

## FLUX RESIDUES AND WHAT TO DO ABOUT THEM

Soldering fluxes invariably leave a trace of residue behind them after doing their job of cleaning corrosion from those surfaces being soldered. Most of them also generate nasty fumes, at least when heated, and for that reason Hakko recommends the use of a fume-extraction device to keep these fumes away from the operator's breathing apparatus. That subject is treated elsewhere; we shall now go on to the subject of cleaning up the boards once the soldering work is done.

### SEMI-AQUEOUS CLEANING OF ROSIN<sup>1</sup> FLUXES.

Aqueous saponifiers have been available and have been successfully used by electronic assemblers for decades. *Saponifiers* are alkaline materials that react with rosin, forming water washable *soaps*. The soaps created by this reaction must be washed off the assemblies with generous amounts of water. Saponifiers that are available to the industry are available in concentrates suitable for use in both batch type (dishwasher) and in-line spray cleaning equipment. A good saponifier will have both an anti-foaming agent and an anti-smutting agent incorporated into its chemistry. The *anti-foaming agent* will keep the amount of foam manageable in automated cleaning equipment. The *anti-smutting agent* prevents discoloration from appearing on certain metals such as anodised aluminium, which may react with the alkalis in the saponifier.

Semi-aqueous cleaners use terpenes as the cleaning agents. The fumes are not particularly toxic but have an overpowering reek; turpentine is a concentration of terpenes and oils, and we all know what that smells like.

In the past, water-soluble fluxes have been highly activated acid fluxes. Residues left by these fluxes are conductive and very corrosive and must be removed from the board lest damage occur to the traces, or inadvertent high-resistance shorts develop.

Water soluble fluxes are available in pH neutral and halide free formulations. Fluxes that contain no volatile organic compounds (VOCs) are the most recent addition; visit any of the flux manufacturers' websites for complete information on what is available.

### ROSIN-BASED FLUXES.

The oldest, most popular and still most effective soldering flux. This flux is an organic compound consisting primarily of colophony, a complex rosin found in pine trees. The active agents in rosin flux are *abietic acid* and *plicatic acid*; it is the reaction between these organic acids and metallic oxides on the joint materials that provides the cleaning required for solder to 'wet' the joint. In a world free of stickybeaks and activists it would be sufficient to inform operators that these organic acids, when exposed to soldering temperatures, combine with oxygen and yield products of partial combustion which may be irritating to the skin and eyes, or exacerbate respiratory problems. Abietic acid may also cause skin irritation at room temperature - some people are unable to hug a pine tree - and there is some correlation between colophony and allergic reactions.

Some rosin-based fluxes contain additional chemical activators, usually organic fatty acids, which help the fluxing process along by making the compound even more acidic than usual. This helps soldering, to be sure, but may add even more irritants to the air. Rosin-based flux leaves a residue behind after the soldering

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<sup>1</sup> THE DIFFERENCE BETWEEN 'ROSIN' AND 'RESIN'...THE FORMER IS A SPECIAL CASE OF THE LATTER...NO EXTRA CHARGE FOR THIS SERVICE.

ROSIN: A TRANSLUCENT, AMBER-COLORED TO ALMOST BLACK, BRITTLE, FRIABLE RESIN OBTAINED BY CHEMICAL MEANS FROM THE OLEORESIN OR DEADWOOD OF PINE TREES, OR FROM TALL OIL, AND USED FOR MAKING SOLDERING FLUX, VARNISH, PAPER SIZE, SOAP, AND IN ROSINING VIOLIN BOWS.

RESIN: ANY ONE OF VARIOUS SOLID OR SEMISOLID AMORPHOUS FUSIBLE FLAMMABLE NATURAL ORGANIC SUBSTANCES USUALLY FORMED IN PLANT SECRETIONS, GENERALLY TRANSPARENT OR TRANSLUCENT YELLOWISH TO BROWN, WHICH ARE ELECTRICAL NONCONDUCTORS SOLUBLE IN ORGANIC SOLVENTS BUT NOT IN WATER. ALSO, ANY OF A LARGE CLASS OF SYNTHETIC PRODUCTS THAT HAVE SOME OF THE PHYSICAL PROPERTIES OF NATURAL RESINS AND USED CHIEFLY IN PLASTICS. SYNTHETIC RESINS ARE WIDELY DIFFERENT CHEMICALLY AND DO NOT INTRODUCE THEMSELVES INTO THIS DISSERTATION.

operation is finished. This residue must be cleaned from the board, both to allow further operations (such as conformal coating) to be carried out with a minimum of fuss and bother, and for cosmetic reasons - charred flux is abominable in the eyes of an inspector. Isopropyl alcohol & methyl alcohol are the solvents of choice; they are cheap, effective, and quick. Semi-aqueous and saponified aqueous cleaners can also be used to remove residues. Prior to the signing of the Montreal Protocol<sup>2</sup>, when concern about health issues related to use of chlorinated solvents became prevalent, rosin-based fluxes were the most commonly used type of flux in the electronics manufacturing industry. Cleaning, alas, requires an increment of time, and 'unproductive' time at that; alcohol fumes are unpleasant to some; we therefore have a choice of:

#### WATER-SOLUBLE FLUXES.

These fluxes are designed to wash away from the board and components with plain, ordinary water, and sometimes they do that. Practically all water-soluble fluxes leave a residue behind. Carboxylic acids (R COOH), relatively weak organic acids, are primary constituents of many water-soluble fluxes, along with a detergent (called a 'surfactant' in the trade) and, of course, water. Both the acid and the detergent can produce irritating fumes.

Water-soluble fluxes are usually washed off with hot water; occasionally a saponifier is added to help the cleaning process. Saponifiers are alkaline, and may be corrosive; they react with the acid residue on the board to form a soap and glycerine, which is relatively easy to wash away in hot water. Fumes are not the problem in the wash process; splatter is. Users must consider corrosion and other failures related to higher humidity when using these fluxes. Because of their high activity, including high halide content in some cases, residue from water-soluble fluxes can cause sustained corrosion and induce electrical problems without adequate cleaning.

#### 'NO-CLEAN' FLUXES.

These have become more widely available since the 1990s due to increasing pressure from environmentalists. These fluxes are based on a wide range of chemistries and composition, but all leave a minimal (and theoretically benign) residue that theoretically does not have to be removed from finished electronic assemblies. These fluxes do not, we are told, require cleaning after use, for they do their work and vanish under the influence of heat. Most if not all of them are more active - that is, more acidic - than their rosin-based predecessors, and all exude chemical residues and products of partial combustion that are even more likely to irritate sensitive membranes than those derived from real wooden trees. Many so-called 'no clean' fluxes are organically based, usually on an alcohol, and have a low solid content. Typical constituents of solder smoke from no-clean fluxes arise from the breakdown of alcohols and include ethane, acetone, formaldehyde, toluene, terpenes, carbon monoxide and carbon dioxide and, of course, alcohol fumes. Whoop!

Some water-based no-clean fluxes have been developed; they do not produce the volatile organic compounds peculiar to alcohol-based fluxes, though their use entails special equipment to preclude splattering and continuous testing to verify the acid concentration. Such fluxes are extremely active and should be handled carefully to avoid severe skin irritation.

You will have noticed, no doubt, that most soldering fluxes are organic compounds that break down under heat, and emit objectionable fumes of one sort or another. The chemical reaction between the acid in the flux and the oxides on the board contributes to the release of fumes, though the compounds thus generated are but a small part of the total.

Inhaling rosin-based solder flux fume can lead to occupational asthma or make existing asthmatic conditions worse. The fume can also cause irritation to the eyes and upper respiratory tract.

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<sup>2</sup> THE 'MONTREAL PROTOCOL ON SUBSTANCES THAT DEplete THE OZONE LAYER' WAS SIGNED IN SEPTEMBER 1987. ADVERTISED AS 'THE FIRST WORLDWIDE STEP TOWARD CONTROLLING OZONE DEPLETION', IT WAS A TYPICAL EMOTIONAL REACTION BY THE SELF-ANNOYED TO QUESTIONS ON SUBJECTS ABOUT WHICH THEY WERE, AND REMAIN, ABYSMALLY IGNORANT.

Rosinless fluxes such as synthetics and 'no-cleans' have been found to be even more irritating than rosin fluxes. Fluxes must react chemically with pad materials to be effective and promote wetting; the acids in these fluxes do that, but the chemical reactions with the metals in the pads and the plastic substrates produce very harsh gases.

