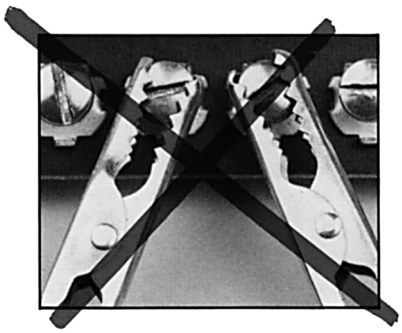
Mechanical Connectors in Strain Gage Circuits

A question that often arises, especially for short-term strain gage measurements, is: "Can I use mechanical connectors (screw-type, etc.) to simplify connecting and disconnecting strain gages in my instrument circuit?".

As for many other simple questions, there is no simple answer to this one. In general, however, it is preferable to use as few mechanical connections as possible in any strain gage circuit. This is because mechanical connections are potentially less stable in joint resistance than soldered connections. When such an answer is given, the next question is apt to be: "But what about my strain gage instruments? All of them are equipped with binding posts or other types of mechanical connectors." True enough. The connectors are there for the convenience of the instrument user, but these are carefully chosen for the intended purpose, and are often gold-plated or gold-flashed to minimize and stabilize the contact resistance.

It is always necessary to keep in mind the relatively small resistance changes involved in strain gage measurements. For a uniaxial working stress of, say, 30 000psi (207MPa) in steel, the strain level is 1000 microstrain. With a 120-ohm gage (G.F. ~ 2.0), the strain-induced resistance change is only about 250 milliohms. Under these conditions a 5-milliohm change in contact resistance will cause an indicated zero-shift of some 20 microstrain -- enough to alarm a careful practitioner. Yet contact resistance changes of this magnitude can be caused by an oxidized connector contact surface or by a poorly terminated leadwire. Even changing the insertion depth of the stripped end of the leadwire into the connector can produce a measurable zero-shift. With AWG #26 wire (0.4mm dia.), for instance, changing the insertion depth by as little as 0.3 in (~8mm) when reconnecting the wire will offset the zero by close to 5 microstrain.

The lesson to be learned from the above is that if mechanical connectors are to be employed within the bridge circuit, a number of precautions should be taken to help ensure accurate strain measurements. One obvious measure is to use high-quality connectors, gold-plated if possible. In addition, however, leadwire terminations should be carefully made. If the wire is stranded, the strands should be wound snugly together, and then uniformly and smoothly tinned. When connecting to a binding post, the wire should be inserted to about the same depth each time, and the binding post should be tightened for a firm but non-crushing grip on the wire. After the strain indicator is turned on and balanced, there should be no perceptible strain indication due to shaking the free portion of the wire. With conventional screw-down binding posts, the preferred leadwire termination is a "spade" terminal, which should be attached to the leadwire by soldering, not by crimping. The spade terminal allows repeatable insertion depth into the connector, and it is not subject to crushing if the binding post is over tightened.



Even the foregoing steps do not guarantee complete freedom from contact resistance variations. The quality of a mechanical connection generally degrades with time; and the rate of degradation depends upon the environment in which the system operates. Thus, monitoring and maintenance of the connection may be necessary to preserve its initial performance. One way to monitor the stability of the connection resistance is to use a highly stable resistor (such as the Vishay Micro-Measurements S-Type) in a verification channel. If the resistor is connected to identical terminals and exposed to the same environment as the active circuits, zero-shift in the verification channel may be indicative of contact resistance variations in the connectors. When contact resistance variations are identified, cleaning of the contact areas may be necessary. Leadwire terminations, if not plated, can be polished; and binding posts or other gold-plated connectors can be washed with GC-6 isopropyl alcohol (but never abraded).

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- Select only, high-quality connectors -- gold-plated when practical
- Use solid, robust leadwire terminations
- Firmly clamp leadwires in connectors, always at the same point on the lead wire
- "Exercise" connectors periodically by moving and re-tightening wire clamps, and by several insertion/ removal cycles of plug-and-socket connectors
- Monitor and maintain the connections for resistance stability and repeatability
- In performing the previous step, be certain to distinguish between contact resistance changes and thermoelectric potentials