AN1004

Mounting and Handling of Semiconductor Devices

Introduction

Proper mounting and handling of semiconductor devices, particularly those used in power applications, is an important, yet sometimes overlooked, consideration in the assembly of electronic systems. Power devices need adequate heat dissipation to increase operating life and reliability and allow the device to operate within manufacturers' specifications. Also, the devices should not be abused during assembly to avoid damage to the semiconductor chip or internal assembly. Very often, device failures can be attributed directly to a heatsinking or assembly damage problem.

This application note will guide the user to the proper utilization of Teccor devices, particularly the TO-220 and TO-202 epoxy packages. These two packages are among the most popular and versatile of the many varieties available from Teccor.

This note is intended to be a basic guideline to assist the semiconductor user. For further details or suggestions on use of Teccor devices, the Teccor Applications Engineering Group is readily available to answer any inquiries.

Lead Forming—Typical Configurations

A variety of mounting configurations are possible with Teccor power semiconductor TO-202, TO-92 and TO-220 packages, depending upon power requirements, heatsinking, available space, cost considerations, etc. A few typical examples below are described along with some basic design rules.

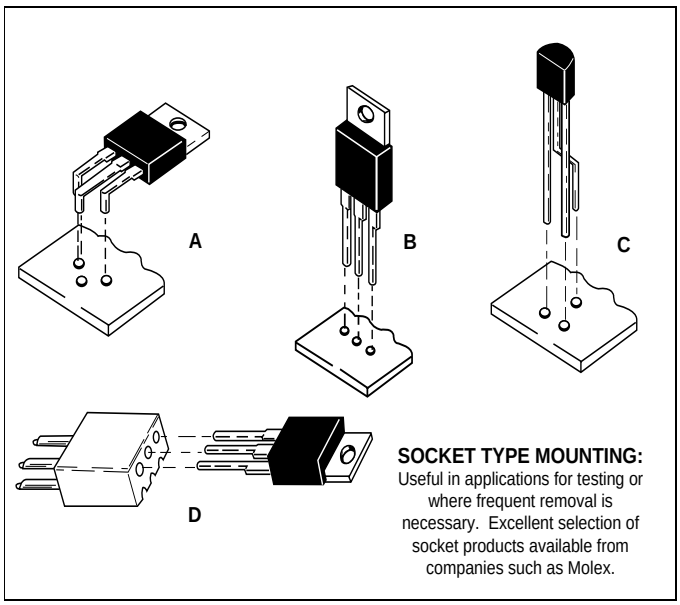

Figure 17.1 Component Mounting

These are suitable only for vibration-free environments and low-power, free-air applications. For best results, the device should be in a vertical position for maximum heat dissipation from convection currents.

Standard Lead Forms

Teccor encourages users to allow Teccor to perform all lead and tab form options for the user. Teccor has the automated machinery and expertise to produce pre-formed parts at minimum risk to the device and greater convenience for the consumer. See “Lead Form Dimensions” section for a complete list of readily available lead form options. Contact Teccor for information regarding custom lead form designs.

Lead Bending Method

Leads may be easily bent and may be bent to any desired angle, provided that the bend is made at a minimum .063" (0.1" for TO-218 package) away from the package body with a minimum radius of .032" (.040" for TO-218 package). Leads should be held firmly between the package body and the bend so that strain on the leads is not transmitted to the package body.

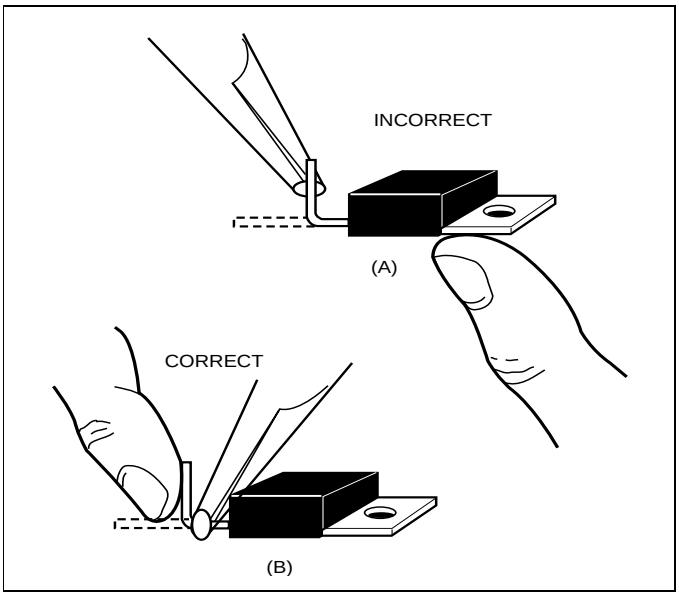

Figure 17.2 Lead Bending Method

When bending leads in the plane of the leads (spreading), bend only the narrow part. Sharp angle bends should be done only once as repetitive bending will fatigue and break the leads.

The mounting tab of the TO-202 Package may also be bent or formed into any convenient shape so long as it is held firmly between the plastic case and the area to be formed or bent. Without this precaution, bending the tab may fracture the chip and permanently damage the unit.

Heatsinking

Use largest, most efficient heatsink as practical and cost effective to extend device life and increase reliability. *Many power device failures are a direct result of improper heat dissipation.* Heatsinks that have a mating area smaller than the metal tab of the device

are unacceptable. Heatsinking material should be at least .062" thick to be effective and efficient.

Note that in all applications the maximum case temperature (T_C) rating of the device must not be exceeded. Refer to the individual device data sheet rating curves (T_C vs I_T) as well as the individual device outline drawings for correct T_C measurement point.

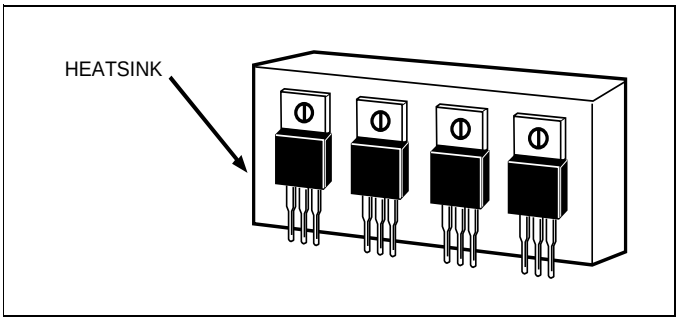

Figure 17.3 Several TO-220 THERMOTAB Devices Mounted to a Common Heatsink. All are electrically isolated from each other.

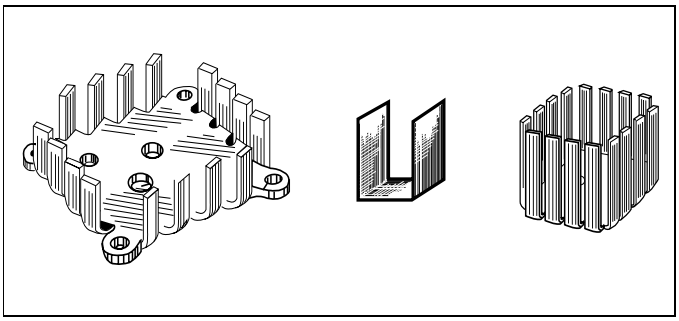

Figure 17.4 PC Board Mount Examples

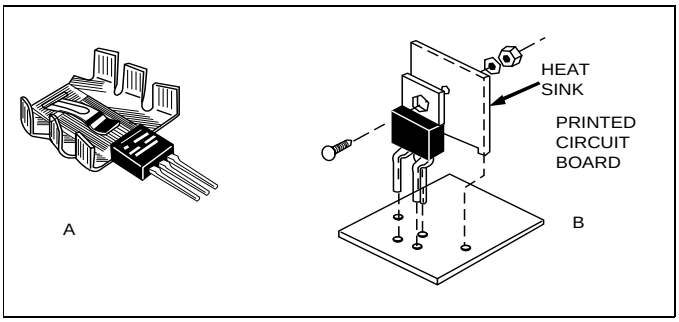

Figure 17.5 Vertical Mount Heatsink: Several types available. Keep heatsink vertical for maximum convection.

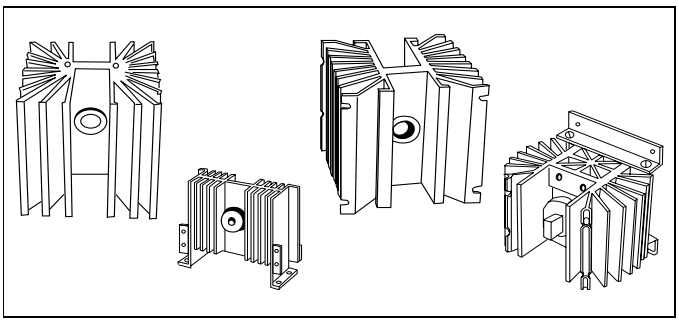

Figure 17.6 Extruded Aluminum Examples: When coupled with fans, these types have the highest efficiency.

Heatsinking Notes

Care should be taken not to mount heatsinks near other heat-producing elements such as power resistors. Black anodized heatsinks may absorb more heat than they dissipate this way.

Some heatsinks can hold several power devices. Make sure that if they are in electrical contact to the heatsink, the devices do not short-circuit the desired functions. Isolate the devices electrically or move to another location. Recall that the mounting tab of Teccor isolated THERMOTAB devices is electrically isolated so that several devices may be mounted on the same heatsink without extra insulating components.

Allow for adequate ventilation. Route heatsinks to outside of assembly for maximum airflow, if possible.

Mounting Surface Selection

Proper mounting surface selection is essential to efficient transfer of heat from the semiconductor device to the heatsink and from the heatsink to the ambient. The most popular heatsinks are flat aluminum plates or finned extruded aluminum heatsinks.

The mounting surface should be clean and free from burrs or scratches. It should be flat within .002 in/inch and a surface finish of 30 to 60 microinches is acceptable. Surfaces with a higher degree of polish do not produce better thermal conductivity.

Many aluminum heatsinks are black anodized to improve thermal emissivity and prevent corrosion. Anodizing results in high electrical but negligible thermal insulation. This is an excellent choice for isolated TO-220 THERMOTAB devices. For applications of TO-202AB devices where electrical connection to the common anode tab is required, the anodization should be removed. Iridite or chromate acid dip finish offers low electrical and thermal resistance. Either TO-202AB or isolated THERMOTAB devices may be mounted directly to this surface, regardless of application. Both finishes should be cleaned prior to use to remove manufacturing oils and films. Some more economical heatsinks are painted black and the paint should be removed in the area where the semiconductor is to be attached due to the high thermal resistance of paint.

Bare aluminum should be buffed with #000 steel wool followed by an acetone or alcohol rinse. Immediately, thermal grease should be applied to the surface and the device mounted down to prevent dust or metal particles from lodging in the critical interface area.

The use of thermal grease is essential for good thermal contact to fill in the air pockets between the semiconductor and the mounting surface, thereby decreasing the thermal resistance by a factor of nearly 20.

Teccor engineering recommends Dow-Corning 340 as a proven effective thermal grease. Fibrous applicators are not recommended as they may tend to leave lint or dust in the interface area. Assure that the grease is spread adequately across the device mounting surface and torque device down to specification. Contact Teccor Applications Engineering for assistance in choosing and utilizing the proper heatsink for specific application.

Hardware And Methods

TO-220AB

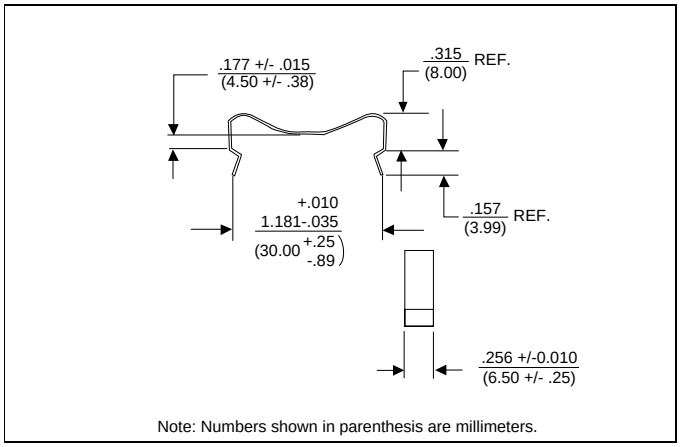

Figure 17.7 TO-220AB

The mounting hole for the Teccor TO-220AB devices should not exceed .140 (6/32) clearance. No insulating bushings are needed for the "L" Package (isolated) devices as the tab is electrically isolated from the semiconductor chip. 6/32 mounting hardware, especially round head or Fillister machine screws, are recommended and should be torqued to a value of 6.0 inch-lbs.

Punched holes are not acceptable due to cratering around the hole which can cause the device to be pulled into the crater by the fastener or can leave a significant portion of the device out of contact with the heatsink. The first effect may cause immediate damage to the package and early failure while the second can create higher operating temperatures which will shorten operating life. Punched holes are quite acceptable in thin metal plates where fine edge blanking or sheared-through holes are employed.

Drilled holes must have a properly prepared surface. Excessive chamfering is not acceptable as it may create a similar crater effect as above. Edges must be deburred to promote good contact and avoid puncturing isolation materials.

For high voltage applications, it is recommended that only the metal portion of the TO-220 package (as viewed from the bottom of the package) be in contact with the heatsink to provide maximum oversurface distance to prevent a high voltage path over the plastic case to a grounded heatsink.

TO-202

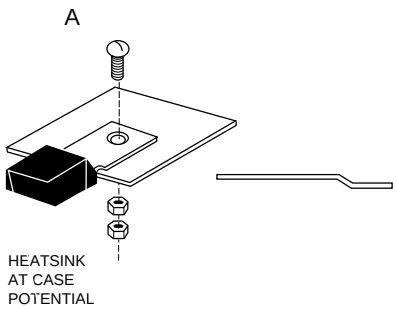

Figure 17.8 TO-202

The mounting hole should not exceed .112 (4/40) clearance. Since tab is electrically common with anode, heatsink may or may not need to be electrically isolated from tab. If not, use 4/40 screw with lock washer and nut.

Mounting torque is 6 inch-lbs.

A nylon bushing and mica insulation are required to insulate the tab in an isolated application. A compression washer is recommended to avoid damaging the bushing. Do not attempt to mount non-formed tabs to a plane surface as the resulting strain on the case may cause it or the semiconductor chip assembly to fail. Teccor has the facilities and expertise to properly tab form TO-202 devices for the convenience of the consumer.

TO-218

The mounting hole for the TO-218 device should not exceed .164 (8/32) clearance. Isolated versions of TO-218 do not require any insulating material since mounting tab is electrically isolated from the semiconductor chip. Round lead or Fillister machine screws are recommended. Maximum torque to be applied to mounting tab is 8.0 inch-lbs.

The same precautions given for the TO-220 package apply to the TO-218 package concerning punched holes, drilled holes, and proper prepared heatsink mounting surface. Also for high voltage applications, it is recommended that only the metal portion of the mounting surface of TO-218 package be in contact with heatsink in order to achieve maximum oversurface distance to prevent a high voltage path over the device body to grounded heatsink.

General Mounting Notes

Care must be taken on both packages at all times to avoid strain to the tab or leads. Axial strain on the leads should be avoided. Mounting holes for the tab and the leads should be carefully measured and any forming of the tab or leads should be done beforehand for easy insertion of the part onto the board or heatsink. Refer to the section on Lead Forming before attempting lead form operations.

Figure 17.9 "Pop" Riveting Technique

For less demanding and more economical applications, rivets may be used. 1/8" all aluminum "pop" rivets can be used on both TO-220 and TO-202 packages. Use a .129" – .133" (#30) drill for the hole and insert the rivet from the top side. An insertion tool, similar to a "USM" PRG 430 hand riveter, is recommended. A wide selection of grip ranges is available, depending upon the thickness of the heatsink material. Use an appropriate grip range to securely anchor the device, yet not deform the mounting tab. The recommended rivet tool has a protruding nipple that will allow easy insertion of the rivet and keep the tool clear from the plastic case of the device.

A “Milford” #511 (Milford Group, Milford, CT) semi-tubular steel rivet set into a .129" receiving hole with a riveting machine similar to a “Milford” S256 is also very acceptable. Contact the rivet machine manufacturer for exact details on application and set-up for optimum results.

Pneumatic or other impact riveting devices are not recommended due to the shock they may apply to the device.

Under no circumstance should any tool or hardware come into contact with the case. The case should not be used as a brace for any rotation or shearing force during mounting or in use. Non-standard size screws, nuts, and rivets are easily obtainable to avoid clearance problems.

Always use an accurate torque wrench to mount devices. No gain may be achieved by overtorquing devices. In fact, over-torque may cause the tab and case to deform or rupture, seriously damaging the device. The curve below illustrates the effect of proper torque. See Figure 17.10.

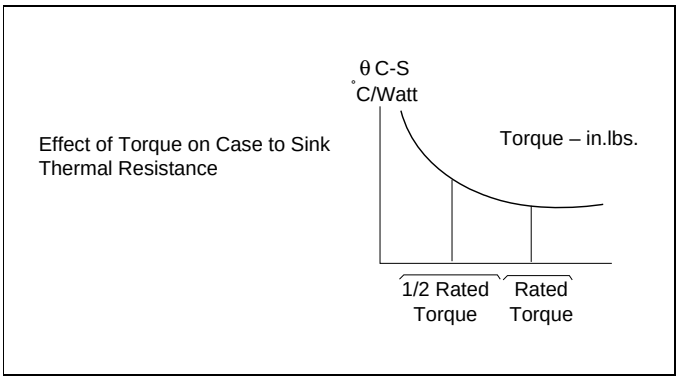

Figure 17.10 Effect of Torque to Sink Thermal Resistance

With proper care, the mounting tab of a device can be soldered to a surface. The heat required to accomplish this operation can damage or destroy the semiconductor chip or internal assembly. For spring clips, see “Surface Mount Soldering Recommendations” (AN1005) in this catalog.

Spring-steel clips can be used to replace torqued hardware in assembling thyristors to heatsinks. Clips snap into heatsink slots to hold the device in place for PC board insertion. Clips are available in several sizes for various heatsink thicknesses and thyristor case styles. Popular types shown are available from Thermalloy, Dallas, Texas.

Spring-steel Clip Part Number	Thyristor Case Style	Heatsink Material Thickness in Inches
CLP-101	TO-220, TO-218	.050-.080
CLP-201	TO-220	.050-.080
CLP-202	TO-220	.090-.125
CLP-203	TO-220	.050-.080

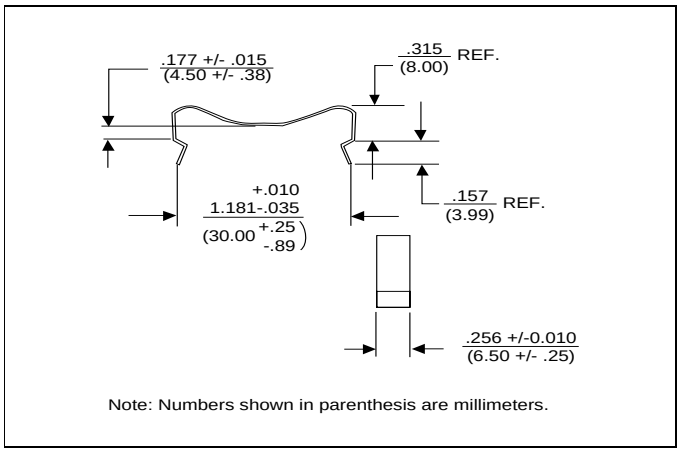

Figure 17.11 CLP-101

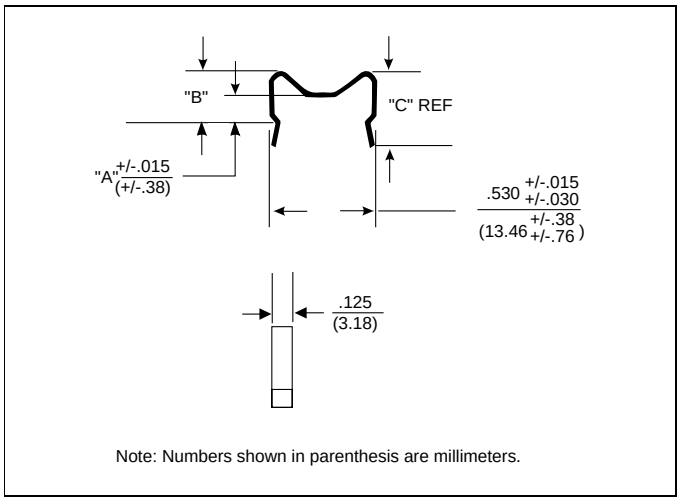

Figure 17.12 CLP-201, CLP-202

Catalog No.	Dim “A”	Dim “B”	Dim “C”
CLP-201	.165 (4.19)	.350 (8.89)	.535 (13.59)
CLP-202	.225 (5.72)	.410 (10.41)	.595 (15.11)

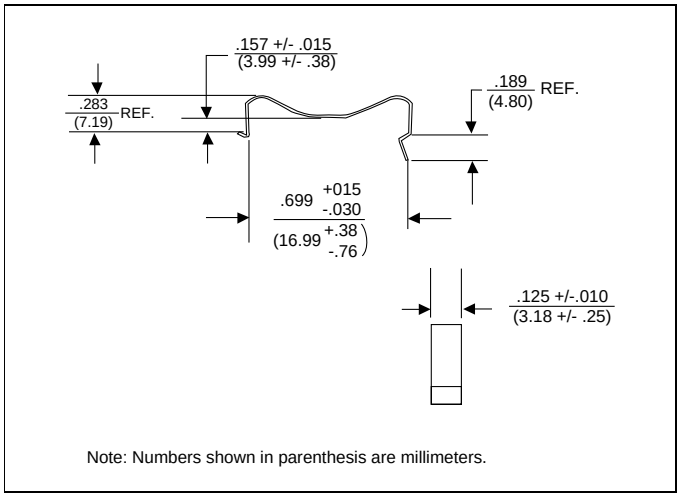

Figure 17.13 CLP-203

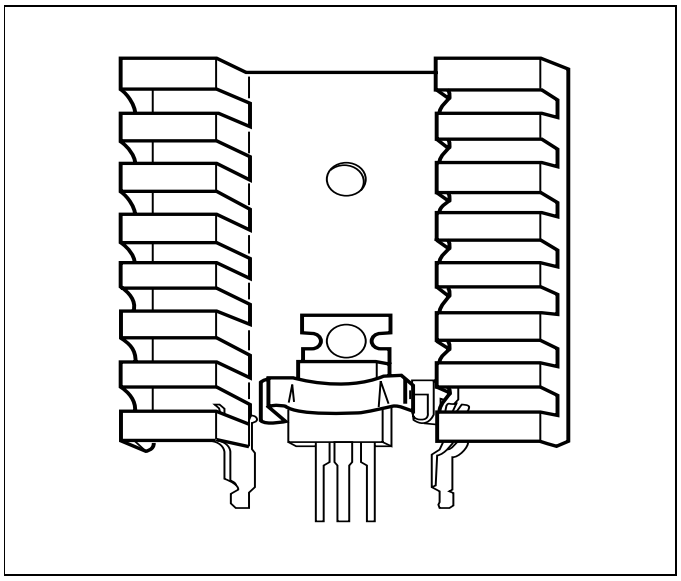

Figure 17.14 Typical Heatsink Using Clips

Soldering Of Leads

A prime consideration is the soldering of device leads into PC boards, heatsinks, etc. Significant damage can be done to the device through improper soldering. In any soldering process, do not exceed the data sheet lead solder temperature of +230°C for 10 seconds, maximum, ≥1/16" from the case.

Three types of soldering will be discussed: hand soldering, wave soldering, and dip soldering.

Hand Soldering

This method is mostly used in prototype breadboarding applications and production of small modules. It has the greatest potential for misuse. The following recommendations apply to Teccor TO-92, TO-202, TO-220, and TO-218AC packages.

Select a small to medium duty electric soldering iron of 25 to 45 watts designed for electrical assembly application. Tip temperature should be rated at 600°- 800° F (300°C-425°C). The iron should have sufficient heat capacity to heat the joint quickly and efficiently in order to minimize contact time to the part. Pencil tip probes work very well. Heavy duty electrical irons of greater than 45 watts or flame-heated irons and large heavy tips are not recommended as their tip temperatures are far too high and uncontrollable and can easily exceed the time-temperature limit of the part.

Teccor FASTPAK devices require a different soldering technique.

Circuit connection can be done by either quick-connect terminals or solder.

Since most quick-connect .250 female terminals have a maximum rating of 30 Amps, connection to terminals should be made by soldering wires instead of quick-connects.

A number 10 AWG stranded wire is recommended to be used for MT1 and MT2 for load currents above 30 Amps. Soldering should be performed with 100 watt soldering iron which should not remain in contact with the wire and terminal longer than 40 seconds, so as not to damage the Fastpak triac.

The following 3-terminal quick-connect connector plug, or equivalent, is recommended for use with this package. Check connector manufacturer's data sheet for proper usage.

Load Current	P/N
25 amps MAX	AMP 172410-1 (Housing)
	AMP 63239-1 (.250 Receptacle)
	AMP 63195-1 (.187 Receptacle)

For the new Teccor TO-218X package, the basic rules as described before apply; however, a larger iron may be required to apply sufficient heat to the larger leads to efficiently solder the joint.

Again do not exceed the lead solder temperatures of +230°C for 10 seconds, maximum, ≥1/16" (1.59mm) from the case.

A 60/40 or 63/37 Sn/Pb solder is acceptable. This low melting point solder used in conjunction with a mildly activated rosin flux is recommended.

The device should be inserted into the board or socket and, if required, the device attached to the heatsink first. Each lead should be individually heatsinked as it is soldered. Commercially available heatsink clips are excellent for this use. Hemostats may also be used if available. Needle-nose pliers are a good heatsink choice; however, they are not as handy as stand-alone-type clips.

In any case, the lead should be clipped or grasped between the soldier joint and the case as near to the joint as possible. Avoid straining or twisting the lead in any way.

Use a clean pre-tinned iron and solder the joint as quickly as possible. Avoid overheating the joint or bringing the iron or solder into contact with other unheatsinked leads.

Wave Solder

This is one of the most efficient methods of soldering large numbers of PC boards quickly and effectively. Guidelines for soldering by this method are supplied by equipment manufacturers. Points to be emphasized are that the boards should be preheated to avoid thermal shock to semiconductor components and the time-temperature cycle in the solder wave should be regulated to avoid heating the device beyond the recommended temperature rating. A mildly activated resin flux is recommended. See Figure 17.15 for typical heat and time conditions.

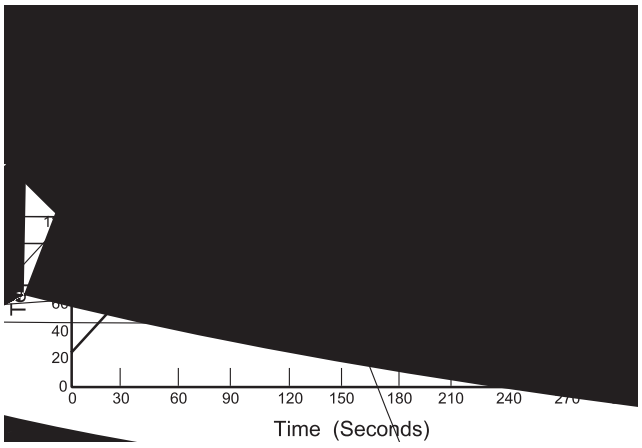

Figure 17.15 Reflow Soldering with Pre-Heating

Dip Soldering

This is very similar to wave soldering, but is a hand operation. The same considerations as above should be followed, particularly the time-temperature cycle which may become operator dependent. Due to the wide process variations that may occur, this method is not recommended.

Board or device clean-up is left to the discretion of the customer. Teccor devices are tolerant to a wide variety of solvents. They conform to MIL-STD 202E method 215 “Resistance to Solvents.”