

RERATING

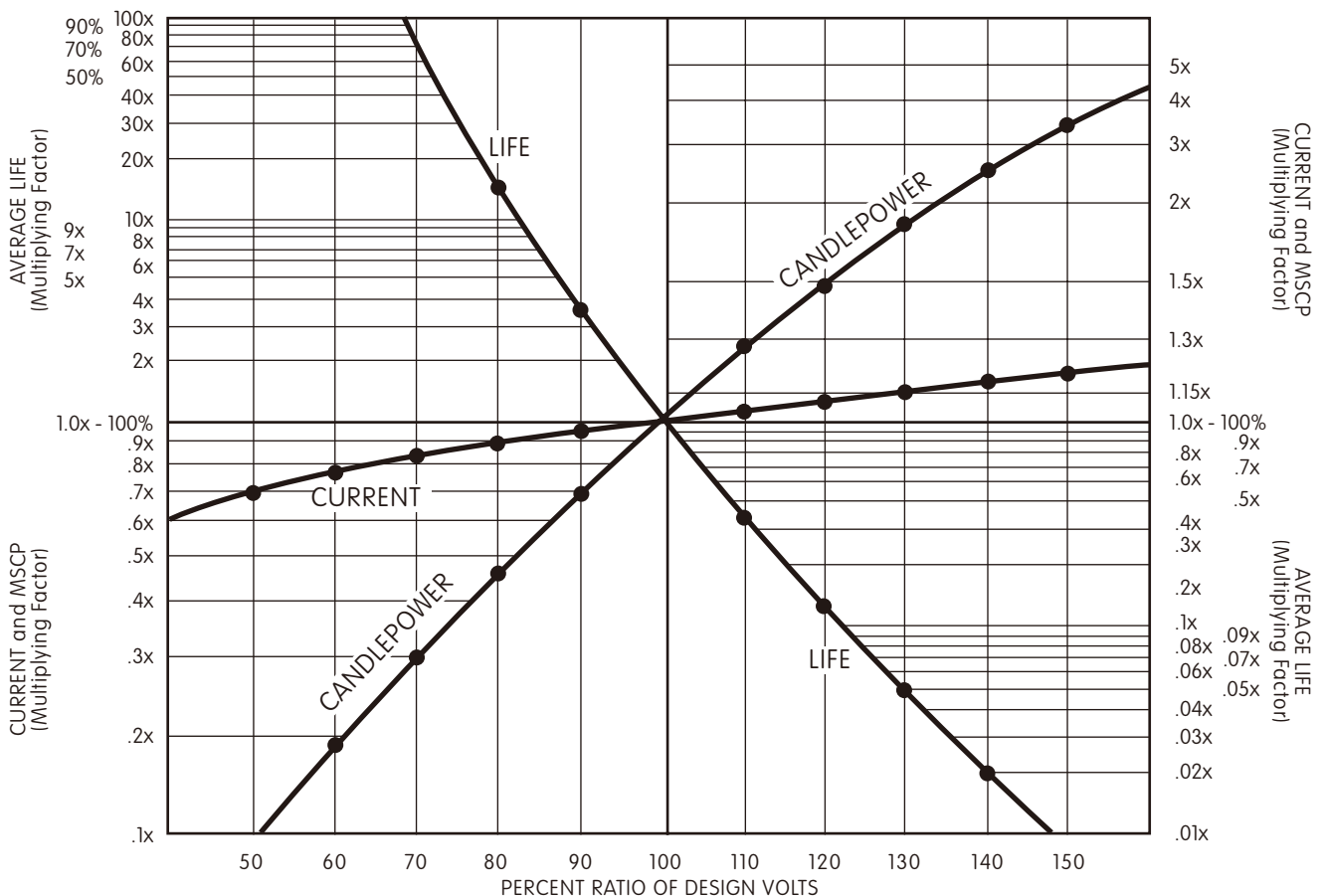
When a lamp is to be operated at a voltage other than the rated or design voltage, the rerated lamp specifications should be calculated to determine suitability for the user's application. The following formulas assist in predicting the rerated effect on luminous intensity, endurance and current. Results are most reliable for applied voltages close to the rated voltage.

$$\text{Rerated MSCP} = \text{Rated MSCP} \times \left[\frac{\text{Applied Voltage}}{\text{Rated Voltage}} \right]$$

$$\text{Rerated Life} = \text{Rated Life} \times \left[\frac{\text{Rated Voltage}}{\text{Applied Voltage}} \right]$$

$$\text{Rerated Current} = \text{Rated Current} \times \left[\frac{\text{Applied Voltage}}{\text{Rated Voltage}} \right]$$

For your convenience, the graph below illustrates the way current, candlepower, and life performance vary with percent changes in applied voltage. The graphed values are typical for miniature and subminiature lamps with the average life based on rated voltages at 60 cycles AC, in room temperature, and under static conditions.



Source: General Instrument Chicago Miniature Brand Incandescent and Neon Lamps, Catalog No. 8400-Rev 1, (Chicago, Illinois: General Instrument Corporation), page 3.

APPLICATION CONSIDERATIONS

LEDs

Light emitting diodes (LEDs) operate at relatively low current and DC voltage levels and have comparatively unlimited service life. Their characteristics do not change significantly with age, and they are not easily damaged by shock or vibration. A variety of NKK's switches and indicators are offered with red,

green, yellow, amber, blue, white, or bicolor (red/green) LEDs.

Most of the LEDs used in our products require a ballast resistor connected in series with the LED. In addition, we offer 5-, 12-, and 24-volt lamps with internal resistors in the YB series.

Incandescent Lamps

Lamp life is determined in a laboratory environment where conditions are near perfect. Actual applications, unlike the test environment, involve many factors which can greatly affect the values listed in lamp specifications. Of all the operating characteristics, lamp life is the least predictable. The lamp filament must deteriorate to produce illumination, and actual life is a function of this unpredictable rate of deterioration. Thus, exact life performance cannot be

determined for any incandescent lamp under any set of conditions.

Lamps perform at their maximum when used at their rated AC voltages or below. There are many known conditions or factors that affect lamp life. Using the lamp in abusive environments such as high ambient temperatures, high shock and/or vibration, constant illumination, and DC voltage accelerates deterioration of the tungsten filament.

Neon Lamps

Neon lamps are low-current, long-life sources limited by the high ionization voltage of neon (≥ 80 volts) for use in line voltage circuits. A series resistor is required in all neon lamps for current limiting. Larger lamps often include an integral resistor sized for a specific voltage.

Neon lamps glow with a low intensity, amber light. Bright light and vivid colors are not obtainable

with neon lamps. Their typical 1.5mA current drain, better than 25,000-hour service life, and good resistance to shock and vibration make them an excellent alternative in many line voltage applications. For best visibility they should be used with clear lenses and diffusers. Other suitable colors are red, orange, yellow, or white.

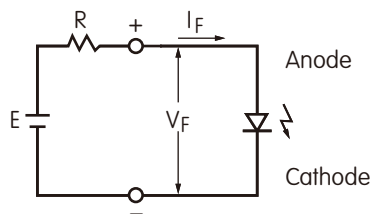
LED & Lamp Part Numbers for Each Series

| PN | Type | Series | PN | Type | Series | PN | Type | Series |
|--------|---------|-----------|-------|------|--------------|-------|------|--------------|
| AT070 | LED | EB M MB24 | AT618 | LED | EB M MB24 | AT630 | LED | HB |
| AT602 | Incand. | LW MLW | AT621 | LED | YB | AT631 | LED | KB LB YB YB2 |
| AT602N | Neon | LW MLW | AT622 | LED | MLW | AT632 | LED | KB LB YB YB2 |
| AT607 | Incand. | LB | AT624 | LED | HB | AT633 | LED | HB |
| AT607N | Neon | LB | AT625 | LED | KB LB YB YB2 | AT634 | LED | KB YB YB2 |
| AT611 | Incand. | KB YB | AT627 | LED | LB | AT635 | LED | KB LB |
| AT615 | Neon | KB | AT628 | LED | YB YB2 | AT636 | LED | KB YB YB2 |
| AT617 | LED | EB M MB24 | AT629 | LED | HB | | | |

Ballast Resistors

BALLAST RESISTOR CALCULATIONS & RECOMMENDATIONS

If the source voltage is greater than the rated voltage of a lamp or LED, a ballast resistor must be connected in series with the lamp. The following circuit diagram and formula will assist in calculating the value of the required ballast resistor.



$$R = \frac{E - V_F}{I_F}$$

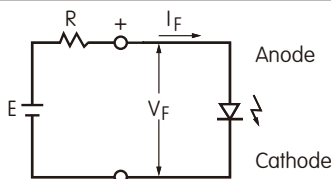
Where: R = Resistor Value (Ohms)
E = Source Voltage (V)
V_F = Forward Voltage (V)
I_F = Forward Current (A)

Watt recommendations provide a margin to reduce heat rise and increase life.

| FORWARD | | SOURCE VOLTAGE | | | | | | | | | | | | | | | | | | | |
|----------------|----------------|----------------|-----|-----|-----|-----|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|
| VOLTAGE | CURRENT | E | | | | | | | | | | | | | | | | | | | |
| V _F | I _F | 5V | | 6V | | 9V | | 12V | | 14V | | 16V | | 18V | | 22V | | 24V | | 28V | |
| V | mA | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W |
| 1.65 | 25 | 130 | 1/4 | 180 | 1/2 | 300 | 1/2 | 430 | 1 | 510 | 1 | 560 | 1 | 680 | 2 | 820 | 2 | 910 | 2 | 1.1K | 2 |
| 1.70 | 30 | 110 | 1/2 | 150 | 1/2 | 240 | 1 | 360 | 1 | 430 | 1 | 470 | 2 | 560 | 2 | 680 | 2 | 750 | 2 | 910 | 3 |
| 1.75 | 40 | 82 | 1/2 | 110 | 1/2 | 180 | 1 | 270 | 1 | 300 | 2 | 360 | 2 | 430 | 2 | 510 | 3 | 560 | 3 | 680 | 3 |
| 1.77 | 20 | 160 | 1/4 | 220 | 1/4 | 360 | 1/2 | 510 | 1/2 | 620 | 3/4 | 750 | 3/4 | 820 | 1 | 1.0K | 1 | 1.1K | 1 | 1.3K | 1.5 |
| 1.80 | 48 | 68 | 1/2 | 91 | 1/2 | 150 | 1 | 220 | 2 | 240 | 2 | 300 | 2 | 330 | 2 | 430 | 3 | 470 | 3 | 560 | 3 |
| 1.85 | 20 | 160 | 1/4 | 220 | 1/4 | 360 | 1/2 | 510 | 1 | 620 | 1 | 750 | 1 | 820 | 1 | 1.0K | 1 | 1.2K | 2 | 1.5K | 2 |
| 1.90 | 8 | 390 | 1/8 | 510 | 1/8 | 910 | 1/4 | 1.2K | 1/4 | 1.5K | 1/4 | 1.8K | 1/4 | 2.0K | 1/2 | 2.4K | 1/2 | 2.7K | 1/2 | 3.3K | 1/2 |
| | 15 | 220 | 1/8 | 270 | 1/4 | 470 | 1/2 | 680 | 1/2 | 820 | 1/2 | 1.0K | 1 | 1.1K | 1 | 1.5K | 1 | 1.5K | 1 | 1.8K | 2 |
| | 16 | 200 | 1/4 | 220 | 1/4 | 430 | 1/2 | 620 | 1/2 | 750 | 1 | 910 | 1 | 1.0K | 1 | 1.2K | 1 | 1.3K | 1 | 1.6K | 1 |
| | 20 | 150 | 1/4 | 200 | 1/4 | 360 | 1/2 | 510 | 1/2 | 620 | 3/4 | 750 | 1 | 820 | 1 | 1.0K | 1 | 1.1K | 1 | 1.3K | 2 |
| 1.95 | 26 | 120 | 1/4 | 160 | 1/2 | 300 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 620 | 1 | 820 | 2 | 910 | 2 | 1.1K | 2 |
| | 15 | 220 | 1/8 | 270 | 1/4 | 470 | 1/2 | 680 | 1/2 | 820 | 1/2 | 1.0K | 1 | 1.1K | 1 | 1.5K | 1 | 1.5K | 1 | 1.8K | 2 |
| | 20 | 150 | 1/4 | 200 | 1/4 | 360 | 1/2 | 510 | 1/2 | 620 | 3/4 | 680 | 3/4 | 820 | 1 | 1.0K | 1 | 1.1K | 1 | 1.3K | 2 |
| 1.96 | 24 | 130 | 1/4 | 160 | 1/2 | 300 | 1/2 | 430 | 1 | 510 | 1 | 560 | 1 | 680 | 2 | 820 | 2 | 910 | 2 | 1.1K | 2 |
| | 16 | 200 | 1/4 | 240 | 1/4 | 430 | 1/2 | 620 | 1/2 | 750 | 1/2 | 910 | 1 | 1.0K | 1 | 1.3K | 1 | 1.3K | 1 | 1.6K | 1 |
| 2.00 | 15 | 200 | 1/8 | 270 | 1/4 | 470 | 1/2 | 680 | 1/2 | 820 | 1 | 910 | 1 | 1.1K | 1 | 1.3K | 1 | 1.5K | 1 | 1.8K | 1 |
| | 20 | 150 | 1/4 | 200 | 1/4 | 360 | 1/2 | 510 | 1 | 620 | 1 | 750 | 1 | 820 | 1 | 1.0K | 1 | 1.1K | 2 | 1.3K | 2 |
| | 24 | 120 | 1/4 | 160 | 1/2 | 300 | 1/2 | 430 | 1 | 510 | 1 | 560 | 1 | 680 | 2 | 820 | 2 | 910 | 2 | 1.1K | 2 |
| | 25 | 120 | 1/4 | 160 | 1/2 | 270 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 620 | 2 | 820 | 2 | 910 | 2 | 1.1K | 2 |
| | 26 | 120 | 1/4 | 160 | 1/2 | 270 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 620 | 1 | 820 | 2 | 910 | 2 | 1.0K | 2 |
| 2.07 | 48 | 62 | 1/2 | 82 | 1/2 | 150 | 1 | 200 | 1 | 240 | 1 | 300 | 2 | 330 | 2 | 430 | 3 | 470 | 3 | 560 | 3 |
| | 16 | 180 | 1/8 | 240 | 1/4 | 430 | 1/2 | 620 | 1/2 | 750 | 1/2 | 910 | 3/4 | 1.0K | 3/4 | 1.3K | 1 | 1.3K | 1 | 1.6K | 1 |
| 2.10 | 15 | 200 | 1/8 | 270 | 1/4 | 470 | 1/2 | 680 | 1/2 | 820 | 1/2 | 1K | 1 | 1.1K | 1 | 1.3K | 1 | 1.5K | 1 | 1.8K | 1 |
| | 20 | 150 | 1/4 | 200 | 1/4 | 360 | 1/2 | 510 | 1 | 620 | 1 | 680 | 1 | 820 | 1 | 1.0K | 1 | 1.1K | 1 | 1.3K | 1 |
| | 24 | 120 | 1/4 | 160 | 1/2 | 300 | 1/2 | 430 | 1 | 510 | 1 | 560 | 1 | 680 | 2 | 820 | 2 | 910 | 2 | 1.1K | 2 |
| | 25 | 120 | 1/4 | 160 | 1/2 | 270 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 620 | 2 | 820 | 2 | 910 | 2 | 1.1K | 2 |
| | 30 | 100 | 1/4 | 130 | 1/2 | 240 | 1 | 330 | 1 | 390 | 1 | 470 | 2 | 510 | 2 | 680 | 2 | 750 | 2 | 910 | 2 |
| | 40 | 75 | 1/2 | 100 | 1/2 | 180 | 1 | 270 | 1.5 | 300 | 1.5 | 360 | 1.5 | 430 | 2 | 510 | 2 | 560 | 3 | 680 | 3 |
| 2.15 | 45 | 68 | 1/2 | 91 | 1/2 | 160 | 1 | 220 | 2 | 270 | 2 | 330 | 2 | 360 | 2 | 430 | 3 | 510 | 3 | 620 | 3 |
| | 16 | 180 | 1/8 | 240 | 1/4 | 430 | 1/2 | 620 | 1/2 | 750 | 1/2 | 910 | 3/4 | 1.1K | 3/4 | 1.2K | 1 | 1.3K | 1 | 1.6K | 1 |
| 2.16 | 20 | 150 | 1/4 | 200 | 1/4 | 360 | 1/2 | 510 | 1 | 620 | 1 | 680 | 1 | 820 | 1 | 1.0K | 1 | 1.1K | 1 | 1.3K | 1 |
| | 16 | 180 | 1/8 | 240 | 1/4 | 430 | 1/2 | 620 | 1/2 | 750 | 1/2 | 910 | 3/4 | 1.0K | 3/4 | 1.2K | 1 | 1.3K | 1 | 1.6K | 1 |

BALLAST RESISTOR CALCULATIONS & RECOMMENDATIONS

If the source voltage is greater than the rated voltage of a lamp or LED, a ballast resistor must be connected in series with the lamp. The following circuit diagram and formula will assist in calculating the value of the required ballast resistor.



$$R = \frac{E - V_F}{I_F}$$

Where: R = Resistor Value (Ohms)
E = Source Voltage (V)
V_F = Forward Voltage (V)
I_F = Forward Current (A)

Watt recommendations provide a margin to reduce heat rise and increase life.

| FORWARD | | SOURCE VOLTAGE | | | | | | | | | | | | | | | | | | | | |
|----------------|----------------|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|------|-----|------|-----|------|-----|-----|
| VOLTAGE | CURRENT | E | | | | | | | | | | | | | | | | | | | | |
| V _F | I _F | 5V | | 6V | | 9V | | 12V | | 14V | | 16V | | 18V | | 22V | | 24V | | 28V | | |
| V | mA | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | Ω | W | |
| 2.20 | 20 | 150 | 1/4 | 200 | 1/4 | 360 | 1/2 | 510 | 1 | 620 | 1 | 750 | 1 | 820 | 1 | 1.0K | 1 | 1.1K | 2 | 1.3K | 2 | |
| | 26 | 110 | 1/4 | 160 | 1/2 | 270 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 620 | 1 | 820 | 2 | 910 | 2 | 1.0K | 2 | |
| | 30 | 91 | 1/2 | 130 | 1/2 | 220 | 1 | 330 | 1 | 390 | 1 | 470 | 2 | 510 | 2 | 680 | 2 | 750 | 2 | 820 | 3 | |
| 2.25 | 20 | 150 | 1/4 | 200 | 1/4 | 360 | 1/2 | 510 | 1 | 620 | 1 | 750 | 1 | 820 | 1 | 1.0K | 1 | 1.1K | 2 | 1.3K | 2 | |
| 2.27 | 20 | 150 | 1/4 | 200 | 1/4 | 330 | 1/2 | 510 | 1/2 | 620 | 3/4 | 750 | 3/4 | 820 | 1 | 1.0K | 1 | 1.0K | 1 | 1.2K | 1 | |
| 2.30 | 20 | 130 | 1/4 | 180 | 1/4 | 330 | 1/2 | 510 | 1/2 | 620 | 3/4 | 680 | 3/4 | 820 | 1 | 1.0K | 1 | 1.0K | 1 | 1.2K | 1 | |
| 2.35 | 40 | 68 | 1/4 | 91 | 1/2 | 160 | 1 | 240 | 1 | 300 | 2 | 330 | 2 | 390 | 2 | 510 | 3 | 560 | 3 | 620 | 3 | |
| 2.80 | 20 | 110 | 1/4 | 160 | 1/4 | 330 | 1/2 | 470 | 1/2 | 560 | 1 | 680 | 1 | 750 | 1 | 1.0K | 1 | 1.1K | 1 | 1.3K | 1 | |
| 3.20 | 20 | 91 | 1/8 | 150 | 1/4 | 300 | 1/2 | 470 | 1/2 | 560 | 1/2 | 680 | 3/4 | 750 | 3/4 | 1.0K | 1 | 1.0K | 1 | 1.2K | 1 | |
| 3.30 | 20 | 91 | 1/8 | 150 | 1/4 | 300 | 1/2 | 430 | 1/2 | 560 | 1/2 | 680 | 3/4 | 750 | 3/4 | 1.0K | 1 | 1.0K | 1 | 1.2K | 1 | |
| 3.40 | 20 | 82 | 1/8 | 130 | 1/4 | 300 | 1/2 | 430 | 1/2 | 560 | 1/2 | 680 | 3/4 | 750 | 3/4 | 1.0K | 1 | 1.0K | 1 | 1.2K | 1 | |
| 3.50 | 20 | 75 | 1/4 | 120 | 1/8 | 270 | 1/4 | 430 | 1/2 | 560 | 1 | 620 | 1 | 750 | 1 | 1.0K | 1 | 1.1K | 2 | 1.3K | 2 | |
| | 30 | 47 | 1/8 | 82 | 1/4 | 180 | 1/2 | 270 | 1 | 360 | 1 | 430 | 1 | 470 | 2 | 620 | 2 | 680 | 2 | 820 | 2 | |
| 3.80 | 26 | 47 | 1/8 | 91 | 1/4 | 200 | 1/2 | 300 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 750 | 1.5 | 820 | 1.5 | 1.0K | 2 | |
| | 30 | 39 | 1/8 | 75 | 1/4 | 180 | 1/2 | 270 | 1 | 330 | 1 | 430 | 1 | 470 | 2 | 620 | 2 | 680 | 2 | 820 | 2 | |
| 3.90 | 30 | 36 | 1/8 | 68 | 1/4 | 180 | 1/2 | 270 | 1 | 330 | 1 | 390 | 1 | 470 | 2 | 620 | 2 | 680 | 2 | 820 | 2 | |
| 4.00 | 26 | 39 | 1/8 | 82 | 1/4 | 200 | 1/2 | 330 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 750 | 1.5 | 820 | 1.5 | 1.0K | 2 | |
| | 30 | 33 | 1/8 | 68 | 1/4 | 130 | 1/2 | 270 | 1 | 330 | 1 | 390 | 1 | 470 | 2 | 620 | 2 | 680 | 2 | 820 | 2 | |
| 4.20 | 20 | 39 | 1/8 | 91 | 1/8 | 240 | 1/4 | 390 | 1/2 | 510 | 1 | 620 | 1 | 680 | 1 | 910 | 1 | 1.0K | 1 | 1.2K | 1 | |
| | 30 | 27 | 1/8 | 62 | 1/4 | 160 | 1/2 | 270 | 1 | 330 | 1 | 390 | 1 | 470 | 2 | 620 | 2 | 680 | 2 | 820 | 2 | |
| 4.30 | 20 | 36 | 1/8 | 82 | 1/8 | 240 | 1/4 | 390 | 1/2 | 470 | 1/2 | 560 | 1 | 680 | 1 | 910 | 1 | 1.0K | 1 | 1.2K | 1 | |
| 4.40 | 26 | 24 | 1/8 | 62 | 1/4 | 180 | 1/2 | 300 | 1/2 | 390 | 1 | 470 | 1 | 560 | 1 | 680 | 1.5 | 750 | 1.5 | 910 | 1.5 | |
| 5.00 | 25 | — | — | 47 | 1/8 | 160 | 1/2 | 300 | 1 | 360 | 1 | 470 | 1.5 | 560 | 1.5 | 680 | 2 | 820 | 2 | 1.0k | 2.5 | |
| 5.50 | 12.5 | — | — | 82 | 1/8 | 330 | 1/2 | 160 | 1 | 560 | 1/4 | 910 | 1/2 | 1.1K | 1 | 1.5K | 1 | 1.6K | 1 | 1.8K | 1 | |
| | 25 | — | — | 43 | 1/8 | 160 | 1/4 | 300 | 1/2 | 360 | 1/2 | 470 | 1 | 560 | 1 | 680 | 1 | 820 | 1.5 | 1.0K | 1.5 | |
| | 45 | — | — | 24 | 1/8 | 91 | 1/2 | 160 | 1 | 200 | 1 | 270 | 1.5 | 300 | 1.5 | 390 | 2 | 430 | 3 | 560 | 3 | |
| | 52 | — | — | 20 | 1/8 | 82 | 1/2 | 150 | 1 | 180 | 1.5 | 220 | 1.5 | 270 | 3 | 330 | 3 | 390 | 3 | 470 | 3 | |
| 12.00 | 12.5 | — | — | — | — | — | — | — | — | 160 | 1/8 | 330 | 1/8 | 510 | 1/4 | 820 | 1/2 | 1K | 1/2 | 1.3K | 1 | |
| | 15 | — | — | — | — | — | — | — | — | 150 | 1/8 | 270 | 1/8 | 400 | 1/4 | 680 | 1/2 | 820 | 1/2 | 1.5K | 1 | |
| | 20 | — | — | — | — | — | — | — | — | 100 | 1/8 | 200 | 1/4 | 300 | 1/2 | 510 | 1 | 620 | 1 | 820 | 1 | |
| | 26 | — | — | — | — | — | — | — | — | 82 | 1/8 | 160 | 1/4 | 240 | 1 | 390 | 1 | 470 | 1 | 620 | 1 | |
| 24.00 | 10 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 400 | 1/8 |
| | 13 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 330 | 1/2 |