



TECH NOTE:	11-007
TITLE:	E Coils – Field Assessment
DATE:	03-17-11
REVISION:	1.0

Description: this process describes the field assessment of Hydra Force E Coils in mobile for spreader valves.

Background: Hydra Force E Coils are used in many mobile applications for directional and proportional flow control for motor and cylinder functions. The E coil is designed for long life in severe mobile environments, but care should be taken to protect the coil and cartridge valve stem from physical damage during its life.

No Regular Service: E coils do not require any maintenance and should not be removed from the valve stem unless they are going to be replaced due to failure. Removal of the coil can easily damage or bend the valve stem which will affect valve performance. Use caution with the coil/valve assembly, bent stems will not function properly.

Coil Status: The coil's functional status can be field determined by measuring the coil resistance at the black connector using a multi-meter. **Do not remove the coil to take the measurement, just unplug the valve cable connection.** Acceptable coils are +/- 0.75 ohms from nominal. Baseline resistance values will change over time. **Failed coils will show extremely high (>10 ohms) or extremely low (<1 ohm) resistance measurements.**

ER Coil Part No.	Operating Voltage	Resistance at 20°C
4303212	12 VDC	4.5 ohms

Auger, Spinner & Pre-Wet Coils:



Coil Mounting: coils are held in place by a single nut from the top that must not be tightened more than 20 ft. lbs. **Nominal torque settings are 10-12 ft. lbs. Over tightening can damage the coil or the valve stem underneath.**

Corrosion/Debris: externally mounted valves will accumulate dirt and corrosion over time. The metal casing on the coil is designed to protect the sealed coil inside and is designed to discolor, rust and corrode without affecting the function of the valve assembly. **No regular maintenance (where the coil is removed) should be undertaken.** The coil should be left in place unless the electrical readings indicate the presence of a failed coil.

Series E Environmental Coils

NEW SERIES E WATER-PROOF / WEATHER-RESISTANT SOLENOID VALVE COILS

New Series E coils are the latest innovation in coil technology from Hydraforce. They are designed to meet the demanding requirements of mobile and industrial applications where weather resistance is required. Models with Deutsch DT and Metri-Pack® integral connectors and new dual leadwire models meet or exceed all IP69K standards for weather resistance, offering superior reliability under the most demanding conditions. Series E coils have passed what is known in the construction, agricultural and mobile equipment markets as the "Thermal Shock Dunk Test."

Series E coils feature a new, fully encapsulated coil winding technology. Deutsch and Metri-Pack® connectors are molded into the coil encapsulation, assuring IP69K weather resistance. An external metal shell serves as the element to concentrate the magnetic flux for the coil winding and also functions as a rugged container for the coil. No O-rings or waterproofing kits are required.

Models are available to fit most standard 08, 10, 12, and 16 size valves. In most applications, these coils can be used to retrofit HydraForce valves already in field operation and will offer superior weather resistance.

New Amp Junior Timer Models rated to IP69K are in development

Thermal Shock Dunk Test Rated

Series E coils with leadwires, Deutsch DT and Metri-Pack® connectors have passed what is known in the construction, agricultural and mobile equipment markets as the "Thermal Shock Dunk Test." (See page 3.400.2 for a description of this test.)

Easy Installation

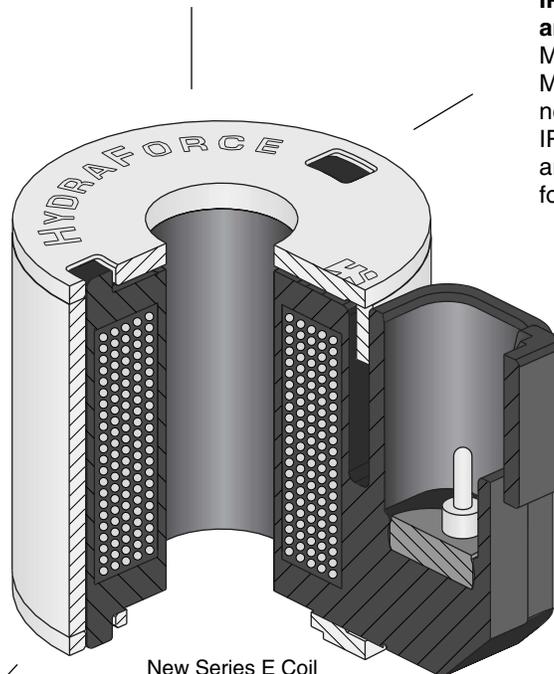
No O-rings, external sealing, or waterproofing kits required.

IP69K Rated with Integral Connectors and with New Dual Leadwires

Models with Deutsch DT and Metri-Pack® connectors as well as the new dual leadwire models are rated for IP69K. DIN and dual spade connections are rated for IP65. (See page 3.400.2 for a description of ratings.)

Fully Encapsulated Windings

Coils are fully encapsulated for zero leak paths when ordered with integral connector options.



Field Retrofit-able

In most cases, Series E coils can be used to replace existing coils on HydraForce valves already in operation.

Shock Resistant

Integral grommet for Deutsch DT connectors increases durability under conditions of high random shock.

Rugged Metal Shell

The rugged external metal shell provides exceptional protection against physical damage, ensuring durability under harsh operating conditions. It is salt spray rated for 96 hours per ASTM B117 specifications.

High Temperature Operation

Class H magnetwire and insulation materials allow high temperature operation and ensure long life under demanding conditions. Continuous-duty operation up to 100°C and 115% of nominal voltage.

NOTE: Some coils, including those manufactured prior to 1-1-04, may differ slightly in construction from this illustration. See page 3.400.15

Series E Environmental Coils

IMPROVING DURABILITY TO ASSURE LONG LIFE IN THE HARSHTEST ENVIRONMENTS

HydraForce has made design changes to the industry-leading environmentally-hardened Series E coils. The new design provides longer life under high-temperature conditions, as well as easier and more convenient interchange with our Series D standard-duty coils.

The Story Behind the Ratings

To appreciate the performance of the new Series E coils, it is helpful to have a working knowledge of the testing conducted to assure coil life in the harshest environments. Many OEMs request a coil that is IP67 or IP69 rated. These ratings do not address the issue of the effect of high temperatures on coil life and operation. Therefore they are of limited value in evaluating the suitability of a coil for use in typical mobile equipment applications.

Why temperature matters: When a coil is heated, the air inside the coil expands, creating internal pressure, causing the heated air to attempt to exit the coil. If the coil is then submerged in cold water, the air within the coil cools and contracts, drawing water into the coil through any seams or voids in the coil encapsulant. Eventually the water will find its way into the winding area, causing the coil winding to corrode or short-circuit, resulting in coil failure.

IP ratings are international specifications for electrical equipment which define various levels of protection against failure resulting from contamination by water or other foreign substances. The IP67 rating is based on submerging the coil in one meter of water for 30 minutes. The coil is then inspected for evidence of water infiltration. The IP67 specification loosely states that "ingress of water in quantities causing harmful effect shall not occur." The exact meaning of the phrase "harmful effect" is not precisely defined, and is therefore open to some interpretation. In this test, the coil is not subjected to high temperatures, so the effects of thermal stress are not considered.

The IP69 rating, which is currently only part of the DIN version of this specification, first requires that the coil pass the test for IP67 as described above. Beyond that, the coil and its integral electrical connector are subjected to a rigorous high-pressure water spray. The water is mixed with detergent, is held at a temperature of 80°C., and is sprayed at the coil from a distance of 100 mm (4 inches) at a pressure of 100 bar (1450 psi). Again, the specification does not precisely define the amount of water ingress that would be considered unacceptable.

DESCRIPTION OF SERIES E COIL RATINGS

**IP69K: Coils with Metri-Pack® connectors (EY option)
Coils with Deutsch DT04-2P connectors (ER option)
Coils with Dual Lead Wires (EL option), and Coils with Leads and Weather-Pack® Connector (EW option)**

The coil is protected against intrusion of dust and high pressure water wash at 1450 psi (100 bar) with the source located 4 to 6 inches (100 to 150 mm) from the coil.

**IP65: Coils with DIN 43650 connectors (EG option)
Coils with Dual Spade connectors (ES option)**

The coil is protected against intrusion of dust and can withstand low-pressure water spray from a distance of 10 feet (3 meters).

HydraForce Ratings

Working with major mobile equipment OEMs, HydraForce has developed even more rigorous tests that are designed to assure that our coils will perform reliably under the harshest real-world application conditions. Both our original and our new Series E coils meet or exceed the requirements of what is known as the "Thermal Shock Dunk Test." In this test the coil is thermally "soaked" for two hours in an ambient temperature of 100°C. The coil is then immersed immediately in a 0°C salt-water bath for two hours. This procedure is repeated ten times. The coil is then inspected for water ingress. By HydraForce's standards, the coil is considered to have passed this test if there is NO detectable water ingress, as determined by visual inspection and a "high pot" test. This standard requires a totally sealed coil that is impervious to moisture infiltration, even under widely varying ambient thermal conditions.

The new Series E coils can now withstand at least 10 cycles of the "Thermal Shock Dunk Test."

In addition to the requirements of the industry-recognized, "Thermal Shock Dunk Test," described above, HydraForce further tests these coils for durability against failure due to vibration, as well as against failure due to the application of voltage above the coil's standard duty rating while it is simultaneously subjected to continually varying ambient temperatures.

Beyond enhancing the durability of the coils, we have decreased the wattage by approximately 10%. This reduces the power consumption and also allows the operating temperature range to be extended. The new design also improves the ease and convenience of interchanging these coils with HydraForce's Series D (standard duty) coils, the original Series E coils, as well as the older "W-style" waterproof option. The new Series E coils use the same retaining nuts as the Series D coils, simplifying interchangeability, inventory and assembly requirements and procedures.

See page 3.400.15 for detailed information describing the differences between the original Series E coils and the new Series E coils, including part number cross-references for the coils, the retaining nuts, and the spacers used on the dual-solenoid valves.

Thermal Shock Immersion Test:

**Coils with Metri-Pack® connectors (EY option)
Coils with Deutsch DT04-2P connectors (ER option)**

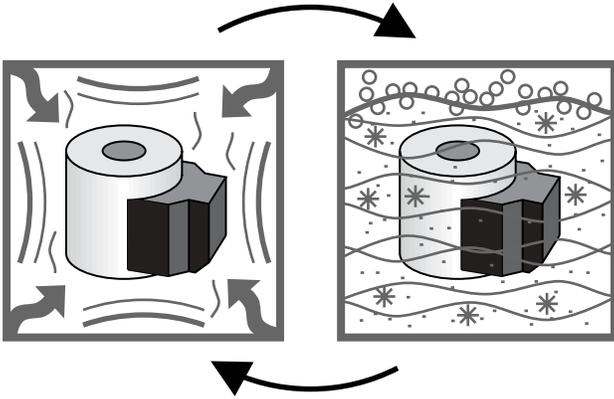
Known in the construction, agricultural and mobile equipment industries as a "thermal shock dunk test," the coil is heated for 2 hours at 105°C, then immediately immersed into 0°C water for 2 hours. No water intrusion into the coil is allowed. This test is repeated for a total of ten trials. The coil is then tested for operational standards.

Metri-Pack® and Weather-Pack® are registered trademarks of Delphi Packard Electric Systems

Series E Environmental Coils

OUR COIL TESTING PROGRAM IS THE MOST STRINGENT AND RIGOROUS IN THE INDUSTRY

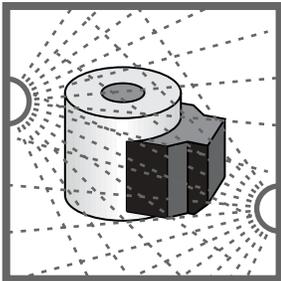
1.) Extended Thermal Shock Immersion Test – IP67 Ref. Exceeds IP67 per standard EN60529



The purpose of this test is to try to induce cracks in the encapsulation of the coil.

The coil is heated for two hours at an ambient temperature of 105°C (±5°C), then immediately immersed in a solution of water, detergent and salt at a temperature of 0° to 5°C for two hours. The coils is then visually inspected for cracks and water penetration. This process is repeated ten times.

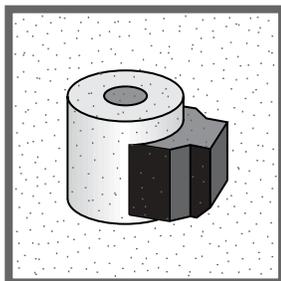
2.) Salt Spray Test DIN 50 021 Level 1 (Ref: Standard ASTM B117)



This accelerated test is designed to simulate the corrosive environment that the coil will encounter during the life of the vehicle.

The coil is subjected to a continuous salt spray as per ASTN B117 for a period of 20 hours. The coil is then rinsed and dried.

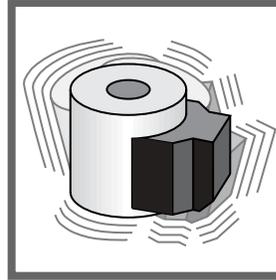
3.) Inorganic Dust Test ANSI/ASAE EP455 Section 5.3



This tests for the effects of dust on the coil.

The coil is placed in a dust chamber containing the equivalent of air cleaner fine dust. Sufficient air movement is provided to maintain a minimum 0.88g per cubic meter with the coil positioned in its normal mounting position. The test is run for a minimum of 24 hours.

4.) Vibration Test



This accelerated test simulates random vibration that the coil will encounter when used on heavy-duty equipment.

Functional performance is monitored under the following vibration levels shown in the table below for 72 hours in each of the three perpendicular axes. The coil is then checked for impaired function, loose parts and fatigue cracks induced by the test.

Vibration Test Profile:

Frequency (Hz)	Measured PSD (G ² /Hz)	Acceleration Factor	Accelerated Test PSD (G ² /Hz)
20	0.422	x 2	0.844
25	0.781	x 2	1.562
76	0.174	x 2	0.348
137	0.00283	x 7.2	0.020374
216	0.00073	x 7.2	0.005256
261	0.00119	x 7.2	0.008568
320	0.00042	x 7.2	0.003024
399	0.0000415	x 7.2	0.000298
626	0.0000265	x 7.2	0.0001908
712	0.000452	x 7.2	0.0032544
799	0.0000491	x 7.2	0.00035352
966	0.00117	x 7.2	0.008424
1424	0.00000965	x 7.2	0.00006948
1597	0.00012	x 7.2	0.000864
1996	0.0000154	x 7.2	0.0001108

Series E Environmental Coils

COIL TESTING PROGRAM (cont'd)

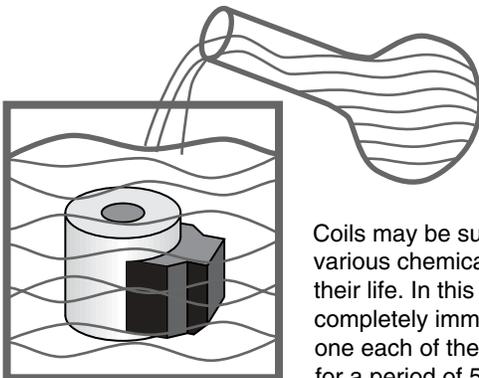
5.) Operating Shock



This test simulates sudden, severe shock induced when the vehicle is driven over rough terrain.

The coil must withstand a 5 ms pulse of 490 m/sec^2 (50 g). Impaired function, loose parts, and fatigue cracks caused by this test result in part rejection. The test is repeated a total of five times in each of the three perpendicular axes.

6.) Chemical Resistance



Coils may be subjected to various chemicals throughout their life. In this test a coil is completely immersed in only one each of the following fluids for a period of 5 minutes.

Twelve coils are used at a time.

After immersion the coils are heated for four hours at 50°C and the cycle is repeated for a total of ten trials. Impaired function as a result of this test is cause for failure.

- Gasoline
- Engine Oil
- Hydraulic Fluid
- 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

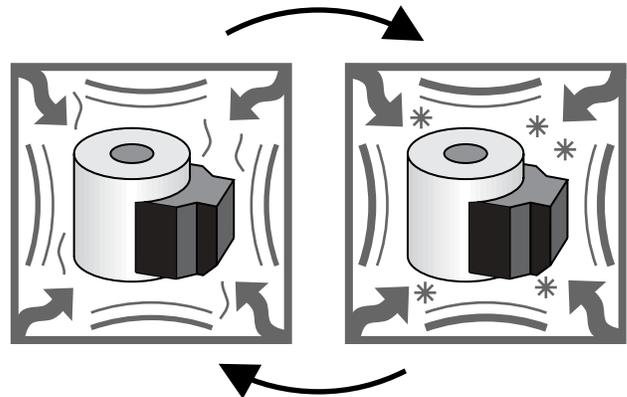
7.) Bench Handling Shock



This test simulates the effects of dropping a coil while it is being handled.

The coil is dropped from a distance of 450mm ($\pm 5\text{mm}$) onto a solid oak bench top at least 44mm thick. The test is repeated by dropping the coil once on all practical edges and faces. Impaired function as a result of this test is cause for rejection.

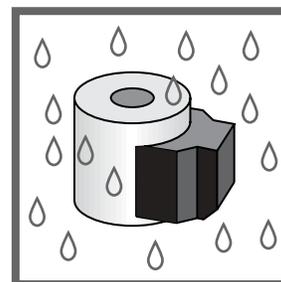
8.) Storage Temperature



This test simulates the effects of storage in extreme temperatures for some time.

While not in operation, the coil is subjected to $+105^\circ\text{C}$ and then -55°C for 20 hours each. Impaired function as a result of this test is cause for rejection.

9.) Humidity



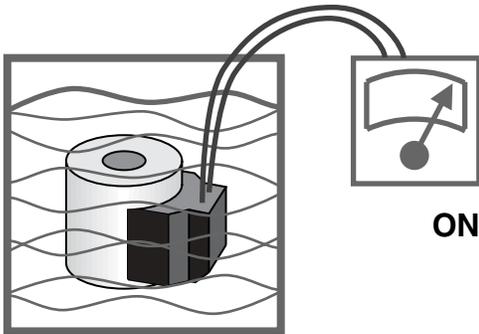
This test simulates the effects of relative humidity on the coil.

The coil is soaked at 40°C and 95% relative humidity for 168 hours each while the coil is not in operation. Impaired function as a result of this test is cause for rejection.

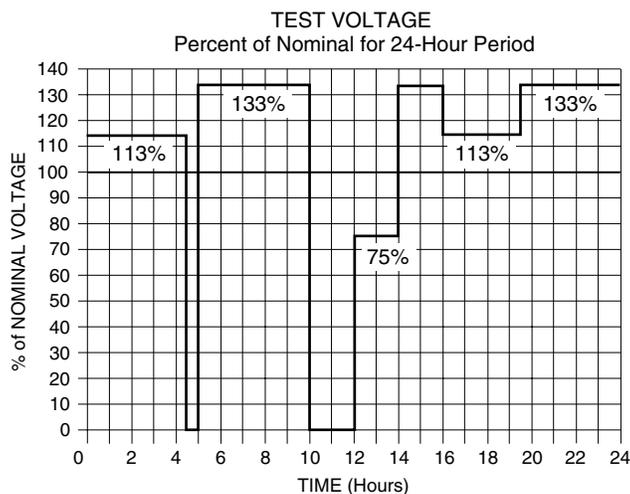
Series E Environmental Coils

COIL TESTING PROGRAM (cont'd)

10.) Continuous Immersion – IP68 Ref. Standard EN60529



In this test the coil is immersed while powered on.
The coil is immersed in 1 meter of water at an ambient temperature of 25°C (±5°C) for 120 hours while powered according to the chart below. Impaired function as a result of this test is cause for rejection.



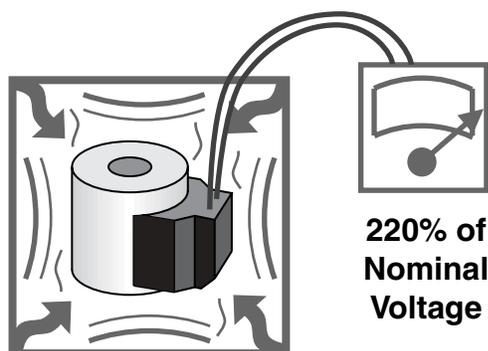
11.) Maximum Load Cycling



This accelerated test simulates temperature cycling to induce cracks or separation between components of the coil.

Coils are installed in an environmental chamber set to 85°C and 133% of nominal voltage is applied for 1 hour. After 1 hour, the power is immediately switched off and back on within 2 seconds. 133% of nominal voltage is then applied for a period of 5 minutes. After 5 minutes, power is immediately switched off and then back on within 2 seconds. This 5-minute cycle is repeated for a total of 168 hours (power is turned off and on within 2 minutes every 5 minutes). Cracks in the encapsulation, separation in components, or impaired function are cause for rejection.

12.) Jump Start



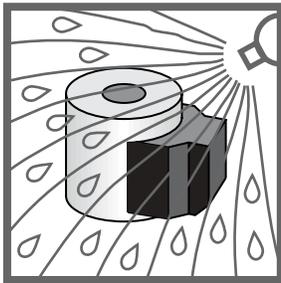
This test simulates the voltage required to jump start heavy equipment.

The coil is thermally soaked in an environmental chamber at 70°C for 2 hours. It is then subjected to 220% of nominal voltage for 5 minutes.

Series E Environmental Coils

COIL TESTING PROGRAM (cont'd)

13.) High Pressure Cleaning – IP69K Ref. Standard DIN 40 050, part 9



This test simulates high-pressure steam-jet cleaning of a component.

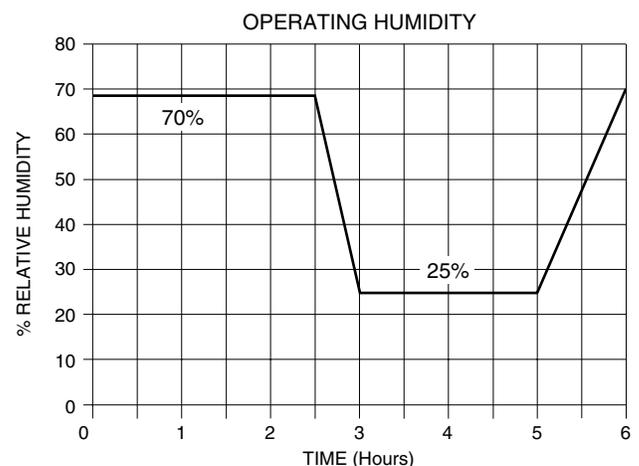
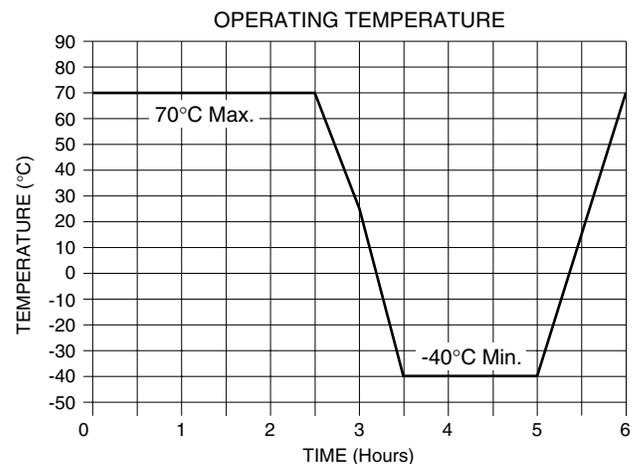
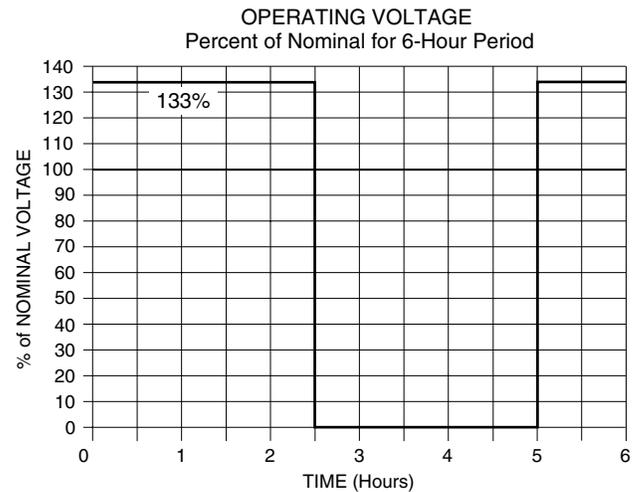
14.) Combined Operating Voltage, Humidity and Temperature



This test simulates the combined effects of some of the previous tests.

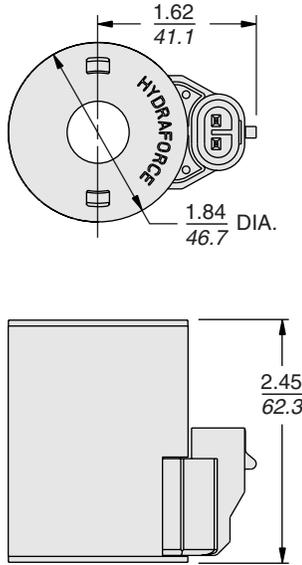
The coil is simultaneously subjected to the voltage, temperature and humidity profiles shown in the graphs below. The cycle is repeated for a total of 600 hours (25 days). The coils are inspected every 20 cycles for cracks in the encapsulation, separation of components, or impaired function as a result of this test. Any induced flaws will result in rejection.

14.) Combined Operating Voltage, Humidity and Temperature (continued)



Series E Environmental Coils

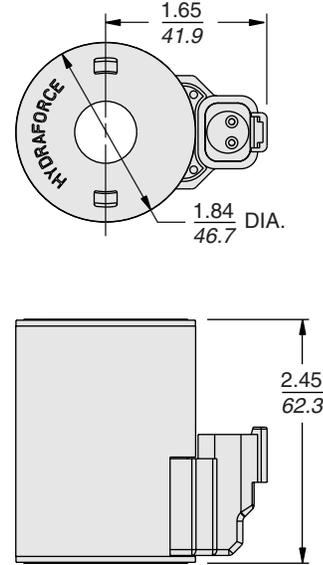
70-SIZE SERIES E COILS



INCH
MILLIMETRE

EY

IP69K Rated Coil
Thermal Shock Dunk Test Rated Coil
Metri-Pack® 150 Connector
 Mating Connector: Delphi Packard No. 12052641



INCH
MILLIMETRE

ER

IP69K Rated Coil
Thermal Shock Dunk Test Rated Coil
Deutsch DT04-2P Connector
 Mating Connector: Deutsch No. DT06-2S
 HF Part No. 4001417

ER Coil Part No.	Operating Voltage	Resistance at 20°C	Initial Current Draw	Power	Coil Weight
4303212	12 VDC	4.5 ohms	2.7 amps	32.8 watts	408 g. (14.4 oz.)
4303224	24 VDC	17.9 ohms	1.3 amps	30.3 watts	408 g. (14.4 oz.)

Please note: Electrical specifications for Series E coils differ from those for standard HydraForce coils. (Refer to page 3.200.1 for standard coil specifications.)

