QA Technology Company, Inc.

Spring Force Considerations

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When selecting probe spring force for vacuum fixtures, consider these factors:

1) **Total probe spring force:** The collective force of the probes must not exceed the vacuum fixture system's capability to move the tested product into contact with the probes.
2) **Condition of contact surfaces:** Contact pressure (a function of spring force and tip geometry) must be high enough to penetrate oxides and contaminants that accumulate on both the test pad and the probe tip.
3) **Distribution of probes across the probe field:** Avoid densely concentrated areas of high force so as not to damage the product or cause fixture actuation problems. Spring force is not the sole determinant of good electrical contact – surface contact area, tip geometry, contact materials and cleanliness, impact as the product engages the probe tips and even vibration all affect contact resistance.

Calculating the Limits:

For a conventional vacuum fixture, the total spring force limit is calculated by multiplying the surface area of the product by atmospheric pressure, then dividing the result by the spring force per probe. The result is multiplied by an efficiency factor that accounts for fixture leaks, spring force tolerances, vacuum considerations (details below), etc. Improving the system efficiency will allow a faster rate of actuation and can increase the capacity of the fixture, but spring force may never exceed the force applied by atmospheric pressure.

This formula can be used to calculate either the maximum number of probes of a given spring force, or the maximum spring force allowed for a given number of probes.

<u>Example</u>

6" x 10" (15.2 cm x 25.4 cm) board and 5.5 oz (156 gm) probes.

Units	Area of Board	x	Atmospheric Pressure	x	Force Unit Conversion	÷	Force per Probe	x	System Efficiency	=	Max No. of Probes
English:	60 in^2	x	14.7 psi	x	16 oz/lb	÷	5.5 oz	x	60 %	=	1,500
Metric:	387 cm^2	x	1.03 kg/cm^2	x	1000 gm/kg	÷	156 gm	x	60 %	=	1,500

Probe Distribution:

Concentrations of probes around connectors or large pin packages may exceed 1 atmosphere in a small area of the product while the total force may be below the maximum limit. If the concentration of probes is near the edge of the product, the vacuum seal may break and prevent the product from seating in the fixture. Uneven probe distribution can result in excessive flexing of the product – particularly with thin boards. Applying the same formula, the maximum probes per square inch can be calculated:

Units	Area of Board	x	Atmospheric Pressure	x	Force Unit Conversion	÷	Force per Probe	x	System Efficiency	=	Max No. of Probes
English:	1 in^2	x	14.7 psi	x	16 oz/lb	÷	5.5 oz	x	60 %	=	25
Metric:	6.45 cm^2	x	1.03 kg/cm^2	x	1000 gm/kg	÷	156 gm	x	60 %	=	25

This limit can be exceeded if the stiffness of the board or pattern of probes allows an even distribution of the collective spring force over the surface of the product.

Vacuum Considerations:

When calculating probe spring force limitations, the efficiency factor is used to define the vacuum system's ability to overcome probe spring force. The two factors that are typically referenced are "CFM" and "Inches of Mercury." Cubic feet per minute is the measure of the vacuum system's capacity to move air over time. The higher the CFM the better the vacuum system's ability to draw the product down quickly and overcome initial seal leakage. A vacuum reservoir will compensate for low pump CFM, absorbing the initial rush as the vacuum system evacuates the fixture and seats the product. Inches of mercury is the measure of the system's ability to draw a complete vacuum. Thirty inches is one atmosphere (a full vacuum). Anything less than 30 inches can be considered a percentage of 1 atmosphere and used in the probe limit calculation above as the efficiency factor. The example used in the limit calculation was .60 which represents 18 inches of mercury.

Calculating Spring Force for a Chosen Stroke:

Probes are not always used at rated stroke, and it is necessary to know the spring force at any given stroke in order to properly design the fixture. A probe's spring force at any chosen stroke can be calculated with the formula:

F = P + (S (Fg - P) ÷ Sg) where:

F	=	The force at a chosen stroke (oz or gm)
S	=	The chosen stroke (in or mm)
P	=	The preload force (oz or gm)
Fg	=	The force at a given stroke (oz or gm)
Sg	=	The given stroke (in or mm)

Example: Find the force at .200 stroke for the standard force spring in the 100-25 series:

Known:
P = 1.6 oz (45 gm), Fg = 5.5 oz (156 gm) at Dg = .167 in (4.24 mm).

F = 1.60 + (.200(5.5 **-** 1.6) ÷.167) = **6.3** oz (**179** gm)

Spring Force vs. Contact Resistance:

Close examination of the probe tip and the contact surface reveals that the surfaces are comprised of microscopic hills and valleys. The hills, not all being the same height or angle to the target, do not all make contact with the target surface. The current flow through the probe tip is constricted through the hills that make contact. Increasing the pressure forces the taller hills to penetrate and allows the shorter hills to come into contact thus increasing the surface area capable of carrying current.

Most lead platings and solders contain tin. Tin alloys form a thin, hard, brittle oxide layer within minutes when exposed to air. This oxide layer is highly resistive. Fortunately, the underlying material remains softer than the oxide layer and easily deforms under sufficient pressure. The oxide layer is stretched and broken as the underlying layer is deformed. The cracks between the oxide layer become the primary path for current. When spring force is increased, greater deformation takes place and allows increased break up of the oxide layer.

Specifying spring force is not a casual consideration. Check spring force selection or changes with the fixture manufacturer since these choices are closely tied to the fixture design.

References

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