

1. Design and Features

The tubular solenoids are designed and manufactured to obtain the maximum force output with the minimum of weight and size. Features include a large force output in a small size, minimum flux leakage by design, and a low level of operational noise. The structure consists of a slender cylinder as shown in Fig. 1 and 2. The outside case is a high permeable steel to improve efficiency. Both pull and push type configurations are available as standard.

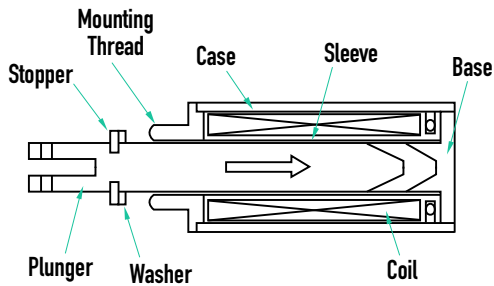


Fig. 1 Pull

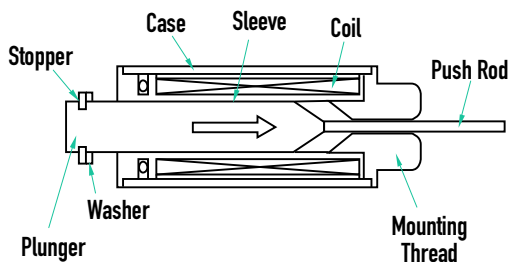


Fig. 2 Push

2. Stroke and Force

The tubular solenoid is designed for longer strokes than the conical push-pull type solenoid. As such, the pole piece designs are conical to maximize performance over longer strokes. To improve efficiency, the solenoid stroke should be minimized in the application.

3. Operational Considerations

A) Temperature

The coil data for tubular solenoids shows the values at ambient temperature 20°C and with a standard heat sink. If a solenoid is used at the ratings shown in the coil data, it is designed so that the coil temperature rises and reaches equilibrium at approximately 85°C. In applications where the ambient temperature is higher than 20°C or the heat sink is smaller than

indicated in the catalog, possible thermal damage can occur. Temperature rise tests should be performed by the customer to assure that the coil does not reach 120°C. Coils can be constructed to operate at temperatures higher than 120°C without thermal damage. Please consult the factory for details.

B) Air Gap Spacer

The tubular solenoid has an air gap spacer installed between the plunger stopper and the case. This spacer is installed to prevent the plunger and base from coming into mechanical contact with each other, which would cause residual magnetism.

C) Return Spring

The tubular solenoid does not include a return spring. Therefore, the application must include a return spring or modification at the factory.

D) Plunger and Shaft Modifications

It is not recommended that the customer modify the plunger or shaft, as the shafts are manufactured and plated at the factory. Any special configurations can be supplied. Please consult the factory for details.

4. General Characteristics

Insulation class	Class E (120°C) Lead wire class A (105°C)
Dielectric strength	AC 1000V 50/60 Hz 1 min. (at normal temperature and normal humidity)
Insulation resistance	More than 100 Mohm at DC 500V megger (at normal temperature and normal humidity)
Expected life	Standard life: 2 million cycles Extended life: 5 million cycles Long life: 10 million cycles

(Solenoid cycle life is very dependent upon side load, frequency of use, and environmental conditions. Cycle life tests should be performed by the customer.)

5. How to Select a Solenoid

Before selecting a tubular solenoid, the following information must be determined:

A) Force

The actual force required in the application should be increased using a safety factor multiplier of 1.5 to arrive at the force value that should be used in your specification.

B) Duty cycle

Use the aforementioned formula to calculate duty cycle. Also note the maximum on time (see page 2)

C) Stroke

Stroke is determined by application requirements.

D) Operating voltage

Operating DC voltage is determined by application and voltage available.

After determining these specifications, one can find the correct size solenoid for the application, using the force-stroke characteristic tables and graphs. The coil data is also shown for different size of magnet wire. If the exact operating voltage is not in the coil data table, use the nearest voltage shown in the table.

NOTE: When the operating voltage falls between 2 coil sizes, always use the higher AWG. numbered coil so as to prevent potential thermal damage. To determine the force output of the solenoid after temperature rise, please use the amp-turn force graphs (page 73) after calculating the amp-turns.

6. Ordering Information

When ordering a tubular solenoid, the correct part number needs to be determined from the following combination of characteristics (1-4):

- (1) M-Metric Thread
 F-SAE Thread
- (2) Solenoid Size (example-130)
- (3) Coil Wire Number (AWG)
- (4) L-Pull, Standard Life
 H-Push, Standard Life
 LE-Pull, Extended Life
 HE-Push, Extended Life
 LL-Pull, Long Life
 HL-Push, Long Life

Example of a complete part number:

(1) (2) (3) (4)
 F 130 35 LL

This part number is for a solenoid with (1) SAE threads, (2) size 130, (3) with 35 AWG coil wire, and (4) long life (coatings on plunger) bearings.

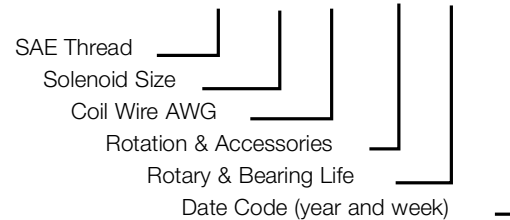
7. Labeling

For tubular solenoids the part number labeling is as follows:

A) Standard Solenoid (no modifications)

The solenoid label will have the part number and the date code (which identifies the year and week of manufacture).

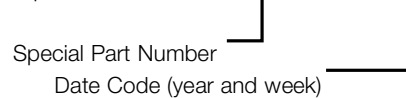
Example: F 490 26 141 R 9801



B) Special Configuration (required for any modification to a standard design)

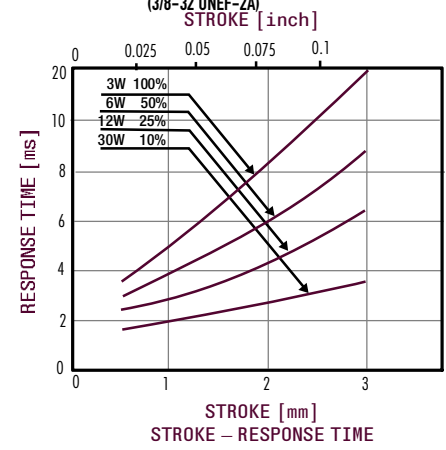
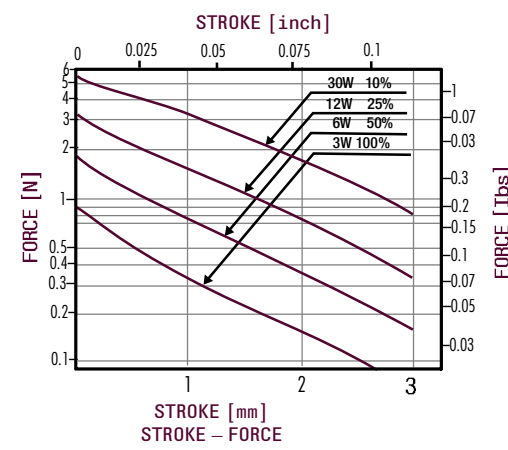
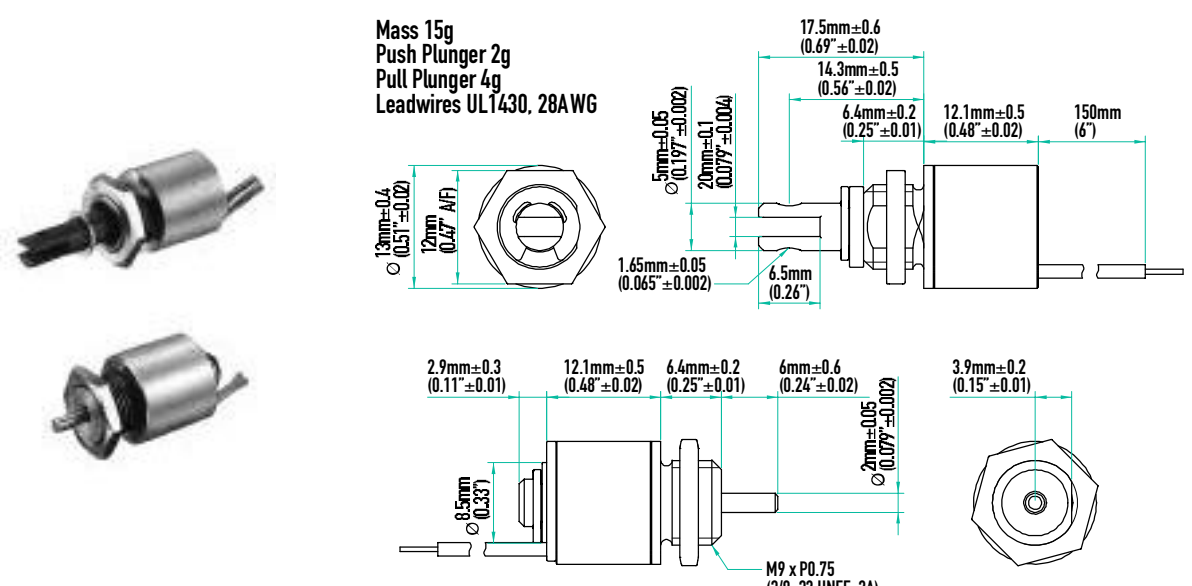
Any change from the standard catalog design requires that a custom part number be assigned which will also include the date code of manufacture.

Example: F94123R 9801



[Size 133 pull, 133 push tubular solenoid]

Unit : $\frac{mm}{(inch)}$
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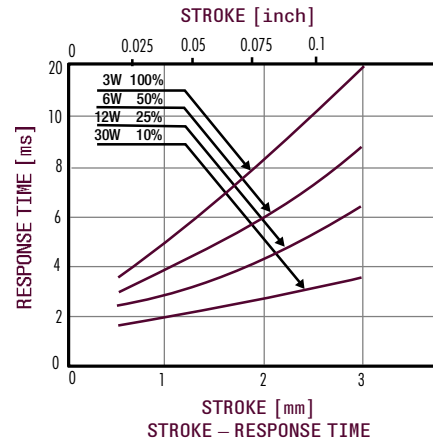
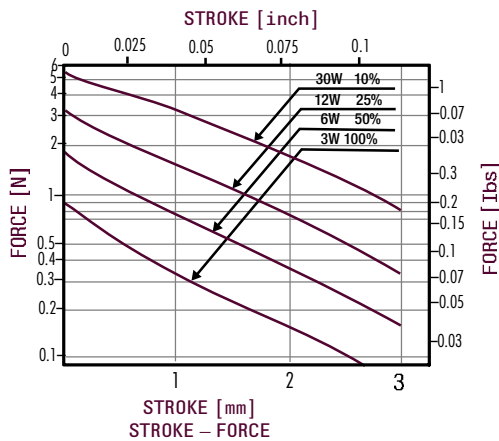
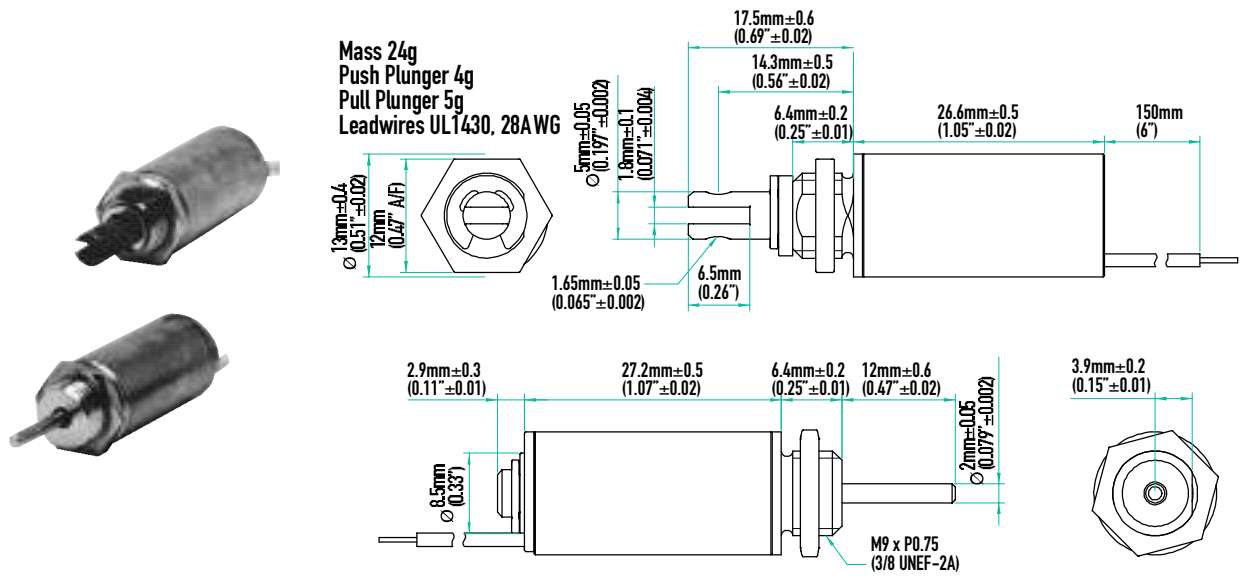
Coil Data

Heat sink : 50x50x3mm aluminum

duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	38	4	1
watts at 20°C			3	6	12	30
ampere-turns at 20°C			232	330	465	735
AWG no.	resistance Ω±10% (at 20°C)	no. turns	volts DC			
29	1.03	141	1.7	2.4	3.4	5
30	1.6	175	2	3	4.3	7
31	2.5	217	2.7	3.8	5.4	9
32	3.9	268	3.4	4.8	7	11
33	6.1	332	4.3	6	9	14
34	9.5	410	5.4	7.7	11	17
35	14.8	506	6.8	10	14	22
36	23.0	625	8.5	12	17	27
37	35.8	770	10.8	15	22	34
38	55.7	949	13.6	19	27	43
39	86.5	1169	17	24	34	54
40	134	1440	21.6	31	43	68
41	209	1774	27	39	55	87
42	324	2184	34.5	49	69	109
43	503	2688	43.5	62	87	137

[Size 130 pull, 130 push tubular solenoid]

Unit : $\frac{\text{mm}}{\text{inch}}$
SHOWN ENERGIZED



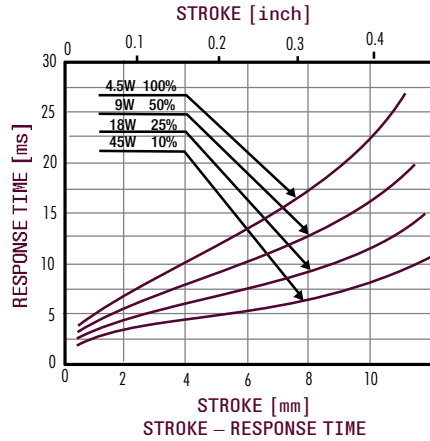
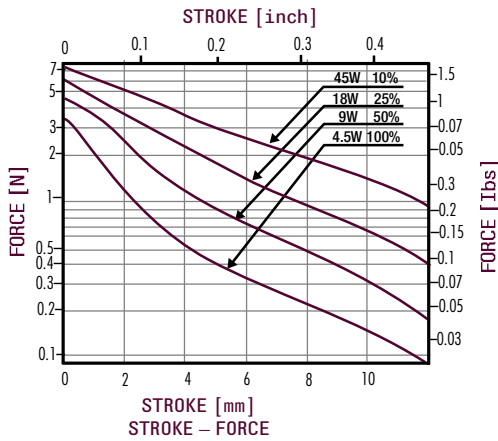
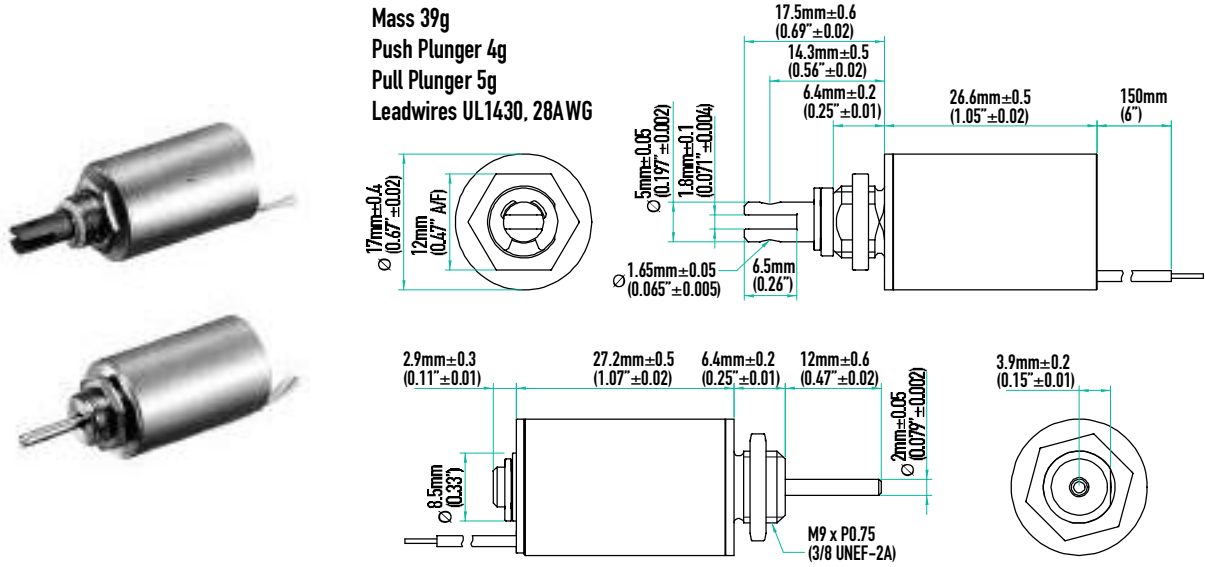
Coil Data

Heat sink : 50x50x3mm aluminum

duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	50	5	2
watts at 20°C			4	8	15	40
ampere-turns at 20°C			453	640	905	1440
AWG no.	resistance $\Omega \pm 10\%$ (at 20°C)	no. turns	volts DC			
29	2.68	372	3.3	4.5	6.5	10.4
30	3.94	426	4.2	5.9	8.4	13.3
31	7.36	632	5.3	7.4	10.5	16.8
32	10.1	704	6.5	9.2	13	21
33	18.1	990	8.3	11.7	16.5	26
34	25.6	1100	10.6	14.9	21	34
35	44.2	1500	13.6	19.2	27	43
36	71.3	1932	16.9	24	34	54
37	99	2170	21	29	41	66
38	159.5	2768	26	37	52	83
39	300	3980	34	48	68	109
40	469	4884	44	61	87	138
41	709	6024	53	75	107	170
42	1152	7784	67	95	134	213
43	1780	9330	87	112	173	275

[Size 170 pull, 170 push tubular solenoid]

Unit : $\frac{\text{mm}}{\text{inch}}$
SHOWN ENERGIZED



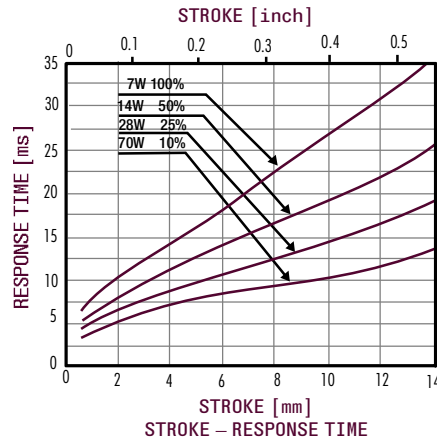
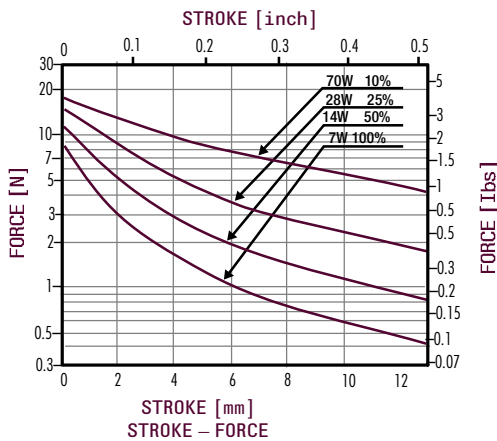
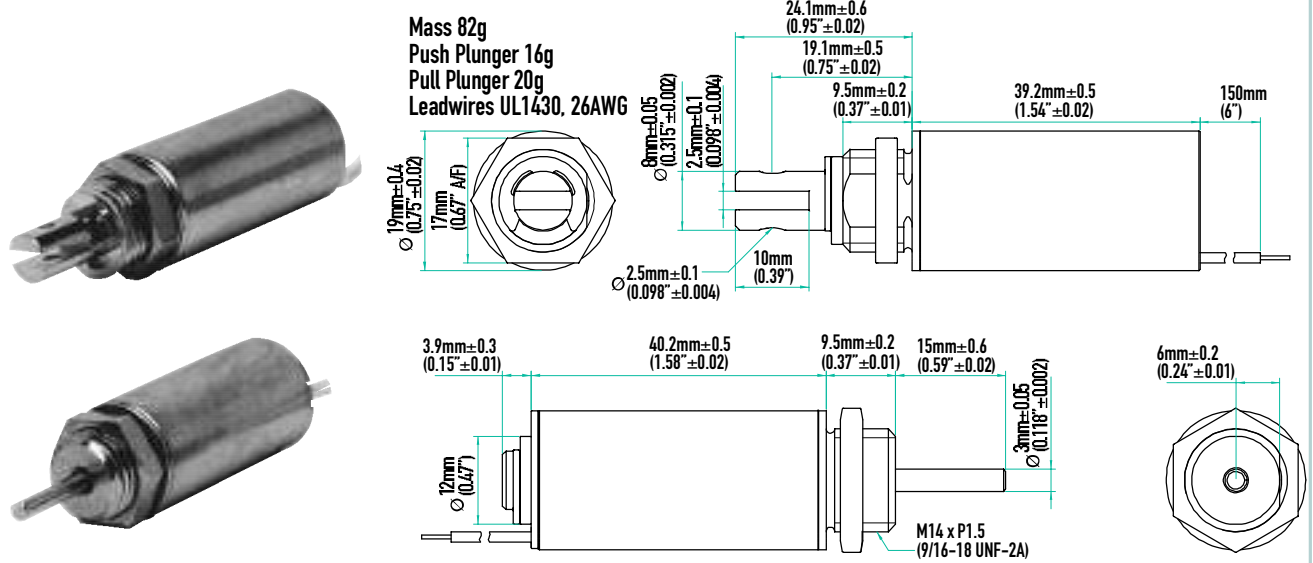
Coil Data

Heat sink : 50x50x3mm aluminum

duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	50	5	2
watts at 20°C			4.5	9	18	45
ampere-turns at 20°C			631	892	1262	1995
AWG no.	resistance $\Omega \pm 10\%$ (at 20°C)	no. turns	volts DC			
27	2.83	520	3.4	4.9	6.9	10.9
28	4.90	695	4.4	6.3	8.9	14.1
29	6.59	760	5.5	7.7	10.9	17.3
30	11.0	985	7.0	10.0	14.1	22
31	18.0	1246	9.1	12.9	18.2	29
32	28.2	1580	11.3	15.9	23	36
33	46.3	2080	14.0	19.9	28	44
34	68.5	2460	17.6	25	35	56
35	119	3260	23	33	46	73
36	177	3700	30	43	60	95
37	280	5000	35	43	60	95
38	408	6000	43	61	86	136
39	715	8080	56	79	112	177
40	1108	9700	72	102	144	228
41	1763	12000	93	131	185	293

[Size 190 pull, 190 push tubular solenoid]

Unit : $\frac{\text{mm}}{\text{inch}}$
SHOWN ENERGIZED

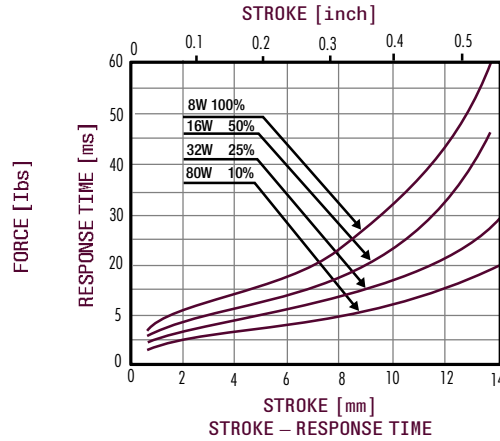
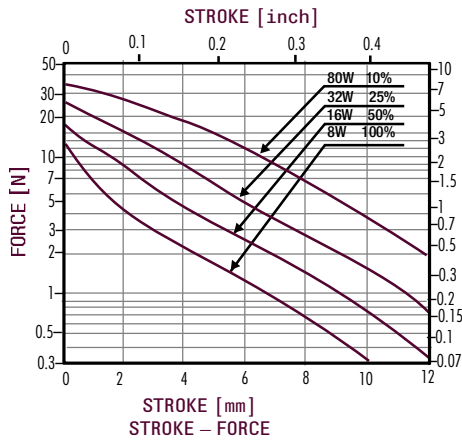
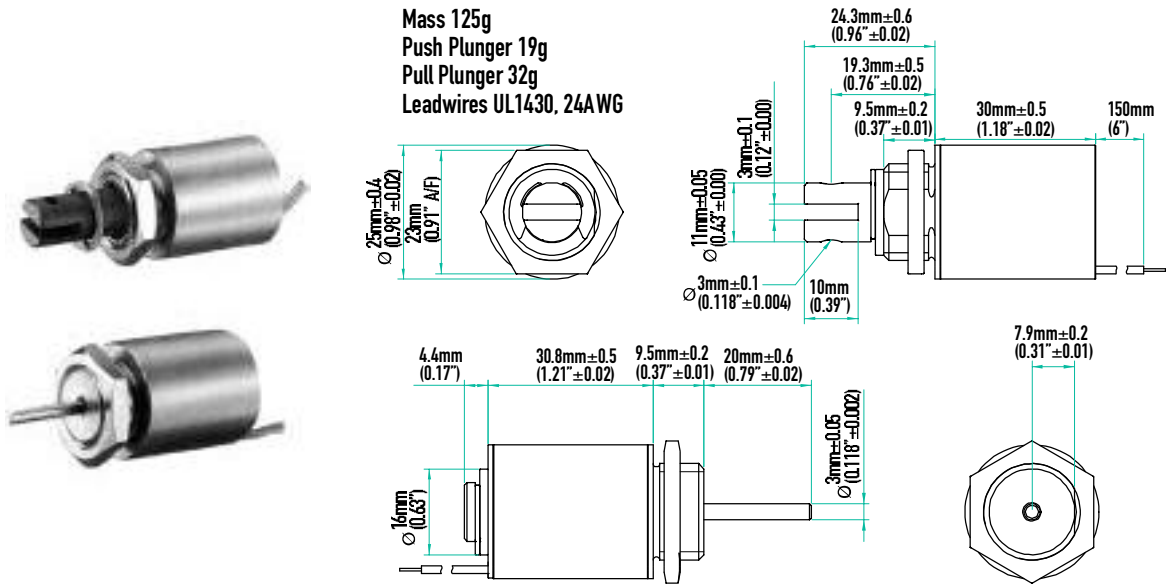


Coil Data

Heat sink : 80x80x3mm aluminum

duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	230	25	6
watts at 20°C			7	14	28	70
ampere-turns at 20°C			760	1075	1520	2403
AWG no.	resistance $\Omega \pm 10\%$ (at 20°C)	no. turns	volts DC			
25	1.65	372	3.4	4.9	6.9	10.9
26	3.10	551	4.4	6.2	8.7	13.8
27	4.33	615	5.4	7.7	10.9	17.2
28	7.78	870	6.9	9.8	13.8	22
29	10.7	960	8.6	12.2	17.2	27
30	18.6	1308	11	15.6	22	35
31	30.9	1722	13.9	19.6	28	44
32	41.6	1890	17	24	34	54
33	69.0	2448	22	31	44	69
34	110	3060	28	39	56	88
35	176	3860	28	39	56	88
36	266	4686	44	62	88	139
37	435	6214	54	77	109	172
38	658	7420	69	97	137	217
39	1135	9792	90	127	180	284

[Size 253 pull, 253 push tubular solenoid]



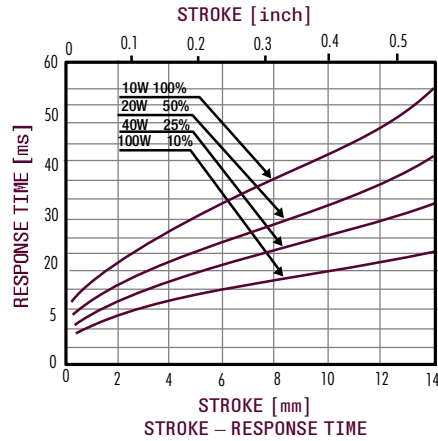
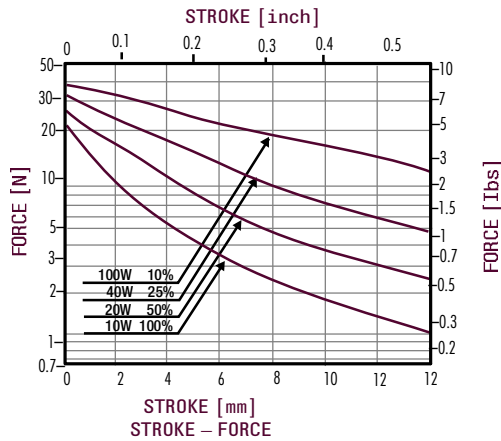
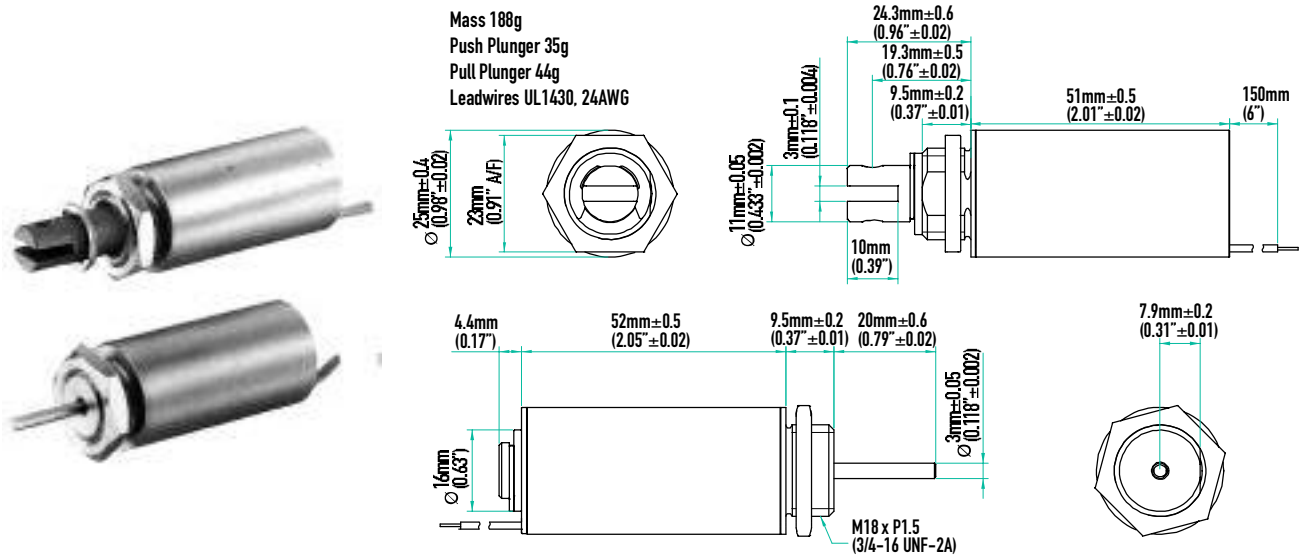
Coil Data

Heat sink : 100x100x3mm aluminum

duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	360	32	8
watts at 20°C			8	16	32	80
ampere-turns at 20°C			666	942	1332	2106
AWG no.	resistance Ω±10% (at 20°C)	no. turns	volts DC			
25	1.91	328	3.9	5.5	7.8	12.3
26	3.49	460	5.1	8.7	12.3	19.4
27	4.79	520	6.1	8.7	12.3	19.4
28	8.27	696	7.9	11.2	15.8	25
29	14.7	910	10.8	15.2	22	34
30	18.6	1020	12.1	17.2	24	38
31	31.3	1360	15.3	22	31	48
32	50.3	1620	21	29	41	65
33	76.8	2060	25	35	50	79
34	121	2570	31	44	63	99
35	207	3350	41	58	82	130
36	308	4100	50	71	100	158
37	490	5100	64	91	128	202
38	720	6000	80	113	160	253
39	1320	8550	103	145	206	325

[Size 250 pull, 250 push tubular solenoid]

Unit : $\frac{\text{mm}}{\text{inch}}$
SHOWN ENERGIZED



Coil Data

Heat sink : 100x100x3mm aluminum

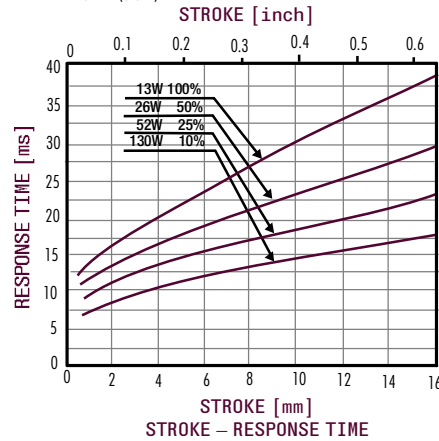
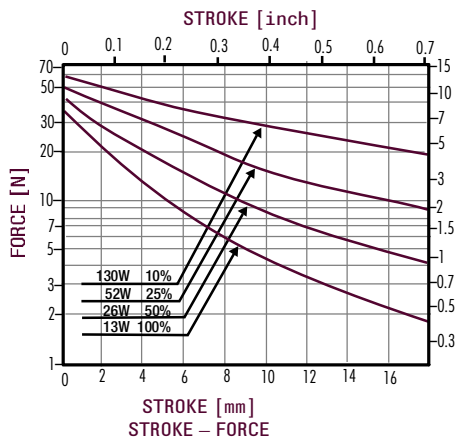
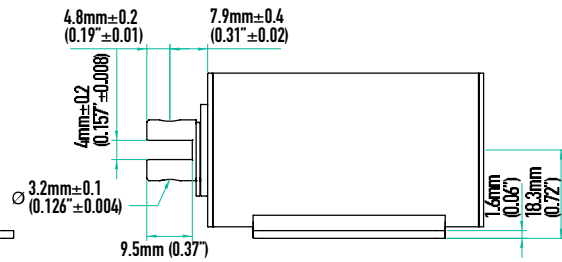
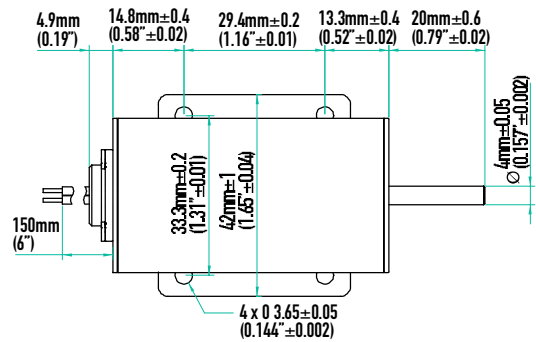
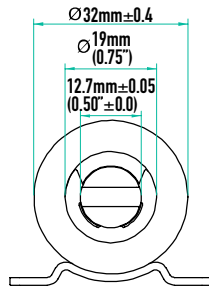
duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	360	32	8
watts at 20°C			10	20	40	100
ampere-turns at 20°C			1090	1541	2180	3447
AWG no.	resistance $\Omega \pm 10\%$ (at 20°C)	no. turns	volts DC			
23	1.49	402	4.1	5.8	8.2	13
24	2.87	600	5.2	7.4	10.4	16.4
25	3.98	672	6.6	9.3	13.1	21
26	7.06	940	8.3	11.7	16.6	26
27	9.83	1050	10.4	14.6	21	33
28	16.9	1415	13.2	18.6	26	42
29	27.0	1820	16.4	23	33	52
30	45.0	2365	21	30	42	66
31	71.6	2990	26	37	53	84
32	107	3660	32	46	65	102
33	172	4550	42	59	83	132
34	265	5550	53	75	106	167
35	443	7310	67	95	134	212
37	1032	11000	104	147	207	328
38	1535	12930	131	185	262	415

[Size 320 pull, 320 push tubular solenoid]

Unit : $\frac{mm}{(inch)}$
SHOWN ENERGIZED



Mass 299g
Push Plunger 53g
Pull Plunger 54g
Leadwires UL1430, 22AWG



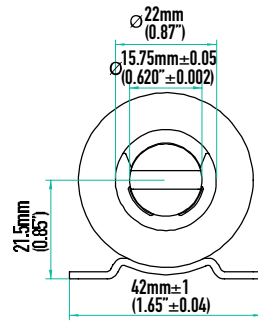
Coil Data

Heat sink : 130x130x3mm aluminum

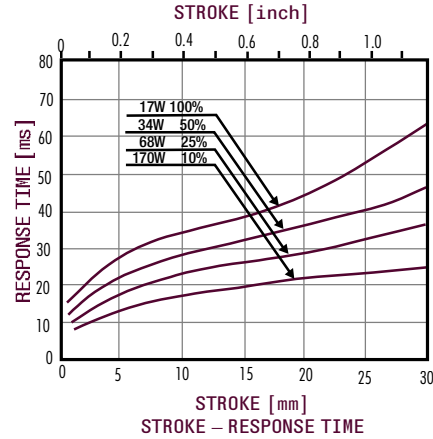
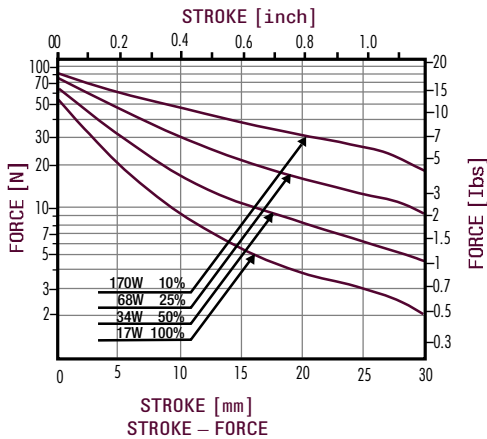
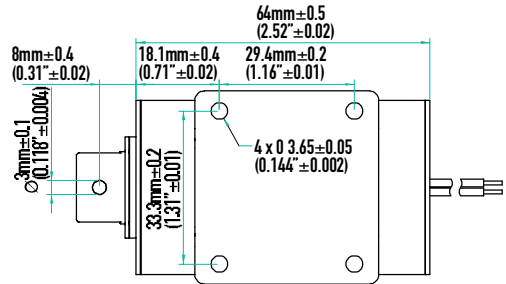
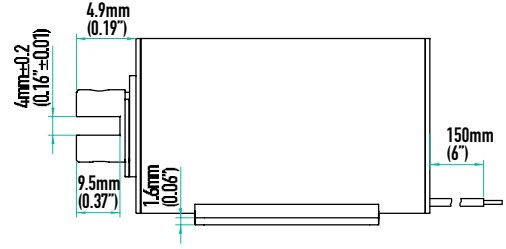
duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	390	60	18
watts at 20°C			13	26	52	130
ampere-turns at 20°C			1500	2121	3000	4743
AWG no.	resistance $\Omega \pm 10\%$ (at 20°C)	no. turns	volts DC			
			4.3	6.1	8.6	13.5
21	1.40	496	4.3	6.1	8.6	13.5
22	2.52	700	5.4	7.7	10.9	17.2
23	3.52	780	6.8	9.6	13.6	22
24	6.04	1056	8.6	12.2	17.2	27
25	8.47	1176	10.9	15.4	22	34
26	14.1	1540	13.8	19.5	28	44
27	22.5	1970	17.3	24	35	55
28	36.1	2484	22	31	44	69
29	55.1	3060	27	38	54	86
30	88.1	3805	35	49	70	110
31	147	5044	44	62	88	139
32	214	5592	54	76	107	170
33	354	7744	69	98	138	218
34	566	9730	88	124	175	277
35	900	12200	111	157	222	351

[Size 380 pull tubular solenoid]

Unit : $\frac{\text{mm}}{\text{inch}}$
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Mass 497g
Plunger 95g
Leadwires
UL1430, 20 AWG



Coil Data

Heat sink : 150x150x3mm aluminum

duty cycle = $\frac{\text{"on" time}}{\text{"on" time} + \text{"off" time}} \times 100\%$			100% continuous	50% or less	25% or less	10% or less
MAX. "on" time in seconds			∞	420	100	25
watts at 20°C			17	34	68	170
ampere-turns at 20°C			1800	2546	3600	5692
AWG no.	resistance $\Omega \pm 10\%$ (at 20°C)	no. turns	volts DC			
19	0.93	432	3.9	5.5	7.8	12.4
20	1.34	488	4.9	6.9	9.8	15.5
21	2.34	680	6.2	8.7	12.3	19.5
22	3.35	770	7.8	11.1	15.7	25
23	5.58	1030	9.8	13.9	19.7	31
24	9.30	1344	12.4	17.6	25	39
25	14.9	1712	15.7	22	31	50
26	24.0	2180	19.9	28	40	63
27	36.9	2680	25	35	50	79
28	58.4	3322	32	45	63	100
29	87.5	4008	39	56	79	124
30	148	5292	50	71	101	159
31	224	6360	63	90	127	200
32	344	7956	78	110	155	246
33	554	10070	100	141	199	315