

TECHNIQUE

Strain Gage Soldering Techniques

Table of Contents

[Introduction](#)

[Soldering Station and Pencil](#)

[Soldering Flux](#)

[Soldering Tip Preparation](#)

[Tinning Tabs and Terminals](#)

[Tinning Leadwires](#)

[Leadwire Attachment](#)

[Cleanup and Inspection](#)

[Summary](#)

Total of 10 Pages



<http://www.measurementsgroup.com>

A Measurements Group **Strain★Smart** Hypertext Publication

Also available in printed form as Measurements Group Tech Tip TT-609

TECHNIQUE

Strain Gage Soldering Techniques

Introduction

The most common method of making electrical connections in strain gage circuits is by means of soft solders, in wire form. Other methods, such as spot welding, brazing, compression bonding, paste solders, and conductive epoxies, are also available, but find only limited application. Solders have many advantages for strain gage use - they are low in cost, readily available in various alloy compositions to provide a range of melting temperatures, and are easily obtained in the form of either solid wire or wire with a core of flux. They are convenient to use, and offer an excellent combination of electrical and mechanical properties.

Although soldering is basically a simple procedure, it must be done with appropriate tools, supplies, and techniques to assure accurate strain measurement. This is particularly true when test requirements are severe in the sense of approaching the limits of the strain gage circuit capabilities; e.g., long-term stability, high-elongation measurements, fatigue endurance, etc. Use of improper materials or techniques can significantly degrade strain gage performance.

The purpose of this publication is to outline recommended procedures and materials for attaching leadwires to strain gage solder tabs or to bonded printed-circuit terminals. These reliable, experience-proven methods are based on the use of a professional quality [soldering station](#), in conjunction with Micro-Measurements *M-LINE* [solders](#) and installation accessories.



Strain Gage Soldering Techniques

Soldering Station & Pencil

For precision soldering of strain gages, it is always necessary to use a temperature- or power-controlled soldering station that provides low voltage and adjustable temperature to the soldering iron tip. An unregulated soldering iron, connected directly to the power line, is not ordinarily suitable for strain gage use because the tip temperature is apt to be far too high. This tends to oxidize the tip, and to instantly vaporize the flux, making soldering much more difficult. In addition, the unnecessarily high temperature may damage the strain gage, the bonding adhesive, or even the test specimen. For these reasons, the soldering station should incorporate provision for adjusting the soldering temperature to suit varying installation conditions and requirements. The temperature must be adjusted, of course, to accommodate the melting points of the different solders commonly used for strain gage connections, but also to allow for environmental conditions such as drafts or outdoor soldering in cold weather. Moreover, the temperature controller should be carefully designed to ensure that it does not generate electrical noise that could adversely affect nearby measuring instruments when both are in use.

Design of the soldering pencil also requires special consideration. It should be light in weight, with a very flexible power cord, and with the gripping area thermally insulated from the heating element. These characteristics contribute to the comfort, ease, and precision of soldering, and minimize operator fatigue during long periods of use. The soldering tip itself should be of the flat, chisel, or screwdriver type. Pointed tips should not be used, because they tend to draw solder away from the work area, and thus make it more difficult to achieve a proper joint. In contrast, flat tips act to confine the solder, while offering greater surface area for better heat transfer and more effective soldering, generally.

Micro-Measurements soldering units incorporate all of the above features and a number of others, designed to help the user easily make consistent, reliable solder joints. These soldering units are widely used by professional strain gage installers everywhere, in both stress analysis laboratories and in transducer manufacture.



Strain Gage Soldering Techniques

Soldering Flux

The function of a soldering flux is to remove oxidation from the members being joined (solder tabs, terminals, leadwires), and to prevent further oxidation during soldering. For making leadwire splices, or soldering directly to constantan foil or copper terminals, the flux contained in a rosin-core solder is usually sufficient. With higher temperature solders, however, it may be necessary to supply additional flux. A liquid activated-rosin flux such as [M-Flux AR](#) is recommended for this purpose.

Acid fluxes should never be used on constantan strain gages or copper terminals, or for splicing copper leadwires; and paste fluxes, containing chlorides, should not be used under any circumstances for strain gage soldering. When tinning bare (without soldering options [S](#), [DD](#), or [DP](#)) solder tabs of Micro-Measurements [K-](#) and [D-alloy](#) strain gages, a liquid acid flux ([M-Flux SS](#)) is recommended. After the tinning operation, the residual flux must be completely neutralized within one to two minutes; and then the leadwire joint can be completed using the same solder and M-Flux AR rosin flux or a rosin-cored solder.



Strain Gage Soldering Techniques

Soldering Tip Preparation

New soldering tips should always be tinned with solder prior to initial use. This is easily accomplished by wrapping 1 to 2 inches (25 to 50 mm) of solder wire around the working portion of the tip while the soldering iron is cold, before applying power to the soldering station. If rosin-core solder is used, no external flux is required. With solid-wire solder, however, the wrapped tip should be dipped into liquid rosin flux ([M-Flux AR](#)) to provide sufficient flux for initial tinning. Set the control on the soldering station to the appropriate temperature range for the solder, and apply power to the unit. Allow the soldering pencil to heat until the solder wrapped around the tip melts completely. Remove excess melted solder from the tip with a dry [gauze sponge](#). Never knock the heated soldering pencil against any object to remove excess solder, since this may result in personal injury or damage to the soldering pencil.

NOTE

Cross-alloying of solders can change the electrical, chemical, thermal and mechanical properties of the solder being used. To prevent cross-alloying, it is recommended that only one type of solder be used with each soldering tip. Of course, if one type of solder is incorporated in a gage with solder dots and another type is added, a mixture is produced. This mixture cannot be expected to have melting and strength properties any better than those of the lower temperature component.

Soldering Tip Oxidation

Oxidation of the soldering tip seriously hinders the soldering operation. The tendency for oxidation can be minimized by ensuring that excess melted solder remains on the tip at all times when it is not actually in use. Negligent maintenance practices, or wiping the hot tip with materials that char on the surface, will produce a buildup of oxide that prevents proper soldering. If the tip does become oxidized, the following procedure is effective for cleaning and re-tinning:

1. Set the soldering station to the appropriate temperature range for the solder in use.

2. Place several drops of [M-Flux SS](#) on a glass plate. Re-tin the soldering surface by holding the heated tip in the SS flux while feeding solder onto the tip. A generous amount of solder is essential for proper tinning.
3. Wipe the excess solder from the tinned tip with a dry gauze sponge.

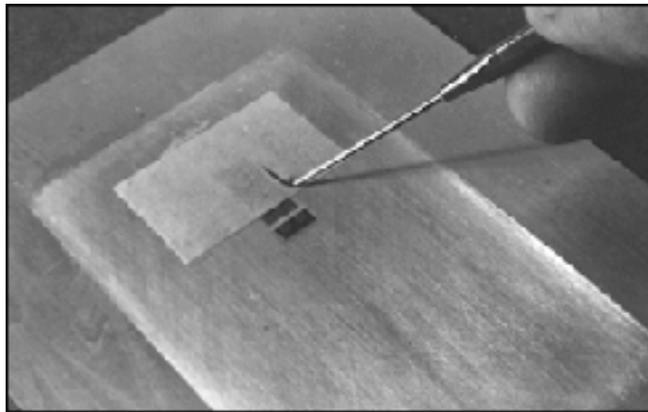
For severely oxidized tips, it may be necessary to repeat this operation several times to obtain a properly tinned surface. The soldering tip should never be filed or sanded, since this may remove the plating on the tip, accelerating the oxidation and leading to the early deterioration of the tip. After the cleaning operation, remove excess solder, re-tin and clean the tip several times, using rosin-core solder, or solid-wire solder with M-Flux AR.



Strain Gage Soldering Techniques

Tinning Tabs & Terminals

All strain gage solder tabs, terminals, and leadwires must be properly tinned before making soldered connections. This helps ensure active surface wetting and good heat transfer during the soldering operation. Tinning stranded leadwires to produce a formable solid conductor will also greatly simplify the leadwire attachment procedure.



Gage grid and upper portion of solder tabs masked with drafting tape.

Before tinning the solder tabs on open-face (unencapsulated) strain gages, the measuring grid should be protected with M-Line [PDT-1](#) drafting tape. The drafting tape is positioned to cover the entire grid and the upper portion of the solder tabs, as shown in the accompanying figure. This not only shields the grid from soldering flux and inadvertent solder splash, but also restricts the flow of solder on the tabs. The tinned area on the solder tabs should be only large enough to easily accommodate the leadwire size in use. The latter consideration is particularly important when making installations for dynamic applications or large-strain measurement.



Strain Gage Soldering Techniques

Tinning Procedure

The tinning procedure for strain gage tabs and terminals consists of first cleaning and reapplying a small amount of solder to the hot soldering iron tip. Next, apply a drop of [M-Flux AR](#) to the tab or terminal (this step can be omitted if a rosin-core solder is used). When soldering directly to bare [Karma](#) or isoelastic foil, use [M-Flux SS](#) on the gage tabs only. Hold the soldering pencil in a nearly horizontal position (<30 deg), with the flat surface of the tip parallel to the solder tab or terminal. Place the solder wire flat on the gage tab, and press firmly with the tinned hot soldering tip for about one to two seconds, while adding approximately 1/8 in (3 mm) of fresh solder at the edge of the tip. This procedure assures that there is sufficient solder and flux for effective tinning. Simultaneously lift both the soldering pencil and solder wire from the tab area.

NOTE

Lifting the soldering iron before lifting the solder may result in the end of the solder wire becoming attached to the tab; lifting them in the reverse order can leave a jagged (spike) solder deposit on the tab. When the operation is performed properly, it will produce a small, smoothly tinned area on the tab or terminal.

If the [M-Flux AR](#) or a rosin-core solder is used in the tinning, it is not necessary to remove the residual soldering flux at this time. However, when [M-Flux SS](#) is employed to tin the bare solder tabs of [K-](#) or [D-alloy](#) gages, the acidic flux residue must be removed immediately following the tinning operation. To remove the residue, apply [M-Prep Conditioner A](#) liberally, and wash the area with a soft brush; then blot dry with a clean [gauze sponge](#). Next, wash again with freely applied [M-Prep Neutralizer 5A](#), and blot dry with a clean gauze sponge.

NOTE

Special procedures for tinning and wiring strain gages supplied with preattached solder dots are described in Measurements Group Tech Tip TT-606, [Soldering Techniques for Lead Attachment to Strain Gages with Solder Dots](#).



Strain Gage Soldering Techniques

Tinning Leadwires

Of course, leadwire ends must be stripped of insulation before tinning, and this should be done with a thermal wire stripper to avoid the damage to the wire that often occurs when mechanical wire strippers are used. After the wires are stripped, the ends of stranded conductors should be twisted tightly together before tinning. The bare leadwire ends can then be tinned easily with the following procedure:

1. Remove excess solder from the soldering tip, using a dry [gauze sponge](#). Then melt fresh solder on the hot tip to form a hemisphere of molten solder about twice the diameter of the wire to be tinned.
2. If rosin-core solder is used, slowly draw the bare wire through the molten solder while continuously adding fresh solder to the interface of the wire and soldering tip. With solid-wire solder, apply [M-Flux AR](#) to the wire end before starting to tin, and proceed in the same manner. This will produce a smooth, shiny coating of solder over the bare wire.

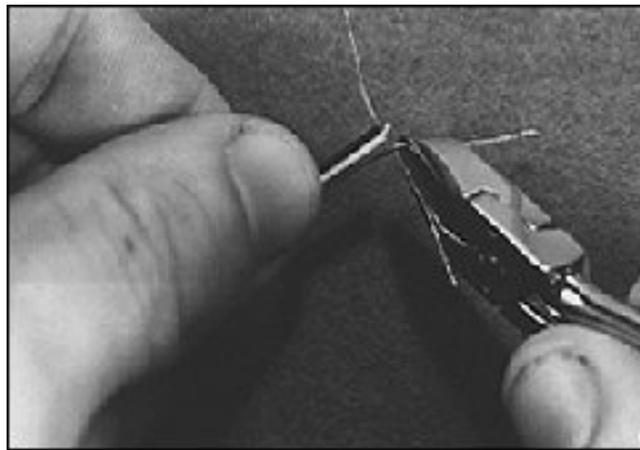
For applications employing bondable terminal strips and stranded instrumentation wire, it may be convenient to use a single strand of the wire as a jumper between the terminal and the strain gage solder tab. In such cases, the single wire strand should be separated out before twisting and tinning the remaining strands (see Measurements Group Tech Tip TT-603, [The Proper Use of Bondable Terminals in Strain Gage Applications](#)).



Strain Gage Soldering Techniques

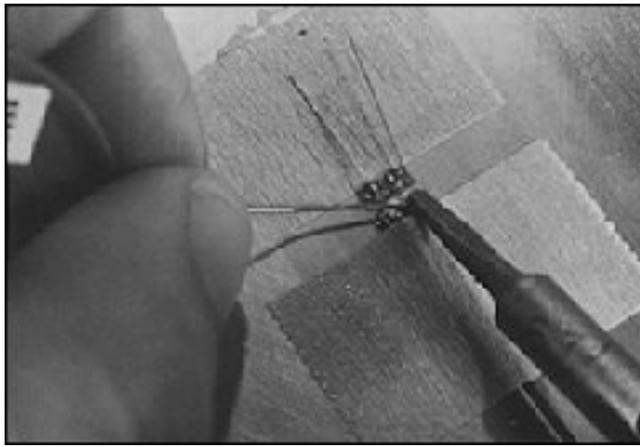
Leadwire Attachment

Leadwires should be formed and routed to the strain gage or terminal strip, then firmly anchored to the test-part surface with drafting tape before making the soldered connection. Attempting to route the leadwires after completing the solder joint will often result in damage to the gage or terminals. Routing into the connection area should be along a minimum strain direction (such as the "Poisson" direction in a uniaxial stress field) particularly for high elongation or dynamic tests. The tinned leadwire end should be trimmed short enough so that it will not protrude through the connection area, and cannot inadvertently make electrical contact with the test-part surface or adjacent solder connections. The accompanying figure illustrates this stage in the procedure.



Trimming leadwire ends before taping in place.

In the final preparatory step, bend the leadwire end slightly to form a spring-like loop, and tape the wire firmly in place over the connection area, using [PDT-1](#) drafting tape. The tape should be within about 1/8 in (3 mm) of the connection area, as shown in the accompanying figure.



Leadwire end taped to surface in preparation for soldering.

Clean and re-tin the soldering iron tip with fresh solder. The temperature of the iron should be adjusted so that the solder is easily melted, without rapidly vaporizing the flux. If the iron temperature is either too low or too high, it may cause poor solder connections, or it may damage the strain gage, terminal, or bonding adhesive. Apply a small amount of [M-Flux AR](#) to the joint area and, holding the soldering pencil nearly horizontal, firmly press the flat surface of the tip on the junction for about one second; then lift the tip from the soldered joint. If needed, additional flux can be provided during the joining operation by feeding a little fresh solder into the joint from a spool of rosin-core solder. This procedure should result in a smooth, hemispherical solder joint, without any peaks or jagged areas. If the solder joints are not smooth and uniform in size, repeat the soldering procedure, using additional flux and/or solder as necessary.



Strain Gage Soldering Techniques

Cleanup & Inspection

After completing the soldering operation, it is imperative that all traces of residual flux be completely removed with [M-LINE RSK Rosin Solvent](#). The same solvent is used to soften the mastic of the drafting tape, permitting its easy removal. Do not try to pull away the tape with tweezers or other tools, because this may result in damage to the soldered connections or the strain gage grid. Thoroughly clean the entire installation area with generously applied rosin solvent and a soft-bristled brush. Clean the solder connection area until no visible signs of residual flux remain, and blot the area dry with a clean [gauze sponge](#). Any traces of residual flux can cause gage instability and drift, and will inhibit bonding of the installation's protective coating. Incompletely removed soldering flux is the most common cause of degraded performance in strain gage installations. Residual flux mixed with a protective coating application can completely destroy the coating objective.

Visually inspect the soldered joints for any gritty or jagged joint surfaces, and for traces of flux. Solder connections should be smooth, shiny, and uniform in appearance. Any soldered joints that look questionable should be re-soldered, and flux removed. Check the resistance-to-ground of the completed gage installation, using the [Model 1300 Gage Installation Tester](#). Low or marginal resistance readings suggest a leakage path between the soldered connections and the test-part surface. This condition usually results from residual soldering flux, or from bare leadwire conductors partially shorting the gage tabs or terminals to the test part. Soldered joints should not be tested by pulling on the leadwire, or by probing at the joint area. These practices frequently cause lifting or tearing of the solder tab from the gage backing material.



Strain Gage Soldering Techniques

Summary

The ability to make consistently good soldered joints is essential for precision strain gage measurements. The techniques described here are straightforward and easily mastered, but they are most effective when used with professional soldering equipment which is specially designed for making soldered connections in strain gage circuits. The soldering pencil should be lightweight, with a flat chisel or screwdriver tip, and it should be connected to the soldering station with a very flexible power cord. Requirements for the soldering station include low-voltage operation of the soldering pencil, and provision for temperature adjustment to suit the type of solder and the application conditions. The equipment should not generate electrical interference that could affect sensitive measuring instrumentation. Solder selection is based primarily on the expected operating temperature range of the strain gage installation; and all solder tabs, bondable terminals, and leadwire ends should be tinned before soldering the joints. Soldered joints should always be smooth and shiny, with no jagged or irregular edges, and all traces of residual flux must be thoroughly removed prior to the application of protective coating. Use of the recommended materials and techniques, with careful attention to detail, will result in consistently proper and reliable soldered connections.

