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ABSTRACT

In describing the cleaning of electronic components and subassemblies, it must be taken into consideration that each part to be cleaned presents an individual problem. The method of cleaning must be tailored to the type of part to be cleaned as well as to the type of soil to be removed.

This paper reviews some of the methods used in cleaning electronic parts, particularly printed circuits, as well as other critical hardware which is used in support of electronic assemblies. Some of the methods covered include the use of abrasives, acids, solvents and alkalies, and the employment of these in combination with ultrasonic and other automatic systems.

The clean room in use at IBM Huntsville is described briefly, along with the solutions and solvents used in cleaning electronic and supporting parts. Cleanliness requirements for the area and the materials, together with procedures for meeting them give added emphasis to the critical nature of today's contamination control programs.

The paper concludes with a summary of the cleaning procedures and the clean room benefits to be obtained by using present day technologies to improve them.

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INTRODUCTION

In discussing the cleaning of electronic components and subassemblies, it must be taken into account that each part to be cleaned presents an individual problem. Each manufacturer has his own methods for producing parts. This results in the parts being contaminated with a great variety of soil, cleaning agents, preservatives, packaging material, and other contamination. The method of obtaining a clean part must be tailored to the type of part to be cleaned as well as the type of soil to be removed. This paper will review some of the methods used in cleaning electronic parts, particularly printed circuits, as well as some of the other critical parts which are used in support of electronic assemblies. The role played by the clean room in obtaining this type of cleanliness will also be discussed.

METHODS AND MATERIALS

One of the first things to keep in mind when cleaning any item is that it is usually much easier to keep it clean during processing than to attempt to clean it when it is finally completed.

BASE MATERIAL CLEANING

Starting with the printed circuit board in its original form, the first step is to review briefly the various methods of obtaining a clean base material. Since most of this material arrives from the manufacturer with some type of protective material on its surface, the first step usually consists of removing this coating. A vapor degreaser with trichloroethylene or perchlorethylene usually works well for this purpose. The next step is to remove any oxides, fingerprints, or other surface contamination that may be present.

Two of the most commonly used methods of cleaning are acid and abrasive. The use of abrasive cleaning has been questioned from time to time because of the possibility of small particles of pumice being imbedded in the surface. However, if further cleaning is to be done later, it is not felt that these pumice particles will constitute a serious problem. Once the base material has been cleaned, the next step is the application of the photo or ink resist for subsequent plating or etching, or both.

CLEANING FOR ELECTROPLATING

In preparing boards for electroplating, each manufacturer usually has his own method. As a rule, a thorough degreasing followed by an alkaline clean and one of the standard acid solutions will prepare the surface for electroplating. One of the best methods for cleaning copper is the use of chromic acid; however, because of the danger of contamination of the plating solutions by chromates, this method is unpopular and not generally used. A more acceptable material is ammonium persulfate at a concentration of about two pounds per gallon.

An excellent electrolytic process was developed some years ago using a 50 percent solution of phosphoric acid (by volume) with stainless steel cathodes. The only drawback to this method was that parts that had already been etched were found to have the circuitry reduced by the electrocleaning process. The process removes metal very rapidly at the edges; this is especially troublesome where the photo or ink resist meets the exposed portion of a copper circuit. In such cases, a groove is usually cut into the copper at this point and sometimes actually severs the circuitry. Where the entire circuit is to be plated, no problem occurs.

CLEANING AFTER PLATING

Once the plating cycle has been completed, other problems in cleaning are revealed. The three most serious problems to be eliminated are: (1) removing the plating and cleaning residues from the board, (2) getting the etching residues off, and (3) getting the solder flux off. Needless to say, in cases one and two, a thorough rinsing is of prime importance. There are also various neutralizing solutions that can be used as an aid to removing the chemical contaminates. An ultrasonic cleaning can be safely employed at this point. In some cases, a scrubbing with a mild abrasive is required to completely eliminate some of the byproducts of the etching materials, particularly in the case of ferric chloride, which leaves particularly stubborn residues.

PROTECTING THE CLEAN BOARD

After final cleaning, after etching and plating, and prior to soldering, it is advisable to use a protective coating. A satisfactory one is called Copper-Seal and is manufactured by S. C. Robison Company, Westfield, New Jersey. This coating is applied by dipping and can be air dried. Later, when it is desired to spin- or dip-solder coat these boards, the coating is easily removed by spraying with trichloroethylene. As an alternate removal method, ultrasonics may also be employed.

REMOVING SOLDER FLUX

Removing solder flux after dip- or hand-soldering presents a rather persistent problem, since this is the most common contaminate that is encountered in the cleaning of electronic assemblies--particularly printed circuit boards. There are a great many commercial flux removers on the market. Each one has its own special merits and usually is very efficient if keyed to the type of solder flux being used. Among the standard solvents are alcohol, Ketone,* and Freon.

One of the important factors to be considered when removing flux is that it should be done as soon as possible after soldering. Flux is best removed while still warm. The sooner it is done, the better and more efficient the cleaning process will be. Parts left lying around for several days will be much more difficult to clean. The passing of time allows the flux to harden and to become very difficult to remove.

CLEANING WITH ULTRASONICS

Great care must be used when considering ultrasonic cleaning. It is one of the best and most effective methods of cleaning, particularly for such items as electronic assemblies where small nooks and crannies, blind holes, etc. are involved and complete removal of impurities is difficult.

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*Trademark for fluorinated hydrocarbons, E.I. du Pont de Nemours & Co, Wilmington, Delaware.

However, ultrasonic cleaning can have a disastrous effect upon the components themselves. Diodes, triodes, transistors, and other types of semiconductor are sometimes adversely affected by the high frequenceies and vibrations involved in the use of ultrasonics. The bad feature here is that it is very difficult to tell just exactly how much damage is being done, unless the damage is total and complete. Total and complete damage is not the usual case. If parts are not completely destroyed, it may lead the user to believe that no damage is done, when actually what is happening is that the active life of the component is being considerably reduced.

Again, with ultrasonics as with any other type of cleaning, the media which are used must be effective for the type of soil to be removed. For example, use of ultrasonics in a clean room can cause considerable difficulty because of the vapors given off by the activated solutions. These vapors often carry particles of impurities which then drift around in the air and tend to settle upon a clean surface of a critical part. To avoid this (except when employed under a hood with a suitable exhaust system to carry away any harmful vapors), ultrasonics are never used in the clean room.

OTHER CLEANERS

A mild brushing with a bristle brush and solvent is effective. Spraying methods are also satisfactory. Degreasers using low-temperature solvents, such as Freon, are also very widely used for this purpose. However, some type of physical dislodging is generally required in order to remove the last of the stubborn contaminates. A standard flux removal cycle, then would probably involve an organic solvent, in a solution of ammonium hydroxide (about 2 percent for neutralizing), followed by a de-ionized water rinse. De-ionized water is preferred because tap water contains chlorides. Further, there is no real point in cleaning the board thoroughly if it is to be re-contaminated with chloride-loaded tap water.

NOMENCLATURE PROTECTION

Sometimes the solvent selected is excellent for removing flux, but it can attack the nomenclature printed on the electronic components. In discussing the protection of component nomenclature from the attack of flux-removing solvents, one effective method is the spraying of a very light coating of Hysol* 12-007. This is first reduced with toluene to a sprayable consistency, applied, and then baked in an oven for about 1-1/2 hours at 165 degrees Fahrenheit. In an operation of this type, it is important that the plastic material not be permitted to contact component leads; otherwise, good soldering will not be accomplished.

ASSEMBLY PROTECTION

The final item to be considered after all cleaning is finished is how to protect the clean surface. This is usually done by application of a plastic coating, often referred to as a conformal coating, consisting of either urethane or epoxy. If this is not to be done immediately, the part should be protected by keeping it in a plastic bag or other inert atmosphere where outside contamination cannot get to it. The use of a plastic bag or other container is recommended at all times when the board is not actually in work.

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* Hysol Corporation, Olean, New York

CLEAN ROOMS

As the use of critical parts for space work increases, more attention is being paid to the requirement for clean environments for electronic assembly work. Particularly with NASA Quality Document NPC 200-4, it is found that environmental requirements are being stressed. Temperature, relative humidity (which runs 30 to 50 percent), and positive pressure are being specified for electronic assembly areas. Facility design criteria (like those for interior finish which state that floors, walls, and ceilings shall be of a material that does not generate particles and is easily cleaned) are also specifying lighting requirements calling for 100-foot candles on working surfaces. In addition, exhaust requirements are being specified to prevent recontamination of electronic assemblies and to protect personnel, where required. Thus it can be seen that the clean room is beginning to play a rather prominent part in producing electronic assemblies, as well as other stages of space work.

Many of the critical parts for the launch vehicles, including some which are operated by the electronic assemblies, must be cleaned to previously unheard-of limits. IBM Huntsville, for example, works to Marshall Space Flight Center Specifications, which require that there shall be no particle above 20 microns in any dimension on a critical surface. To achieve this, a highly clean area is required and all materials and tools used in the area must also be clean.

CLEAN MATERIALS

Water used in the IBM Huntsville clean room must be de-ionized. The water is required to meet a specific resistance of 50,000 ohms minimum. It must meet a pH between 6 and 8 and it may not have particles above 20 microns in size in any dimension. Some rather elaborate equipment is needed to meet these requirements, including filters that must meet the micron count. For drying and testing of clean surfaces, ordinary air cannot easily be made to meet the specification; therefore, dry nitrogen gas is used for this purpose. Here again, no particle over 20 microns in any dimension is permitted, and the maximum allowable concentration of hydrocarbons is 0.3 part per million by weight. The moisture content for GN_2 is limited to 24 parts per million maximum.

CLEAN SOLVENT

The cleanest commercial solvents available are not acceptable under the most critical MSFC specifications and, consequently, must be refiltered after delivery. IBM accomplishes this by circulating the solvent through a special pumping unit having a series of three filters and back through a recirculating system. It passes first through a 10-micron filter, then through a 2-micron filter, and finally through a half-micron absolute filter. In this way a solvent is obtained which meets the acceptable cleanliness level.

SPECIAL AREAS

By this time, it is clear that this type of cleaning could not be accomplished in an ordinary clean room. It was necessary to install laminar flow type clean benches in the clean rooms. All final cleaning, testing, and packaging of the critical parts are done in these benches.

At times, combination items, such as a value that has internal surfaces that must be cleaned to an extremely critical cleanliness level, will have an electronic activating unit attached. This unit also must be kept clean, although the level is not nearly so critical. To handle an item of this nature, the electronic assembly must first be cleaned, tested, and checked out. Then it must be packaged very carefully. The next step is to get the valve cleaned and checked out, being extremely careful that the materials used to clean the valve do not contact the electronic assembly. When both electronic and mechanical assemblies have met the specified cleanliness levels, the proper packaging is performed and the part is sealed. Not until then may it be removed from its clean environment. It is not unpackaged again until it is once more in a clean room and is ready for assembly onto a larger unit.

CONCLUSION

It can be seen, then, that cleaning of electronic and related parts has come a long way, and that a great deal still remains to be done. Many cleaning methods are available and many more are under study. The old standby methods such as abrasive, alkali solvents, and acid are still in use, and new combinations of these are proving effective.

The use of controlled environments is making new levels of cleanliness possible. In spite of all this, the old rule of suiting the cleaning technique to the material to be cleaned and the type of soil to be removed still holds true, and probably shall continue to do so.