MILL-MAX MFG. CORP.
190 PINE HOLLOW ROAD
OYSTER BAY, NY 11771
516-922-6000
WWW.MILL-MAX.COM

SPRING LOADED CONTACT: SPECIFICATIONS, MECHANICAL & CLIMATIC TESTS

VERSION 2.0

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Tested in accordance with international standard IEC 60512 environmental testing procedures.

Scope

The reliability of Mill-Max's family of spring-loaded contacts has been verified by a sequence of mechanical and climatic tests. The mechanical sequence included two new tests devised by Mill-Max specifically for spring loaded contacts when they are used as battery contacts in portable instruments.

The test results are applicable to our range of low-profile spring-loaded contacts, as all these contacts are built around the same plunger and spring geometry. Usually, the only difference between them is the shape and dimensions of the contact sleeve.

TECHNICAL SPECIFICATIONS

Material characteristics

Sleeve
Screw-machined brass, 20µ" gold plated over 100µ" nickel.

Plunger
Screw-machined brass, 20µ" gold plated over 100µ" nickel.

Spring
Beryllium copper alloy 172, 10µ" gold plated over 50µ" nickel.

Mechanical characteristics

Force characteristics are dependent on the specific Mill-Max contact type.
Typically: 25 grams @ minimum stroke, 60 grams @ mid stroke & 95 grams @ maximum stroke.

Mechanical life: 1,000,000 cycles min.

Electrical characteristics

Rated current:	2A continuous, 3A peak
Rated voltage:	100 V_{RMS} / 150 V_{DC}
Contact resistance:	20 mΩ max.

Environmental characteristics

Operating temperature:	-55 °C / +125 °C
Solderability:	235 °C for 5 sec. per IEC 60068-2-54/Ta
Resistance to soldering heat:	280 °C for 10 sec. per IEC 60068-2-20/T
Resistance to corrosion:	Per IEC 60068-2-42/Kc & 60068-2-43/Kd

Mechanical and climatic stess test requirements

Group I: Mechanical test sequence:

Test #	Test			Measurement to be performed		Requirements
	Title	IEC #	Severity or condition of test	Title	IEC #	
T1	Spring force	13b	Pre-cycled	Contact force	13b	45-85 grams @ mid (half) stroke
T2	Contact resistance	2a	Fixtured @ mid stroke. Pre-cycled	Contact resistance	2a	<20 mΩ
T3	Orbital motion (X-Y axes)	N/A	Fixtured for x-y motion @ min, mid & max strokes. Pre-cycled	Contact disturbance	2e	No spike >1µs and >1.15V with 0.5A applied
T4	Vertical Motion (Z axis)	N/A	Fixtured for z axis motion. Pre-cycled	Contact disturbance	2e	No spike >1µs and >1.15V with 0.5A applied
T5	Vibration (sinusoidal)	6d	STB fixtured for min, mid & max strokes. Pre-cycled	Contact disturbance	2e	No spike >1µs and >1.15V with 0.5A applied
T6	Vibration (random)	6e	STB fixtured for min, mid & max strokes. Pre-cycled	Contact disturbance	2e	No spike >1µs and >1.15V with 0.5A applied
T7	Shock (half sinus)	6c	STB fixtured for min, mid & max strokes. Pre-cycled	Contact disturbance	2e	No spike >1µs and >1.15V with 0.5A applied

Group II: Climatic test sequence:

T8	Rapid change of temperature	11d	As defined in detailed description	Initial contact resistance	2a	<20 mΩ
T9	Dry heat	11i	As defined in detailed description			
T10	Damp heat, first cycle	11m	As defined in detailed description			
T11	Cold	11j	As defined in detailed description			
T12	Damp heat, second cycle	11m	As defined in detailed description	Final contact resistance	2a	<20 mΩ

Group III: Current-carrying capacity:

T13	Current carrying capacity	5a	Fixtured @ mid (half) stroke	Max. temperature rise after each current step	5a	Thermally stable >1min

DETAILED DESCRIPTIONS OF TESTS:

T1: SPRING FORCE

Test requirements per IEC 60512-13-2/13b, under the following conditions:

- Test object: Individual pin in insulator and soldered on PCB
- Test object conditions: Before and after 100k, 250k, 500k & 1000k pre-cycles
- Compression stroke: Mid (half) stroke = 0.0275” deflection
- Sample size: Average of 4 pins out of the 2x4 pin test part
- Tested direction: Axial (flat probe against plunger tip)
- Equipment used: Chatillon model HTC test gantry
  Mark 10 model BG2 digital force gage having 0.5 gram resolution
  Dial indicator having 0.001” resolution

Acceptance criteria: within the range of 45-85 grams @ mid (half) stroke

T2: CONTACT RESISTANCE

Test requirements per IEC 60512-2-2/2a, under the following conditions:

- Test object: Individual pin in insulator and soldered on PCB
- Test object conditions: Before and after 100k, 250k, 500k & 1000k pre-cycles
- Test principle: Four wire method
- Mating contacts Gold plated copper pads
- Compression stroke: Mid (half) stroke = 0.0275” deflection
- Test current: 0.5A ±5%
- Averaging: 2 samples, 3 measurements of each
- Equipment used: Voltage supply: 5V stabilized ±2%
  Shunt resistor: 10Ω ±1%
  Custom test fixture: four-wire principle
  Voltmeter: 0.1% resolution

Acceptance criteria: contact resistance <20mΩ

T3: ORBITAL MOTION (X-Y AXES)

(Non standard test)

This custom test was introduced specifically for Spring Loaded Contacts to verify the continuity of the plunger to the sleeve and its backup path through the internal spring. The xy-motion (wiggle) tries to misalign the plunger radially, so that a momentary gap is created between the plunger and the sleeve with the spring alone being the electrical path. For digital signals, momentary loss of continuity can be disastrous.

Test requirements

- Test object: Single pin, no insulator
- Frequency Random range: 0-200Hz <16dB Attenuation
- Amplitude peak: 0.6mm (1.2mm)
- Duration of test: >3min
- Test direction: Orbital in x-y plane (radial to plunger movement)

- Equipment used: Orbital machine, custom made
  Event detector with >30ns sensitivity

Acceptance criteria: No contact interruption >1µs and >1.15V with 0.5A applied

T4: VERTICAL MOTION (Z AXIS)
(Non standard test)

This custom test was also introduced specifically for Spring Loaded Contacts to verify the continuity of the plunger to the contact pad and also check the free movement of the plunger in the shell. The amplitude of the z-axis motion was set to achieve full stroke. Oscillation frequency was varied from zero to 125Hz in order to detect any stickiness or inertia of the plunger.

Test requirements

- Test object: Single pin, no insulator
- Frequency (sine) range: 0-125Hz
- Amplitude max: 1.2 mm
- Duration of test: >3min
- Tested direction: Z axis (axial to plunger movement)
- Equipment used: Membrane based linear oscillation machine
  Event detector with >30ns sensitivity

Acceptance criteria: No contact interruption >1µs and >1.15V with 0.5A applied

T5: VIBRATION (SINUSOIDAL)

This test is used to produce fretting corrosion (wear through the surface gold plating and create localized oxidation of the nickel underplate; ie: dielectric spots). This test verifies the continuity at resonance and continuous shock levels of ±10 G.

Test requirements per IEC 60512-6-4/6d, 60068-2-6/Fc under the following conditions:

- Test object: Assembled part mounted in Standardized Test Block (STB)
- Frequency range: 0-200Hz
- Amplitude max: 8mm
- Duration of test: >3min
- Acceleration peak: 10 G (98.1m/s^2)
- Tested direction: All three (xyz) axes
- Equipment used: Membrane based linear oscillation machine
  Accelerometer ADXL190EM-1
  Event detector with >30ns sensitivity

Acceptance criteria: No contact interruption >1 µs and >1.15V with 0.5A applied, $Accel_{peak}$ >10G

T6: VIBRATION (RANDOM)

Same as sinusoidal, but with all the frequencies inherently present (white noise is the random signal source). This test represents the “mild” continuous shock seen by equipment used or transported in vehicles.

Test requirements per IEC 60512-6-5/6e, 60068-2-34/Fd under the following conditions:

- Test object — Assembled part mounted in Standardized Test Block (STB)
- Frequency range — 0-200Hz <16dB Attenuation
- Amplitude max — 5mm
- Duration of test — >3min
- Acceleration peak — 10 G (98,1m/s^2)
- Tested direction — All three (xyz) axes
- Equipment used: — Membrane based linear oscillation machine
  Accelerometer ADXL190EM-1
  Event detector with >30ns sensitivity

Acceptance criteria: No contact interruption >1us and >1.15V with 0.5A applied, $Accel_{peak}$ >10G

T7: SHOCK (HALF SINUS)

Shock situations put contacts under high stress in both traverse and axial directions. Shock levels greater than 50G can create all sorts of structural damage and misalignment of the contacts. Momentary shock has to be accommodated by the flexibility of the plunger without loss of electrical continuity.

Test requirements per IEC 60512-6-3/6c, 60068-2-27/Ea under the following conditions:

- Test object: — Assembled part mounted in Standardized Test Block (STB)
- Acceleration range: — 50 G minimum (1G = 9.81ms^2)
- Amplitude max: — 0.6mm
- Duration of pulse: — 4-7ms
- Tested direction: — All three (xyz) axes
- Equipment used: — Vertical shock machine 40-90 G range, custom made
  Accelerometer ADXL190EM-1
  Event detector with >30ns sensitivity

Acceptance criteria: No contact interruption >1 μs and >1.15V with 0.5A applied, $Accel_{peak}$ >50G

T8: RAPID CHANGE OF TEMPERATURE

Test requirements per IEC 60512-11-4/11d, 60068-2-14/N, 60068-2-1/A, 60068-2-2/B under the following conditions:

- Test object: — In non-operating condition
- Temperature TB: — -55°C
- Temperature TA: — +125°C
- Duration of one cycle: — 30 minutes
- Number of cycles: — 5
- Test equipment used: — Heraeus 29990 temperature chamber

Acceptance criteria: Measure initial contact resistance prior to T8 (<20 mΩ).

T9: DRY HEAT

Test requirements per IEC 60512-11-9/11i, 60068-2-2/B, under the following conditions:

- Test object: In non-operating condition
- Temperature: +125°C
- Duration of the test: 16 hours
- Test equipment used: Weiss 222/14127 temperature chamber

T10 & T12: DAMP HEAT, CYCLIC

Test requirements per IEC 60512-11-12/11m, 60068-2-30/Db under the following conditions:

- Test object: In non-operating condition
- Relative humidity: 90...100%
- Upper temperature: +55±2°C
- Lower temperature: +25±3°C
- Duration of one cycle: 24 hours
- Number of cycles: 1
- Test equipment used: Weiss 22/13258 temperature chamber

T11: COLD TEST

Test requirements per IEC 60512-11-10/11j, 60068-2-1/A under the following conditions:

- Test object: In non-operating condition
- Temperature: -55°C
- Duration of the test: 2 hours
- Test equipment used: Weiss 6832 temperature chamber

Acceptance criteria: Measure final contact resistance after T11 (<20 mΩ).

T13: CURRENT-CARRYING CAPACITY

Test requirements per IEC 60512-5-1/5a. Temperature rise versus electrical current through a spring-loaded contact was measured under the following conditions:

- Single contact, ion free air
- Contact compressed to half stroke against a gold plated "dead contact"
- Contact connected to a regulated DC power supply through an ammeter
- DC current is maintained constant until thermal stability is achieved at each of the selected current levels
- Micro-miniature thermocouple is placed with thermal compound touching the contact plunger
- Results are an average of 3 contacts tested

Acceptance criteria: No damage to part, max temperature rise recorded at each current step.

Group I: Mechanical test results:

Test	Description	Requirement	Number of pre-cycles				
			0	100k	250k	500k	1000k
T1	Contact force @ mid stroke [grams]	45-85grams	55 √	57 √	56 √	52 √	53 √
T2	Contact Resistance [mΩ]	<20mΩ	7.2 √	6.8 √	7.2 √	6.4 √	6.4 √
T3	Orbital xy motion @ min stroke	<1µs	√	√	√	√	√
	Orbital xy motion @ mid stroke	<1µs	√	√	√	√	√
	Orbital xy motion @ max stroke	<1µs	√	√	√	√	√
T4	Vertical z motion @ max stroke [Hz]	<1µs	125 √	125 √	125 √	125 √	125 √
T5	Vibration sinusoidal x @ min stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal y @ min stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal z @ min stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal x @ mid stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal y @ mid stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal z @ mid stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal x @ max stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal y @ max stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration sinusoidal z @ max stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
T6	Vibration random x @ min stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration random y @ min stroke [G]	≥10G	>10 √	**7 x**	>10 √	>10 √	>10 √
	Vibration random z @ min stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration random x @ mid stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration random y @ mid stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration random z @ mid stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration random x @ max stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration random y @ max stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
	Vibration random z @ max stroke [G]	≥10G	>10 √	>10 √	>10 √	>10 √	>10 √
T7	Shock x axis @ min stroke [G]	≥50G	84 √	N/A	N/A	N/A	N/A
	Shock y axis @ min stroke [G]	≥50G	50 √	N/A	N/A	N/A	N/A
	Shock z axis @ min stroke [G]	≥50G	51√	N/A	N/A	N/A	N/A
	Shock x axis @ mid stroke [G]	≥50G	78 √	82 √	82 √	81 √	79 √
	Shock y axis @ mid stroke [G]	≥50G	51 √	84 √	73 √	84 √	77 √
	Shock z axis @ mid stroke [G]	≥50G	50 √	62 √	76 √	78 √	80 √
	Shock x axis @ max stroke [G]	≥50G	51 √	N/A	N/A	N/A	N/A
	Shock y axis @ max stroke [G]	≥50G	65 √	N/A	N/A	N/A	N/A
	Shock z axis @ max stroke [G]	≥50G	51 √	N/A	N/A	N/A	N/A

Notes:

1. For contact force test (T1), average force of 4 pins out of the 2x4 pin test part

2. For T3, T5, T6 & T7; three spring compression points were compared:
   Min stroke = load of 30 grams
   Mid (half) stroke = load of 60 grams
   Max (full) stroke = load of 90 grams

3. [G] units are peak acceleration: 9.81m/s^2

4. Pass criteria: <1µs: (1 millionth of a second) no electrical interruption
   10 G: minimum 10 G of peak acceleration

5. Test markings: **x (in bold)** = Fail
   √ (check mark) = Pass

6. N/A = not required by standard

Group II: Climatic test results

Initial values of contact resistance before climatic sequence:

	Contact resistance [mΩ]
Average	3.80
Min.	3.0
Max.	5.5
Std. Dev.	0.753
Range	2.5

Final values of contact resistance after climatic sequence:

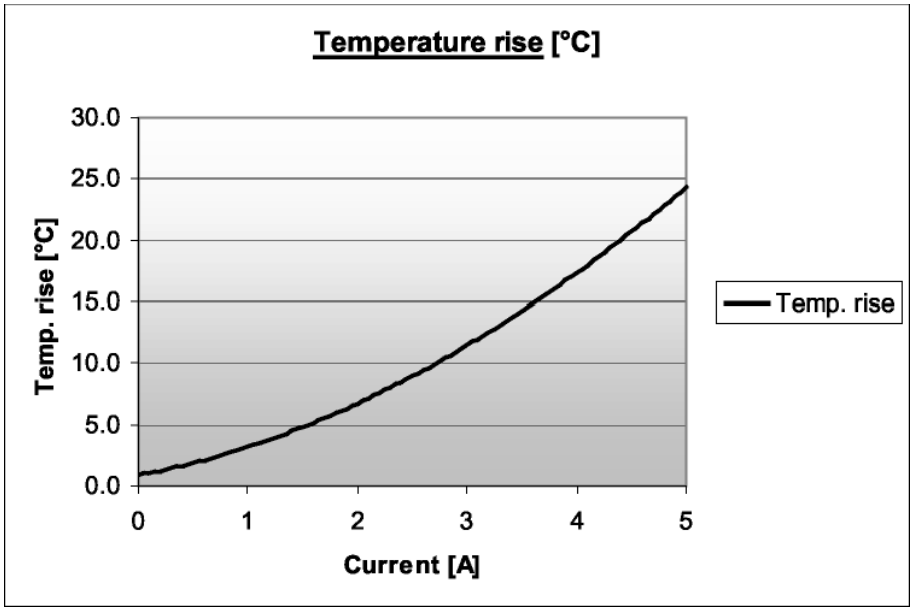
	Contact resistance [mΩ]
Average	3.40
Min.	3.0
Max.	5.5
Std. Dev.	0.810
Range	2.5

No significant change has been detected after the climatic test sequence.

Group III: Current-carrying capacity test results:

			Current [A]					
			0	**1**	**2**	**3**	**4**	**5**
Sample 1	**Ambient**	**Temp. [°C]**	20	20	20	20	20	20
	Component	**Temp. [°C]**	21	22	27	35	46	38
	Delta	**Temp. [°C]**	1	2	7	15	26	18
Sample 2	**Ambient**	**Temp. [°C]**	20	20	20	20	20	20
	Component	**Temp. [°C]**	21	24	26	30	35	42
	Delta	**Temp. [°C]**	1	4	6	10	15	22
Sample 3	**Ambient**	**Temp. [°C]**	20	20	20	20	20	20
	Component	**Temp. [°C]**	21	22	25	31	40	50
	Delta	**Temp. [°C]**	1	2	5	11	20	30

Average	**Component**	**Temp. [°C]**	21.0	22.7	26.0	32.0	40.3	43.3
	Delta	**Temp. [°C]**	1.0	2.7	6.0	12.0	20.3	23.3



Conclusions

Our mechanical test sequence included many industry standard tests as well as two non-standard tests conceived by Mill-Max (T3 and T4). It was our feeling that standard tests alone did not accurately emulate a “real world” condition. We performed the mechanical tests using pre-cycled parts (100k, 250k, 500k, 1million pre-cycles) as well as virgin parts. We also tested our parts at three different stroke positions. The test standard only requires testing be performed at ½ stroke; but we took this a step further by testing at initial load, ½ stroke, and full stroke. By performing these tests under these more difficult circumstances, we are confident that our spring-loaded low-profile contacts are both mechanically and electrically stable.