (contact solvent/blend suppliers for specific recommendations). Desiccants are materials such as molecular sieve or silica gel which will absorb water. If alcohol containing solvent formulations are being used, molecular sieves with three Angstrom pores are required. This pore size will remove water from the solvent condensate return line without removing the alcohol. However, refer to the solvent manufacturer for specific desiccant recommendations and sources.
- Keep vapor defluxers away from heat sources; especially sparks, space heaters, welding operations and open flames to prevent thermal degradation of the solvent vapors.

6.3 Conveyorized Spray Cleaning

6.3.1 Definition and Description of Process A cleaning method whereby parts are transported by some mechanical means such as belt or chain, and solvent is delivered by a mechanical pump. Conveyorized spray cleaning in the form of an automated vapor spray defluxer is a popular method of defluxing PWAs where volume and tight process control justifies the capital expense. The modern conveyorized machine employs multiple cleaning and rinsing stages. Parts are transported from above a vapor line to an area well below the vapor/air interface where cleaning methods such as spray and/or immersion take place. Parts are then transported back up and out of the vapor containing area to the next step in the manufacturing process.

6.3.2 Equipment (all may not be available on all equipment)

- Particulate filter systems
- Desiccant water removal system
- Solvent recovery still
- Liquid level controls
- Pressure gauges for spray and/or filters
- Adjustable load/unload conveyor extensions
- Temperature monitoring instrumentation
- Automatic solvent transfer systems
- Aqueous rinse and drying stages
- Immersion tanks
- Dehumidification coils
- Liquid seals (to permit very high pressure spraying without an increase in emissive solvent losses)
- Hot vapor dryer
- Emergency stop buttons at each end of unit in case of conveyor jam
- Containment pan under the unit that can contain the contents of the cleaner in case of a leak or spill
- Cool-down coils in the liquid full sumps to lower the vapor pressure of the solvent during idle periods
- Sliding covers to seal off the entrance and exit to the cleaner during idling

6.3.3 Precautions Conveyorized spray cleaning systems, by virtue of being highly automated, have most equipment safety and operator safety items built into them. Nevertheless the same basic precautions would apply as to the batch vapor defluxer.

6.4 Ultrasonics

6.4.1 Definition and Description of Process When a liquid is mechanically agitated by application of energy through contact with special transducers operating at frequencies ranging from 19 kHz to 150 kHz, a phenomenon occurs known as cavitation. Cavitation is the rapid, sequential formation and collapse of microscopic bubbles in the solvent. The collapse of these cavitation bubbles expends a tremendous force and the occurrence of these bubbles by the millions provides a rapid and powerful scrubbing action on the surfaces to be cleaned. Ultrasonic cleaning is a popular choice when there are inaccessible areas and where the contamination is particularly difficult to remove. However, the user must be aware of potential electrical damage or the generation of latent defects in component. Therefore, ultrasonic cleaning processes should be properly qualified by testing the components using industry developed test methods (see Paragraph 6.4.3). Ultrasonic cleaning equipment is available in many forms such as immersible transducer packages for use in existing tanks, separate ultrasonic tank plus generator, integrated tank/generator, and as

an add-on or built-in accessory for vapor defluxers. Recent advances in this area include sweep frequency ultrasonics, where the frequency is continually varied over a small range to prevent harmonics; and the use of mixtures of harmonic multiples of the base frequency. In these new techniques, the goal is to provide enhanced solvent agitation while eliminating the possibility of damage that had been seen in certain cases with the older lower fixed frequency units.

6.4.2 Equipment Options (all may not be available on all equipment)

- Covers (sliding or rolling, not lifting type)
- Baskets (designed so to not attenuate the effect of the ultrasonics; discuss optimum designs with the ultrasonic equipment supplier)
- Heaters
- Cooling Coils
- Filter systems
- Timers
- Temperature control system
- Acoustical insulation system
- Desiccant drier in condensate return line
- Extended freeboard

6.4.3 Precautions

- A. Where solvent is used, the same precautions apply as in batch vapor defluxers.
- B. Noise - Ultrasonic cleaners generate frequencies that can irritate and damage hearing of operators and workers nearby. To reduce ultrasonic irritation it is advisable to consider one or more of the following:
 - a. Cover when not in use.
 - b. Insulate tank.
 - c. Mount tank below bench surface (flush mount).
 - d. Mandatory ear muff use for operators and nearby workers; combined with periodic hearing tests.
 - e. Component damage - the military has generally disallowed the use of ultrasonic cleaning, based on results from early fixed frequency cleaning problems with all metal components such as TO-5 cans. Their conclusion, that certain components such as semiconductors may be damaged, has been investigated by UK military contractor and US Navy teams. Safe use conditions, especially with modern non-fixed frequency units, are possible. When used in defluxing, component testing is advised; IPC has generated tests for both loose components and attached components to qualify ultrasonic cleaning processes (see IPC-TM-650, Test Methods 2.6.9.1 and 2.6.9.2).

6.5 Cold Cleaning Equipment

6.5.1 Definition and Description of Process Cold cleaning is the process of removing soils and fluxes from metal parts, metal assemblies, and printed wiring assemblies through use of an organic solvent at room temperature or heated to less than the boiling point. Typical equipment requirements include a cover, a facility for draining solvent from the cleaned parts (preferably while enclosed in the cold cleaning tank), and a durable label summarizing the operating requirements.

Cleaning equipment can be spray, ultrasonics, brush, wave, or soak. Cold cleaning is used when heat might damage parts. It is not, in general, as effective as vapor defluxing. Also, certain flammable cleaning solvents are not safe to heat and must be used cold.

Unless the solvent has a vapor pressure of less than 0.6 psig (33 torr) at 38°C (100°F) and is heated to less than 49°C in use, additional controls are required. The control options (only one is required) are as follows:

- The distance from the top of the solvent vapor to the top of the tank, called the freeboard, must be at least 100% of the width of the equipment opening.
- A refrigerated air space above the liquid, or carbon adsorption system, or other equivalent emission control device.

6.5.2 Equipment Options (all may not be available on all equipment)

- Covers (sliding or rolling, not lifting type)
- Baskets (designed so to drain quickly)
- Cooling Coils
- Filter systems (if the solvent is circulated by pumping)

6.5.3 Precautions When solvent is used, the same precautions apply as vapor degreasing. The operating requirements demand that the cover be closed when not in used, the cleaned parts be drained for at least 15 seconds and that the waste solvent be disposed of without permitting greater than 20% by weight evaporation to the atmosphere.

6.6 Soak Tanks

6.6.1 Definition and Description of Process Any vessel containing cleaning fluid and not otherwise agitated by pump, air, ultrasonics, or boiling can be classified as a soak tank. Soak tanks are an earlier cleaning method and have largely been replaced by newer, more efficient equipment. Soak tanks are currently used as a precleaning station prior to more critical final cleaning.

6.6.2 Equipment Options (all may not be available on all equipment)

- Drain valves
- Baskets

- Filter systems
- Covers

6.6.3 Precautions When solvent is used, the same precautions apply as vapor defluxing.

6.7 Wave Cleaning

6.7.1 Definition and Description of Process A cleaning method wherein cleaning fluid is pumped up into a wave form similar in size and shape to a wave soldering station. Wave cleaners are used as single or multiple cleaning stations and as a precleaning station. Solvent cleaning with wave type equipment is not as popular as other methods due to inadequate control of solvent loss and has essentially disappeared.

6.7.2 Equipment Options (all may not be available on all equipment)

- Solvent recovery still
- Fume hood

6.7.3 Precautions

- A. When solvent is used, the same precautions apply as vapor defluxing.
- B. To prevent excessive evaporation due to constant pumping, it is common to select a solvent with a low evaporation rate.

6.8 Brush Cleaning

6.8.1 Definition and Description of Process A cleaning method usually thought to include a conveyor and one or more rotating brushes mounted in common or separate tanks. Brush cleaning is used in defluxing with both aqueous and solvent cleaning fluids. Brush cleaning with solvents was popular in the past when bottom side only cleaning was desired for printed wiring assemblies, but is rarely seen today.

6.8.2 Equipment Options (all may not be available on all equipment)

- Solvent recovery still (special precautions are needed for flammable solvents)

6.8.3 Precautions When solvent is used, the same precautions apply as vapor defluxing. To prevent evaporation due to rotation of brushes and the constant exposure to air, it is common to select a solvent with a low evaporation rate that will still evaporate quickly enough to be practical, yet has a TLV that provides adequate protection for the workforce. While used with 1,1,1-trichloroethane, it has fallen into disuse as this solvent is no longer produced.

6.9 Equipment Retrofitting (Upgrading) For more information on options available, retrofitting, and standard items, please contact specific equipment manufacturers.

6.9.1 Increasing Freeboard Increasing the freeboard of a vapor defluxer or cold cleaning tank is simply a matter of creating an extension on the existing tank and relocating the cover. This cost is minimal and has the advantage of requiring no additional utility cost and minimum maintenance. Where practicable, this optional requirement is the least expensive and the most likely to result in reduced overall operating costs. There is very little incremental savings with a freeboard/width ratio in excess of one (1.0 or 100%). However, in some cases it may be advisable to add freeboard in excess of 100% to accommodate freeboard chillers, sub-zero cooling coils and the mechanisms associated with automated basket transports and covers.

6.9.2 Refrigerated Freeboard A refrigerated freeboard chiller is intermediate in capital expense. An additional utility cost is experienced to operate the refrigeration compressor and, like all refrigeration systems, this equipment should be on a regular maintenance schedule. The refrigeration coils can be expected to condense atmospheric moisture. Care must be taken to remove this moisture from a solvent operation to prevent unnecessary equipment corrosion, thus a separate trough for such extra coils is usually added to remove condensed water from the cleaner. Solvent stabilizer chemicals are usually at least partially soluble in water. Therefore, excessive water contamination of the solvent will result in partial loss of stabilizer concentrations from the solvent, as well as removal of water soluble or miscible alcohols.

6.9.3 Carbon Adsorption Carbon adsorption systems require a sizeable fan to draw air from the cleaning operation and force it through the carbon bed system. The adsorbed solvent is removed from the carbon bed by injecting low pressure steam and condensing both the solvent and water in a condenser. Compressed air is used to operate the automatic valves. Two carbon beds are required for continuous operation to allow desorption of one while the second is processing the ventilation air stream. This system is the one recovery system that can collect and recover solvent vapor mixed with air, even in relatively low concentrations.

This equipment is the most expensive to purchase, install, maintain, and operate, and is not compatible with all solvent systems. The energy demand for this equipment is also much larger than that required for the refrigerated chiller. Relatively large quantities of steam are necessary to strip the solvent from the carbon bed. This results in severe stabilizer loss into the condensed water and may lead to concerns with regard to contamination of the waste water stream. Although it is the least frequently chosen, carbon

adsorption provides a unique solvent recovery capability. However, the general guideline is that vapor in air levels must be at least 500 ppm to make this recovery method economical. Since only a very few solvents in use today have allowed workplace in air levels above this figure, the technique will not be widely used.

NOTE: In addition, CAA may require the installation of a continuous emissions monitoring system (CEMS) to verify and document correct operation of the dual bed system. CEMS instrumentation can be costly and require specialized maintenance for reliable operation. Compliance with Federal, State, and local regulations concerning use and control of these solvents is bound to cause some problems, but users will follow industry practices.

7 CLEANING AFTER MANUAL SOLDERING

7.1 Introduction Assemblies may require manual soldering for the following reasons:

- Addition of components after mass soldering and cleaning which are heat sensitive or cannot be sealed to prevent solvent entrapment.
- Rework of defective solder connections.
- Replacement of defective components.
- Engineering upgrades.

The cleaning of the assembly after any of these operations is determined by the type of soldering operation that has been done. Replacement of defective connections and/or defective components generally will allow cleaning of the assembly in the same manner as used for post mass solder cleaning. Addition of components that cannot be sealed to prevent solvent entrapment will require brushing an appropriate solvent on the completed solder connection to remove the residue. To determine the solvent needed, refer to Section 5.1 on manufacturing residues. For repair/rework, always select the mildest flux that will provide a defect-free connection. Generally it is best to clean within 15 minutes after soldering.

7.2 Cleaning Required The amount of cleaning necessary after manual soldering operations is determined by:

- The flux used.
- Subsequent assembly/test.
- The end user requirement of the assembly.

The fluxes and pastes used in the aforementioned soldering operation are as follows:

- L (Rosin Core) consists of white rosin. Residues are non-conductive and noncorrosive, thus cleaning may not be necessary unless assemblies will be subsequently conformally coated.
- L (No Clean Core) usually consists of dibasic acid activator. Residues are nearly nonconductive and noncorrosive,

thus cleaning may not be necessary unless assemblies will be subsequently conformally coated.

- L or M (Rosin Core; mildly activated) fluxes have low corrosivity. Where cleaning is required, residue may be removed with solvent. Mildly activated fluxes contain small amounts of activators to promote soldering efficiency. This is the least corrosive type flux that is normally practicable to use in soldering.
- L or M (No Clean Core; mildly activated) fluxes also have low corrosivity. Where cleaning is required, residue may sometimes be removed with solvent or water. Mildly activated fluxes contain small amounts of activators to promote soldering efficiency. This is the least corrosive type flux that is normally practicable to use in soldering.

Note: Fluxes and pastes with residue activity levels exceeding M should not be used for manual soldering operations. Class L and M pastes are suitable for manual soldering or rework soldering.

7.3 Cleaning Methods The following are commonly used methods for cleaning PWAs after manual soldering.

7.3.1 Aerosol Spraying The surface to be cleaned should be sprayed with solvent from a distance of 100-130 mm (3.9-5.1 inches) in a well-ventilated area. Assemblies should be washed from top to bottom. Liquid and force of spray will dissolve or flush away dirt and flux. The area to be cleaned can be sprayed directly with solvent or dispensed through a nozzle with a brush attached.

7.3.2 Manual Brushing An acid brush is dipped in stainless steel dispenser containing solvent and the area of the PWA containing the flux is brushed and repeated several times. The excess flux and solvent is wiped with absorbent lint-free cloth. The brushing method dilutes the flux and spreads it over the PWAs. Subsequent cleaning methods (i.e., vapor defluxing, etc.) will be required to completely remove flux residues.

7.3.3 Combination Manual Brushing An acid brush is dipped in stainless steel dispenser containing high boiling solvent, such as an alcohol/hydrocarbon combination, and the area of the PWA containing the flux is brushed and repeated several times. The excess flux and solvent is wiped with absorbent lint-free swab. Rinsing and drying are accomplished by applying a fresh swab soaked in a volatile alcohol, such as 2-propanol. The brushing method dilutes the flux and spreads it over the PWAs. Subsequent cleaning methods (i.e., vapor defluxing, etc.) will be required to completely remove flux residues.

7.3.4 Vapor Defluxing (Vapor Only) Vapor defluxing involves suspending the board in a chamber filled with vapors from a boiling solvent. Solvent will condense on the

board until the board reaches the same temperature as the vapors. This step will last from 30 seconds to 3 minutes, depending on the mass of the board. This method is generally not as effective as a multiple step vapor defluxing process that includes immersion in the boiling sump, since the typical PWA does not have enough heat capacity to condense the volume of solvent needed for effective cleaning.

7.3.5 Vapor Defluxing (Immersion and/or Spray) Vapor defluxing in a two or more sump unit is the preferred method to carry out the cleaning process. Immersion in the boiling sump provides not only contact with the heated solvent but also the agitation provided by boiling. The combination of these effects scrubs the PWA much more rapidly than immersion in the vapor. Spraying of the PWAs should only be done under the vapor blanket using warm solvent. Constant circulation of the condensate solvent through the spray wand is the most effective method to accomplish quality cleaning with minimal losses.

7.3.6 Vapor Defluxing (Ultrasonics) Vapor defluxing in a two or more sump unit is the preferred method to carry out the cleaning process. Immersion in the boiling sump provides not only contact with the heated solvent but also the agitation provided by boiling. Immersion in the ultrasonically agitated rinse sump provides the agitation needed to get the solvent in and out of crevices and blind holes, as well as under components much more rapidly than immersion in the vapor alone.

7.4 Cleaning Protocol If manual rework or addition of sensitive parts is required, then some spot cleaning will be needed. Some users prefer to do a final clean prior to conformal coating to ensure meeting the cleanliness requirement in J-STD-001. Requirements for Soldered Electrical and Electronic Assemblies.

8 PROCESS CONTROL

8.1 Introduction Prior to discussing equipment options and recommendations for those options, it is necessary to understand EPA and OSHA regulations for solvent cleaning systems, as these regulations basically are designed to control solvent emissions from cleaning equipment. Please review Section 9 for this information.

8.2 Equipment Options and Recommendations

8.2.1 Manually Operated or Open Top Cleaning Systems

8.2.1.1 Cover The cover should be of such a design that when it is opened and closed it either rolls or slides in a horizontal motion across the top of the tank. It should never be designed in such a manner that it requires a hinged top or lift which could result in pulling some sol-

vent vapor from the cleaning system. Covers can be either manually operated by sliding or rolling or can be powered by a motor or pneumatic mechanism.

8.2.1.2 Minimum Freeboard Minimum freeboard ratio of 100% to 150% for all solvents, with higher values used for more expensive (per kg. basis) solvents or those with lower allowed workplace vapor in air levels.

8.2.1.3 Refrigerated Freeboard Devices can be employed for controlling diffusional losses from the vapor blanket and in some cases control evaporating solvent from carry-out problems while in the freeboard area of the unit.

8.2.1.4 Automatic Work Transport System Most equipment manufacturers offer automatic transport systems which utilize programmable controls. These systems are easily changed to suit a specific cleaning application or cleaning cycle. There are three main benefits utilizing this type of system for open top cleaning units:

- Controlled cleaning cycle
- Reduces solvent usage by eliminating operator violation of proper cleaning practices.
- Increases throughput

8.2.1.5 Ventilation System With Solvent Vapor Recovery Unit (Carbon Adsorption Unit) Ventilation systems are not normally recommended on most electronic cleaning applications since generally these cleaning units are small in size and carry-out and emissions are minimized. However, with some applications and some large cleaning units, ventilation may be required to comply with regulations. It then may be economically feasible to install a Solvent Vapor Recovery Unit with the ventilation system.

Special Note: Some State Implementation Plans (SIPs) require a solvent recovery unit on any defluxer or degreaser which is being ventilated. Therefore, it is incumbent for the user to check with their local Air Quality Office for compliance.

8.2.2 Conveyorized Cleaning System Conveyorized cleaning systems can be provided with the following equipment (either provided with the system in its design or as optional items that can be purchased from manufacturers).

8.2.2.1 Deep Freeboard For entrance and exit areas of the unit, 50% freeboard is desirable for conveyorized cleaning systems but not mandatory. This will vary with different state implementation plans. The rest of conveyorized area requires a least 100% freeboard.

8.2.2.2 Refrigerated Freeboard Devices for controlling diffusional losses from the vapor air interface and for partial control of evaporating solvent from entrapped areas of product as it exits the cleaning system.

8.2.2.3 Special Drying Methods If solvent entrapment is unpreventable due to product design, special drying methods should be employed in one or more of the following:

- Vapor area
- Freeboard area
- Special drying tunnel
- Hot vapor drying

8.2.2.4 Ventilation System with Carbon Adsorption

The primary purpose of the carbon adsorption system is to adsorb solvent concentrations (in the ppm level or higher) entrained in the ventilation air. Most carbon adsorption systems offered by manufacturers are capable of removing 85% to 95% of solvent entrained in an air stream. This method of solvent consumption control is most effective when employed on a cleaning system that has solvent entrapment on the product that is being cleaned and it can be introduced into a proper drying tunnel for evaporating. The general guideline for acceptable economics of carbon adsorption systems is that the vapor in air levels must be at 500 ppm or greater. Since these levels typically exceed the accepted workplace in air limits for today's solvents, the payback resulting from this recovery technique may become marginal.

Special Note: The normal carbon adsorption system utilizes steam injection into the carbon bed to release adsorbed solvent. Some solvents are not compatible with gross amounts of water which are the results of steam injection of the carbon beds. You should consult with your chemical supplier prior to the installation of carbon adsorption system for a particular vapor cleaning unit.

8.3 Equipment Location and Operation.

8.3.1 Location

8.3.1.1 General The system should be located in an area where vapors cannot stagnate. Room size and ventilation requirements should be reviewed from equipment manual.

8.3.1.2 Clearance Adequate worker space should be provided around cleaning unit for maintenance.

8.3.1.3 Drafts System should be installed so that it is not affected by drafts caused by windows, doors, fans, unit heaters, ventilators, etc. Ambient air velocity should not exceed 15 meters (49.2 feet) per minute.

8.3.1.4 Ovens No cleaning unit should be installed adjacent to open flames or near high temperature surfaces above 400°C (750°F). Welding operations and space heaters should not be located in proximity of solvent cleaning equipment.

8.3.2 Operation

8.3.2.1 General

- All cleaning units are provided with specific operating instructions from the equipment manufacturers and should be reviewed by all owners.
- Cold cleaning units should be operated with cover closed. Cleaned parts must be drained for at least 15 seconds.
- Systems should be covered when not in use. Well designed, manually operated, down time covers should be provided.
- Plumbing valves and pumps should be checked periodically for both liquid solvent and solvent vapor leakage.
- Porous or adsorbent material should not be cleaned.

8.3.2.2 Hot Vapor Systems

- Work shall remain in the vapor area until all condensation has ceased.
- Work shall not be introduced or withdrawn from the vapor area faster than 3.4 meters (11 feet) per minute.
- Introduction of moisture into the cleaning system should be avoided.
- Work load should not occupy more than 50% of the cross sectional area of the tank.
- The work load should be sized to minimize the fluctuation of the vapor level.
- All spraying should be done at least 150 mm (5.9 inches) below the vapor level.

8.4 Maintaining the Cleaning System Most cleaning system manufacturers supply well-written manuals for maintenance. This should be regularly and strictly adhered to in order to properly minimize solvent losses and to maintain a consistently clean product emerging from the machine. In addition, a training program for existing and new cleaning equipment operators and maintenance personnel should be established.

8.5 Proper Still Practices

8.5.1 Solvent Recovery Still Separate distillation units are normally employed under the following conditions:

In conjunction with cleaning unit

- a. When large amount of soil must be removed from the product and therefore contaminates the cleaning system very quickly.
- b. When it is required that the product being cleaned be subjected to a pure solvent rinse for final cleaning prior to exiting the unit. A still is required only if this requirement exceeds the built-in distillation capability of the unit.
- c. If the cleaning system is conveyORIZED and down time for maintenance must be held to an absolute minimum.

- d. If the product is to be immersed in the vapor defluxer boiling sump.

Separate from the cleaning unit

- When many small cleaners are used in a factory, none of which is large enough to justify a dedicated still.
- When all the small cleaners are removing the same or almost the same soil, so there is minimal danger of cross-contamination. This case would include combining all the solvent from the small cleaners plus solvent used on the benchtop for manual cleaning operations.
- Preferably, if all the small cleaners can be connected to the common still by piping, which minimizes losses and prevents spills.
- If the product is to be immersed in the vapor defluxer boiling sump to provide faster and more effective cleaning.

8.5.2 Advantages of a Separate Distillation System

- Concentrates the majority of the soils removed by the cleaning system in the distillation unit.
- Reduces down time on cleaning system for cleanout and cleanup of the unit.
- Provides additional distillate throughput to the cleaning system in order to remove soils from cleaning zones.
- Provides an automatic method of removing soils from the cleaning system.
- Allows easy method for sludge removal from cleaning unit.
- Allows immersion in a cleaner defluxer boil sump.

8.5.3 Maintaining the Distillation System A distillation system performs two major functions:

- Concentrates soil residues within its body
- Repurifies solvent for cleaning systems

It then must be properly maintained in order to provide these two basic functions for the cleaning system. When operating with a cleaning system the distillation unit is normally an automatic system. It is provided with a level monitoring device which controls a solvent pump which withdraws contaminated solvent from the cleaning system and automatically distills this solvent. It then feeds it back to the cleaning system. An operator is not normally required during production hours.

At some point in time the distillation rate will be reduced due to the increase of the soil level within the still boil sump. The in-plant maintenance department must set up a regular program for boil down, sludge dumping and clean up of the distillation system. The following methods will help the maintenance department determine at what time and which intervals the distillation unit should be isolated from the cleaning system and the still bottom residues removed:

The temperature of the still boil sump has increased over the normal boiling point of the solvent. In the case of some rosin fluxes this temperature increase will be approximately 4 to 5°C (8 to 10°F) over the boiling point of the solvent.

If the product being cleaned in the cleaning system is not completely cleaned (when a still is attached to a cleaning system), the distillation rate of the still must have been substantially reduced. This situation should be investigated and corrected.

In the case of some of the azeotropic alcohol blends, it is important that the flux content of the boiling sump not exceed 9% by volume (8% by weight). Excessive flux in the boiling sump reduces the alcohol content of the vapor and rinse sumps which in turn affects cleaning performance. (Flux content of a boiling sump liquid can be determined with a Goetz bulb.)

General data – Large amounts of water will extract alcohol and stabilizer from certain azeotropes and/or blends and change their composition. Once the solvent has been exposed to gross amounts of water it cannot be reconstituted by simple distillation. Therefore, care should be taken to minimize introduction of water into equipment distilling these types of solvents.

When residues become too viscous and heat transfer is reduced, the still temperature needs to be increased to complete the distillation process. See 8.5.3.1.

All stills are furnished with high temperature liquid cut-out thermostats*. Suggested high temperature thermostats settings for different solvents are listed in Table 6.

Table 6 Suggested High Temperature Thermostats Settings

Solvent	Thermostats Setting
Methylene Chloride	49°C (120°F)
Trichloroethylene	93°C (200°F)
Perchloroethylene	129°C (265°F)
1,1,1 -Trichloroethane	82°C (180°F) (provided for reference)
Trichlorotrifluoroethane (CFC-113)	54°C (130°F) (provided for reference)
<i>n</i> -Propyl Bromide	93°C (200°F)

* Basic function of this control is to shut the distillation unit down to prevent over heating of heater elements and therefore possibly cause solvent decomposition. This thermostat is to be used only as a safety control and not for normal operating cut-off.

Note: The operation of stills for flammable or combustible solvents is outside the scope of this handbook, due to the much greater safety issues involved.

8.5.3.1 Cook-Down and Clean-Up Procedures Isolate the distillation unit from the main cleaning system (switch still pump from “automatic” to “off” position), allow the still to continue to boil down and divert the distillate to a

drum or storage tank. Turn the heat switch to "OFF" when the solvent level reaches approximately 25 mm above the heating elements. Allow the solvent residues to cool. Shut down condenser coolant supply system. Drain residues (if still hot or warm provide additional ventilation). Residues should be placed in proper container tank for disposal.

8.5.3.1.1 General Procedures In the design of some distillation units it may be necessary to actually pump the still bottoms into the container receiving this residue. After complete draining of this distillation unit, the operator or maintenance person should then observe the interior of the still. If caked rosin or soil residues can be seen on the heating element, it may be necessary to open up the distillation unit, remove the heating element and clean the element. Heating elements for distillation units can normally be brushed or scraped to removed the baked on residues from the coil. Steam cleaning also does an excellent job of removing soil-flux residues. If it is determined that the interior of the still body has sufficient residue on the sides, the body then should be scraped or steam cleaned.

Caution: Prior to any interior cleaning the machine should be completely ventilated to remove any residual solvent or solvent vapor that is still inside the system. This can be accomplished by forced ventilation systems such as a fan, compressed air or blower exhausting outside the building. Any individual that enters this unit must wear a harness and lifeline in addition to an approved respiratory protection such as a hose mask operating from a remote source of compressed or self-contained breathing apparatus. A second person must be in attendance at all times as an added safety precaution. Continue ventilation of the unit while maintenance personnel clean the unit interior. Do not turn off the ventilation system until all personnel have exited the unit and the unit has been completely closed.

8.5.3.1.2 Optional Cleaning Procedures In some cases chemical cleaning with hot alkaline baths or with formulated organic solvent carbon removers is often practiced. These aggressive chemicals should be flushed out with water immediately after use. Once the cleaning operation has been completed and the excess rinse water removed, it then will be necessary to completely reassemble the various components that have been removed for cleaning. Close the drain valve and re-attach the door. Refill the still and return to normal operation**.

**Consult the solvent supplier for proper residue disposal procedures and regulatory compliance.

Special Note: In many cases it may be only necessary to boil the distillation unit down, drain the still residues, and then refill the distillation unit for normal operation. This is especially true in stills heated by hot water, steam, or heat pump systems. These particular systems do not have a tendency to bake rosin flux and soils onto the heating ele-

ments therefore it may be necessary to clean up the interior of the distillation unit only on an annual or semi-annual basis. This frequency of clean up can only be determined by actual operation of distillation unit under the solid loads from the cleaning operation.

8.5.4 Still Solvent Drying Unit Some alcohol azeotropic and blend solvents require desiccant type drying units; either silica gel or molecular sieves are normally used in these drying compartments. It is necessary that the desiccant be changed on a routine basis in order to assure its water adsorbing capabilities. Most desiccants can be regenerated by baking out the adsorbed water. Please see the instruction furnished with the distillation unit for the proper procedures for the particular desiccant recommended.

Some solvents, such as 1,1,1-trichloroethane require only gravity water separation compartments (which would replace a desiccant drying unit).

For effective functioning of the water separator or desiccant dryer, the temperature of condensate should be kept below maximum values as listed in Table 7.

Table 7 Upper Condensate Temperatures

Solvent	Condensate Temperature
Hydrochlorofluorocarbon	30°C (86°F)
Methylene Chloride	38°C (100°F)
Trichloroethylene	73°C (164°F)
Perchloroethylene	88°C (190°F)
1,1,1 -Trichloroethane	65°C (149°F) (provided for reference)
Trichlorotrifluoroethane	44°C (112°F) (provided for reference)
<i>n</i> -Propyl Bromide	73°C (164°F)

Note: Condensate should be retained in this compartment from 3.0 to 5.0 minutes. For instance, 1,1,1-trichloroethane requires a minimum of 5.0 minutes retention time at 65°C (149°F) to properly separate water. (Certain azeotropes may require even lower temperatures, since halogenated solvent-alcohol azeotropes are always minimum boiling point formulations.)

8.6 Solvent Monitoring

8.6.1 Introduction There are two basic needs for solvent monitoring of the cleaning process: a) incoming inspection, and b) in-process monitoring. Numerous detailed analytical methods are needed for determining incoming (virgin) solvent quality and less elaborate methods are needed for in-process monitoring or assembly solvent quality. Most solvent suppliers can assist in specific tests for their products. Emphasis in this section will be placed on the in-process aspects of determining/monitoring solvent quality.

8.6.2 Need for Monitoring Whether using cold cleaning or vapor defluxing methods, contamination buildup of both suspended matter and dissolved materials must be controlled to ensure adequate cleaning and prevent inadvertent contamination of the product.

In vapor defluxing, buildup of contaminants in the boiling sump could increase the boiling temperature of the solution to a point where the cleaning operation is impaired because of poor vapor generation, resulting in a decrease in cleaning efficiency. Continued buildup of organic contaminants can result in sludge formation, “coking” of heating elements, potential heater failure, and solvent breakdown. In practice, this is rarely seen, as the addition of new solvent to compensate for everyday losses keep the levels of contaminant low and relatively constant.

Decomposition of solvent due to heat, hydrolytic instability or exposure to “white metals” (such as aluminum, zinc, magnesium, beryllium or various alloys of such metals), can result in inhibitor depletion and the generation of corrosion byproducts which can damage products processed through the solvent. In addition, prolonged exposure without corrective action/maintenance can detrimentally affect assembly/process equipment.

8.6.3 Methods of Monitoring

8.6.3.1 Hydrocarbon & Oxygenated Solvents Hydrocarbon solvents are not generally used for high volume assembly cleaning operations due to their flammability and volatility. However, where applicable, contaminant levels may be monitored by:

- qualitative observation of solvent discoloration
- quantitative determination of suspended solids and/or dissolved solid materials as percentage (nonvolatile matter) – ASTM-D-2109
- boiling point elevation
- specific gravity changes – ASTM D-2111

8.6.3.2 Halogenated Solvents Halogenated solvents/blends or azeotropic compositions can be monitored using many of the techniques applicable to hydrocarbon solvents. However, since most halogenated solvents/blends/azeotropes are used in vapor defluxing or defluxing where elevated temperatures are employed, additional tests should be used to monitor possible solvent decomposition due to water contamination, exposure to white metals, inhibitor depletion, or a combination of the above which could produce corrosion byproducts harmful to both product and equipment.

8.6.3.2.1 Chlorinated & Brominated Solvents Methods of monitoring solvent quality are:

- 1) Specific Gravity - ASTM Method D-2111
- 2) Distillation Range - ASTM Method D- 1078
- 3) Boiling Point Elevation - Refer to Paragraph 8.5.3.
- 4) Non-Volatile Residues - ASTM Method D-2109
- 5) Acid/Alkalinity - ASTM Method D-2989
- 6) Water Content - ASTM Method D-3401

The previous methods, although useful, are more suited for analyzing the quality of incoming (virgin) solvent. For day-to-day monitoring, the more commonly used method is:

Acid Acceptance Testing - ASTM Method D-2942

This method determines not the amount of acid present but rather the amount of inhibitor (acid acceptor/stabilizer) present/remaining to protect the solvent from the problem previously called “going acid,” but more precisely, degradation to unwanted or harmful decomposition products. Guidelines for interpreting test results (listed as weight percent of sodium hydroxide) and therefore quality of solvent are readily available. Kits can be obtained from chlorinated or *brominated* solvent suppliers or in-house kits can be easily prepared since the constituents for the test are readily available from chemical suppliers. Some solvent suppliers will, at no charge, provide defluxer solution analysis for several solvent parameters: water content, non-volatile residue (NVR) levels and acid acceptance.

Note: that most of the methods used for the traditional chlorinated solvents can be used for the new *brominated* solvents with only minor modifications.

8.6.3.2.2 Fluorinated Solvents As with other halogenated solvents the fluorocarbon-based solvents may be analyzed for purity/contaminants using various methods previously mentioned: boiling point elevation, total nonvolatiles and moisture content.

Pure fluorinated solvents in the absence of water do not normally react with “white metals” producing corrosive byproducts. However, fluorocarbon-based solvents in the presence of water or blended with other solvents (especially alcohols), along with elevated temperatures associated with vapor defluxing, decrease the solvent/solutions compatibility with reactive metals thereby requiring in-process monitoring. The more commonly used analytical methods for periodic in-process evaluation of solvent quality are:

- 1) Acid Acceptance - ASTM Method D-2106
- 2) Hydrolyzable Chlorides - ASTM Method D-3443
“Chloride in Trichlorotrifluoroethane”
- 3) pH Measurement - IPC Test Method No. 2.3.30

The fluorocarbon producer will provide recommended allowable levels of contamination and acid buildup in fluorocarbon solvent blends and azeotropes for defluxing and/or degreasing applications. Note that most of the methods used for the traditional chlorofluorinated solvents can be used for the new HCFC, HFC or HFE solvents with only minor modifications.

8.6.4 Summary In-process monitoring of cleaning solvents is essential in assuring the efficiency and longevity of cleaning equipment, adequate cleaning of product without

exposure to adverse/corrosive conditions and to minimize solvent usage and costs. It should be an integral part of any electronics assembly process control program involving solvent cleaning.

9 ENVIRONMENTAL CONSIDERATIONS

9.1 Introduction Over the last thirty years, many environmental laws and regulations have been enacted that impact the electronics industry. The complexity of these laws and regulations has resulted in a great deal of confusion among regulated entities. This section will clarify five major compliance issues. They are:

- Clean Air Act (CAA) and Clean Air Act Amendments of 1990 (CAAA) air emission requirements including:
 - Volatile Organic Compound (VOC) emissions under Title I
 - Ozone depleting substance (ODS) usage under Title VI
 - Hazardous Air Pollutant (HAPs) emissions under Title III
 - Permitting of "Major Sources" under Title V
- Water discharges under the Clean Water Act (CWA) including the discharge of total toxic organics (TTOs)
- Hazardous waste generation under the Resource Conservation and Recovery Act (RCRA) and subsequent amendments
- Past improper waste disposal under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) also known as Superfund
- Toxic chemical release reporting under the Superfund Amendment and Reauthorization Act (SARA)

9.2 The Clean Air Act On November 15, 1990, amendments to the Clean Air Act of 1970 (previously amended in 1977) were signed into law. These amendments contain important provisions, which regulate the use of solvents. These provisions are contained in two titles:

- Attainment and Maintenance of Air Quality Standards (Title I)
- Stratospheric Ozone Protection (Title IV).

9.2.1 Volatile Organic Compounds The Clean Air Act (CAA) requires states to meet six National Ambient Air Quality Standards (NAAQS) for specific pollutants. NAAQS establish the maximum concentration allowed for each pollutant in the background air in all areas of the country. Those pollutants include Nitrogen Oxides (NO_x), Carbon Monoxide (CO), and Ozone.

The CAA's NAAQS provisions apply to areas of the country that do not currently attain an NAAQS for a particular pollutant (these areas are called "nonattainment areas"). The 1977 Amendments required states to submit State

Implementation Plans (also called "SIPs") to the Federal Environmental Protection Agency (EPA) that details how states will achieve attainment with the NAAQS by 1987 at the latest.

Despite this deadline, many areas continue to exceed the ozone NAAQS. The 1990 amendments subdivided non-attainment areas into various categories according to the severity of their nonattainment problem. If you are located in a nonattainment area and your facility emits a nonattainment pollutant, you may have to meet stricter requirements for air pollution control for that pollutant than if you were located in an attainment area.

Electronic manufacturers are most likely to be affected by requirements in the nonattainment areas for ground-level ozone (also called "smog"). Ozone is a pollutant that is not discharged to the environment but is created by the reaction of ozone precursors (volatile organic compounds - also called "VOCs") and sunlight. VOC emissions are directly related to ozone production. Cleaning processes are likely to emit VOC, which combine with daylight to form smog.

Many common solvents are regulated as VOCs. The chlorinated solvent trichloroethylene is regulated as a VOC. EPA delisted perchloroethylene as a VOC in 1996, leaving individual states with the option of continuing to regulate it as a VOC or to exempt it from VOC classification. While most states have exempted perchloroethylene as a VOC, several states and regional air quality boards have not, and continue to regulate perchloroethylene as a VOC. State and local regulatory agencies should be consulted for clarification.

9.2.2 Ozone Depleting Substances The CAA amendments also contain provisions for controlling the use of chemicals believed to destroy stratospheric ozone - a layer of atmosphere that protects the earth by filtering harmful sunrays. EPA has established two lists of such substances: a list of Class I substances and a list of Class II substances. Class I substances refer to substances containing chlorofluorocarbons (CFCs) or methyl chloroform. Class II substances include hydrochlorofluorocarbons (HCFCs).

In 1992, EPA issued its final rule implementing Section 604 of the Clean Air Act. That section implemented the United States' obligations under the Montreal Protocol by limiting the production and consumption of substances with a potential to deplete stratospheric ozone. Carbon tetrachloride, trichlorotrifluoroethane (CFC-113) and 1,1,1-trichloroethane (methyl chloroform) were identified as Ozone Destroying Substances (ODSs). This rule, published as 40 CFR Part 82, Subpart A, required the phase out of production of these products for emissive uses by December 31, 1995.

Existing supplies of these solvents (produced prior to the phase out), and recycled product can continue to be sold

into emissive markets. Exceptions to the ban include product manufactured for transformation (chemical intermediate) processes, and “essential” uses as approved by the EPA (such as asthma inhalers).

Additionally, 40 CFR Part 82, Subpart E requires that products containing or manufactured with ODSs must be specially labeled identifying the presence of an ODS.

The Clean Air Act also required the EPA to establish a program to identify alternatives for ODSs, and to publish lists of acceptable and unacceptable substitutes. This program, the Significant New Alternatives Policy (SNAP) program is described in 40 CFR Part 82, Subpart G. Once EPA’s acceptability list is established,¹¹ it is illegal to replace a regulated ODS with any substance determined as harmful to human health or environment, if other substitutes with reduced overall risk are currently or potentially available. Acceptable replacements for CFC-113 and 1,1,1-trichloroethane include aqueous cleaners, semi-aqueous cleaners, oxygenated solvents, terpenes, trichloroethylene, perchloroethylene, and methylene chloride.

9.2.3 Hazardous Air Pollutants Section 112 of the Clean Air Act lists 189 hazardous air pollutants (HAP) for which the EPA has set National Emission Standards. Some solvents, such as methylene chloride, perchloroethylene, trichloroethylene, 1,1,1-trichloroethane, carbon tetrachloride and chloroform are included in the CAA Section 112 HAP list.

EPA issues Maximum Achievable Control Technology (MACT) standards to reduce emissions of hazardous air pollutants. Each MACT standard controls emissions of one or more air toxics from a specific air pollutant source. The MACT is the best control technology already in use for a given type of industry.

Under the CAA’s National Emission Standard for Hazardous Air Pollutant (NESHAP) program, “major” sources of air toxics must use the MACT-specified technology. Facilities are considered “major sources” if their potential emissions are 10 tons/year or more of a HAP or 25 tons/year of a combination of HAPs.

NESHAP standards require affected users to employ certain control technologies to reduce emissions. Typically, record keeping, reporting, and emission control technologies may need to be upgraded to meet the requirements of these standards.

In 1994, the EPA finalized the Halogenated Solvent Cleaning NESHAP. This standard is published in 40 CFR Part 63, Subpart T, and affects new and existing halogenated solvent cleaning operations. For guidance, consult EPA

publication EPA-453/R-94-081, EPA Guidance Document for the Halogenated Solvent Cleaner NESHAP.

9.2.4 Operating Permit Title V of the Clean Air Act Amendments of 1990 requires “major sources” of CAA criteria pollutants to obtain an operating permit that consolidates the facilities’ air pollution control obligations. Although the threshold for triggering these requirements are 100 tons/year for most pollutants, the thresholds for VOCs and nitrogen dioxides can be as low as 50 to 10 tons per year, depending upon where the facility is located. Check with your local air quality agency to determine your Title V operating permit obligations. It is expected that the Title V permitting thresholds will not be triggered for the majority of IPC member companies.

9.3 The Clean Water Act Discharges into navigable waters or tributaries have required a permit since the turn of the century. The modern version of the Clean Water Act (CWA) was passed in 1972 and amended in 1977, 1978, and again in 1982. Although the CWA is almost 30 years old, the Act has not yet been fully implemented. The Clean Water Act has two sections that can have a significant impact on industry operations: spill reporting requirements and the National Pollutant Discharge Elimination System (NPDES).

9.3.1 Spill Reporting Under Section 311 of the Clean Water Act, the EPA established a list of reportable quantities for specific chemicals (40 CFR 117.3). In July 1985, this list was incorporated into a master chemical list regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (also known as “CERCLA”) found at 40 CFR 302.4. These reportable quantities (RQ) range from 1 pound to 5000 pounds and were derived from a variety of criteria. Chemical spills in amounts equal to or exceeding their respective RQs during any 24 hour period must be reported immediately to the US Coast Guard National Response Center¹² or the nearest Coast Guard District office (33 CFR 153.203).

Violations of this provision can be costly. The Coast Guard can assess a fine in addition to assessing the cost of clean up. In addition, the EPA can take judicial action to recover tens of thousands of dollars, depending upon the severity of the event. Willful discharges may be subjected to judicial fines of up to \$250,000. Failure to report spills could result in a fine of up to \$10,000 or imprisonment of not more than one year, or both.

9.3.2 National Pollutant Discharge Elimination System (NPDES) Sections 301, 304, 306, 307, and 402 of the Clean Water Act authorize the establishment of regulations

11. EPA’s acceptability list for substitutes can be obtained by calling the Stratospheric Ozone Information Hotline at 1-800-296-1996, Monday through Friday, 10:00 a.m. to 4:00 p.m. EST.

12. US Coast Guard National Response Center, Washington, D.C., Telephone: 800-424-8802

and the issuance of permits to control the discharges of pollutants to waters of the United States. The National Pollutant Discharge Elimination System (NPDES) permit program governs such discharges. Facilities that discharge wastewater are considered as direct dischargers if they discharge directly into a waterway. They are considered indirect dischargers if they discharge into a treatment facility that then treats the wastewater and then discharges the treated wastewater into a waterway. Only direct dischargers need to obtain NPDES permits.

Direct dischargers in the electronics industry are subjected to either one of the following effluent limitation categories depending upon when they begin to discharge wastewater:

- electroplating point source category
- metal finishing point source category

The Clean Water Act effluent limitation guidelines include limits on such parameters as Biological Oxygen Demand (BOD), pH, metals, and Total Suspended Solids (TSS) and companies must meet those limits through the use of specified technology.

9.3.3 Total Toxic Organics The Metal Finishing Point Source Category assumes that proper management of solvent wastes (i.e., ensuring that concentrated toxic organic wastes such as solvent defluxers, degreasers and paint strippers are not dumped into wastewaters) will allow discharges to meet a total toxic organics (TTO) discharge level of 2.13 ppm for multiple chemicals. If a facility can certify that no dumping of solvents occurs, the facility will not have to do continuous monitoring of TTO but will only have to issue management plans to certify compliance with TTO limits.

9.3.4 Summary of Clean Water Act Impact on Solvent Systems The effect of the Clean Water Act on solvents used in processing printed wiring boards should be limited since solvent systems are specifically designed to minimize discharge in wastewater. If, however, chlorinated or fluorinated solvents reach the waste water effluent, they are subject to current regulations for total toxic organics if the effluent goes to a publicly owned treatment works (POTW) or to surface waters.

9.4 RCRA - General Enacted by Congress in 1976, RCRA (the Resource Conservation and Recovery Act) was designed to “close the loop” in environmental legislation by regulating the management of both hazardous and non-hazardous solid waste. EPA generally defines solid waste as any solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, or agricultural operations.

9.4.1 RCRA - Hazardous Waste In terms of hazardous waste, RCRA regulates its handling from the time it is first generated to its ultimate disposal. Facilities must determine

whether a material is a hazardous solid waste. EPA suggests these steps for determining whether a material is a RCRA hazardous solid waste. First, determine if the substance is excluded from RCRA based on 40 CFR 261.4. If the material is not excluded, determine if the material meet one of the following two conditions:

- Determine if the waste is a “listed” hazardous solid waste under RCRA. For example, the waste may be listed as a hazardous waste on the Commercial Chemical (P&U waste, see 40 CFR 261.33), Specific Source (K wastes, see 40 CFR 261.32), or Nonspecific Source (F wastes, see Appendix VII to 40 CFR 261) Lists.
- If the waste is not listed, determine if the waste exhibits one of the four characteristics of hazardous waste - ignitability, corrosivity, reactivity, or toxicity. If so, the waste is a “characteristic” hazardous solid waste.

If the waste meets one of these two conditions, it is generally a hazardous waste regulated by RCRA. RCRA requires that any person generating, transporting, treating, storing, or disposing of such wastes must notify the appropriate EPA regional office or designated state agency. Generators of hazardous waste must also: obtain an EPA identification number; comply with pre-transport requirements relating to packaging, labeling, marking, etc; satisfy recordkeeping and reporting requirements; comply with 90-day storage requirements; not offer waste to a transporter or a disposal facility without an EPA ID number.

9.4.2 Exclusions of Hazardous Waste In the November 17, 1981, Federal Register, the EPA ruled that “de minimis losses” of discarded commercial chemical products or chemical intermediates arising from manufacturing or laboratory operations are not considered hazardous wastes when in mixture with wastewater that is subject to Section 402 or Section 307 (b) of the Clean Water Act.

The rule stated that: “De minimis losses’ include those from normal material handling operations (e.g., spills from the unloading or transfer of materials from bins or other containers, leaks from pipes, valves, or other devices used to transfer materials); minor leaks of process equipment, storage tanks, or containers; leaks from well-maintained pump packings and seals; sample purgings; relief-device discharges; discharges from safety showers and rinsing and cleaning of personal safety equipment; and rinstate from containers that are rendered empty during that rinsing.”

The rule also applies to mixtures of wastewater and certain hazardous wastes from the Nonspecific Source List. Spills of spent solvents from the cleaning application equipment and tanks sometimes can enter process wastewater streams. Mixtures of small amounts of these spent solvents with large volumes of wastewater are no longer considered hazardous wastes as long as the generator is “able to demonstrate that the maximum amount of solvents used during a week divided by the average weekly flow of the influent

into the headworks of the final wastewater treatment step would not exceed the standards established (in the regulations).” In addition, the rule states that wastewater mixtures must go to wastewater treatment system whose discharge is subject to regulation under section 402 or section 307 (b) of the Clean Water Act.

9.4.3 Penalties for RCRA Violations Violation of RCRA provisions may subject a company or individuals to significant civil or criminal penalties. Civil fines of up to \$25,000 per day are provided for in the statute. In addition, substantial fines and imprisonment are provided for anyone who knowingly transports any identified or listed hazardous waste to a facility that does not have a permit; treats, stores, or disposes of any identified listed hazardous waste without having a permit, or in knowing violation of a material condition of a permit; makes any false material statement or representation in any application, label, manifest, record, permit, or other document filed, maintained, or used for the purpose of compliance with the regulations; destroys, alters, or conceals records required by RCRA.

9.4.4 Summary RCRA Impact on Solvent Systems RCRA substantially impacts solvent processing systems for printed wiring boards. Both methylene chloride (U-080) and the no longer produced 1,1,1-trichloroethane (U-226) are listed hazardous wastes under the Commercial Chemicals Category (40 CFR 261.33). Materials that are listed become “hazardous solid wastes” only when they are discharged or intended for discard. In many cases, this means that the “hazardous” listing for these commercial materials would only apply when they are spilled since the disposal of virgin solvents makes little economic sense.

In addition to the Commercial Chemicals List, spent halogenated solvents from vapor defluxers (F001) and spent solvents from other cleaning operations (F002) are listed hazardous wastes. The amount of spent solvents generated by flux removal systems can often be reduced, if desired, through distillation and reuse. In many cases, the remaining waste from such a system can be sent to a licensed solvent reclaimer for credit, or to a permitted hazardous waste incinerator where the recovered still bottoms can be used as a fuel source for certain equipment. Also, a facility can switch to aqueous-based cleaning and stripping solutions although the volume of hazardous waste (as defined by RCRA) from aqueous stripping and defluxing may be greater than the amount generated by solvent systems. These pollution prevention alternatives can reduce a facility’s hazardous waste management costs.

9.5 Superfund - General Many people in industry mistakenly believe that Superfund, or the Comprehensive Environmental Response Compensation Liability Act (CERCLA), provides only for the taxation of certain chemicals to pay for specific hazardous waste sites. How-

ever, Superfund also includes provisions for old-site notification and for the report of releases to the environment and for post-closure liability.

Under CERCLA, what must be reported to the EPA’s National Response Center as a release? The answer depends upon the material that is released and the quantity of that material. Releases that are Federally permitted or that are less than the established reportable quantities for certain chemicals as listed in 40 CFR 302.4 are not subjected to the reporting provisions under Superfund. Other requirements exist in Sections 311, 312, 313 of the Superfund Amendment and Reauthorization Act (SARA). State reporting requirements may have different release values and need to be verified by user.

No additional notification is required for any release that is continuous and stable in quantity and rate, and for which notification already has been given for a period sufficient to establish the continuity, quantity, and regularity, of such release. In short, reports to the National Response Center need only be given for a period sufficient to establish the quantity and regulatory nature of the releases. Thereafter, only statistically significant increases in the release need to be reported but permits may be required.

9.6 Toxic Release Inventory Reporting Requirements Facilities in the electronics industry that have 10 or more full-time employees which manufacture, process, or otherwise use more than 10,000 pounds per year of any toxic chemical listed in 40 CFR 372.65 must file a Toxic Chemical Release Inventory (TRI) to the EPA and to their state agency. The inventory reports releases and off-site transfers (including to recycling facilities) of those chemicals. Facilities are also required to report their pollution prevention and recycling data for TRI chemicals. Reports are due by July 1st of each year. TRI chemicals used by the industry include 1,1,1-trichloroethane, carbon tetrachloride, ethylene glycol, and trichloroethylene.

9.7 Influencing the Regulatory Process Many trade associations - for example, the IPC and the Halogenated Solvent Industry Alliance (HSIA) - are working for scientifically sound regulations. Working to modify the Clean Water Act discharge regulations for the Electroplating Point Category is an example of the effort. IPC’s active involvement in EPA’s Design for the Environment (DFE) Printed Wiring Board project is another example of the industry working with government regulators to promote pollution methods that save the industry money. For more on this project, check out the web site at <http://www.epa.gov/dfe>.

9.8 Applicability These regulations apply to facilities that operate in the United States and its territories (Puerto Rico, Virgin Islands, Guam, etc.). Regulatory information

contained in this handbook is believed to be accurate as of the date of publication. The procedures and recommendations presented in this handbook should not be construed as a recommendation to violate any federal, state, or local laws. Anyone using these products should review any applicable laws, rules, or regulations prior to use.

ANNEX A

TABLES OF FORMULATED CLEANING SOLVENTS

Disclaimer

The information provided in these tables is for the guidance of users in selecting post-soldering cleaning solvents. By mutual agreement, the table is limited to two formulations per family per supplier. Other formulations may be available that will best meet your needs. Contact the suppliers listed in Annex B for information on additional formulations. Being included in or omitted from these tables does not indicate endorsement of or disapproval of any

particular cleaning solvent. Users employing or considering n-propyl bromide should read Annex C.

Trademarks

All trademarks included in Table A-1, Table A-2 and Table A-3 for the convenience of the reader are the property of the respective manufacturers. No endorsement is implied by the appearance of said trademarks in these tables.

Table A-1 Trademark or Name of Cleaning Solvents

Trademark or Name	Type of Cleaning Solvent	Trademark or Name Owner
<i>Abzol</i>	<i>Brominated</i>	Albemarle
Arcosolv	Polypropylene Glycol Ether	Lyondell Chemicals (Arco)
Asahiklin AK-225	HCFC	AGA Chemicals
Axarel	Hydrocarbon	Petroferm
Bioact	Terpene/Hydrocarbon	Petroferm
<i>Hypersolve</i>	<i>Brominated</i>	Great Lakes Chemical Corp
Ionox	Alcohol	Kyzen Corporation
<i>Kyptonol</i>	<i>Brominated</i>	Kyzen Corporation
<i>Lenium</i>	<i>Brominated</i>	Petroferm
Megasolv	Polypropylene Glycol Ether	Petroferm
Novec	HFE	3M
OS	Siloxanes	Dow Corning
Synergy	Terpene/Alcohol	Licensed to Kyzen Corporation
Vertrel	HFC	DuPont Fluoroproducts
	Ester (Ethyl lactate)	Purac America
	Amine, Lactone (NMP)	Lyondell Chemicals (Arco)
Freon	CFC	DuPont
Genesolv	HCFC (141b)	Allied-Signal

Table A-2 Hydrogenated and Oxygenated Solvent Formulations

Product Name	Axarel® 2200	Axarel® 2400	Bioact® SC-10	Bioact® EC-7M	Arcosolv® PM	Arcosolv® PNP	Megasolv® JB	Ionox BC	Synergy CCS	NMP	Ethyl Lactate	Cyclohexane/ Isopropanol
General Solvent Type	Hydro-carbon base	Hydro-carbon base	Terpene/ Hydro-carbon base	Terpene/ Hydro-carbon base	Propylene Glycol Ether	Propylene Glycol Ether	Propylene Glycol Ether	Nonlinear alcohol, oxygenated solvent blend	Nonlinear Alcohol/ Terpene	Lactone; Amine	Ester	Hydrocarbon/ Alcohol Azeotrope ***
Boiling Point °C (°F)	152 (305)		152 (305)	171-189 (340-372)	120 (248)	150 (302)	143 (284)	175°C (347°F)	164°C (327°F)	202 (395)		64 (148)
Flash Point, TCC °C (°F)	44 (111)	58 (134)	41 (106)	48 (118)	32 (89)	48 (119)	46.7 (116)*	72°C (162°F)	48°C (119°F)	93 (199)		
Flammability Limits - LEL (vol% in air)				0.7	3.0	1.3	1.3**	1.2% v/v	1.1%	1.3	1.6	
Flammability Limits - UEL (vol % in air)				6.1	12.0	16.9	10.0**	11.42% v/v	7.9%	9.5	10.6	
Vapor Pressure at 20°C, torr	3.5		<2	<2	11.0	1.8	3.2	0.2	<2	0.2	1.7	
Relative Evaporation Rate (butyl acetate = 1)	0.32	0.23	<1	<1	0.66	0.21	0.25	0.01	<1	0.03	0.22	
Vapor Density (air = 1.00)	0.5	>1	>1	>1	3.0	4.0	4.4	4.1	4.0	3.4		
Liquid Density at 25°C, g/cm ³ (lb/gal)	0.82 (6.84)	0.85 (7.09)	0.80 (6.68)	0.84 (7.01)	0.92 (7.65)	0.89 (7.38)	0.94 (7.84)	1.04	0.950	1.03 (8.57)	1.03 (8.60)	
Surface tension at 20°C, dyne/cm	23.4		24.0	27.6	27.0	27.0	25.0-27.4	29.0	25.0	45.8	30.3	
Viscosity at 20°C, cp	1.8		1.6	0.8	1.7	2.3	1.9**	N/A	N/A	1.6	2.5	
Solubility of water in solvent (weight% at 20°C)				Insoluble	100	100		100%	5-10%	100	100	
Solubility of solvent in water (weight% at 20°C)	7		1	Insoluble	100	100	14**	100%	5-10%	100	100	
Solubility Parameter (Hansen) (Cal/cm ³) ^{1/2}												
- Nonpolar					7.5	7.6				3.5		
- Polar					3.2	2.4				6.0		
- Hydrogen bond					7.5	6.5				8.8		
Solubility Parameter (Hildebrand) (Cal/cm ³) ^{1/2}					11.1	10.3				11.2	15.0	
Kauri Butanol Value	>150		>150	86	∞	∞				∞	>1000	
VOC Content, grams/liter	820		800	840	923	887		1040	950	1024	100%	
Exposure limit, ppm					100	No limit set				No limit set	15	
Atmospheric Lifetime, years												
Global Warming Potential (CO ₂ = 1) =>100 yr ITH	Essen- tially zero	Essen- tially zero	Essen- tially zero	Essen- tially zero				0	0			
Ozone Depletion Potential	0	0	0	0	0	0	0			0	0	0

Blank spaces indicate data not available *PMCC, not TCC **indicates approximate value ***Composition ca. 66/33 of cyclohexane/isopropanol

Table A-3 Halogenated Solvent Blends & Azeotropes

Product Name	AK-225T	AK-225ES	Vertrel® SMT	Vertrel® XMS Plus	HFE-71DA	Abzol® EG*	Hypersolve® AZI*	Kryptonol K9200*	Lenium™ ES*	Freon® TMS	Freon® SMT	Genesolv® 2004
General Solvent Type	HCFC base	HCFC base	HFC base	HFC base	HFE base	nPB base	nPB base	nPB Based	nPB base	CFC base	CFC base	HCFC-141b base
Boiling Point °C (°F)	54 (130)	52 (126)	37 (99)	36 (96)	40 (104)	70 (158)	70 (158)	77°C (170°F)	68 (154)	40 (103)	38 (101)	29 (84)
Flash Point, TCC °C (°F)	None	None	None	None	None	None	None	None	None	None	None	None
Flammability Limits - LEL (vol % in air)	5	None	8	4	5	4	4	N/A		None	None	
Flammability Limits - UEL (vol % in air)	10	None	13	12	13	8	8	N/A		None	None	
Vapor Pressure at 20°C, torr	427 ¹	291	486	465	381 ²	110	110.8	102		429		
Relative Evaporation Rate (butyl acetate = 1)			6.8	7.3		6.2	6.0	6.0	6.0			
Vapor Density (air = 1.00)	7.0	ca. 7	4.1	4.3		4.2**		<5				
Liquid Density at 25 °C, g/cm ³ (lb/gal)	1.34 (11.17)	1.49 (12.42)	1.35 (11.30)	1.22 (10.20)	1.33 (11.09)	1.30 (10.86)	1.19 (11.10)	1.35	1.25 (10.43)	1.48 (12.30)	1.38 (11.55)	1.21 (10.10)
Surface tension at 20°C, dyne/cm	17.6	16.8	15.5	15.9	16.4 ²	25.9**	22.3	22.0		17.4	20.6	19.0
Viscosity at 20°C, cp	0.61	0.61	0.49	0.65	0.45 ²	0.49**	3.55 ²		0.49 ²	0.70	0.52	0.45
Solubility of water in solvent (weight % at 20°C)	0.33 ²	0.33 ²	0.34	0.30		0.05**	0.11			0.27	0.42	0.04
Solubility of solvent in water (weight % at 20°C)	0.062 ²	0.053 ²	0.044	0.040		0.24**	0.240**		1.130			
Solubility Parameter (Hansen) (Cal/cm ³) ^{1/2}												
- Nonpolar			7.1	7.1		7.8**	7.8**	7.8**				
- Polar			3.1	2.4		3.2**	3.2**	3.2**				
- Hydrogen bond			3.3	2.7		2.3**	2.3**	2.3**				
Solubility Parameter (Hildebrand), (Cal/cm ³) ^{1/2}			8.4	8.0		8.9**	8.9**	8.9**				
Kauri Butanol Value	ca. 7	41	30	33	33	125**	>125	125**	>125	45	96	56
VOC Content, grams/liter	200	73	668	560		1330**			1250			
Exposure limit, ppm	50	50	184	215		50-100	50-100	50-100**	50-100	475		
Atmospheric Lifetime, days						11 days	11 days	11 days**	11 days			
Global Warming Potential (CO ₂ = 1) =>100 yr ITH	310	350	657	709	250	0.3	0.3	0.3**				
Ozone Depletion Potential		0.03	0	0	0	0.03	0.03	0.03**	0.03			

¹Value @ 37.8°C²Value @ 25°C

*nPB-based formulations are pending approval by EPA SNAP office.

**indicates data from pure nPB, not the commercial product

1. Blank spaces indicate data not available

2. Exposure limit of 50-100 ppm suggested by EPA while approval is pending.

3. ODP of 0.026 is the current official ODP from the Scientific Assessment Panel (SAP)

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ANNEX B

TABLE OF FORMULATED CLEANING SOLVENT SUPPLIERS

Table B-1 Formulated Cleaning Solvent Suppliers

Cleaning Agent Type	Supplier Name	Supplier Address	Supplier Phone	Supplier Fax
Alcohol	Kyzen Corp.	430 Harding Ind. Dr. Nashville, TN 37211	615-831-0888	615-831-0889
Chlorocarbon	Dow Chemical	2020 Dow Center Midland, MI 48674	517-636-8071	517-636-4500
Chlorocarbon	PPG Industries, Inc.	Solvents & Intermediates Division One PPG Place Pittsburgh, PA 15272-0001	412-434-3131	412-434-2197
Chlorocarbon	Vulcan Chemicals	P.O. Box 385015 Birmingham, AL 35238-5015	205-298-3000	202-298-2955
HCFC	AGA Chemicals, Inc.	2201 Water Ridge Pkwy., Ste. 400 Charlotte, NC 28217	704-329-7600	704-357-6308
HFC	DuPont Fluoroproducts	P.O. Box 80702, CRP 702-2210 Wilmington, DE 19880-0702	800-441-9281	302-996-7152
HFE	3M Chemicals	3M Center, Bldg. 223-6S-04 St. Paul, MN 55144-1000	800-364-3577	
Ethers	Arco Chemical Co.	3801 West Chester Pike Newtown Square, PA 19073-2387	610-359-2000	610-359-2722
Ethers	Petroferm, Inc.	5415 First Coast Highway Fernandina Beach, FL 32034	904-261-8286	904-261-6994
Hydrocarbon	Kyzen Corp.	430 Harding Ind. Dr. Nashville, TN 37211	615-831-0888	615-831-0889
Hydrocarbon	Petroferm, Inc.	5415 First Coast Highway Fernandina Beach, FL 32034	904-261-8286	904-261-6994
Siloxanes	Dow Corning Corp.	P.O. Box 0994 Midland, MI 48686-0994	517-496-4000	517-496-4586
<i>Brominated</i>	Albemarle Corporation	451 Florida Street Baton Rouge, LA 70801	225-388-8011	225-388-7686
<i>Brominated</i>	Great Lakes Chemical Corp.	One Great Lakes Boulevard P.O. Box 2200 West Lafayette, IN 47906	765-497-6100	765-497-5533
<i>Brominated</i>	Kyzen Corp.	430 Harding Ind. Dr. Nashville, TN 37211	615-831-0888	615-831-0889
<i>Brominated</i>	Petroferm, Inc.	5415 First Coast Highway Fernandina Beach, FL 32034	904-261-8286	904-261-6994
Amines, Lactones	Arco Chemical Co.	3801 West Chester Pike Newtown Square, PA 19073-2387	610-359-2000	610-359-2722
Lactate Esters	Purac America	111 Barclay Blvd. Lincolnshire Corporate Center Lincolnshire, IL 60069	847-634-6330	847-634-1992

ANNEX C

EPA POSITION ON *NORMAL PROPYL BROMIDE*

EPA has been reviewing the listing of *n-propyl bromide* (*nPB*) under the Significant New Alternatives Policy (SNAP) program for various uses, including as a solvent (for precision, electronics and general metal cleaning), as well as in aerosol and adhesive applications. At this time EPA has not made a determination of the environmental acceptability of *nPB* under SNAP. EPA is thoroughly reviewing the available toxicological information and the environmental implications of the ozone depletion potential (ODP). Based on its assessment to date, the Agency believes that additional information is needed before regulatory decisions can be formulated. In light of the uncertainties and incompleteness of the necessary data, EPA is unable to predict whether any use will be allowed under SNAP and as such, users should exercise caution. Based on information collected over the next several months, the Agency hopes to issue a proposal in 1999 but is difficult to predict when a final rulemaking will be promulgated.

IPC Task Group Notes to Users on *n-Propyl Bromide* and its Formulations:

1. The EPA needs to evaluate the toxicological data requested in the Advance Notice of Proposed Rulemaking (ANPR), published in the Federal Register, Vol. 64, No. 32, Thursday, February 18, 1999, pp 8043-8048; before final rulemaking.
2. The EPA needs to obtain a more accurate ODP for *nPB*. The present models cannot accurately predict the ODP of short-lived molecules like *nPB*. A Task Group of atmospheric scientists is developing an enhanced model capable of predicting accurate ODPs for short-lived molecules which will also include latitude effects.
3. The final rule will include a recommended upper limit for *nPB* concentrations in workplace air based on expert assessment of the toxicological studies.
4. While awaiting the final rule, it is legal to both sell and use *nPB* for use in electronic cleaning applications, provided an upper workplace *nPB* vapor in air limit of 50-100 ppm is strictly adhered to. It is strongly recommended that users perform routine air monitoring to ensure compliance.
5. All references to or information on *brominated* compounds such as *nPB* in this document are in italics to remind the user that SNAP approval from EPA is pending.
6. When EPA issues a final rule on *nPB*, IPC shall revise the *nPB* data in this document and issue IPC-SC-60B.



ANSI/IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

Definition Submission/Approval Sheet

The purpose of this form is to keep current with terms routinely used in the industry and their definitions. Individuals or companies are invited to comment. Please complete this form and return to:

IPC
 2215 Sanders Road
 Northbrook, IL 60062-6135
 Fax: 847 509.9798

SUBMITTOR INFORMATION:

Name: _____
 Company: _____
 City: _____
 State/Zip: _____
 Telephone: _____
 Date: _____

- This is a **NEW** term and definition being submitted.
- This is an **ADDITION** to an existing term and definition(s).
- This is a **CHANGE** to an existing definition.

Term	Definition

If space not adequate, use reverse side or attach additional sheet(s).

Artwork: Not Applicable Required To be supplied
 Included: Electronic File Name: _____

Document(s) to which this term applies: _____

Committees affected by this term: _____

Office Use	
IPC Office	Committee 2-30
Date Received: _____	Date of Initial Review: _____
Comments Collated: _____	Comment Resolution: _____
Returned for Action: _____	Committee Action: <input type="checkbox"/> Accepted <input type="checkbox"/> Rejected
Revision Inclusion: _____	<input type="checkbox"/> Accept Modify

IEC Classification
Classification Code • Serial Number
Terms and Definition Committee Final Approval Authorization: Committee 2-30 has approved the above term for release in the next revision.
Name: _____ Committee: <u>IPC 2-30</u> Date: _____

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Technical Questions

The IPC staff will research your technical question and attempt to find an appropriate specification interpretation or technical response. Please send your technical query to the technical department via:

tel 847/509-9700

fax 847/509-9798

www.ipc.org

e-mail: answers@ipc.org

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ComplianceNet forum covers environmental, safety and related regulations or issues.

DesignerCouncil@ipc.org

Designers Council forum covers information on upcoming IPC Designers Council activities as well as information, comment, and feedback on current design issues, local chapter meetings, new chapters forming, and other design topics.

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This peer networking forum is specific to solder mask qualification and use.

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Message: subscribe TechNet Joseph H. Smith

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To: LISTSERV@IPC.ORG

Subject:

Message: sign off DesignerCouncil

Please note you must send messages to the mail list address ONLY from the e-mail address to which you want to apply changes. In other words, if you want to sign off the mail list, you must send the signoff command from the address that you want removed from the mail list. Many participants find it helpful to signoff a list when travelling or on vacation and to resubscribe when back in the office.

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To send a message to all the people currently subscribed to the list, just send to <mail list>@ipc.org Please note, use the mail list address that you want to reach in place of the <mail list> string in the above instructions.

Example:

To: TechNet@IPC.ORG

Subject: <your subject>

Message: <your message>

The associated e-mail message text will be distributed to everyone on the list, including the sender. Further information on how to access previous messages sent to the forums will be provided upon subscribing.

For more information, contact Hugo Scaramuzza

tel 847/790-5312

fax 847/509-9798

e-mail: scarhu@ipc.org

www.ipc.org/html/forum.htm

IPC World Wide Web Page www.ipc.org

Our home page provides access to information about upcoming events, publications and videos, membership, and industry activities and services. Visit soon and often.

Education and Training

IPC conducts local educational workshops and national conferences to help you better understand emerging technologies. National conferences have covered Ball Grid Array and Flip Chip/Chip Scale Packaging. Some workshop topics include:

Printed Wiring Board Fundamentals	High Speed Design
Troubleshooting the PWB Manufacturing Process	Design for Manufacturability
Choosing the Right Base Material Laminate	Design for Assembly
Acceptability of Printed Boards	Designers Certification Preparation
New Design Standards	

IPC video tapes and CD-ROMs can increase your industry know-how and on the job effectiveness.

For more information on programs, contact John Riley

tel 847/790-5308 fax 847/509-9798

e-mail: rilejo@ipc.org www.ipc.org

For more information on IPC Video/CD Training, contact Mark Pritchard

tel 505/758-7937 ext. 202 fax 505/758-7938

e-mail: markp@ipcvideo.org www.ipc.org

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"The Acceptability of Electronic Assemblies" (ANSI/IPC-A-610) is the most widely used specification for the PWB assembly industry. An industry consensus Training and Certification program based on the IPC-A-610 is available to your company.

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tel 847/790-5308 fax 847/509-9798

e-mail: rilejo@ipc.org www.ipc.org/html/610.htm

IPC Printed Circuits Expo

IPC Printed Circuits Expo is the largest trade exhibition in North America devoted to the PWB industry. Over 90 technical presentations make up this superior technical conference.



March 16-18, 1999
Long Beach, California



April 4-6, 2000
San Diego, California

For exhibitor information,

Contact: Ken Romeo

tel 630-434-7779

For registration information:

tel 847/790-5361

e-mail: registration@ipc.org

fax 847/509-9798

www.ipc.org

How to Get Involved

The first step is to join IPC. An application for membership can be found on page 74. Once you become a member, the opportunities to enhance your competitiveness are vast. Join a technical committee and learn from our industry's best while you help develop the standards for our industry. Participate in market research programs which forecast the future of our industry. Participate in Capitol Hill Day and lobby your Congressmen and Senators for better industry support. Pick from a wide variety of educational opportunities: workshops, tutorials, and conferences. More up-to-date details on IPC opportunities can be found on our web page: www.ipc.org

For information on how to get involved, contact:

Jeanette Ferdman, Membership Manager

tel 847/790-5309 fax 847/509-9798

e-mail: JeanetteFerdman@ipc.org www.ipc.org



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

Application

for Site Membership

Thank you for your decision to join IPC. IPC Membership is **site specific**, which means that IPC member benefits are available to all individuals employed at the site designated on the other side of this application.

PLEASE CHECK

APPROPRIATE

CATEGORY

To help IPC serve your member site in the most efficient manner possible, please tell us what your facility does by choosing the most appropriate member category.

■
**INDEPENDENT
PRINTED
BOARD
MANUFACTURERS**

Our facility manufactures and sells to other companies, printed wiring boards or other electronic interconnection products on the merchant market.

WHAT PRODUCTS DO YOU
MAKE FOR SALE?

- | | | |
|---|--|--|
| <input type="checkbox"/> One-sided and two-sided rigid printed boards | <input type="checkbox"/> Flexible printed boards | <input type="checkbox"/> Discrete wiring devices |
| <input type="checkbox"/> Multilayer printed boards | <input type="checkbox"/> Flat cable | <input type="checkbox"/> Other interconnections |
| | <input type="checkbox"/> Hybrid circuits | |

Name of Chief Executive Officer/President _____

■
**INDEPENDENT
PRINTED BOARD
ASSEMBLERS
EMSI
COMPANIES**

Our facility assembles printed wiring boards on a contract basis and/or offers other electronic interconnection products for sale.

- | | | |
|--|---|--------------------------------------|
| <input type="checkbox"/> Turnkey | <input type="checkbox"/> Through-hole | <input type="checkbox"/> Consignment |
| <input type="checkbox"/> SMT | <input type="checkbox"/> Mixed Technology | <input type="checkbox"/> BGA |
| <input type="checkbox"/> Chip Scale Technology | | |

Name of Chief Executive Officer/President _____

■
**OEM –
MANUFACTURERS
OF ANY END
PRODUCT USING
PCB/PCAs
OR CAPTIVE
MANUFACTURERS
OF PCBs/PCAs**

Our facility purchases, uses and/or manufactures printed wiring boards or other electronic interconnection products for our own use in a final product. Also known as original equipment manufacturers (OEM).

IS YOUR INTEREST IN:

- purchasing/manufacture of printed circuit boards
- purchasing/manufacturing printed circuit assemblies

What is your company's main product line?

■
**INDUSTRY
SUPPLIERS**

Our facility supplies raw materials, machinery, equipment or services used in the manufacture or assembly of electronic interconnection products.

What products do you supply?

■
**GOVERNMENT
AGENCIES/
ACADEMIC
TECHNICAL
LIAISONS**

We are representatives of a government agency, university, college, technical institute who are directly concerned with design, research, and utilization of electronic interconnection devices. (Must be a non-profit or not-for-profit organization.)

Please be sure to complete both pages of application.



Application for

Site Membership



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

Company Name _____

Street Address _____

City _____ State _____ Zip _____ Country _____

Main Phone No. _____ Fax _____

Primary Contact Name _____

Title _____ Mail Stop _____

Phone _____ Fax _____ e-mail _____

Senior Management Contact _____

Title _____ Mail Stop _____

Phone _____ Fax _____ e-mail _____

Please check one:

- \$1,000.00 Annual dues for Primary Site Membership (Twelve months of IPC membership begins from the time the application and payment are received)
- \$800.00 Annual dues for Additional Facility Membership: Additional membership for a site within an organization where another site is considered to be the primary IPC member.
- \$600.00** Annual dues for an independent PCB/PWA fabricator or independent EMSI provider with annual sales of less than \$1,000,000.00. **Please provide proof of annual sales.
- \$250.00 Annual dues for Government Agency/University/not-for-profit organization

TMRC Membership Please send me information on Membership in the Technology Marketing Research Council (TMRC)

AMRC Membership Please send me information for Membership in the Assembly Marketing Research Council (AMRC)

Payment Information

Enclosed is our check for \$ _____

Please bill my credit card: (circle one) MC AMEX VISA DINERS

Card No. _____ Exp date _____

Authorized Signature _____

Mail application with check or money order to:

IPC
Dept. 851-0117W
P.O. Box 94020
Palatine IL 60094-4020

Fax/Mail application with credit card payment to:

IPC
2215 Sanders Road
Northbrook, IL 60062-
6135
Tel: 847 509.9700
Fax: 847 509.9798

PLEASE ATTACH BUSINESS CARD
OF OFFICIAL REPRESENTATIVE HERE



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

Standard Improvement Form

IPC-SC-60A

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

IPC
2215 Sanders Road
Northbrook, IL 60062-6135
Fax 847 509.9798

1. I recommend changes to the following:

Requirement, paragraph number _____
 Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

Unclear Too Rigid In Error
 Other _____

2. Recommendations for correction:

3. Other suggestions for document improvement:

Submitted by:

Name

Telephone

Company

E-mail

Address

City/State/Zip

Date



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

ISBN #1-580982-32-8

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