SOLDERING OF SMD PARTS

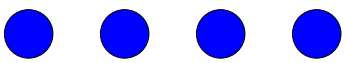
General advice and hints

BGA HANDLING & REWORK

General information

SOLDERING PROFILES

Descriptions for NOKIA approved soldering machines
Zevac DRS 24/ DRS 24L
OK-Metcal BGA 3000/ 3500



INTRODUCTION

IMPORTANT:

This document is intended for use by authorized NOKIA service centers only.

The purpose of this document is to provide some further information about tools that are helpful for soldering actions on PWBs of Nokia mobile phones. It contains general information about soldering SMD parts, land grid arrays but also about storage, handling and soldering ball grid arrays. Additionally, it provides general information about Nokia approved soldering machines, their handling and, if necessary, editing the soldering profiles.
It contains a comprehensive collection of tips and hints to find faults and repair solutions easily that will give support to the inexperienced technician, too.
Saving process time and improving the repair quality is the aim of this document.

Whenever working with materials that are harmful for the person working with them, keep in mind instructions given in the vendors' safety data sheet! Safty data sheets for materials that are used in the document you can also download from Partner Web Site. Furthermore remember that all described service tools are recommended not obligated service tools!

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ESD protection

Highest priority applies to ESD protection! Damage by electrostatic discharge often leads to the failure of a module, not instantly but within a short period of time! The mobile phone's PWB and single components, such as BGAs, LGAs or TQFPs, are sensitive to electrostatic discharge and must be handled correspondingly. Therefore, ESD training should be given to all persons working with ESD sensitive parts, which deals with the basics of ESD and protection against it around the workplace.

There are different ways how components could be damaged:

1. A charge moves fast between two objects with potential difference – most often between a person and component.
2. A component is charged by friction or induction and when it contacts an object with potential difference, a discharge current will go via the component.
3. A component is moved into an electric field that generates potential differences and currents inside the component.

Workers protection

Whenever handling ESD sensitive parts, each person has to wear a wristband that must be connected to the earth bonding point of the workbench. To prevent charging yourself by walking, you have to wear shoes with conductive straps underneath or grounding straps around your shoes. Furthermore, it is necessary to wear an ESD protective coat to keep the electric field of your clothes away from parts at risk. Especially the correct function of the wristband and shoes should be checked at least once a day with the help of designated measurement tools.

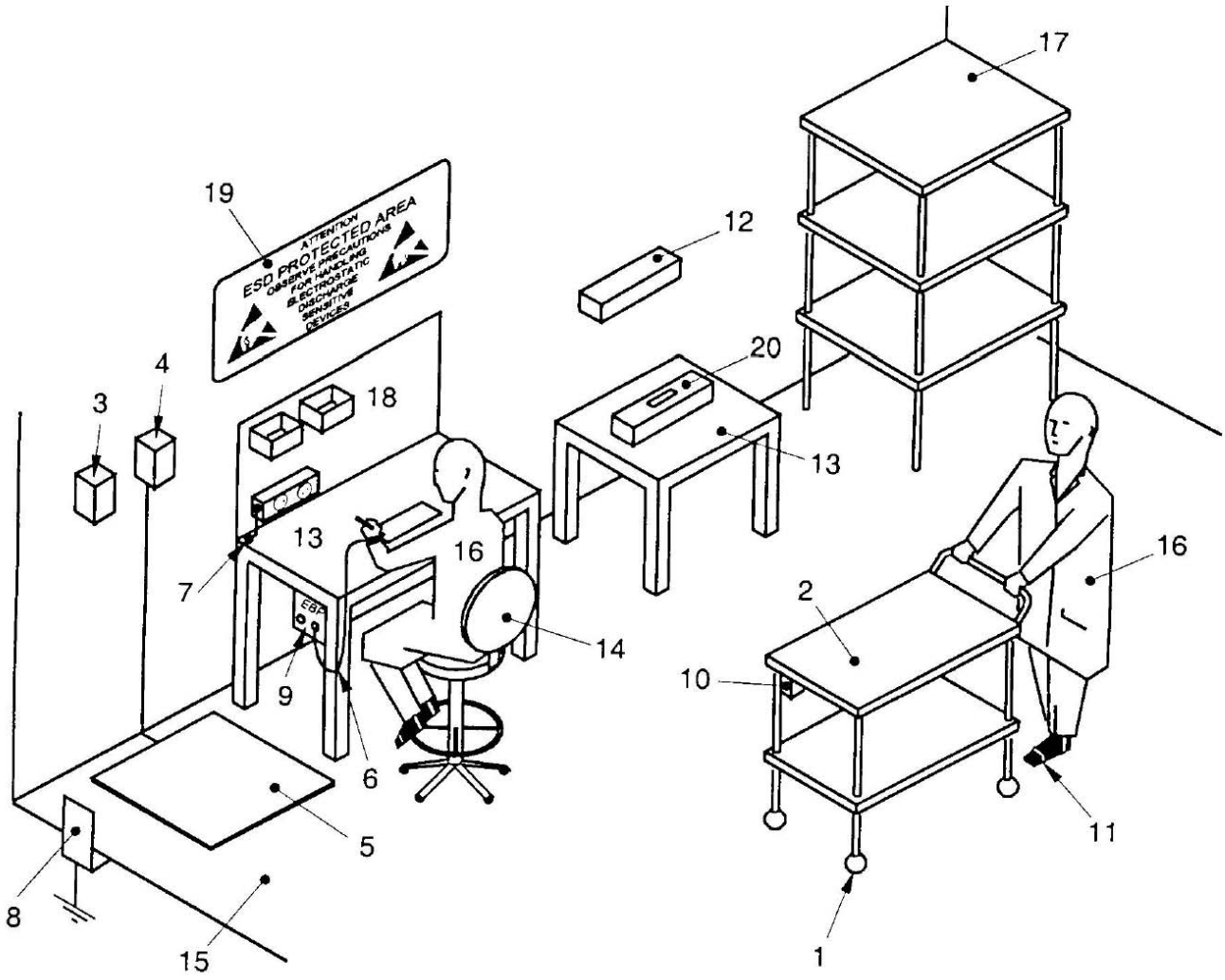
Workbench protection

To protect disassembled phones that are lying on the workbench, every workbench needs to have a conductive tablemat, which must be connected to the earth bonding point. Always keep your workbench clean, as the best conductive mat makes no sense if it is insulated by dirt!

Environment protection

If you work with ESD sensitive components, generally, the work environment must be ESD protected to prevent the destruction of any component. Also flooring, all office materials, such as trash bins, file trays, chairs, and so on, have to fulfill ESD requirements.

This drawing shows the set-up of an ESD protected area (EPA):



1	Groundable wheels	11	ESD protective footwear
2	Groundable surface	12	Ionizer
3	Wrist-strap tester, shall be displayed outside the EPA	13	Working surfaces
4	Footwear tester, shall be displayed outside the EPA	14	Seating with groundable feet and pads
5	Footwear tester foot plate	15	Floor
6	Wrist cord and wrist band (wrist strap)	16	Garments
7	EPA ground cord	17	Shelving with grounded surfaces
8	EPA ground	18	Groundable racking
9	Earth bonding point (EBP)	19	EPA sign
10	Groundable point of trolley	20	Machine

Helpful tools for soldering

Tweezers:
Tweezers are available in many different styles for manifold usages. They are especially helpful for placing SMD parts onto the PWB or removing them.

1: Long tapered version
2: Standard tapered version
3: Special version with flat tips
4: Crooked version to access difficult places

Probe/ dental tool:
Useful to check solderings of components with outlined pins (e.g. TSOP, TQFP). Use the probe very carefully because pins or even the whole pad are easily torn off if you use too much force while searching for loose contacts/ pins!

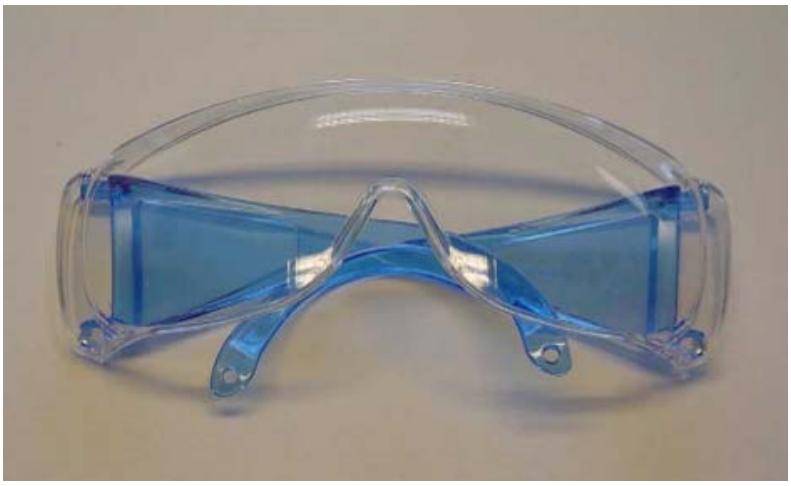
Cleaning brushes:
Cleaning brushes have to be available at every workplace, ideally in two different dimensions (wide and long/ short and thin). The wide one is the better choice to clean a complete PWB; the short one is the right choice for places difficult to access.
TIP: The brush is more reliable if you clean it after use with a cleaning agent, such as isopropanol or "Kontakt WL". By cleaning the brush you avoid releasing old dirt from between the bristles and spreading it all over the next PWB.

Microscope:
A microscope should be available on every workbench. It is indispensable for placing and soldering components as the parts become smaller and smaller. It also is helpful when searching for disconnections, short circuits, liquid damages, and so on.

Gloves:
Gloves should always be worn when handling or reworking mobile phone modules. On the one hand, solder joints may become unreliable if you touch components to be soldered with bare fingers. On the other hand, fingerprints spread all over the PWB will cause corrision on the PWB and lead the module to fail.

Solvents

Whenever using solvents for cleaning purposes: Always put on your pair of goggles and take care that there is sufficient fresh air around your workplace. Furthermore, always pay attention to the vendor's safety instructions when using their products!



Isopropanol
IPA (short term for isopropyl alcohol) is suitable for all cleaning on PWBs. A little while after having cleaned the PWB with isopropanol, you should always check if there is any residue, or if the PWB appears stained, especially in the keyboard area. If this is the case, you have to remove the dirt by means of a dry brush. The best way is to use the wide brush for this action.

"Kontakt WL"
This solvent is suitable for most soiled PWBs. "WL" is also good for adhesive dirt – e.g. liquid residues. After having used "WL", the PWB should also be cleaned very well because this solvent could leave adhesive residues, too. These could agglutinate e.g. the keyboard, so that the keys could not work properly anymore in the near future!

"Kontakt LR"
This product is often used after soldering to clean a PWB. Be careful that you always use an appropriate amount of it because the brush on top of the can partially holds the liquid longer.
If there is too much solvent on the PWB anyhow, clean it very carefully because of the problem described before.

Compressed air
Whenever you use compressed air for cleaning purposes, never use air that is not ionized as this will result in static damage of your module! Always use ionized compressed air machines (e.g. Simco "Top Gun").

Working materials

Solder tin:	Multicore Crystal 502, S-Sn60Pb40E
Solder paste:	ESP SMT Lotcreme 6-Sn62Pb36Ag by GLT Pforzheim/ Multicore solder paste RP15/ NMP code 0770380
Flux:	In liquid form: Stannol 900-3369 In gel form: Multicore Multifix 450-01 rework flux/ NMP code: 7540021
Solder removal flex:	Chemtronics Soder-Wick (50-3-100) / Plato-Wick XL (2-5/4-5)
Solder iron/ station:	Weller PU 50/ Metcal MX-500

Solder tin

Tin is available in several thicknesses. The thinnest with a diameter of 0.23 mm is recommended for very small components (e.g. chip resistors, chip capacitors). For larger components, such as power amplifiers or connectors, you should use tin with a larger diameter, e.g. 0.5 mm. The tin with small diameter can also be used for bigger components, but you need a larger amount of tin to get the same effect.

Solder paste

This material should mainly be used to solder shieldings, LGAs and connectors with contacts at the bottom of their case. Solder paste can also be used to solder other parts, such as oscillators, but always be careful to take an appropriate amount of it. Too much solder paste can cause short circuits in the periphery or in the component itself.
Solder paste must be stored at +8° Celsius (check technical datasheet!), otherwise the paste will become useless after 10 to 14 days because it quickly becomes spoiled at higher temperatures (i.e. the flux in the paste dries up). But even if it is stored at the correct temperature, shelf life of e.g. Multicore solder paste RP15 is limited to four weeks. Therefore, the opening date should always be written onto the syringe to ensure that the open solder paste has not exceeded shelf life. Too old solder paste usually produces small tin balls all over the PWB instead of a silvery shiny solder joint.
The best way to get the right amount of solder paste onto your PWB is with the help of a dispenser (e.g. by Weller or GLT) or the syringe itself. For both needles with different diameters are available. Check out for yourself with which diameter you can work best.

Flux

For daily rework, we use two different sorts of flux:

One is the liquid form, available in plastic bottles with a brush on the top, as fluxpen or brushpen.
But please note that there is usually no need to add flux to a solder joint because flux already is part of the solder tin. Nevertheless, liquid flux may help, for example, if the flux of solder tin has already evaporated. It is also very helpful for reworking oxidized pads beneath a BGA component.
But whenever you use liquid flux, be very careful not to drown the PWB in flux. Large amounts of flux will lead to a failure of the phone after a short period of time, especially if you cover contact pads of connectors or even the keypad. If this happens anyway, clean the PWB with appropriate materials, such as “Kontakt LR” and ionized compressed air.

The second kind we use is flux in the form of gel. This flux is also available in a syringe. It is mainly used to solder BGAs on BGA rework machines (e.g. Zevac, OK/ Metcal, Martin).

For both types of flux counts: if there is no need to clean the PWB after rework, you got the right amount of flux!

1. Gel flux (a little more fluid) used on OK/ Metcal rework machines (RMA rework flux gel)
2. Liquid flux with brush on top (Stannol 900-33699)
3. Gel flux for BGA rework by Multicore (Multifix 450-01, NMP Code: 7540021)

**Whenever working with any kind of flux, always pay attention to the vendors’ saftey data sheet!
Saftey data sheets of NMP recommended flux types you can also find on Partner Web Site.**

Solder removal wick

Use this tool to remove residues of old solder from the PWB, e.g. after a defective BGA component has been taken off the PWB.
Whenever working with solder removal wick, make sure that the temperature of your soldering iron, soldering tip size and area to be cleaned on the PWB are matching. In case it is not possible to get the old tin melting, try using a bigger soldering tip to transfer more heat to the PWB or increase the temperature of your soldering iron, if possible. Another symptom that something is wrong is that you have to apply pressure on the soldering tip/ PWB.
Cleaning the PWB without damaging it will only be possible if the above-mentioned conditions are fulfilled. Otherwise, torn-off pads will surely be the result. Especially single pads with microvias only are easily torn off, and the PWB is irretrievably damaged!

An alternative to solder removal wick are machines offered by different manufacturers that remove residues of solder tin from the PWB. These machines work similarly to a soldering iron, but the tip of the machine consists of a vacuum nozzle by which the melted solder is sucked up. But also for these machines counts that you can damage the PWB if the solder tip is too cold, or if you try to remove tin with pressure on the tip!

The different wicks

1 - Chemtronics Soder-Wick (50-3-100)
2 - Plato-Wick XL (3-5 or 4-5)

Soldering irons

We use the two different types described below.
Other useful soldering irons you can find in the recommended service tools list on PWS.

1. Weller PU50 soldering station
2. Metcal MX500 soldering station

In the ideal case, two soldering stations (irons) should be on every workbench. One soldering iron should have a small or thin solder tip for smaller joints, while the second soldering iron should have a larger tip for bigger joints, such as groundings. Together both soldering irons can also be used to solder/ desolder all SMD components connected with two joints to the PWB.

Special soldering tips for soldering, e.g. TQFP packages, are provided by Metcal. These tips are designed especially for a technique that is called "drag soldering". This tip cartridge is shaped like a horse's hoof – it holds just the right amount of solder. Using these cartridges prevents the failures commonly seen when soldering TQFP packages such as bent contact pins or short circuit solder terminals. The technique has to be trained for a while, but it is the fastest way to solder this kind of surface mounted components.

Hint:
Soldering tips/ cartridges remain usable for a longer time if the tip is cleaned after rework with a damp (not soaking wet!) sponge. After that, some fresh tin should be added to the soldering tip to prevent scaling of the tip.

To clear up a misconception: soldering **without** applying pressure on the part to be soldered is the only method that will work. Working with pressure on the tip or PWB will cause a bent soldering tip or, in the worst case, a damaged PWB as a result of a crooked solder tip!
If soldering does not work, probably the combination of tip/ component or joint area/ temperature does not fit! In this case, exchange the soldering tip with a larger one or increase the temperature of the soldering station.

Whenever a soldering tip is crooked, exchange the tip immediately. One argument for this action is that the crooked tip cannot transfer the heat as well as an intact tip. Another reason is the above-mentioned risk of damaging the PWB with the defective soldering tip.

Weller station – PU 50

Weller soldering stations have their heater in the front area of the soldering iron. The heater increases the temperature of the added soldering tip until the temperature preselected at the soldering station is reached. This takes approximately 2 minutes depending on the soldering tip used and the preselected temperature. But whatever item you try to solder on the PWB, usually a temperature of 380° Celsius is enough for all repair actions and should not be exceeded. If the temperature set at the soldering station is reached, the green LED switches from continuous shining to flashing. Now you can work with the soldering iron.

The adjusted temperature value is now held at the tip – you can use the iron everytime without preheating after not having used it for a while. This can be a disadvantage because the degree of wear and tear is as high as if the tip was permanently in use. If you know that the soldering iron will not be in use for a longer time, you should lower the temperature at the station to prolong the soldering tip´s life. If you want to resume work after a while, the soldering iron/ tip must be heated again, but this takes only a couple of seconds.
Changing soldering tips is recommended in cool condition because the tip and its holder are very hot and could be deformed by using tools such as tongs to open the holder. After a short cooling phase, the tip can usually be changed after having screwed off the holder without any tools. Only if the holder cannot be removed without tools in cool condition, you should loosen the holder very carefully with the help of tongs. Take care not to damage the heater of the soldering iron or the holder itself! After having changed the soldering tip, the screw of the holder should be tightened by hand only – more force is not necessary!

In connection with the Weller soldering station, we mainly use a thin tip (type DX 4771) for the 25W soldering iron and a larger tip (type DX 5688) for the 50W soldering iron. These tips are useful for nearly all soldering actions.

Metcal station – MX 500

These soldering stations are completely different from Weller soldering stations. In Metcal soldering stations the heater is integrated into the soldering tip. Furthermore, the time to get the soldering tip up to the right temperature is very short at approximately 20 seconds. When the soldering station is not in use, the temperature of the tip is maintained with little power. Only if heat is given off by touching a joint to be soldered with the soldering tip, the soldering station recognizes the fall of temperature at the tip and increases the power of the heater.
Another advantage of the Metcal soldering station is that it switches to stand-by mode after 25 minutes of inactive time. Once switched to stand-by, it has to be turned off and on again to start re-heating.
The current mode is indicated by two LEDs at the left upper corner of the station: the green LED shows that the station is in power-on mode, while the yellow LED indicates stand-by mode.

Exchanging a soldering tip is very easily done just by pulling the tip out of the handle using the rubber pad at the cable of the soldering iron. There is no need to wait until the tip has cooled down.
If the tip is exchanged while the soldering station is active, the station switches to stand-by mode itself, so that you have to turn the station off and on again to work with it.
Metcal provides a rather large variety of soldering tips with different shapes and temperature ranges for the soldering station MX 500. Samples of some special tips are shown in the picture below.


The MX-500 soldering station and two examples of soldering tips for special use:
On the left, you can see the soldering tip in knifestyle (SMTC x161), which is best for soldering e.g. flexfoils. The other soldering tip in hoofstyle (SMTC x147) is very useful for soldering TQFP parts with “drag” technique.

For all Metcal tips there are four temperature scales to choose from (302°C to 496°C). Depending on the desired joint, we recommend the STTC/ SMTC Series 500, 600 and 700 in the temperature scale from 302°C to 412°C (for SMD soldering).

Lead-free soldering

In general the same tools having been used for Sn/Pb connections (e.g. soldering irons, rework flux, solder wick...) up to now can be used for rework of lead-free soldering joints. Only change is the higher melting temperature of lead-free solder tin, which is 217°C with the alloy Nokia uses. As a result longer heating times are required for lead-free solder joints compared to conventional Sn/Pb joints. Nevertheless, always keep in mind not to exceed maximum heating time/temperature for components/PWBs in rework!

If rework of small components is necessary with help of a soldering iron, use solder wire consisting of the same alloy the used solder paste does. Recommended solder wire is Multicore Crystal 502 Ecosol TSC 96SC (95.5%Sn/3.8%Ag/0.7%Cu).
For LGA- or shielding rework you have to use lead-free solder paste. Recommended type is Multicore 96SCLF300AGS88.5, NMP code is 7600033.
Remember that also profiles of BGA rework systems have to be modified accordingly if it is necessary to replace BGA components with lead-free balls underneath!

Please note:

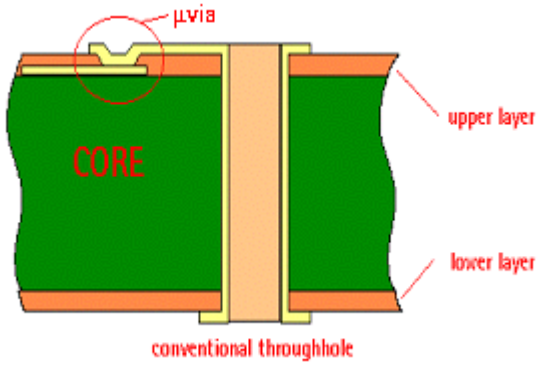
Lead-free solder joints do not have the same shiny surface as Sn/Pb connections have; the surface usually is dull. This is no sign for process faults or mishandling, it is the normal appearance of lead-free solder joints!

Lead-free solder alloy has 5 to 10 times lower absorbance compared to leaded one. When solder joints are checked with x-ray this results in contrast decrease between lead-free solder joints and background, compared to the same leaded joint.

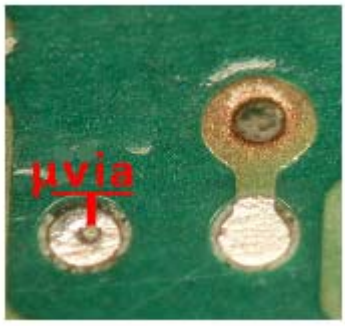
Soldering and desoldering techniques

General information

The possibilities to solder or desolder a component mainly depend on its construction and on the location where it has to be soldered: small parts such as chip resistors or chip capacitors with only two connections should always be soldered by means of a soldering iron. Only in exceptional cases, controlled hot air should be used for these parts (e.g. if solder joints are not accessible with a soldering iron). Small parts such as chip resistors, chip capacitors or baluns with more than two connections should be removed with controlled hot air. Soldering these parts can be done with the help of a soldering iron or, if joints cannot be accessed, with controlled hot air.
BGAs, power amplifiers, filters, or multichip modules must only be soldered and desoldered with a BGA rework machine (e.g. OK-Metcal/ Zevac/ Martin). One reason for this is the so-called “popcorn effect” of BGAs. This means that BGAs collect moisture in their cases. If the part is now heated up in an uncontrolled manner, the moisture evaporates very quickly and leads to cracks in the BGA. As a result of this, the new part fails instantly or after a short period of time.
Another reason is that we have PWBs with µvias nowadays. These µvias are a new form of connection between the different layers of a PWB. Unlike drilled throughhole connections, which are rather robust, µvias are very sensitive to thermal and mechanical stress. To keep this stress as low as possible it is necessary to heat up the PWB from both beneath and above.



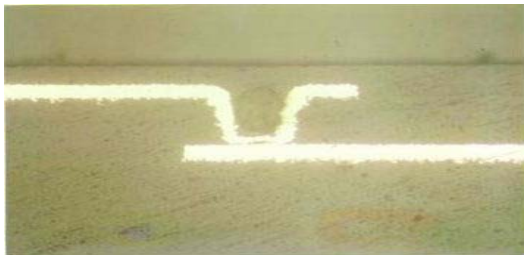
Scheme of PWB with µvia



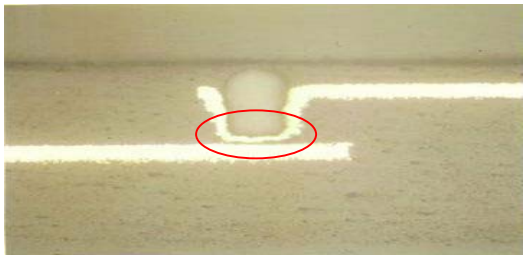
µvia versus throughhole connection

Example of a cracked µvia:

Before thermal cycling



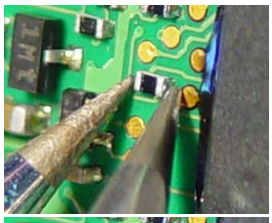
After thermal cycling



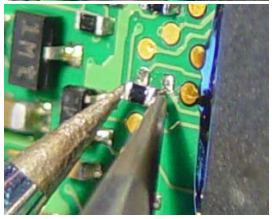
Rework of chip resistors/ capacitors with two connections

This is usually done with two soldering irons or a soldering tip in form of twezzers. Only if joints on the PWB cannot be reached with the soldering iron, rework is also possible with controlled hot air (see next page).

Nevertheless, whenever working with the soldering iron on the PWB, always keep in mind that tip temperature must not exceed 350°C ± 10°C. Furthermore, the maximum exposure time at a soldering joint is 3 seconds!

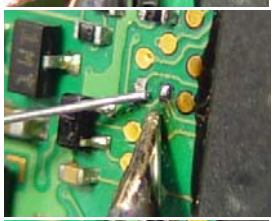


The easiest way to rework a SMD part with two connections is by using two soldering irons. Access the part from both sides...

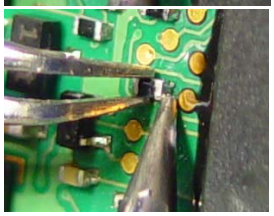


...and take it away with the help of the soldering tips when both joints are melted.

After the part has been removed, clean the joint area carefully with solder wick...

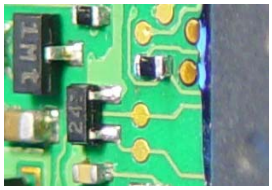


...and tin-plate one pad with fresh solder tin.



Now pick up the spare part with the help of tweezers and position it on the correct spot of the pad. By using the soldering iron you can now melt the solder on the previously tin-plated pad so that the spare part is fixed.

Finally you have to solder the second connection of the reworked part...

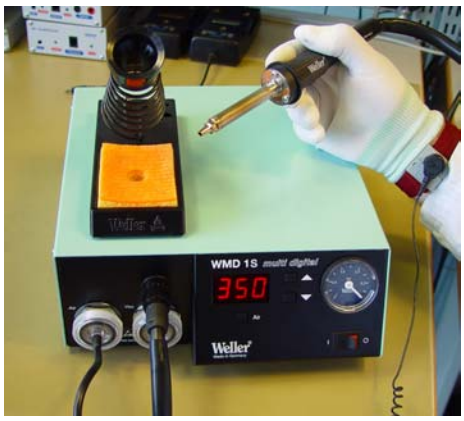


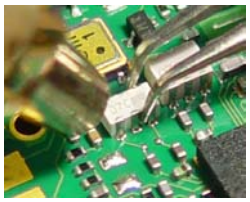
...and after cleaning the PWB there is no visible difference to other joints!

Rework of chip resistors/ capacitors or other small parts (e.g. baluns) with the help of controlled hot air

The method described below is also useful for parts where you cannot access the solder joints with soldering irons (e.g. C109 in NHM-5/6). But always remember that the temperature on the PWB's surface may not exceed 260°C! The temperature on the PWB is well indicated by the solder joints you are working on: as long as the joint does not melt, you have not reached 183°C (in case of Sn/Pb connections)!

Never use equipment that gives you no control over the airflow and temperature at the output (e.g. Leister Hot Jet S)!





Exchanging parts as shown in the picture is very easy with the help of controlled hot air. You only have to heat up the part...

...and pick it up with the help of tweezers when the solder is liquid.

After that remove the old solder from the PWB with the help of solder wick...

...and tin-plate the pads with fresh solder tin. Now add a little flux (do not drown the PWB in flux!) to the solder joints...

...and place the new part with the help of tweezers onto the solder joints.

Finally heat up the spare part with controlled hot air...

...and clean the PWB with e.g. "Kontakt LR". Done!

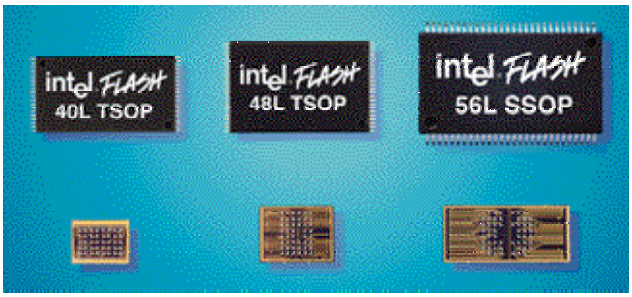
BGA rework

- General information
- Handling of BGAs
- Self-centering of BGAs
- Desoldering BGAs, cleaning pads, adding flux
- Rework of oxidized (black) pads
- Solder joints – the way they should look like

General information

Soldering integrated circuits with the help of BGA rework machines becomes more and more indispensable in daily work as the amount of BGA components rises with every new product.

BGA components have the advantage that one can build a circuit with a much smaller case compared to former technologies, while the functions of the chip increase. Furthermore, the possible amount of connections a BGA could have is much larger than e.g. a TSOP component of the same size could have.



The name BGA is the abbreviation for “ball grid array”. This refers to the arrangement of the solder balls, which are underneath the component and not at the sides of the circuit unlike earlier.
This leads to problems because the solder joints are not longer accessible with a conventional soldering iron. Using a hot-air fan for rework is not allowed since BGA components need a specific rise in temperature per second! This is only ensured by using BGA rework machines for repair purposes. These machines support profiles, in which the rise of temperature and time length is predefined so that BGA components cannot be damaged e.g. by the so-called “popcorn-effect”. Furthermore, BGA rework machines always heat the module from above and beneath. This keeps thermal/ mechanical stress as low as possible.
Using this method, it is even possible to solder plastic packed connectors without destroying them!
Suitable machines are e.g. OK-Metcal BGA 3500 or Zevac DRS24:

Handling of BGAs

BGAs are highly integrated circuits that have to be handled in a special way for a successful repair!

BGA components are sensitive to electrostatic discharge. Therefore, ESD protection always has to be ensured when working with these parts. Furthermore, it is not allowed to touch BGAs with bare fingers, as residues at the balls will lead to unreliable solder joints. Therefore, always wear gloves when handling BGA components!
Additionally, these components are moisture-sensitive. Therefore, ordered components always have to arrive in a sealed, metalized vacuum bag with moisture indicator card and dryer inside. Shelf life of components in a sealed bag is one year.
Components outside the bag should be left in tape and reel and stored in ESD suitable boxes until the parts are used. As BGA parts have different moisture sensitivity levels, they should always be stored in a temperature chamber (e.g. Heraeus UT6) at a stand-by temperature of 60°C. These storage conditions make baking the components before soldering them unnecessary.
Floor life (outside of bag) depends on the component's sensitivity that is shown in the following table:

Jedec-level	Description	Floor Life (Out of Bag)
1	Non-Moisture Sensitive	Unlimited at 30°C/85%RH
2	Limited Moisture Sensitive	1 Year at ≤30°C/60%RH
2A	Limited Moisture Sensitive	4 weeks at ≤30°C/60%RH
3	Moisture Sensitive	1 Week at ≤30°C/60%RH
4	Highly Moisture Sensitive	72 Hrs at ≤30°C/60%RH
5	Extremely Moisture Sensitive	48 Hrs at ≤30°C/60%RH
5A	Extremely Moisture Sensitive	24 Hrs at ≤30°C/60%RH
6	Bake Before Use	Time on label (TOL)

In case that floor life has exceeded, it is necessary to bake the parts. Baking conditions depend on the time the part has been unprotected in the environment and on the moisture sensitivity (JEDEC) level:

Unprotected moisture sensitive component, exposure time in environment:	Action required:
JEDEC class 2a, 3, 4: more than 48 h, but less than 168 h	Baking instructions: 12 (+10, -2) h @55 ±5°C, RH ≤5%
More than 168 hours	Baking instructions: 168h@55±5°C, RH ≤5%
JEDEC class 5, 5a or 6: more than 24 h	Baking instructions: 12 (+10, -2) h @55 ±5°C, RH ≤5%
More than 24 hours	Baking instructions: 168h@55±5°C, RH ≤5%

If storage conditions are not fulfilled and/ or baking is not performed the soldering process will not be successful. The component might even crack because of the so-called "popcorn effect".

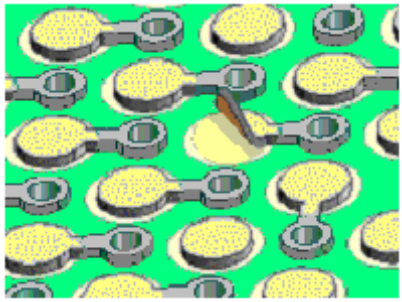
Note that the storage conditions described also apply to several other parts a mobile phone consists of. For detailed information refer to the "Special Component Handling Instructions" of the respective product, which is usually published as a Service Bulletin.

Desoldering BGAs, cleaning pads, adding flux

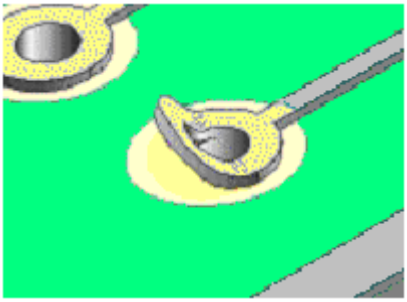
For desoldering BGA components only BGA rework machines are allowed. Reasons for this are, on the one hand, the very sensitive µvia connections, which can easily be damaged by uncontrolled hot air. On the other hand, the pads under a BGA component often consist only of the pad itself and a µvia to the next layer. These pads are easily torn off if no controlled rework process is ensured. The rule states that even if only one pad is torn off (even it is not in use), the PWB has to be scrapped since the mechanical stability of the BGA on the surface of the PWB cannot be ensured!

For cleaning the pads after having removed a BGA component there are two main possibilities:
The first is using solder wick (-> page 9), the second is using a machine for cleaning purposes.
These machines work similarly to a soldering iron, but the tip consists of a vacuum nozzle by which the melted solder can be sucked up. Nevertheless, with both methods it is possible to damage the PWB if the tools are not handled in the right way! You must never apply force to the pads – if you feel you have to, this is a sign of too low temperature or wrong soldering tip and will surely lead to torn-off pads! In this case, increase the temperature of your soldering iron or exchange the tip. This is often necessary, especially if you try to clean the ground areas under a BGA component. When using solder wick, you have found the right temperature/ tip combination if the old solder melts 1-2 seconds after having applied heat via the solder wick. But remember that also too high temperature will result in pads loosening from the PWB. Therefore, keep the cleaning process as short as possible!

Loose pad under BGA after removing solder



Loose throughhole after too much heat supplied by a hot-air fan



For adding flux to a new component to be soldered the best choice are so-called “flux transfer plates”, which are, for example, delivered by Metcal. These plates have an area with predefined depth. The procedure is to add flux to the transfer plate, spread the flux over the plate by means of a squeezer and dip the balls of the new component into the flux. As there are different plates available that match the ball diameter of the component, you always get the right amount of flux onto the new part.

Self-centering of BGAs

For reworking new BGA components the optical adjustment with the vision system of BGA rework machines is recommended. This adjustment can be made by vision systems with stereo microscope (Zevac) or with camera and monitor (OK-Metcal), depending on the machine used.
For adjusting there are printed marks for any kind of BGA on every PWB (as additional help), which are for the different chip sizes and actually intended for production. These marks give also a good clue for positioning the circuit.

After having removed the old BGA, you have to pay attention to the following things in preparation for the new component:

- Remove old solder completely from all pads
- Possible oxidized pads must be cleaned thoroughly
- Joint area has to be cleaned very carefully, e.g. with “Kontakt LR”
- Add flux for BGA soldering, ideally with the help of a flux transfer plate

As the rework machines are very easy to handle, positioning of new components is usually no problem. Furthermore, the profiles that are downloadable from the Partner Website contain additional information regarding the correct handling.
Nevertheless, misadjustment of the vision system of your rework machine will result in displaced components, but note the following:
Depending on the component, the shift can be up to 50% of the diameter of the pad (see picture below)! Up to this percentage, the displacement will be automatically adjusted during the soldering process because of the surface tension of the melted solder tin. Currently, this works with every BGA component except for the Flash circuits that have only four lines of solder balls and four or eight prop balls underneath and do not correct their position by themselves. Therefore these parts have to be positioned exactly!

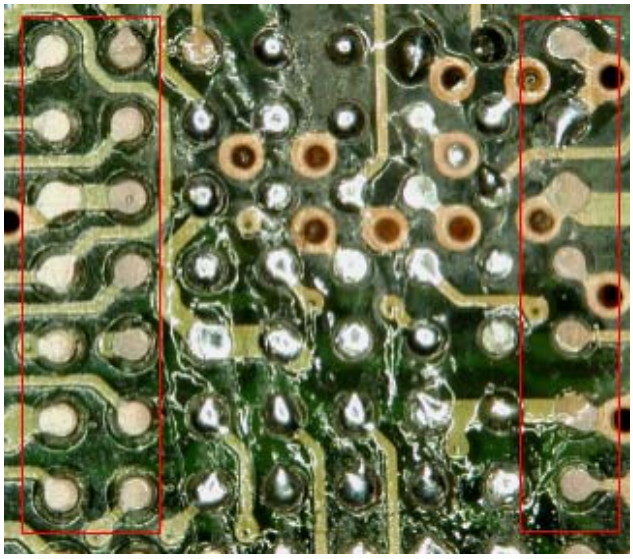
By heating the component, the displaced part positions itself:

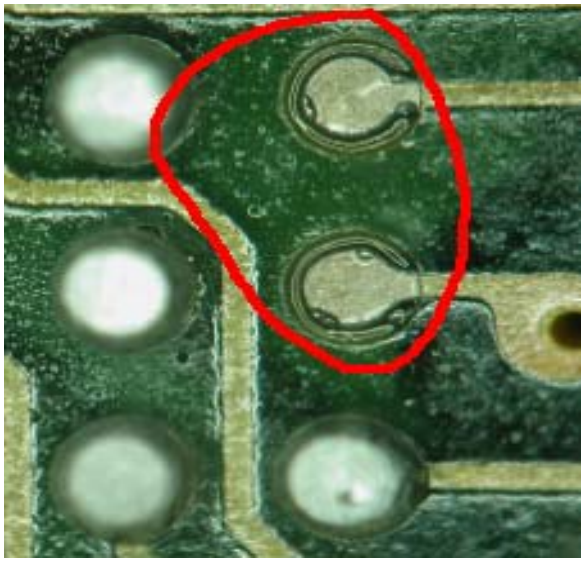
If the component is displaced more than 50% (measured at the pad!), you have to place the BGA correctly once more. As the pads are hardly visible, the displacement can also be checked at the printed edge marks for every BGA on the PWB. In case of doubt, positioning should be done again, as the component is useless after the reflow cycle!

Rework of oxidized (black) pads

This kind of “poor solderings” underneath BGAs is called this way because of their oxidized coating on the surface.
If these pads appear after BGA removal, a possible reason can be former mechanical stress of the PWB due to dropping or twisting the phone.
Although you may not recognize any physical damage after having removed a BGA, cracked µvias caused by physical stress can result in intermittent faults. Therefore, evaluate possible repair actions very carefully!
If you can exclude dropping or twisting by checking the rest of the PWB, you should try to resolder the affected pads. At first, the old solder must be removed with the help of a soldering iron and solder wick. If necessary, a little flux added to the area to be cleaned can support this action. After this, all the black pads should be visible as shown in the pictures below.

Examples of oxidized pads





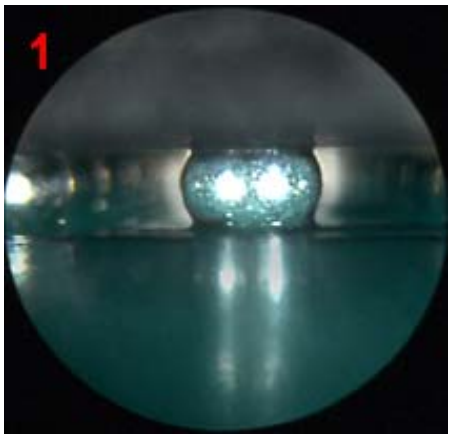
Oxidization is removed best with the help of a hot soldering iron, a little flux on the oxidized pads and a little solder tin. When you try to tin-plate the pads now with solder tin, the activated flux will remove the oxidized coating from the pad’s surface. But do not apply any pressure with the soldering iron onto the PWB during this process! Especially with a hot soldering iron, single pads are easily torn off! If this happens, you have to scrap the whole module.

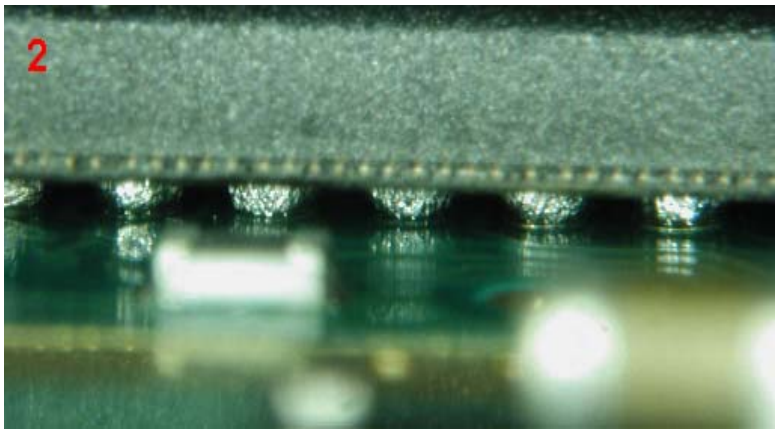
After having tin-plated the pads, the solder tin must be removed once more to check whether all pads are completely cleaned. If some of the pads are still oxidized, you should check how much work it would take to remove the rest or whether rework would be uneconomical. This decision depends on the number of pads difficult to be reworked and how much time it would take. If you decide to rework the pads once more, repeat the procedure described above. In case that all pads are ok after that, you can clean the PWB and resolder the new BGA component.

Solder joints – the way they should look like

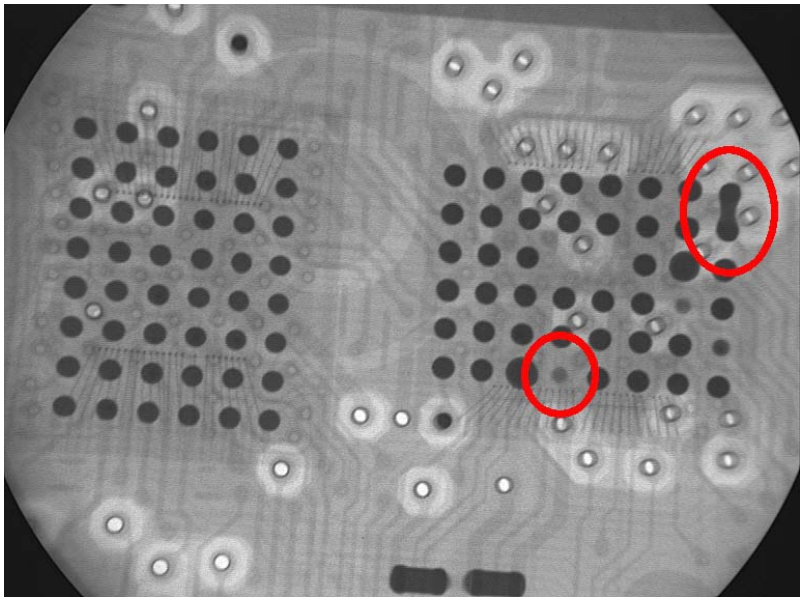
Because of shieldings and other surrounding components, it is usually very difficult to inspect the appearance of a soldered BGA component with a microscope. Nevertheless, in the following you will find some pictures that show the way the balls should look like, and, of course, the way they should not look like. For visual inspection of solder balls are also machines from different manufactors available (e.g. Weller, Metcal).

Solder balls should be round and shiny like the one shown in picture one.
Poor or cold solderings under a BGA component look like shown in picture two: the surface is not shiny but rough or porous. If balls appear like this, probably too little flux was used, or the profile used for rework was too long or too hot. These are no reliable solder joints!





Another helpful tool for checking solder joints under a BGA component are x-ray machines. With the help of these machines deformed balls, torn-off pads and short circuits under a soldered BGA component can be made visible without removing the component:



LGA rework

There are two main possibilities to rework LGA components:

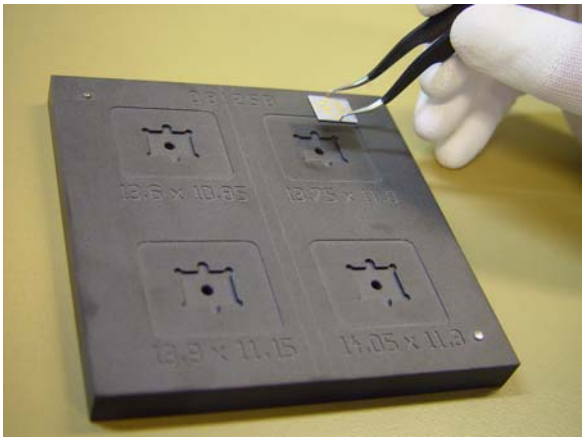
Method 1:

- Remove the old part with BGA rework system.
- Clean the pads with solder wick, remove rests of flux e.g. with alcohol.
- Tinplate the pads regular with fresh solder tin and add an appropriate amount of flux.
- Align the new part with optics to its intended place on PWB and start the reflow process.

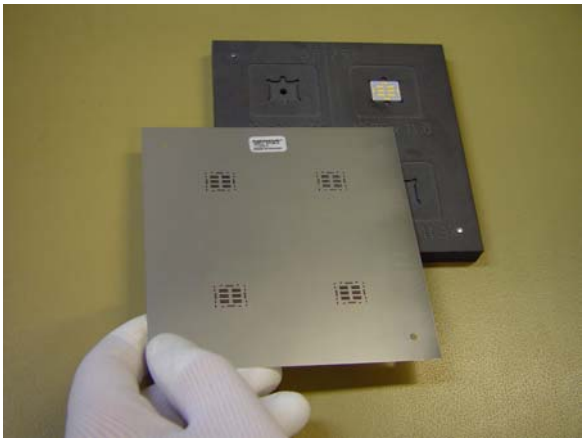
The procedure is more or less the same as it is for small components with more than two connections (as described on page 17). The only difference is that you have to use BGA rework system, as it is not advisable to rework larger LGAs with controlled hot air.

Method 2 (with LGA rework jig):

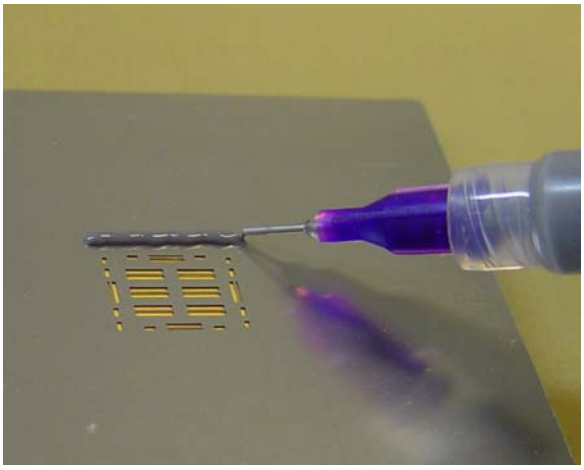
- Remove the old part with BGA rework system.
- Clean the pads with solder wick, remove rests of flux, e.g. with alcohol.
- Put the new part into the LGA-jig. If the jig has more than one hole, check which hole the part fits in the best. The new part may neither slide around inside the hole nor get stick in it.



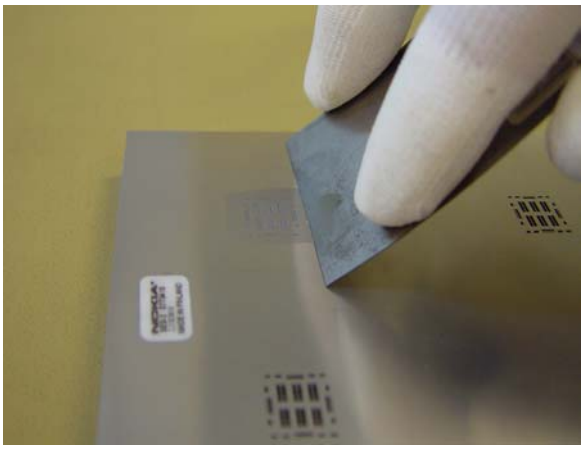
- Put the stencil onto the LGA rework jig.



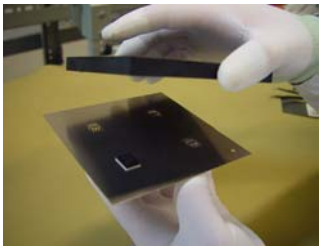
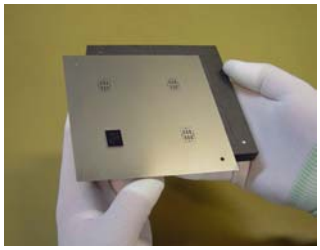
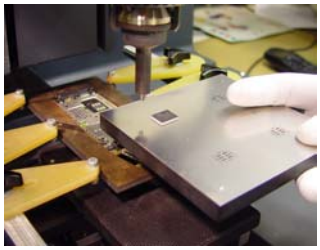
- Add an appropriate amount of solder paste onto the stencil.



- Use the squeegee to spread the paste over the LGA. This should be done holding the squeegee at an angle of 45° to the stencil, and not more than twice as otherwise the amount of paste pressed through the stencil is too high.



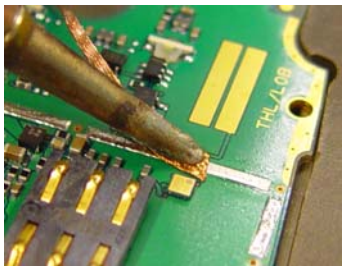
- Take the whole LGA rework kit and turn the upside down, remove the jig and put the stencil (without bending it!) with the component on it the other way round onto the LGA jig. As result you have the new part on the top and can put it to the BGA rework system for reflow.

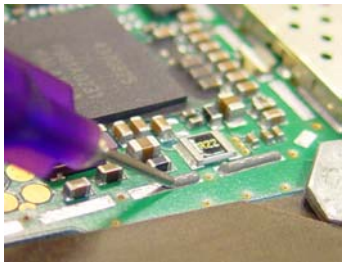
Shielding rework

Whenever it is necessary to rework a shielding including its soldered frame: Never cut off the frame with help of side cutting pliers as pads are easily ripped off and the PWB is damaged irretrievable!
For rework of a soldered shielding frame always use a BGA soldering station and the matching nozzle (which is also mentioned in the profiles comments!).

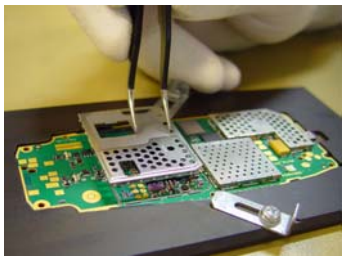
Always use the matching nozzle for the shielding that needs to be reworked. If necessary, do not forget to preheat the nozzle!



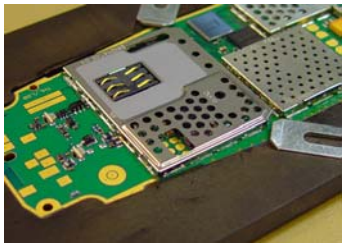
After that the frame has been removed, clean the contacts pads from old solder tin. This works very well with Metcals soldering iron MX 500 and a flat solder tip!
Clean the PWB from rests of flux with e.g. “Kontakt LR”.



Add an appropriate amount of solder paste onto the pads for the new shielding frame. Be careful not to use too much solder paste! If the amount is too high, the shielding will be soldered onto the new frame so that it is not possible to open the shielding! Furthermore take care that you do not produce shorts to other parts near the shielding frame.



As most optics of BGA rework systems are not capable to show the entire shielding, you have to place the new shielding manually onto the PWB with help of tweezers.



After successful reflow with the matching nozzle there is no visible difference to a shielding soldered in production!

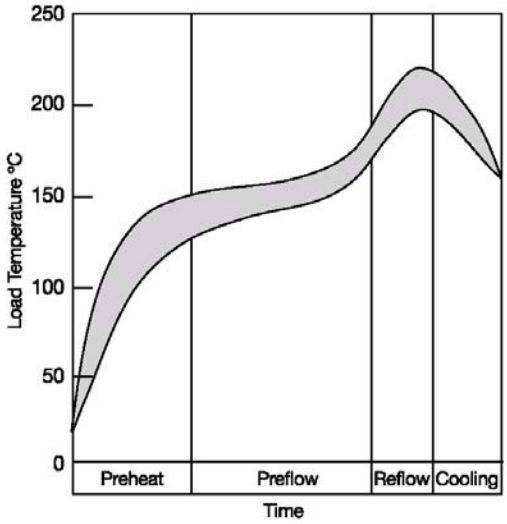
Explanation of soldering profiles for Zevac and OK-Metcal

General profile description

Before using any soldering profile on the Zevac machine, it is necessary to preheat the nozzle to the right working temperature!
Whenever using a rework profile, ensure that the nozzle temperature is at least 150°C. You can check this in the control process window, which displays the temperatures for both nozzle and bottom heater in the right upper corner. If the nozzle temperature is below 150°C, you have to run the preheating profile. If you ignore this, your soldering process will not be successful!
If an interruption between two soldering processes lasts longer than 5 minutes, it also is necessary to reheat the nozzle, as the nozzle temperature will certainly be below 150°C. In case the interruption takes longer than 20 minutes, you even have to restart a new control process window.
The above-mentioned times are valid only for Zevac machines. It is not necessary to preheat the nozzles of the OK-Metcal BGA 3000 / 3500 because the preheating phase is integrated into the soldering profile and the nozzle is built completely differently from nozzles from Zevac.

Every profile is divided into different phases:

The first phase of every profile is the preheating phase. This phase is used for heating up the PWB with care to 150°C, and it lasts 40-60 seconds. Maximum temperature gradient in this phase is 5°C per second.
The second phase is the preflow phase, which is sometimes also called soak phase. In this phase the added flux is activated to remove possible oxidation from the surface to be soldered. The preflow phase takes 40-80 seconds and heats the PWB to maximum 200°C. Temperature gradient in this phase must not exceed 3°C/s.
In the third phase the temperature on the PWB reaches a maximum of 230°C and the solder tin is melting. The time period above 200°C must not exceed 30-45 seconds; the time period with the peak temperature of 230°C is allowed for maximum 10 seconds. Temperature gradient is as in preflow phase 3°C per second.
The last phase is the cooling down phase. The length of this phase depends on the time the previous phases have taken and ensures that solder joints can harden. The maximum temperature gradient in the cooling down phase is –5°C.



Note that the profile described above is valid only for the hot air convection process. It is not applicable for the infrared heating method!

Profile editing

If it is necessary to adjust the profiles to different workplace environments with other conditions, you should only change the times in the two soldering phases in steps of 5 seconds up- or downwards to improve the results.
The temperatures in the single steps should not be varied too much, because these are mostly the highest possible values prescribed for BGAs and PWBs! Nevertheless, if changing the temperatures seems to be necessary, always ensure that the temperature on the PWB's surface does not exceed 260°C!
The nozzle airflow in all profiles is usually adjusted in such a way that good soldering is the result. If increasing the airflow seems to be necessary, check the process very carefully – the part to be soldered or the periphery can easily be blown away if the airflow is too strong!
So be careful with all settings in the profiles and be sure to make the right decision regarding changing any level of an individual profile. If any cycle time or temperature setting is set too high or long, the risk of burning the PWB or destroying the BGA is high.

Reference 1: Soldering profiles made for Zevac DRS 24

Air pressure:	Input 5 bar and internal adjustment of 40 psi
Humidity:	50 %
Temperature:	24° Celsius

Reference 2: Soldering profiles made for OK-Metcal BGA 3000/ 3500

Air pressure:	Input 5 bar
Humidity:	50 %
Temperature:	24° Celsius

Air filter system used on both machines:
PACE Arm Evac 250 Centralfilter System working on power level 1 (of 3)

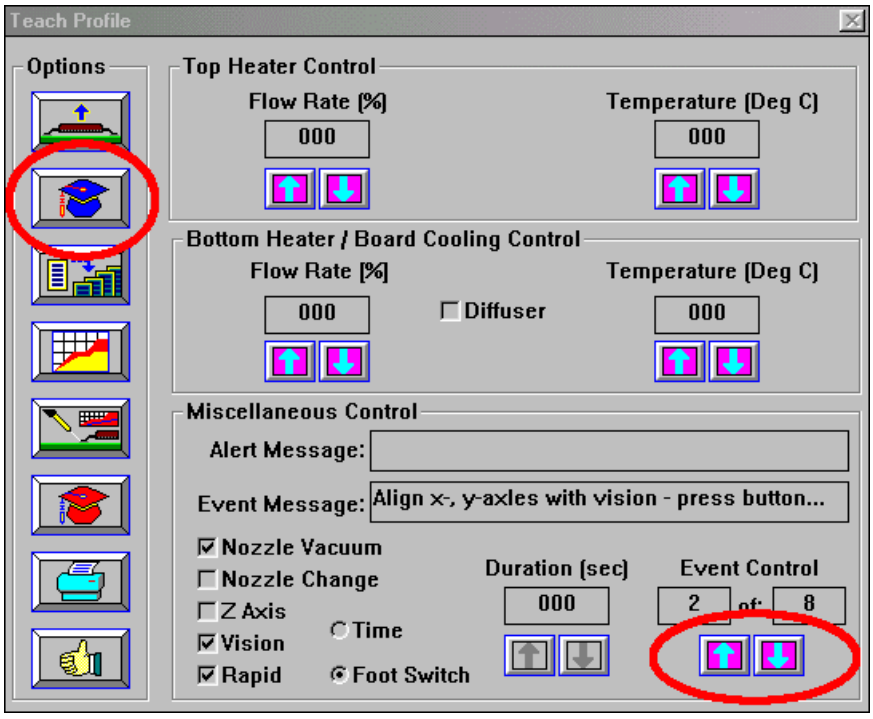
Please note:
The performance of any profile will vary if there are differences in temperature, humidity or air pressure. Using the soldering machine in a windy place or setting the fume extraction too high may even corrupt a profile – we have had cases in which running our Pace filter system on power level 2 resulted in poor solderings of BGAs!
So evaluate possible actions very carefully if a profile does not work well!
Never forget that also regular calibration of the rework machines is necessary to achieve proper solder joints!

Zevac DRS24 profile editing

To edit a profile, it is necessary to open an existing file in the beginning of the process. After that you have to end the profile with the "thumb up" button. Now you can go to "Options" menu and select "Edit".
The first thing you can edit is the information sheet, which contains the type of nozzle and flux to be used and information on the item that shall be soldered with the selected profile. To continue click the "thump up" button. The following window offers some helpful information concerning tools and methods the user should pay attention to. To close this window, click the "thumb up" button again. Now you will get the settings window.

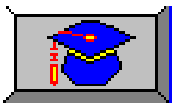
Settings window

In the settings window you have the important settings of all steps the profile consists of. Here it is also possible to edit the different steps. On the left of the window, you find the control buttons you can use. These are described on the following page.
In the upper part of the window you can set the temperatures and airflow for both nozzle and bottom heater. The nozzle airflow must be set to a minimum value of 15%; otherwise the temperature you have set will be deleted.
In the lower part of the window you can decide in which way the machine shall be used, e.g. based on time limits or temperature limits. Furthermore, the nozzle position, usage of vision, vacuum or thermo elements can be set. Step information or alerts can be given here, also.

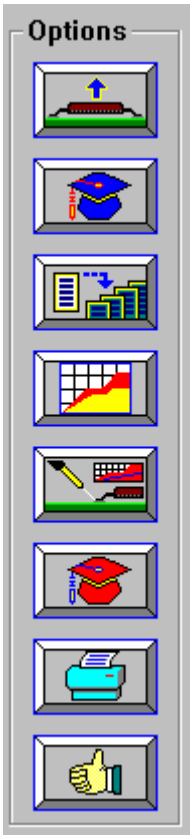


Important:

Whenever you have made changes in a profiles step, it is absolutely necessary to click the "Blue Hat" button on the left in the settings window before proceeding to the next step, otherwise all new settings will be lost!



Control buttons of the settings window



In- or out-profile (info button only)

Confirmation of every change or new entry

Step insert

Shows graph with all temperatures, measurements and timescales

Thermo element settings

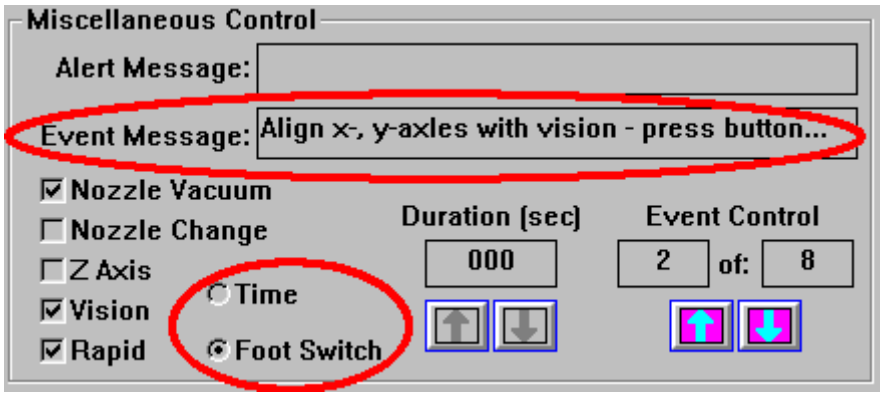
Delete step

Print complete Profile Settings for archives

End button / leave window

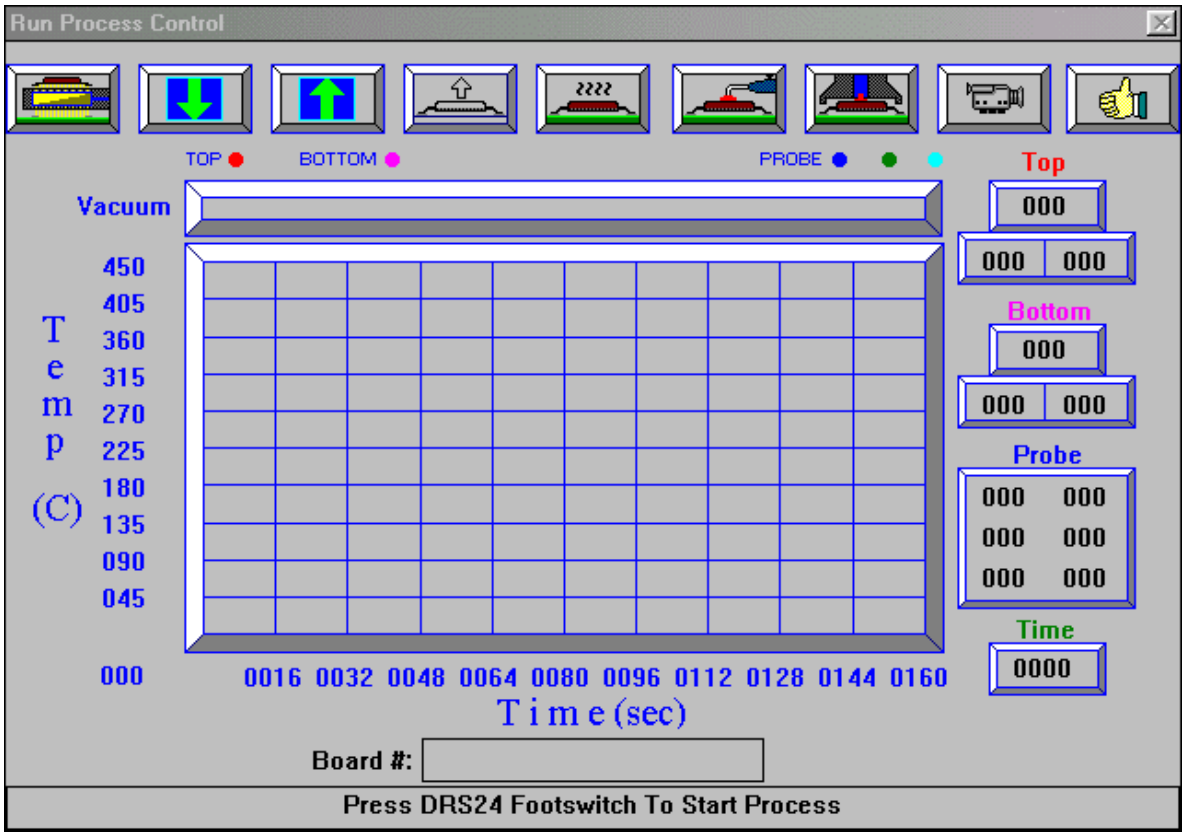
Steps and messages

In this part of the settings window you have the possibility to add remarks, e.g. what exactly has to be done before continuing with the next step. Furthermore, you can predefine, by clicking “Time” or “Foot Switch”, whether the next step shall begin automatically after a predefined period of time or only by pressing the footswitch. This makes sense, as different users will need different periods of time to e.g. align the BGA with the vision system, whereas switching between the different soldering phases has to be done automatically.



Control process window

In the control process window you will get all information about a running process. You also have the possibility to use the action buttons in the top of the window in case there is a problem during the process. Functions of the action buttons you can find below.
Furthermore, you can find information about temperature and airflow on the right: the upper three squares (marked red, “Top”) tell about the nozzle airflow (top square); the two squares below are target temperature (right square) and current temperature (left square). The same applies to the three squares that are marked magenta (“Bottom”): the top square is the airflow of the bottom heater; the two squares below are again target and current temperature.
In the chart itself, you can see the temperatures for both nozzle and bottom heater displayed as line graphs.



Vision Nozzledirection Hotplate Itemsuck (optional) Vacuum End

Additional information for Zevac DRS 24L

Regarding the wrong statement that the profiles for the full and light version of the DRS 24 are said to be fully compatible: it is absolutely necessary to make some modifications! All profiles are based on the DRS 24 full version, but there are changes in both airflow and profile length. The main reason for this is a completely different airflow system used in the light version. For this new airflow system a minimum flow value of 35% for the nozzle and the preheater must be set, otherwise there will be no airflow!
The value itself is irrelevant; it just has to be over 35%. The airflow itself is adjusted manually at the control panel on the left of the soldering machine.
For the bottom heater flow there is an instrument on the left of the front side integrated into the machine. This one permanently measures the airflow, based on a **linear** scale – usually, it must be set to approximately 30% (depending on the conditions, where the machine is placed) The flow meter with a **logarithmic** scale, which is mounted on the left side of the machine, is used to permanently check the airflow through the nozzle. Which flowmeter value corresponds to which airflow in percent, you can check in the table below:

Flowmeter value	Airflow in percent
2,1-2,2	80%
1,4-1,5	50%
1,3-1,4	40%
1,1-1,2	35%
1,0-1,1	30%

These values are based on a calculation by ZEVAC!

Regarding the first installation and / or maintenance intervals: The settings made for main adjustment should be tested by running any profile and checking if the values (nozzle and preheater temperatures) correspond to base settings – if not, you have to adjust them to the temperatures needed in the profiles.
For example:
The peak temperature at the nozzle outlet is not 250° Celsius ± 2% -> adjust temperature again, otherwise all profiles will not work properly!

Note: The profiles' reliability may vary if temperature, humidity and air pressure differ from the values mentioned below. If the profiles do not work well, check the environment of the machine. It has been observed that even a windy place or filter systems working too powerfully may lead to poor soldering results!

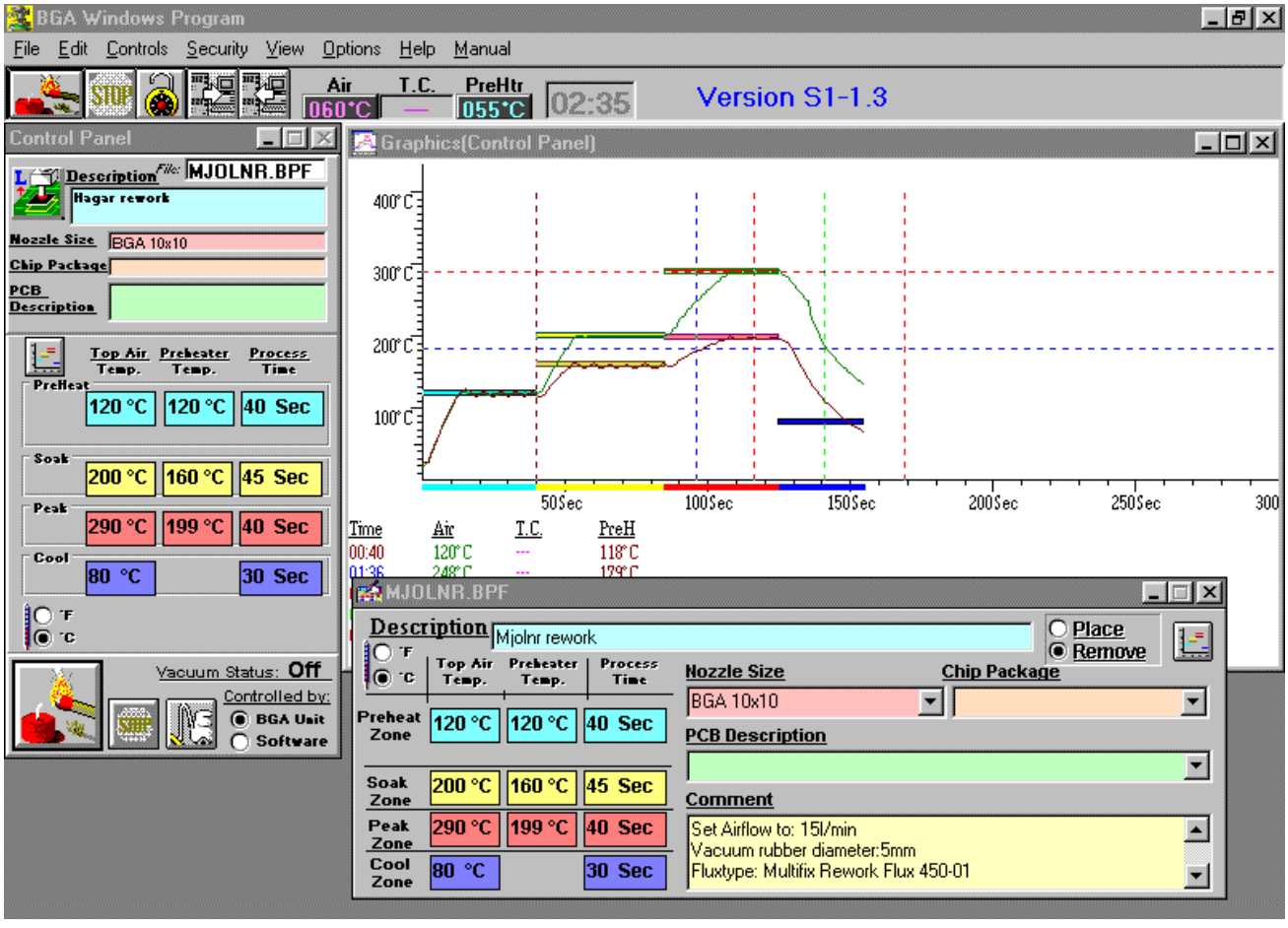
All profiles were made under the following conditions:

Air pressure input: 5 bar/ internal adjustment to 40 psi
Humidity: 50%
Temperature: 24° Celsius
Air filter system: PACE Arm Evac 250 (running on power level 1)

OK/ Metcal BGA 3000/ 3500 profiles and editing

Note: Although all profiles have been tested in the version currently available on the PWS, changes of the profiles may become necessary for other machines of the same type as it is not possible to calibrate neither airflow nor heater temperatures!

To use a profile you have to open it from the library running the BGA windows program. After having loaded the profile, you will get a window named as the chosen profile (in the picture below it is BFPSCC.BPF). This window contains all parameters of the profile and some additional information, such as nozzle used and airflow. To use the profile you have to move it per drag and drop into the control panel. This copies all parameters into the control panel window, and you can start the profile by clicking the ignition button (on the left at the bottom of the control panel window). Here you can edit time and temperature parameters, if necessary. With the stop button you can interrupt a running profile, while the hoover button is used to switch the vacuum on or off. On the right at the bottom of the control panel window you can choose whether process controlling shall be done by the software or by the BGA control unit. For running any profile, click the software button, but note that although you choose this, you have to adjust the airflow manually at the BGA control unit!
In the graphics window you will get an overview of the whole process in form of line graphs. Here it is also possible to change parameters of the profile. This can be done by clicking and holding the colored crossbars and then moving the mouse to decrease or increase the temperature or length of it. But always keep in mind the maximum temperatures and gradients, which are also described on page 23!



Abbreviations

BGA	ball grid array
EPA	ESD protected area
ESD	electro static discharge
IPA	isopropyl alcohol
LGA	land grid array
NMP	Nokia Mobile Phones
PWB	printed wiring board
PWS	Partner Web Site
RMA	rosin mildly activated
SMD	surface mounted device
SMT	surface-mount technology
SSOP	shrink small outline package
TQFP	thin quad flat package
TSOP	thin small outline package

Change History

Originator	Status	Version	Date	Comment
TS Training Group	Draft	0.1	18-02-2003	First Draft version
TS Training Group	Approved	1.0	29-04-2003	First approved release
TS Training Group	Approved	2.0	21-08-2003	Lead-free information, LGA & Shielding rework information added