| Revision History | | |
|---|---|---|
| Revision | Date | Description |
| -- | 3 Jan 07 | 1st Draft Release |
| Draft A | 24 Jan 07 | Added § 19.0, Lead Wire Pull Strength |
| Draft B | 2 Feb 07 | §7.0, is now, "…but the open end of the cable is either not to be submerged or is sealed against water ingress." |
| Draft C | 12 Feb 07 | **1)** Added Table of Contents.<br>**2)** Combined all water jet tests into § 3.0.<br>**3)** Re-numbered all |
| Draft D | 21 Aug 07 | § 15.2, Added Short to Ground test procedure |
| Release | 9 Jul 09 | Release |

## 1.0 Scope

The purpose of this testing is to assure field reliability of electrical and electronic components in the wide variety of environmental conditions experienced in industrial and mobile applications. The goal of both Sun Hydraulics and component suppliers shall be product designs which exhibit world class robustness and reliability for the end customer.

The tests described below are considered comprehensive but not all-inclusive. Sun Engineering and Supplier Engineering are responsible for determining a suitable test program which will ensure trouble free field operation for the end customer.

Wherever practical, components should be tested until failure to determine overall design margin.

Suppliers shall maintain records and data for each test performed. Copies of all data shall be supplied to Sun Hydraulics on a routine basis.

Where conflicts exist between this specification and any referenced industry specification, this specification shall take precedence.

## 2.0 Acceptance Tests

These tests demonstrate basic functionality of the component's insulation system. These tests should be run prior to and after any environmental durability tests.

**2.1.0 Hi Potential ("Hi Pot" or Dielectric) Test.** A high voltage test used to stress the integrity of a component's insulation between the current carrying windings and the component's chassis. Use a suitable dielectric tester. Conduct tests at 20 ± 2° C. Connect one terminal of tester to all the component's terminals together, one terminal of tester to the component's case or other suitable ground. Apply double the normal AC RMS line voltage plus 1500 volts AC RMS. Example: 24 VDC component, apply 1548 VAC. Apply voltage for 5 seconds. Breakdown current not to exceed .001 amps.

**Note: Hi Pot testing can be destructive. Do not provide parts to customers that have been tested more than 2 times total.**

**Note: Embedded electronic assemblies shall not be Hi-Pot tested, only coils that are a part of the assembly.**

**2.1.1 Extended Hi Pot (Dielectric) Test.** Perform section 1.1.0 test with the component submerged in a container of water with a minimum of 1 inch (25 mm) of water covering the uppermost surface of the component's electrical connections. This test shall be run by special request only.

**Note: Extended Hi Pot testing can be destructive. Do not provide parts to customers that have been tested more than 1 time total.**

**Note: Embedded electronic assemblies shall not be Hi-Pot tested, only coils that are a part of the assembly.**

**2.2.0 Insulation Resistance Test.** A high voltage test used to measure the resistance of a component's insulation between the current carrying windings and the chassis. Use a suitable insulation resistance (megohm) tester. Conduct tests at 20 ± 2° C. Connect one terminal of tester to all the component's terminals together, one terminal of tester to the component's case or other suitable ground. Apply 500 VDC for 5 seconds. Insulation resistance shall be 1 megohm minimum.

### 3.0 Water Jet Test

The purpose of this test is to prove that the component is protected against dust and can withstand a pressure water spray or varying intensity.

### 3.1 Water Jet Test (IEC International Standard 60529 IP64)

The purpose of this test is to prove that the component is protected against dust and can withstand a very low-pressure water spray from a distance of 10 feet. Electrical connectors and cables are attached. The component is not energized during the test.

Spray samples with 2.24 gpm ± .11 gpm (10 L/min) at a distance of 11.8 in to 19.7 in on all surfaces. Jet stream should be between 7 psi and 20 psi (0.5-1.5 bar). The test should be run for a minimum of ten (10) minutes. The component is inspected for signs of cracks and water ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test.

### 3.2 Water Jet Test (IEC International Standard 60529 IP65)

The purpose of this test is to prove that the component is protected against dust and can withstand a low-pressure water spray from a distance of 10 feet. Electrical connectors and cables are attached. The component is not energized during the test.

Spray samples with 3.3 gpm ± .165 gpm (15 L/min) at a distance of 8.2 ft to 9.8 ft on all surfaces. The core of the substantial stream should be approximated 1.6 in at 8.2 ft. The test should be run for a minimum of three minutes. The component is inspected for signs of cracks and water ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Nozzle diameter: 6,3 mm

Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test.

### 3.3 Water Jet Test (IEC International Standard 60529 IP66)

The purpose of this test is to prove that the component is protected against dust and can withstand a mid-pressure water spray from a distance of 10 feet. Electrical connectors and cables are attached. The component is not energized during the test.

Spray samples with 26.4 gpm ± 1.32 gpm (100 L/min) at a distance of 8.2 ft to 9.8 ft on all surfaces. The core of the substantial stream should be approximated 1.6 in at 8.2 ft. The test should be run for a minimum of three minutes. The component is inspected for signs of cracks and water ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Nozzle diameter: 12,5 mm

Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test.

See Section 5.0 for IP 67 and 68 tests

### 3.4 High Pressure Test (IEC International Standard 60529 IP69K; DIN 40 050)

The purpose of this test is to simulate high-pressure steam jet cleaning. Electrical connectors and cables are attached. The component is not energized during the test.

Set assembly to rotate at 5 rpm ± 1 rpm. Spray samples with 4.0 gpm ± .26 gpm (15 L/min) at a distance of 4 to 6 inches from the component. The component should be sprayed on all surfaces for 30 second at 0°, 30°, 60°, and 90° from the component center line for a total of two minutes. The spray nozzle pressure should range between 1450 psi to 1160 psi (100-80 bar). Inspect component for signs of cracks and water ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test.

### 4.0 Extended Thermal Shock Immersion Test

The purpose of this test is to attempt to induce cracks in the overmold, the connector housing, light pipes, and potting compound to compromise the integrity of the component windings and the potting compound that encapsulates the electronics. This test is conducted without power applied to the component. Electrical connectors and cables are attached, but the open end of the cable is not heated nor is it immersed.

The component is heated in an ambient temperature of 105° C ± 5° C for coils (85° C ± 5° C for embedded electronics) for two hours, then immersed in a solution of 85% water, 10% liquid detergent, and 5% (table) salt at 0° C ± 5° C for two hours. The component is inspected for signs of cracks and water ingression. The test is repeated for 10 full cycles. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test.

## 5.0 Water Immersion Test (IEC International Standard 60529 IP67 & IP68)

The purpose of this test is to prove that the component is protected against dust and can withstand being submerged in water. Electrical connectors and cables are attached, but the open end of the cable is either not to be submerged or is sealed against water ingress.

IP67: Immerse sample in water 39.4 in (1 m) deep for 30 min. Water temperature = 25 ± 5°C. The component is not energized during the test. The component is inspected for signs of cracks and water ingression. A functional test of the component is then conducted. Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required. If the component passes three immersion cycles, continue to IP68.

IP68: The component is immersed in water 39.4 in (1 m) deep at 25 ± 5°C. The component is then energized as follows:

| Time (hours in a 24 hour period) | % of Nominal Voltage |
|---|---|
| 0 - 4.5 | 95 |
| 4.5 - 5 | 0 |
| 5 - 10 | 105 |
| 10 - 12 | 0 |
| 12 - 14 | 75 |
| 14 - 16 | 105 |
| 16 - 19.5 | 95 |
| 19.5 - 24 | 105 |

This 24-hour cycle is repeated 5 times, for a total of 120 hours. The component is inspected for signs of cracks and water ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test.

## 6.0 Storage Temperature

This test simulates storage at extreme temperatures for a period of time. The component is not energized during the test.

The component is subjected to 105°C for coils (85° C for embedded electronics) and -55°C for twenty hours each. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required. Signs of physical damage or impaired functional test would be cause for test failure.

## 7.0 Chemical Resistance Test

Components will be used in many different types of chemical environments. This test is designed to test the component functionality in these common environments. Electrical connectors and cables are attached. The component is not energized during the test.

12 components will be used for this test. One component will be submerged in each fluid listed below for 5 minutes, at a depth of 6 in. Without cleaning the component, heat 4 hours at 50°C.

Substances:

| | | |
|---|---|---|
| Gasoline | Hydraulic Fluid | Engine Oil |
| Bearing Grease | Antifreeze | Fertilizer; 28% nitrogen with ammonium nitrate and urea at a pH of 5 |
| Diesel Fuel | Phosphate Wash | Degreaser |
| Windshield Washer Fluid | Battery Acid | Sea Water |

Inspect component for signs of cracking, rust, and substance ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, rust, substance ingression, or failure of the functional test would cause a failure of this test.

## 8.0 Free Fall Test

This test is to ensure that handling shock has no impact on component functionality. Electrical connectors and cables are attached. The component is not energized during the test.

The component will be dropped from a height of 1 m to a concrete ground. This test is repeated by dropping the component once on all practical edges and faces. The component is inspected for signs of cracks and water ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

No signs of degradation of performance, cracking or damage are permitted. Or, component must be damaged to a point that it cannot be installed into the final assembly.

## 9.0 Humidity Test

This test is conducted to view the effects of humidity on the operation of the component. Electrical connectors and cables are attached. The component is not energized during the test.

The component is soaked at 40°C and 95% relative humidity for 168 hours (7 days)

The component is inspected for signs of cracks and water ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, water ingression, or failure of the functional test would cause a failure of this test.

### 10.0 Extended Operation Test

This test shows the effect extreme operating conditions by applying operating voltages, humidity and temperature on the component. Electrical connectors and cables are attached.

The component (as installed in final assembly) is placed in an environmental chamber and subjected to the following conditions:

| Time | Voltage | Temperature | Humidity |
|---|---|---|---|
| 0-2.5 hours | 105% | 70°C | 70% |
| 2.5-5 hours | 0 | -40°C | 100% (no humidity control) |
| 5-6 | 105% | 70°C | 70% |

This 6-hour cycle is repeated 100 times, for a total of 600 hours or 25 days. The component is checked every 120 hours (5 days) during the test duration. The component is inspected for signs of cracks, separation of components, induced flaws, rust, and moisture ingression. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, rust or separation of components, induced flaws, or failure of the functional test would cause a failure of this test.

### 11.0 Vibration Test (JIS D 1601-1995 Table 3, Modified, Stage 7)

This test shows the accelerated effects of vibration on the component. This is used to simulate heavy-duty applications. Electrical connectors and cables are attached and secured in a manner similar to the final installed assembly. The component is energized during the test.

X, Y, and Z axis over a frequency of 33.3 Hz at an overall level of 6.8 G's for a total of four hours each. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of separated sub-components, loose parts, induced flaws, or failure of the functional test would cause a failure of this test.

### 12.0 Operational Shock Test

This test shows the effect operating conditions of a vehicle on rough terrain. The test simulates sudden, severe shock. Electrical connectors and cables are attached and secured in a manner similar to the final installed assembly. The component is not energized during the test.

The component and assembly must withstand a 5 ms pulse 490 m/sec$^2$. The test is repeated five times in three perpendicular axes. The component is inspected for signs of cracking, separation of components, and induced flaws. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracking, separation of components, induced flaws, or failure of the functional test would cause a failure of this test.

### 13.0 Corrosion Test (ASTM B117 – 03)

This test shows the effect of operating conditions in a corrosive environment. Electrical connectors and cables are attached. The component is not energized during the test.

The assembly is placed in the salt spray chamber, suspended between 15° and 30° to the vertical. The temperature of the salt spray chamber should be maintained between 35 ± 2° C. The component and assembly must withstand 5% salt solution that is made into a fog. The fog shall be such that for each 12.4 $in^2$ of horizontal collecting area, there will be a collection from 1.0 to 2.0 ml of solution per hour. The component is inspected for signs of rust, corrosion, separation of components, and induced flaws. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

The chamber should be run for a minimum of 24 hours.

Signs of rust, corrosion, separation of components, induced flaws, or failure of the functional test would cause a failure of this test.

### 14.0 Maximum Load Cycling

This test simulates a temperature cycling environment to specifically induce cracks and encourage separation between components of the component. Electrical connectors and cables are attached. The component is energized during the test.

The assembly is placed in an environmental chamber set to 85°C and 105% the nominal voltage for 1 hour. After one hour the power is switched off and then on within a 2 second window. 105% of the nominal voltage is applied for 5 more minutes. The power is again switched off and on within a 2 second window. This cycle is repeated every five minutes for 168 hours (7 days). The component is inspected for signs of cracks, separation of components, and induced flaws. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

Signs of cracks, separation of components, and induced flaws, or failure of the functional test would cause a failure of this test.

## 15.0 Circuit Protection

These tests determine the component's ability to withstand to improper installation without physical damage. Electrical connectors and cables are attached.

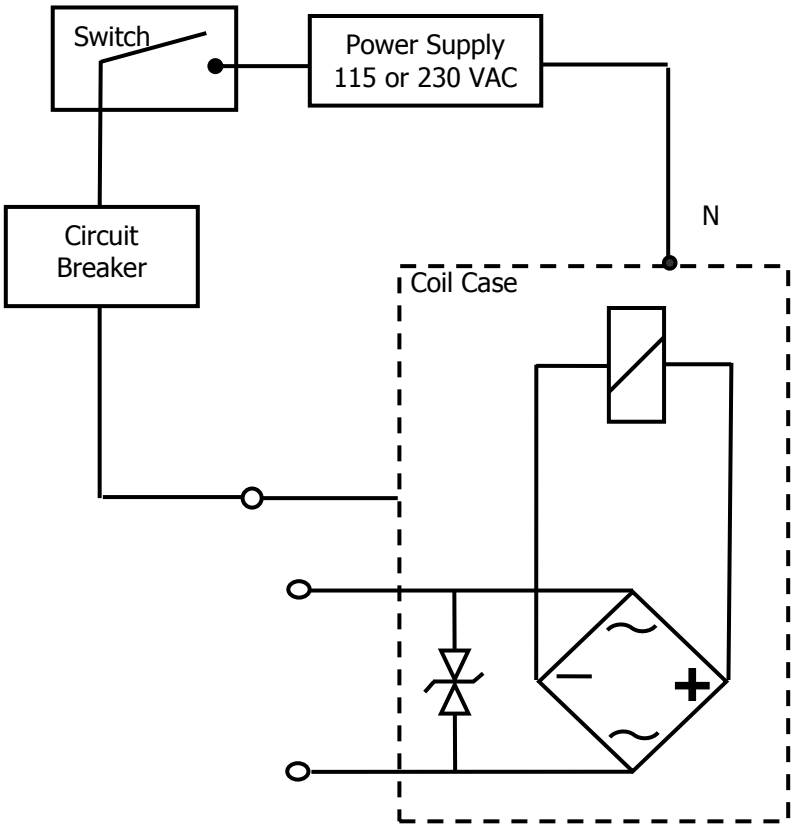
**15.1 Reverse Polarity:** At a temperature of 25 ± 5°C apply typical operating voltage in reverse across the power terminals of the component for 5 minutes minimum. The component may not function with the polarity reversed, but functionality shall return after the polarity is corrected. Perform acceptance tests 2.1.0 and 2.2.0. Perform additional component functional tests as required.

**15.2 Short to Ground:** AC coils only. All components shall be able to withstand continuous short circuit to ground at typical operating voltage and temperature of 25 ± 5°C.

Connect the test coils per the diagram as shown. Install a standard facility-type 20 amp circuit breaker and switch. Set 115 VAC or 230 VAC per normal coil voltage. Close the switch. The breaker should open instantaneously (within ~10 milli-seconds). Open switch and reset breaker. Allow the test coil to cool for 60 seconds minimum.

Repeat test 5 times for each test coil.

Perform acceptance tests 2.1.0 and 2.2.0. The component shall not be functionally or physically damaged after 5 short cycles.



### 16.0 Lead Wire Pull Strength (UL 486)

This test determines the component's ability to withstand to improper handling of lead wires.

**Note: Wire pull testing can be destructive and is intended as a development test only. Scrap all pull test samples.**

At room temperature, measure coil resistance of each test sample and record by unit serial number.

Secure the component in a suitable fixture. Using a suitable linear force tester, apply the pull forces shown in the table to the component's lead wires in the axis of exit from the component's case or chassis. Apply force for 10 seconds minimum.

Resistance shall not vary by more than 5% from the pre-test value. No insulation cracking or other visible damage to the wire or its attachment allowed except due to test fixture restraints. Record pass/fail.

Gradually increase pull force to failure for each sample. Record actual failure pull force. Scrap all test samples after completion.

| Wire Size (AWG) | Min Pull Force (± 0.25 lbs) |
|---|---|
| 22 | 8 |
| 20 | 13 |
| 18 | 20 |
| 16 | 30 |
| 14 | 50 |
| 12 | 70 |
| 10 | 80 |
| 8 | 90 |
| 6 | 100 |
| 4 | 140 |