APPLICATION NOTE AN-13

SOLDERING TO TRANSDUCERS

knowles

The purpose of this Application Note is to aid the user of Knowles transducers to:

- Provide good electrical connections to the transducer
- Avoid undesired connections such as shorts
- Avoid heat damage to the transducer
- Avoid connection failures caused by solder joint deterioration during use
- Avoid electrical noise which may be caused by flux residue

OVERVIEW

The factors for safely soldering with lead-free solder, in order of importance, are:

Heat sink: Transducers, particularly microphones, can be measurably damaged by a soldering iron in less than a second without a proper heat sink. It should be made of high heat conductivity, high heat capacity metal and make intimate contact with a large area of the metal of the transducer housing. Knowles recommends the ET series heat sink when available.

Dwell time: The soldering iron should not remain in continuous contact with the transducer terminal for longer than 3 seconds. Knowles recommends 1 second maximum as normal practice.

Temperature: It should not exceed 400°C (750°F) for passive components or 370°C (700°F) for components with integrated circuits (microphones). Temperatures below 340°C (640°F) are not recommended for most processes.

Wire gage: Suggest 30 AWG stranded hook-up wire or thinner.

Lower soldering temperature does not always mean that the transducer is heated less. A low soldering temperature may result in a longer dwell time to melt the solder and a hotter transducer. It is important that any process developed for soldering should be tested and verified that it causes no change in distortion or sensitivity to the transducer, and results in adequate pull strength and low resistance at the join.

Table 1: Filter characteristics with $a = 1\text{-}2^{-11} = 0.99951171875$

Item	Requirements	Comments
Solder	SAC305 alloy or equivalent	Non-SAC alloys are not recommended
Flux	No-clean, non RMA grade flux	Avoid excess
Cored wire	Diameter 0.5 mm (.020) or smaller	Flux volume in cored wire should be 1-2.2% by weight
Heat Sink	Large thermal mass, good thermal contact to trusducer	Highly recommended
Dwell Time	1 s	Duration of continuous contact of soldering iron with pad
Cooling Time	10 s	Interval between soldering operations on a single transducer
Soldering Temperature	340-370°C (640-700°F)	Active components (microphones, amplified receivers)
	340-400°C (640-750°F)	Passive components (non-amplified receivers)
Soldering Iron	Temperature regulated pencil, 25 W minimum	
Soldering Iron Tip	0.2 mm (0.008 in) to 0.8 mm (0.032 in)	Tip style is user preference
Tip Cleaner	Lead-free, no residue	Use as necesary to keep tip tinned
External wires	Pre-tinned	

KNOWLES TRANSDUCER TERMINALS

The terminals on Knowles transducers have two different forms. On all receivers and some microphone families, the terminals a re contained on a terminal strip at one end of the transducer case, as shown in Figure 1.

Figure 1: Solder pads are located on a terminal strip on back receiver

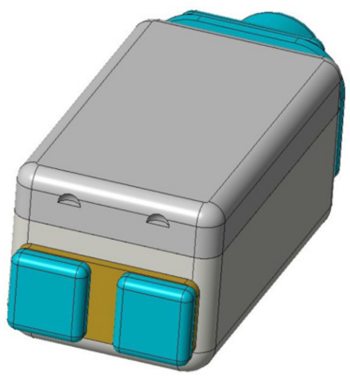
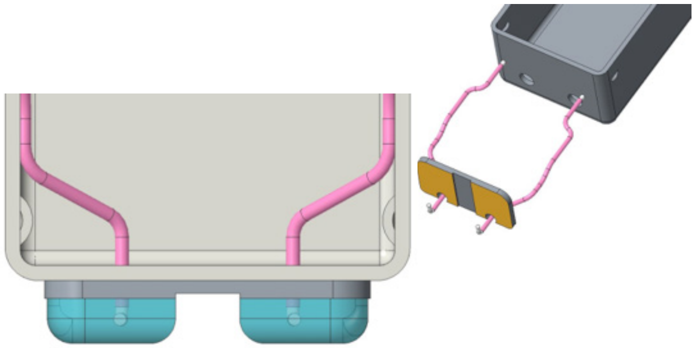


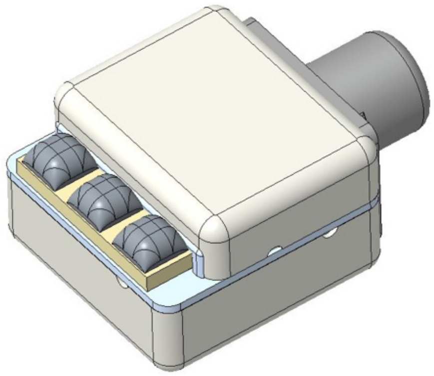
Figure 2 shows the construction of the terminal strip. The electrical connections are by small wires that pass through the transducer case, and through small holes in the terminal areas of the terminal strip. The wires are bent against the terminal strip and attached to it with solder.

Figure 2: Terminal strip provides a connection point for internal and external electrical wires



For some microphone families, the internal circuit hybrid extends to the outside of the case as shown in Figure 3. The terminals are located on this section of the hybrid board and are typically "tinned" with SAC305 lead-free solder.

Figure 3: Terminals on internal circuit



SOLDER

The solder alloy used by Knowles is known internationally as SAC305, with a content of 96.5% tin, 3.0% silver, and 0.5% copper. It is RoHS compliant. SAC305 solder melts at 217°C (428°F). It is not a eutectic alloy, so it has a wider "pasty range" where it is partially molten, and has slightly poorer flow and wetting properties. Because of this, recommended iron temperatures are 340–400°C (640–750°F.)

FLUX

Flux should be a no-clean, non-RMA formulation compatible with lead-free solder. No-clean fluxes are non-conductive and noncorrosive, and normally do not require removal of flux residue after soldering. Compared to RMA rosin flux typically used with lead solder, no-clean is slightly less chemically active, very fluid when molten, and evaporates more rapidly.

When liquid flux is used, avoid excess application as it may migrate to the inside of the transducer and result in damage or leave a sticky film. Dipping the tinned wire in the liquid flux before soldering is normally sufficient.

Knowles uses Kester 0.5 mm (0.020 in) Sn96.5Ag3Cu.5 cored wire solder with 58 core size and 275 no-clean flux (2.2% flux by weight), with very satisfactory results. Comparable products are available from other manufacturers.

SOLDERING EQUIPMENT

The following basic items are common to all wire soldering operations:

- Heat sink with transducer positioning features
- ESD-safe, temperature-regulated soldering station
- ESD-safe shop furniture and other equipment
- Flux-cored SAC305 wire soldering
- No-clean, non-RMA liquid flux
- Tip cleaner
- Tweezers or other tools for positioning wires during soldering
- Bright workspace lighting
- Vision magnification such as a stereo microscope

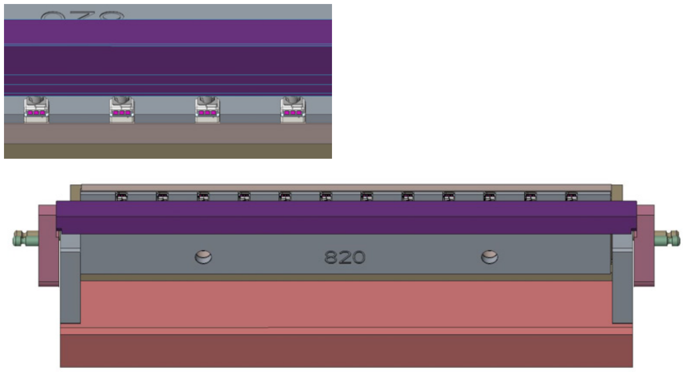
HEAT SINK

The single most important factor for soldering without damage to transducers is the heat sink. A heat sink dramatically increases the amount of time the soldering iron can contact the soldering pad from less than one second without a heat sink to about three seconds. Heat sinks should be considered a critical part of any soldering process.

A heat sink is a large mass of metal which conducts heat away from the transducer with only a minor temperature increase because of its high heat capacity. A well designed heat sink is made from a large block of metal with notches that contacting each transducer on most its surface area yet exposing the solder pads. The contact surfaces must be kept clean of flux residue or other contaminants that would interfere with intimate metal-to-metal contact with the transducer.

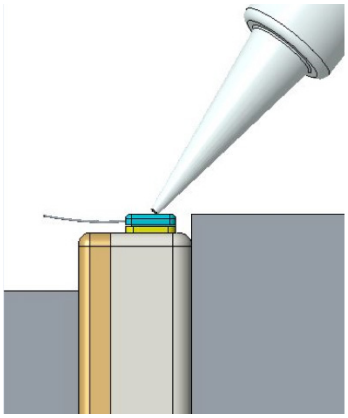
A heat sink may have additional features to simplify the soldering process, such as the Knowles ET heat sink shown in Figure 4. This heat sink holds several transducers at once in fixed and oriented positions. It has a spring-loaded top plate for easy loading and loading.

Figure 4: The heat sink protects 12 transducers and holds them for convenient soldering



The top plate is removable for easy access for cleaning and the spring applies a firm but gentle pressure that assures good contact without crushing the transducer. To help prevent accidental contact between the soldering iron and the receiver case, the heat sink is taller than the transducer terminal board on one side (see Figure 5.) The ET heat sink for most transducers is available directly from Knowles. See TB8 for list a series with soldering fixtures available. Please contact Knowles Customer Service for ordering information.

Figure 5: The solder fixture protects against accidental contact between the solder iron and the transfer case



SOLDERING STATION

The soldering station should be an ESD-rated model that is designed for intricate electronic hand work. It should have at least a 25 Watt pencil iron with a regulated temperature controller. Higher power heaters produce quicker temperature recovery and can improve soldering performance. A regulated iron will apply more heating power to maintain soldering temperature when in use, and otherwise idle at its set temperature.

Unregulated irons idle at very high temperatures but cool excessively when in use. This will initially overheat the terminal but then require extended contact time. The high idle temperature also shortens tip life. Unregulated irons should not be used to solder Knowles products, as their use can result in damaged transducers and inferior solder joint quality.

Tip design greatly affects the amount of heat delivered to the solder. A well tinned, correctly sized and shaped tip will fully melt a tinned solder pad within one second of contact. The size of the soldering iron tip should be in the range of 0.2–0.5 mm (0.008–0.020 in) depending on the size of the transducer terminal pads. In general, the tip diameter should be no greater than half the dimension of the pad.

If it is too large, it will be difficult to position the tip without bridging to adjacent pads or the transducer case. If the tip is too small, it may transfer heat too slowly to melt the solder, and result in overheating of the transducer. The choice of a conical, chiseled or flat tip is left to the preference of the user. Sometimes, a slight bend in the tip may facilitate soldering.

The tip must be maintained in a very clean and brightly tinned condition to produce maximum heat transfer from the iron to the working area. A dirty, oxidized tip will increase soldering time and the potential for heat-related damage. The activity of lead-free solder and non-RMA flux may not be enough by themselves to keep the tip clean and tinned, so a lead-free tip cleaner such as Plato TT-95 should be used when necessary.

ESD PROTECTION

All transducers that contain integrated circuits, which include all microphones, amplified receivers, and active telecoils, are sensitive to electrostatic shock and should be handled accordingly. ESD-safe soldering irons should be used exclusively during soldering. ESD-safe lab benches or surface coverings should be used and grounded wrist straps worn at all times while handling these products.

SOLDERING PROCESS

The process steps required to obtain a reliable electrical connection are:

1. Place transducer in holding fixture, terminal up.
2. Dip pre-tinned wire in liquid rosin flux.
3. Lay tinned tip of wire on terminal pad (Figure 6).
4. Clean soldering iron tip on wet cellulose sponge.
5. If desired, apply small amount of fresh solder to soldering iron tip. Excess solder is undesirable since it will splash and bridge terminal pads to each other, or to the case. Actually, use of a properly tinned iron will preclude the need for additional solder.
6. Apply flat tinned surface of soldering iron tip to the wire (Figure 7).

Figure 6: Wire is held in place with tweeters

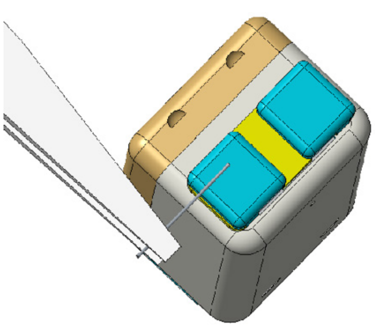
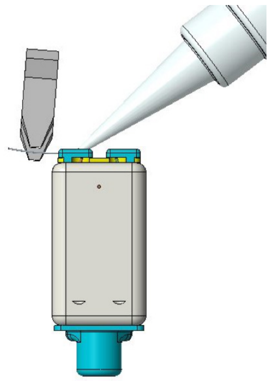


Figure 7: Flat side of tip contacts wire



7. Keep soldering iron tip in contact with wire and terminal until solder on wire and solder on terminal pad liquefy and flow into each other. Remove soldering iron tip immediately and hold wire in place with tweezers until solder solidifies. Total time soldering iron tip is in contact with the wire and terminal should not exceed 3 seconds if tip temperature is correct and wire pre-tinning is adequate.
8. Inspect junction to see that:
   a) Solder has flowed smoothly over wire and terminal pad, completely covering the pad area to reseal the hole in the terminal pad.
   b) Solder has not bridged between adjacent terminal pads or between the terminal pad and the case.
   c) Flexible wires and/or strain relief material and careful routing of wires are needed to avoid strain damage to electrical terminals.

AVOID

- Prolonged contact between the soldering iron tip and terminal pad.
- Any contact between the soldering iron tip and case.
- Wiping the soldering iron tip over the terminal pad. (This can damage the internal wire of the transducer which extends through the terminal pad and is folded flat against the pad.
- Excess solder on the soldering iron tip. (Only a thin, clean solder surface is necessary to provide good heat transfer.)
- Dropping any hot solder on the case or cover of any transducer. This can transfer sufficient heat through the case to burn holes in the diaphragm.
- Excess flux usage, which will leave a gummy, dirt-collecting surface or fillet around the solder joint.

Soldering is not difficult. However, a soldering process for high-volume production that reliably delivers a solid mechanical and electrical junction without overheating the components relies on several factors that are unique to the particular application, so there is no universal, rigidly defined soldering process or temperature that can cover all situations. Any high-volume soldering process should be developed by process engineers familiar with the individual application and tested and verified that it causes no change in distortion or sensitivity to the transducer, and results in adequate pull strength and low resistance at the join.

The process factors that Knowles has learned through experience and verified through laboratory experimentation to be critical to soldering without overheating transducers are the dwell time, the cooling time, and the soldering temperature.

TIMING

Dwell time is the duration of continuous contact between the soldering iron and the solder pad. Testing has demonstrated that, with a good heat sink, Knowles transducers can withstand 3 seconds of dwell time with a 400ºC iron without damage. However, for regular practice Knowles recommends 1 second of dwell time, which is adequate time for a skilled operator with good fixtures to perform a quality solder operation.

Cooling time is the time the transducer has to cool between soldering operations. Performing multiple solder operations on a single transducer in rapid succession can cause as much overheating as a single extended dwell time. Knowles recommends there be at least a 10 second cooling period between soldering operations.

Best practice to ensure adequate cooling time after each solder operation is to arrange multiple transducers, at least 10, on the heat sink. Perform one soldering operation on the first transducer, then one on the second, and so on down the line. By the time the operator has returned to the start to perform the second solder operation, the first transducer has had time to cool iron or dropping hot solder directly onto the case of the transducer.

SOLDERING TEMPERATURE

The measured temperature of a soldering iron tip is typically 10–20°C cooler than the controller setting (the soldering temperatures reported in this document are the controller settings on a Weller WSD 81).

Testing at Knowles demonstrated that with good heat sinks and the recommended dwell and cooling times, transducers with no integrated circuits (all unamplified receivers) are not damaged by solder temperatures up to 400°C (750°F). Transducers with integrated circuits (all microphones and amplified receivers) are good up to 370°C (700°F). Above these temperatures some overheating is possible.

Knowles found that below 340°C (640°F) the lead-free solder is more viscous in its liquid state and did not wet the wire as well as with higher temperatures. This could result in lower mechanical bond strength in some percentage of solder operations, so Knowles does not generally recommend using temperatures any lower. However, temperatures as low as 290°C have been used successfully.

Lower soldering temperature does not always mean that the transducer is heated less. A low soldering temperature may result in a longer dwell time to melt the solder and a hotter transducer.

WIRE PREPARATION

The end of the wire that is attached to the transducer should be pre-tinned with SAC305 solder. The length of the tinned region should be approximately 0.8 mm (1/32 in) for the larger receivers (CI, EF, and similar), and an appropriately shorter length for the smaller terminals on other transducers. Tinning can be performed using the soldering iron or a solder pot with SAC305 solder.

Some wires will require mechanical or chemical stripping prior to tinning, but in all cases excess insulation and chemical strippers must be cleaned from the wire prior to use. Even if the wire has insulation, this must be removed and the wire pre-tinned. The heat required to melt away the solder-able insulation could cause damage to the transducer.The pre-tinned end of the wire should be dipped in a no-clean, non-RMA flux immediately before soldering.

OTHER TIPS

Keep the soldering iron clean and lightly tinned. Avoid wiping the soldering iron over the solder pad as this could damage the connection wire underlying the solder. Avoid touching the soldering iron or dropping hot solder directly onto the case of the transducer.

REMOVAL OF WIRES

If wires must be removed from a transducer, the same precautions and principles listed for soldering apply. If possible, cut wires at or near the terminals in preference to unsoldering. Extreme care should be taken to prevent damage to the transducer wires. Broken wires, internally shorted wires, and wires inadvertently pushed back into the case can result from poor cleanup techniques. Avoid mechanical forces which might pry the terminal board off the case.

In cleaning up, move soldering tip from center of terminal outward, but avoid grounding terminal to case. Use of heat sink fixtures is especially important to control heat during wire removal operations.

ALTERNATE METHODS OF WIRE ATTACHMENT

Other equipment is currently available to provide wire-to-transducer connections, but has not been discussed. Pulsed power soldering irons, solder reflow equipment, energy discharge welding techniques and conductive adhesives are just a few of the methods which might be made to work successfully. However, each of these techniques has limitations and disadvantages which must be investigated thoroughly by the user to determine its effect on the transducer and the function and life of the finished product.

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