Knowles®

TB4

TECHNICAL BULLETIN

SOLDERING TRANSDUCER LEADS

THE SOLDERING PROCESS

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

Provide good electrical connections to the transducer.
Avoid undesired connections (shorts).
Avoid damage to the internal lead.
Avoid heat damage to the transducer.
Avoid connection failures caused by solder joint deterioration during use.
Avoid electrical noise which may be caused by residue from activated flux.
Accomplish the above at lowest possible cost in labour and materials.

The recommendations, details, and comments included have been selected as practical techniques based on experience and research but, of necessity, are limited in scope to the simplest of connecting methods. You are encouraged to delve further into the science of soldering, as your needs demand, keeping in mind the limitations included in this bulletin.

KNOWLES TRANSDUCER TERMINALS

The terminal pads (Figure 1) on most Knowles transducers use a copper and epoxy-glass laminate (similar to materials used for ultra-thin "printed circuits"). This material was chosen for its strength and resistance to mechanical and thermal damage. The terminal is specially designed to permit sealing to the case of the transducer, and the copper-to-insulation bond is of high quality to prevent de-lamination during soldering. The small holes through which the leads protrude are effectively sealed by solder after the leads have been formed flat against the terminal pad. The solder used is the very common 63/37 or 60/40 tin-lead alloy, which becomes liquid at 183-188°C. (361-370°F). Sufficient solder is used to make a high quality connection between the coil leads and the terminal pads, seal the small holes in pads, and to provide a "well tinned" surface for use by your production people in attaching external lead wires.

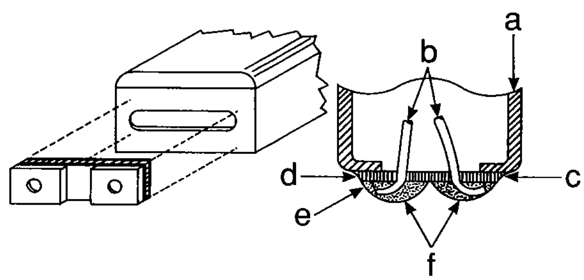

Figure 1

a. Transducer case
b. Leads
c. Adhesive fillet to seal terminal to case
d. Epoxy glass insulation base
e. Copper pad laminate
f. Solder junctions

EXTERNAL LEADS

The type of external leads selected is dependent upon many considerations of design of the final product. While reliable electrical connection is most important, lead flexibility, insulation compatibility, noise problems (electrical and mechanical), and size/form factor can be just as important to the success of the final design. In most cases, however, the lead end to be attached to the transducer should be pre-tinned with a good grade of 60/40 or 63/37 tin-lead solder for approximately 0.80mm (1/32") from the end of the lead. Because of their smaller terminals the EG and EM microphones and the EP receiver will permit a shorter pre-tinned length on the lead. Some leads will require mechanical or chemical stripping of the insulation prior to tinning, but in all cases

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excess insulation and all chemical strippers must be cleaned from the lead prior ot its use. Lead wire tinning can be done by solder pot techniques or by hand iron, or other techniques which may be desirable. Even if "solderable" insulations are used on leads, the leads **must be pre-tinned.** The solderable insulations usually require temperatures in excess of 316°C (600°F) to sucessfully remove the insulation-temperatures which can damage transducers and terminals. The soldering process itself merely requires the solder covered lead wire and solder covered terminal to reach the melting point (liquidus) of the solder - usually 183-188°C (361-370°F). Actual solder temperatures should be 56-83°C (100-150°F) above the liquidus to insure good wetting and flow. A rosin flux is recommended (see appendix A). If "activated" flux is necessary (because of the nature of the lead or insulation), the lead should be thoroughly cleaned after tinning, prior to use. The vendor of the flux should be consulted for recommended cleaning methods.

SOLDERING EQUIPMENT: THE SOLDERING IRON

The choice of soldering equipment can be as complicated as the balance of the product design, but the following basic items are common to all lead wire soldering operations:

1. Soldering iron and tip (and holder)
2. Soldering iron tip cleaner
3. Solder
4. Flux
5. Fixture for holding the transducer in position
6. Tool for holding the lead in position.

The soldering iron should be low power, about 25 watts, with a **controlled temperature** of 290 - 345°C (550-650°F) at all times - even when first contacting the "cold" lead and terminal. Use of higher temperature irons - which cool to less than 290°C (550°F) when in use - is **not** recommended, since the iron will tend to overheat the terminal initially and, if heat capacity is too low, will cool too rapidly to produce a good joint. In addition, the tip will oxidize more rapidly at the higher temperature when the iron is at rest on the bench, shortening the working life of the tip and iron.

"Iron clad" tips work well at these temperatures and do not deteriorate as rapidly as all-copper tips. The heat conductivity of the iron-clad tip is lower than copper, but **proper tinning** of the tip and use of tip cleaner (wet cellulose sponge is recommended) provide a good heat transfer surface. Clad tips should never be filed or abraded.

The tip should be well seated into the heating element, to permit effective and rapid heat transfer. Tip size and shape may vary, but the dimensions shown in Figure 2 have proved to be usable for most applications.

Because the heat absorption and storage mass behind the terminal board is smaller in EA (and smaller) microphones and ED (and smaller) receivers, we recommend the use of a smaller tip. Fig. 3 shows a commercially available tip which is suitable for use with these transducers. Sometimes, a slight bend in the tip may facilitate soldering.

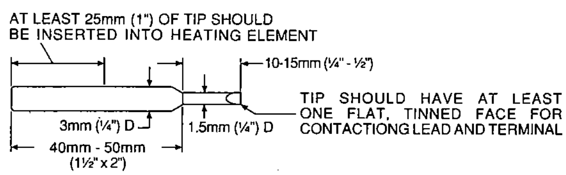
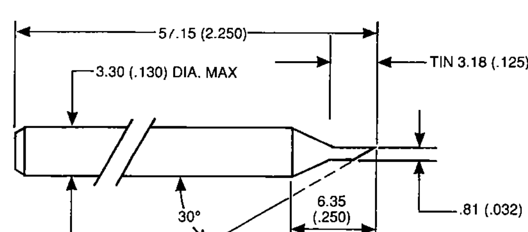


Figure 2

When selecting a soldering iron, a method of controlling voltage to the iron is important. Thermocouple measurements of temperature are most accurate, but use of temperature sensitive papers and wax "Crayons" provide a usable, economical technique, with accuracy better than 2% (see Appendix B). Variability of temperature can be caused by the iron itself, poor fit of tip to heating element and, of course variable input voltage to the iron.



DIMENSIONS IN MM (INCHES)

Figure 3

The use of ungrounded irons and test equipment can present a problem, especially with microphones with built in amplifiers such as the BL, BT, BW, CA, EA, EB, EG, EK, EL and EM, and receivers such as the EP. The insulation between heating element and iron tip can break down, allowing unusual voltages to be applied to the transducer, resulting in damage.

SOLDER AND FLUX

For most applications, the readily available 60/40 tin-lead solder is used. It has a liquidus temperature of 188°C (370°F) (temperature above which the solder is completely liquid). If flux cored solder is used, we recommend that the flux be pure "water white" rosin (see Appendix A). "Activated" fluxes, if used, require post-soldering cleaning for real certainty of corrosion prevention. Most soldering of pre-tinned leads to Knowles terminals (which are pre-tinned by design) requires a minimal amount of pure rosin in alcohol flux to aid in removing the surface oxides which can form on the lead and terminal during storage.

For lead to terminal soldering, wire strand solder, in diameters from .635-1.0mm (.025"-.04") is convenient to use. If flux core is used, the flux should normally be limited to 1.0% to 2.5% by weight, to avoid excess flux residue. Solder vendors should be consulted for their individual specifications.

If post-soldering cleaning is done to remove flux residue, care must be taken to avoid washing any material into the transducer. The introduction of solvents and/or flux residue can permanently damage the transducer, and will void the Knowles Standard Warranty.

FIXTURES AND TOOLS

The fixture for holding the transducer has three basic functions:

1. To orientate the transducer and prevent its movement during soldering.
2. To serve to rapidly carry away heat from the case of the transducer (but work speed rather than this "heat sink" should be relied upon to prevent heat damage).
3. To protect the operator's fingers from the soldering iron tip temperaures.

A simple version of such a fixture is shown in Figure 4. The fixture can have many variations, metal (with high heat conductivity) and a **light** holding force to keep the transducers from moving apply in all designs. In addition, the heat transfer surfaces must be accessible for cleaning. ET-series soldering fixtures for most transducers are available directly form Knowles. Please refer to our data sheet "ET Series Soldering Fixtures" for ordering information.

Care must be taken to avoid touching the case of the transducer with the soldering iron, iron tip, and hot solder. Touching the case of the transducer puts heat into an area which may damage it, resulting in changes to the performance of the transducer. This is particularly important for the smaller transducers, such as EA and smaller microphones and ED and smaller receivers.

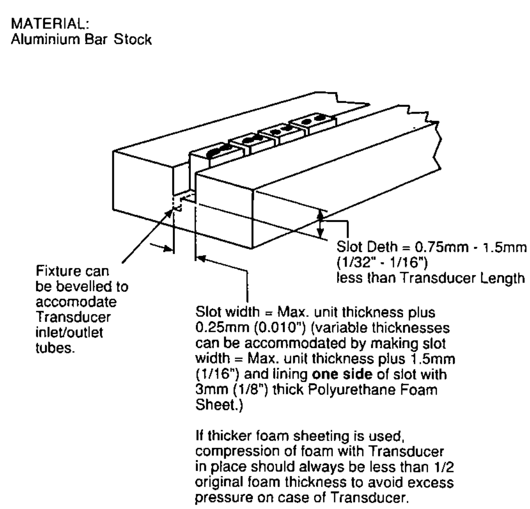


Figure 4

One possible change which could help to reduce the possibility of damage to these transducers is to make the slot in the aluminium heat sink soldering fixture deep enough so the cover of the receiver is below and in intimate contact with the higher surface of the fixture, and the terminal insulator board is level with the other side of the soldering fixture, as shown in Fig. 5. The lead wire to be attached should be brought into the work on the lower side of the fixture, and the soldering iron brought in on the protected higher side of the fixture.

1. Cover of Receiver
2. Tinned soldering iron tip
3. Heat sink surfaces high enough to protect the receiver cover from the iron tip.
4. Heat sink surface low enough to fully expose the solder on the terminal pad.
5. Pre-tinned and fluxed lead. Only tin the lead the minimum length to avoid a stiff lead.
6. Electrical insulator. During soldering operation, it is a heat insulator.
7. Case end surface.
8. Terminal pad.

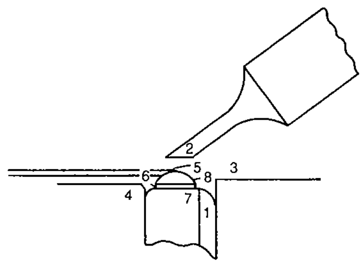


Figure 5

Fixturing to hold the external lead can be built onto the above fixtures, or standard tweezers (preferably non-magnetic) can be used. Many tweezer configurations are available, including "anti-wicking" and "heat sink" designs, which may be useful in controlling the solder flow into stranded lead wires. In addition, optical magnification with a 10X or higher power microscope and use of a good, glare-free light source is helpful when attaching leads, and should be considered as standard equipment when attaching leads to our EG and EM microphones and EH and EP receivers.

LEAD SOLDERING PROCEDURE

1. Place transducer in holding fixture, terminal up.
2. Dip *pre-tinned* lead wire in liquid rosin flux.
3. Lay tinned tip of lead 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 lead (Figure 7).
7. Keep soldering iron tip in contact with lead and terminal until solder on lead and solder on terminal pad liquify and flow into each other. Remove soldering iron tip immediately and hold lead wire in place with tweezers until solder solidifies. Total time soldering iron tip is in contact with the lead and terminal *should not exceed 1 second* if tip temperaure is correct and lead wire pre-tinning is adequate.

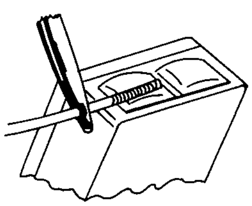


Figure 6

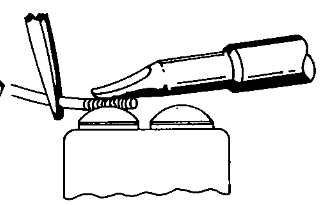


Figure 7

8. Inspect junction to see that:

a) Solder has flowed smoothly over lead and terminal pad, completely covering the pad area to reseal the hole in the terminal pad (see Figure 1).
b) Solder has not bridged between adjacent terminal pads or between the terminal pad and the case.

9. Flexible lead wires and/or strain relief material and careful routing of lead 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 lead of the transducer which extends through the terminal pad and is folded flat against the pad. See Figure 1.)
- 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.

WARNING: Over-heating of rosin reduces its activity as a surface contaminant remover. Avoid using flux at temperatures above 316°C (600°F).

1. Units with broken terminals and units damaged by excessives heat are not covered by Knowles Standard Warranty.

LEAD REMOVAL

If leads must be removed from a transducer, the same precautions and principles listed for soldering apply. If possible, cut leads at or near the terminals in preference to unsoldering.
Any "clean up" of the terminal pads in preparation for re use should consider the terminal design (Figure 1). Extreme care should be taken to prevent damage to the transducer leads - broken leads, internally shorted leads, and leads inadvertently pushed back into the case can result from poor cleanup techniques.[1] 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 lead removal operations.

ALTERNATE METHODS OF LEAD ATTACHMENT

Other equipment is currently available to provide good lead-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 can 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.
For most applications, hand soldering is still the most dependable and most economical lead attachment process, and has been most completely investigated as a production process.

APPENDIX A: Rosin flux

Recommended liquid flux is 20-25% Rosin, WW, in isopropyl alcohol, Type R, MIL-F-14265. Flux cored solders should have flux specification equivalent ot that of the rosin flux specified above.
"Activated" rosins should be used only where post-soldering cleaning with isopropyl alcohol followed by a distilled or de-ionized water rinse is possible. Consult supplier of flux for other flux removal recommendations before use.

APPENDIX B: TEMPERATURE MEASUREMENT MATERIALS

Temperature measurement materials (other than thermocouple techniques)
1. Tempil Corporation, 132 W. 22nd Street, New York, N.Y. 10011 Temperature indicating crayons, pellets, and liquids (liquify or change colour at specified temperature.)
2. Paper Thermometer Co., 10 Stagg Drive, Natick, Massachusetts. Wax coated paper strips (change colour at specified temperature.)
3. Henry Mann Inc., Box 496, Mann Road, Huntingdon Valley, Pa. 19006 Soldering Iron Thermocouple, type HS-1F with CR-1 thermocouple fitting.

APPENDIX C: References

For more detailed information:
1. *Solders and Soldering,* by Howard H. Manko (Alpha Metals, Inc.) McGraw-Hill1964.
2. *Solder...Its Fundametals and Usage,* by Clifford L. Barber (Kester Solder Co.) Available through Kester Solder Co., (4201 Wrightwood Avenue, Chicago, Illinois 60639).
3. American Society for Testing Materials - Several publications on Non-ferrous Metals and Alloys, such as:
ASTM PUBLICATION NO. 319 - "Papers on Soldering" (1962) Available through American Society for Testing and Materials (1916 Race Street, Philadelphia, Pennsylvania 19103).
4. Lead Industries Association, Inc. - (292 Madison Avenue, New York, N.Y. 10017.) - Several bulletins available, such as:

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Soldering Alloys, New Developments in Soldering Equipment and Methods.
5. Tin Research Institute, Inc - (483) W. Sixth Avenue, Columbus, Ohio,; Fraser Road, Greenford, Middlesex, England; also offices in Belguim, Canada, France, Germany, Holland and Italy - Several bulletins available, such as: *Notes on Soldering,* by W. R. Lewis.

ADDENDUM
SOLDERING TRANSDUCER LEADS TO EG AND EM MICROPHONES

THE SOLDERING PROCESS

Soldering involves a tradeoff between heating the solder pool of the pad to the temperature where it will quickly wet the pre-tinned lead wire, and avoiding excessive heat being transmitted to the internal structure of the transducer.
This addendum is intended to help the user of Knowles EG and EM model transducers to obtain good, reliable electrical connections during their lead attach operation, and to avoid some of the problems which may be associated with connecting leads to subminiature transducers.
For most applications, hand soldering is the most reliable and economical method of lead attachment, and the techniques discussed in this bulletin are therefore directed toward this process. Other methods of making electrical connection such as solder reflow, energy discharge welding, etc., may also be used successfully. However, these techniques should be thoroughly investigated by the user to determine their effect on transducer performance.

THE EG/EM TERMINAL

The new design and materials used on the terminals of the EG and EM microphones have been carefully chosen to provide optimum wettability and heat resistance. This enables the user to obtain rapid, dependable solder connections without the need for a larger terminal pad.

THE EG/EM SOLDERING SYSTEM

There are many possible soldering systems which may be used successfully with the EG and EM microphones. One which has given good results is presented below, and contains most of the important parameters required for successful soldering:

- A low power soldering iron (approximately 25 watts).
- A heat sink fixture designed for EG and EM microphones.
- A 1/32" soldering tip, such as the one shown in Fig. 3 in soldering bulletin TB4. A slight bend in the tip may facilitate soldering.
- A method for measuring and controlling tip temperature.
- An optical aid such as binocular microscope producing at least 10x magnification.

HAZARDS ASSOCIATED WITH SOLDERING TRANSDUCER LEADS

There are several factors in the lead soldering process which, if not carefully controlled, can affect the performance of the transducer.

- Heat damage to the transducer may occur if the soldering iron does not have sufficient power or heat capacity to stay in the temperature range of 290-345°C (550-650°F) during the soldering operation. It may also result from using a soldering tip or lead which has not been properly tinned, or if the transducer is inadequately heat sinked. Additionally, even brief contact between the tip of the iron and case of the transducer may result

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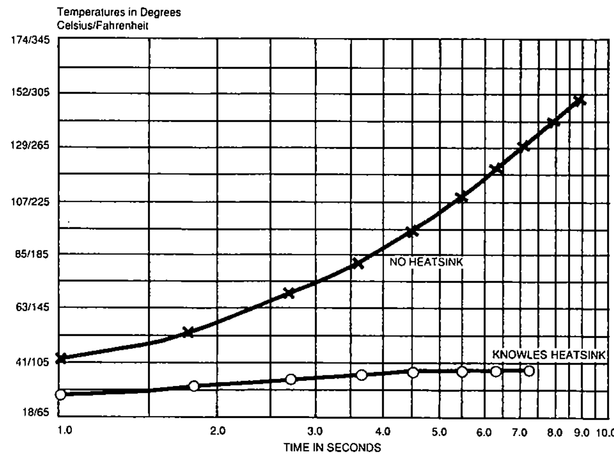
in permanent damage. The performance of the EG and EM microphones, when used with a suitable heat sink fixture, will not be adversely affected by the heat generated in normal lead attach operations.

- Excess solder can cause shorts between the terminals, and grounds between the terminals and the case.
- Contamination of the terminal may degrade the wettability of the pad.
- The application of lead strain relief materials should be reviewed, in order to help prevent damage to the terminal assembly.
- Ungrounded soldering and test equipment can result in unusual voltages which may damage the microphones.



"SAFE" SOLDERING TEMPERATURES AND TIMES

INTRODUCTION

The above graph illustrates the effect of using a heatsink while attaching leads to an EG microphone, and gives general ideas of safe soldering times and temperatures. The data represents results from limited testing and should not be construed as defining hard and fast limits for allowable lead soldering temperatures and times. We feel the data to be sufficiently accurate, however, to describe an area of time versus temperature where it is unlikely that an EG or EM microphone will be damaged.

PROCEDURE

The data for the curves labeled "No Heatsink" and "Knowles Heatsink" were generated by applying a constant known heat input to an EG microphone solder terminal and measuring the temperature at a point where the housing contacts the diaphragm. Heat was applied using the soldering system recommended earlier in TB4 and with a measured maximum tip temperature of 410° C (780° F). These curves may be interpreted to represent worst case conditions for attaching leads. The data points in the upper right portion of the figure indicate the temperature/time coordinates at which an EG microphone lost 3 dB in sensitivity. Again, constant heat was applied to the unit under test. This time, however, heat was not applied to the solder terminal, but to the entire bottom surface of the transducer.

DISCUSSION

The figure indicates that for the soldering system used (tip temperature equal to 410° C (780° F) up to four seconds per lead attachment will not damage the transducer in a heatsink. For lower tip temperatures our experience indicates that this time will increase; however, the time required to melt the solder and make an adequate connection will also increase, raising the overall unit temperature to a level exceeding that created by a hotter iron. Higher tip temperatures will cause rapid solder melting and will quickly oxidize the soldering iron and heat up the transducer as well.

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ADDITIONAL INFORMATION

The information in this addendum is based on experience and research, but is, of course, limited in scope. Additional details on soldering techniques are found in the main body of this Technical Bulletin .
The reader is also encouraged to investigate the soldering process as it applies to his own particular application.

EG/EM MICROPHONES APPLICATION NOTES (PRELIMINARY)

The EG/EM Series miniature electret condenser microphones are 40% smaller than the earlier EA-series microphones and have a new terminal construction which should be easier to use. Early experiments at Knowles connecting lead wires to the terminals of EG microphones cause us to recommend the use of the following equipment and procedures:

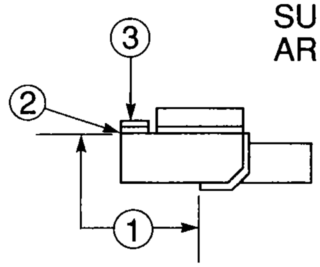
1. Some typical soldering irons are:

A. Ungar "Princess" model, including base #6903, 15 watt heating element #6915 and fine point tip #6963.
B. Hexacon model H10, 12 watt iron.

2. Use of optical magnification of 10x to 30x in a binocular microscope is recommended so the operator can clearly see the terminal pads, soldering work area, and be able to watch the wire lead attachment process. It is quicker and reduces short-to-case grounds and shorts between terminals.

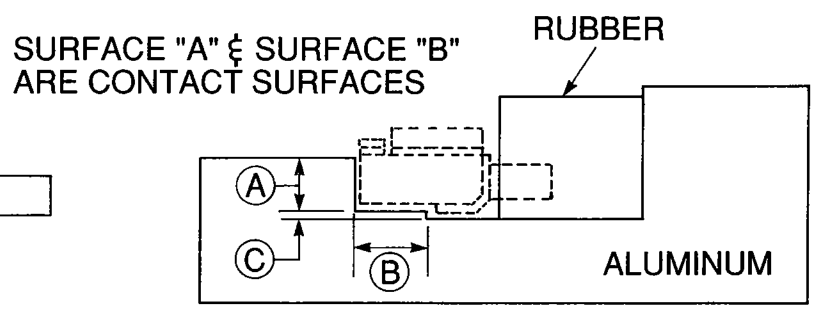
3. Use of a heat sinking fixture is necessary to hold the microphones in position during the soldering process. This fixture should make contact against the microphone case directly below the terminals and against the case surface opposite the terminals. See Fig. 1 below.

4. For engineering work, one possible soldering fixture would be an aluminium bar machined as shown on the sketch. Contact area of the fixture should be ground to assure good contact for heat transfer. See Fig. 2 below.



1 Area for heat transfer
2 Terminal insulator
3 Solder area

Fig 1 - EG-3000/EM-3046 Heat Transfer Area



Critical dimensions

A 1.27-1.35 (.050/ .053)
B 2.29-2.36 (.090/ .093)
C 0.254 (.010)

Fig 2 - Engineering Solder Fixture for EG-3000 or EM-3046