Probe Selection for No Clean Flux Application

Reductions in the use of CFCs for board cleaning have led to increased use of no-clean fluxes. Properly tuned fluxing processes with modern low-solids fluxes result in boards that are readily testable. However, the real world often presents test engineers with no-clean boards coated with layers of contamination ranging in texture from hard and brittle to soft and gummy.

The following summarizes recommendations for probe selection to make reliable contact through contamination layers. This information is drawn from industry studies and from customer feedback about probes in production environments.

The principle behind making electrical contact through contamination is that higher contact pressures better displace and penetrate contamination, resulting in higher reliability. With spring probes, contact pressure is affected by both spring force and contact area. Sharper points will reduce the contact area, thereby increasing the contact pressure; and higher spring force will increase contact pressure as well (for more information, see the following pages). But simply putting the strongest spring behind the sharpest point is not always the solution – there are other factors to consider:

1. Although using higher spring forces will improve contact reliability, the ability of the test fixture to overcome the spring force and actuate fully must be considered. (For assistance in these calculations, request the Applications Note *Spring Force Considerations*).

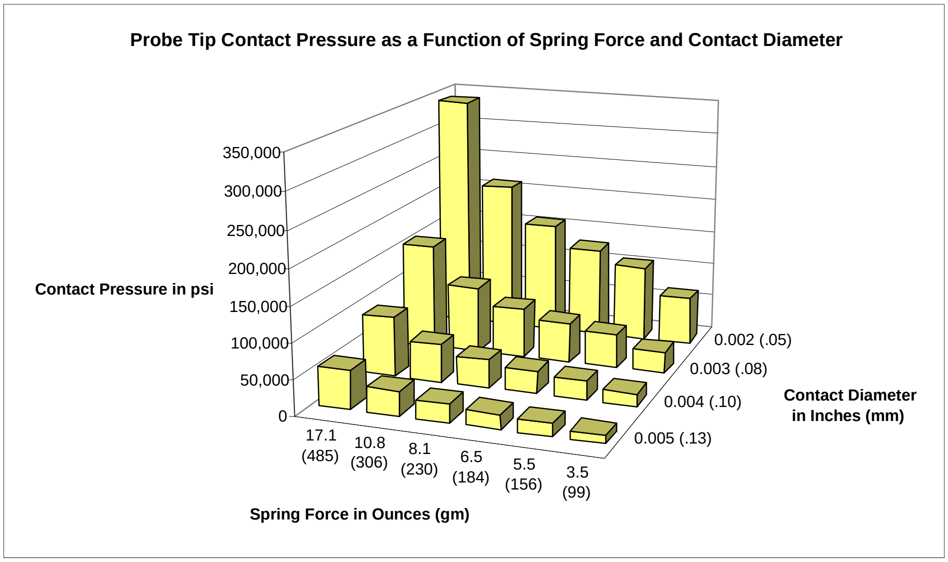
2. The tip style chosen must be physically stable on the surface being contacted. For example, although a sharp chisel point may be ideal for a hole or pad, using it for a through-hole component lead will result in glancing and side loading.

3. Ultimately, the selection of point styles is a subjective decision – experienced test engineers will often have different preferences for the best point style to use on a given contact surface. Testing and field use have shown a particular group of point styles to be well-suited for contacting heavily contaminated contact surfaces:
   - For flat pads, use Sharp Chisels (QA point styles 53 & 63), Sharp Triads (08), Spears (31 & 41), or Razors (6R-S & 8R-S) tips.
   - For leads, use Self-Cleaning Crowns (24, 34 & 55), Tulip (17) and Sharp Triad (08) tips.
   - For holes, use Sharp Chisels (53 & 63), Chisel Triad (18), Blades (51, 61-S & 91-S) or Razors (6R-S & 8R-S) tips.

Steel plungers are harder and will remain sharp longer than beryllium copper, so steel is recommended for applications requiring greater durability. QA's sharpest point styles, the needle (31-S) and Razors (6R-S & 8R-S) are <u>available only in steel</u>. Many of the point styles listed above are available in various combinations of beryllium copper or hardened steel on .050, .075 & .100 inch centers. Please contact QA for the latest specifications or samples.

How Probe Tip Geometry Affects Contact Reliability

The table and graph below show calculated contact pressures (spring force divided by contact area) for the 100-25 Series spear point probe contacting a flat surface. The calculations are based on spring forces and a circular contact area ranging from .002" (.05) to .005" (.13) in diameter the actual contact area depends largely on the geometry and condition of the probe tip. A tip which is blunt (either by design or because it has become worn or flattened during use) will make contact over a larger area than a sharp tip, resulting in lower contact pressures and reduced ability to penetrate contamination layers.



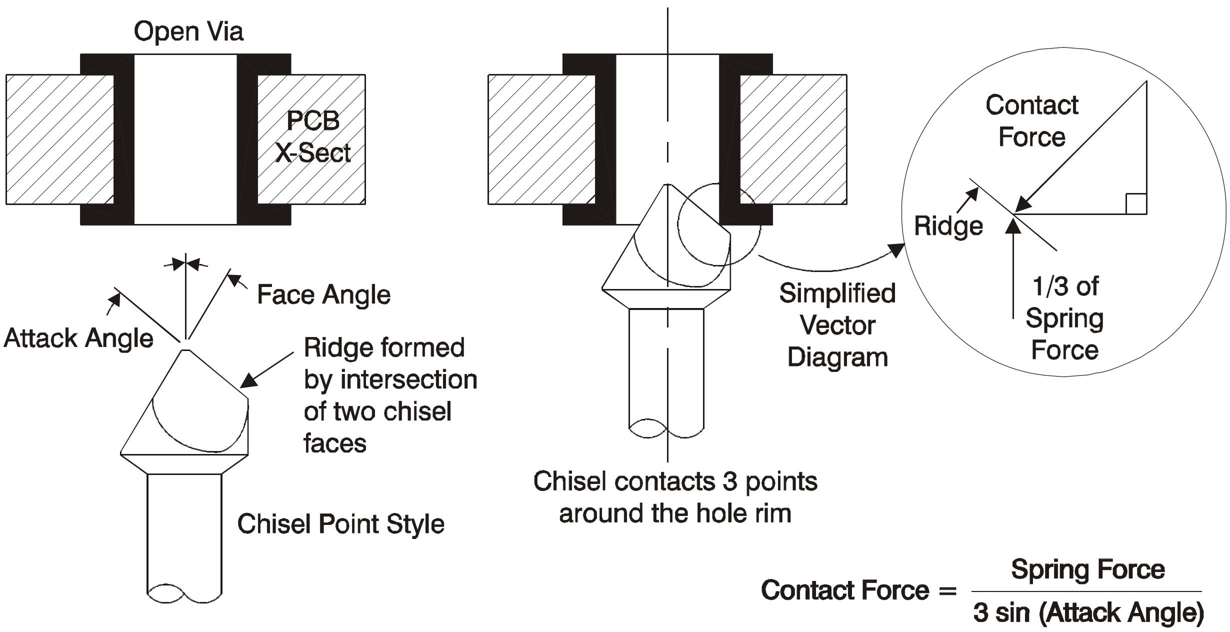
A probe with lower spring force and a relatively sharp tip can develop higher contact pressure than one with high force and a worn tip

Note that the contact pressures shown here are significantly higher than the yield strength of solder, and will cause the solder surface to deform. As a sharp point initially bears against a solder pad, the solder will yield, the area will increase, and the contact pressure will drop until the pressure reaches the yield strength of the solder. As the solder yields, the oxide or flux which covers the solder is disrupted, and uncontaminated solder is brought into contact with the probe tip, allowing electrical contact to be made. The result is a mark left in the solder pad.

For multiple-tip point styles contacting flat pads, make the worst-case assumption that all tips will be touching the pad, and multiply the surface area by the number of points. For example, in the case of the triad point the contact pressure would be one third that of the spear point pressures listed above.

Contact Pressure in Pounds per Square Inch (MPa)				
Spring Force in Ounces (gms)	**Diameter of Contact Area in Inches (mm)**			
	0.002 (.05)	**0.003 (.08)**	**0.004 (.10)**	**0.005 (.13)**
3.5 (99)	69,630 (480)	30,947 (213)	17,408 (120)	11,141 (77)
5.5 (156)	109,419 (755)	48,631 (335)	27,355 (189)	17,507 (121)
6.5 (184)	129,313 (892)	57,473 (396)	32,328 (223)	20,690 (143)
8.1 (230)	161,144 (1111)	71,620 (494)	40,286 (278)	25,783 (178)
10.8 (306)	214,859 (1482)	95,493 (659)	53,715 (370)	34,377 (237)
17.1 (485)	340,194 (2391)	151,197 (1063)	85,048 (598)	54,431 (382)

A chisel contacting the rim of an open via is a special case (a chisel is essentially a pyramid with a triangular base). The area of contact is easy to envision – it is spread over three regions which are the points of contact between the rim of the hole and the three ridges formed by the intersections of the chisel faces. But the force behind the contact is actually higher than the spring force. This is because the reaction force is perpendicular to the *attack angle* of the ridge and increases geometrically as a function of this angle. The vector diagram below describes this, but the important concept in the case of chisels in open vias is that contact pressure will increase not only in response to sharper ridge edges and higher spring force, *but also as the attack angle becomes more acute*.



The relationship between chisel attack angle and the resulting contact force

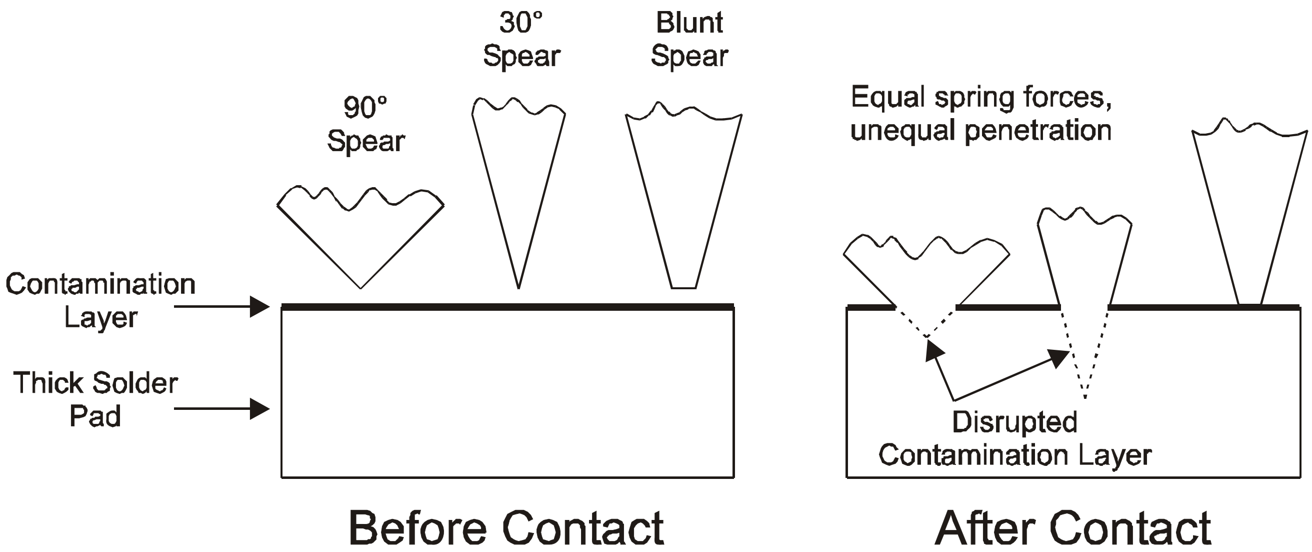
The table at right compares the effect of attack angles on contact force for various chisel point styles. The contact force at *each* of the three contact points around the rim of the hole is equal to the spring force times the **Spring Force Multiplier**. The table shows, for example, that a 53 point style (sharp chisel) has nearly *three times higher* penetrating power than a 03 point style (standard chisel) with the same spring.

This attack angle principle is the same for the various blade point styles (a blade is essentially a pyramid with a diamond-shaped base), but the pressures are higher since there are two points of contact on the rim of the hole instead of three. Blades are the most aggressive point styles for use in open vias. But blades bring another key principle into play – the role of the included angle of the ridge.

The *included angle* is the angle formed between the faces that intersect to make the ridge. For a blade point style, the included angle is smaller (forming a sharper wedge) than for a chisel. The smaller the included angle, the more the contact surface will deform as it yields. Greater deformation means more disruption of the contamination layer, and therefore more reliable contact between the exposed uncontaminated solder and the probe tip. The end result is that even with contact area held constant, more acutely angled points make more reliable contact through contamination. This is demonstrated in the following example.

Spring Force Multipliers for Chisel Points

Probe Series	**Point Style**	**Face Angle**	**Attack Angle**[i]	**Spring Force Multiplier**
039-16	43	30°	49°	.442
050-05	13	53°	69°	.357
	43	30°	49°	.442
050-16	03	30°	49°	.442
	13	45°	63°	.374
	63	15°	28°	.710
050-25	03	48°	-	-
	13	30°	49°	.442
	43	30°	49°	.442
	53	15°	28°	.710
	63	15°	28°	.710
075-25	03	30°	49°	.442
	13	30°	49°	.442
	43	30°	49°	.442
	53	10°	-	-
	63	15°	28°	.710
075-40	03	30°	49°	.442
	43	30°	49°	.442
100-05	03	53°	69°	.357
	13	53°	69°	.357
	23	66°	77°	.342
	33	73°	81°	.337
	53	76°	83°	.336
	63	30°	49°	.442
100-16	03	30°	49°	.442
	13	30°	49°	.442
100-25	03	33°	-	-
	43	30°	49°	.442
	53	10°	-	-
	63	15°	28°	.710
100-40	03	33°	-	-
	43	30°	49°	.442
	53	10°	-	-
125-25	03	45°	63°	.374



Different included angles with equal spring force yield unequal penetration.
Within limits penetration increases disruption of the contamination layer and provides more reliable contact.

It is easier to visualize the effects of included angle with spears than chisels. Consider the case of two spears contacting a flat pad with a thick solder coating. One spear has an included angle of 90º, the other an included angle of 30º. Both have 3.5 ounces of spring force pushing behind them. Since solder yields at about 5000 psi, both spears will penetrate the solder until a conical hole of .007" diameter (at the top) is formed. At this diameter, the solder will no longer yield, since the contact pressure has been reduced to 5000 psi. This means that the 90º spear will penetrate to a depth of .004", while the 30º spear will penetrate much deeper to .014". The greater penetration will cause more disruption of the contamination layer, and more reliable contact will result. For an extreme case, imagine a spear with a .007" diameter flat on the end (blunt spear). This spear would not penetrate the solder at all.

Note also that sharp spears against thin solder layers can penetrate the solder layer. In such cases, the spear will bear against the substrate and stop before achieving the depth calculated as per above

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[i] Attack Angle = 90º - $\tan^{-1}$(tan(90º - Face Angle)/2). The face angle for chisel point styles is listed in the table on page 4 and also in the current QA catalog.