Set Lighting Technician's Handbook

Film Lighting Equipment, Practice, and Electrical Distribution

HARRY C. BOX

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Harry C. Box

Illustrations by Shawn Murphy and Lisa Cyr

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To my mother and father.

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WF Green: Preferred in Europe for same use as Y-1 (Rosco 3110, Tough WF Green; Lee 213, White Flame Green).

MT2: Used with Y-1 to convert white flame arcs to 3200K. Also used as an amber conversion for HMI and CID lights (Rosco 3102, Tough MT2; Lee 232, Super Correction WF Green to Tungsten; GAM 1570, MT2).

½ MT2: Used with Y-1 to make a partial conversion to tungsten. Light looks slightly yellow to daylight film and slightly blue to tungsten film (Rosco 3115, Tough ½ MT2; GAM 1575, ½ MT2).

¼ MT2: Used with Y-1 to warm the daylight balanced arc slightly (Rosco 3116, Tough ¼ MT2).

MTY: Combination Y-1 and MT2. Reduces UV and converts white flame arcs to 3200K (Rosco 3106, Tough MTY; GAM 1565, MTY).

MT 54: A straw colored gel used to warm the color of white flame arc lights and HMIs (Rosco 3134, Tough MT 54).

YF-101: Green gel used with yellow flame carbons to reduce UV and correct to 3200K (Lee 230, Super Correction L.C.T. Yellow; Mole YF-101).

UV Filter: An almost clear gel used to remove UV from arc and HMI sources (Rosco 3114, Tough UV Filter; Lee 226, UV; GAM 1510, UV Shield).

Fluorescent Lights

Although fluorescent lights have been in existence for many years, until relatively recently cinematographers shunned them. Fluorescents are notorious for their green hue, which is accentuated on film. Colors are further debased under fluorescent lights because many fluorescents do not produce a complete and continuous spectrum of light. A color correction has to be made to match fluorescent sources with any other kind of source. Furthermore, the tubes and ballasts hum, and the light will flicker on film if photographed at other than specific shutter angles and frame rates.

Innovations and improvements have made the use of fluorescents less problematic, and cinematographers have discovered their positive qualities: They are lightweight fixtures that put out soft, controllable light that wraps around the features when the fixture is placed close to the subject and creates a pleasing eye light.

Mobile Fluorescent Fixtures

Manufacturers of lighting equipment make fixtures that hold banks of fluorescent tubes that can be mounted on stands or suspended overhead. Most of these fixtures are equipped with high-frequency ballasts, which eliminate the flicker problem. Table 3.12 lists specifications for some common fluorescent fixtures.

Kino Flo

Kino Flo makes an entire fluorescent lighting system specifically for film production work, utilizing various types of lamps, fixtures, and ballasts (Figure 3.39 and Table 3.13).

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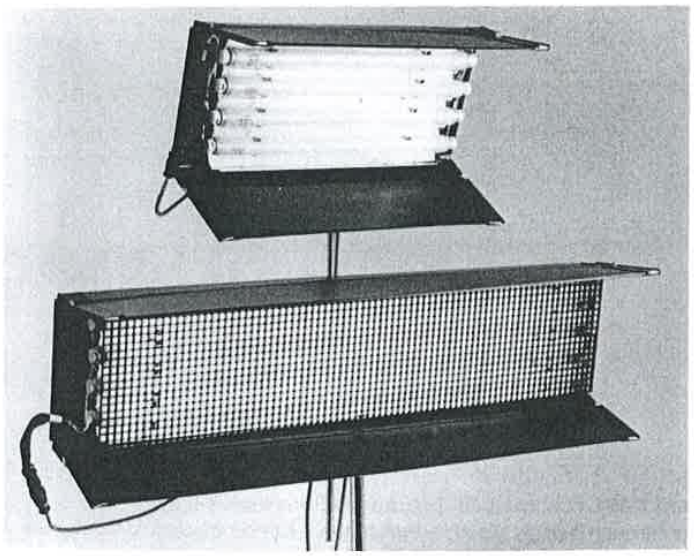
Table 3.12 Fluorescent Fixture Specifications

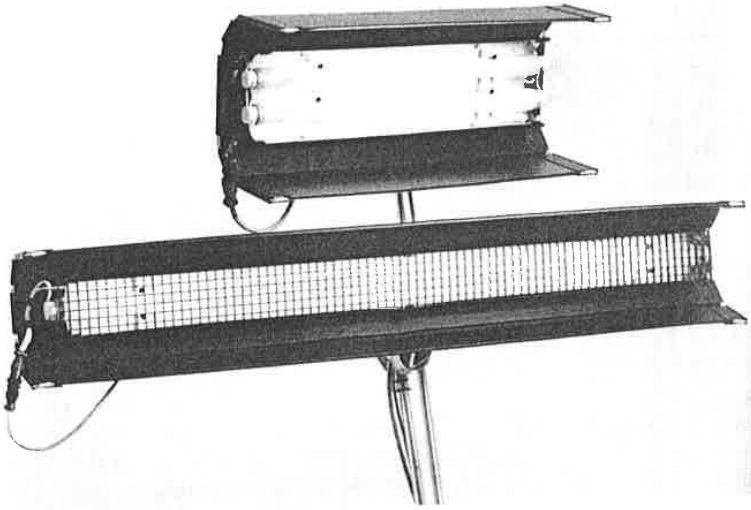
Fixture	*Amperage (A)*	*Voltage (V)*	*No. of Bulbs*	*Type of Bulb*[a]	*Type of Stud*	*Size of Face (in.)*	*Weight (lb.)*
Lowel							
Light-Array	3	120	6	4-ft. T-12	Baby	30 × 54	18
Mole-Richardson							
Eight-tube, 18 in.	2.8	120	8	18-in. T-12	Junior	16.4 × 19	25.25
Four-tube, 4-ft.	1.6	120	4	48-in. T-12	Junior	21.75 × 55.25	42.75
Leonetti (Sunray)							
Four-tube, 4-ft.	5	120	4	48-in. T-12	Baby	8 × 48	23
Eight-tube, 4-ft.	10	120	8	T-12	Baby	16 × 48	36

[a]Length and base type.
[b]Has 25-kHz flicker-free ballast.
[c]Has separate switches for four or eight tubes.
[d]Has high-frequency flicker-free ballast.



A

Figure 3.39 Kino Flo lights: (A) 2- and 4-ft. four-tube fixtures.



B

C

Figure 3.39 Continued. (B) 2-ft. two-tube fixture and 4-ft. single-tube fixture with egg crate louver, (C) single Kino Flo daylight tube (KF-55) attached to harness and shown with single-tube ballast.

D

Figure 3.39 Continued. (D) 12-V DC system with 15-in. fixture, 12-V DC ballast, and clip-on car battery cables.

The ballasts can run either Kino Flo's own lamps (the KF-55) or other commercial lamps such as the Optima 32. The Kino daylight tube has a 5400K color temperature and does not have the green hue present in the color rendering of conventional fluorescent bulbs.

Kino Flo ballasts run at high frequency, resulting in flicker-free operation at any frame rate or shutter setting. The lights turn on instantly, even when cold, requiring no warm-up time. In addition, Kino Flo lighting systems are dimmable to some degree on a variac dimmer. Kino Flo also makes continuously dimmable ballasts for one or two lamps. These ballasts allow the lamp to be restruck instantly at their preset dimmed levels. All Kino Flo ballasts are lightweight and run silently.

The tubes are designed to be versatile and easily controlled for use on a film set. They can be used either in a specially designed fixture (Figure 3.39A and B) or independent of a fixture, fitted with lamp harnesses that attach directly to each lamp end (Figure 3.39C). Because these bare lamps are more vulnerable to breakage, Kino Flo coats the tubes for safety. The coating makes the lamps more durable and ensures that no glass fragments, mercury, or harmful phosphors will be released if the lamp should break.

Kino Flo fixtures come in various sizes, each equipped with a lightweight egg-crate louver that can be used to control the spread and direction of light. The fixture has a snap-on mounting plate for attachment to a C-stand, but because the fixtures are extremely lightweight, they can also be taped or stapled into place.

Text continues on page 99.

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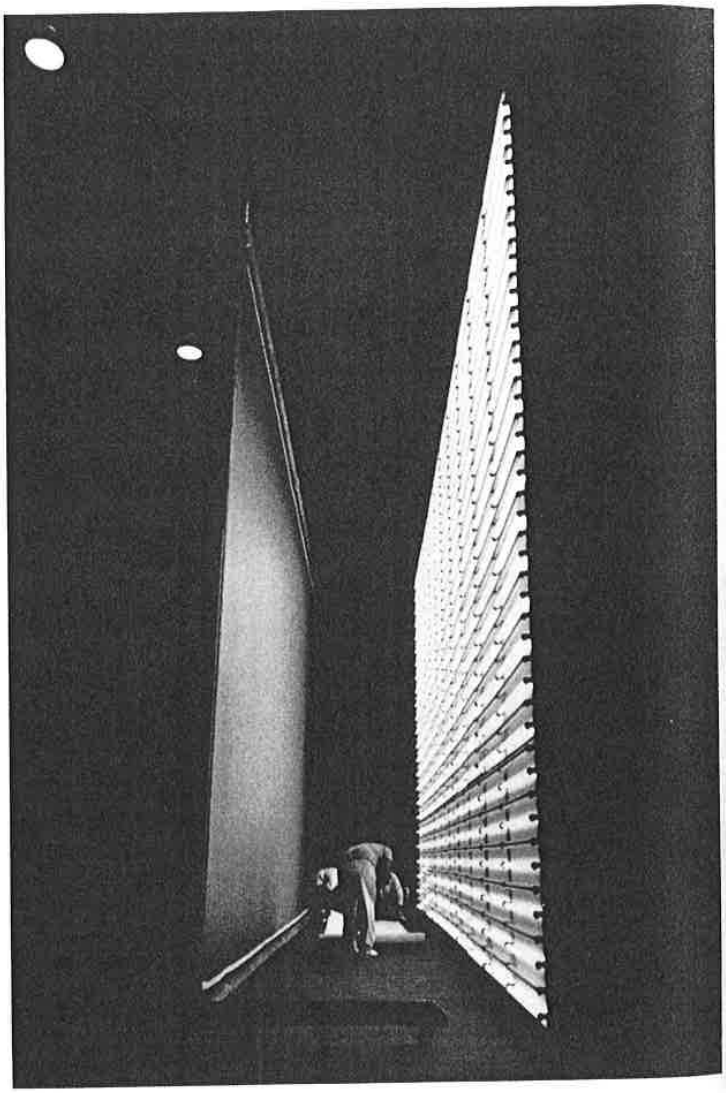
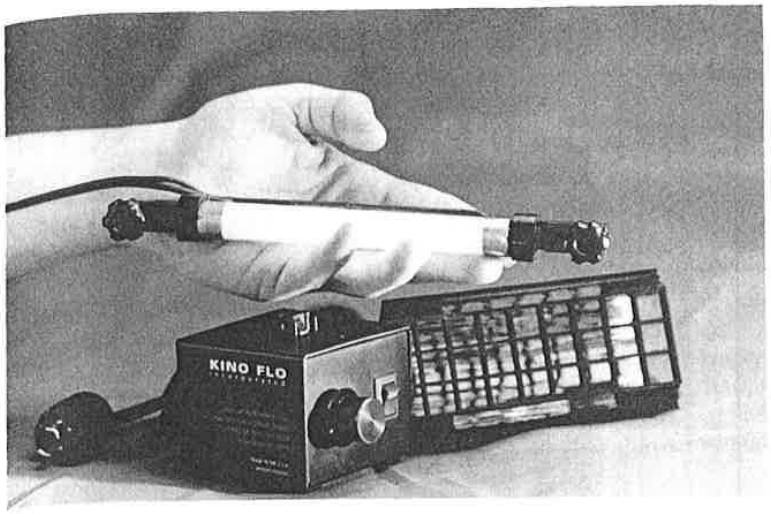


E

Figure 3.39 Continued. (E) rear-lit blue screen for matt photography transpanel system.



G

Figure 3.39 Continued. (F) Mini-Flo, (G) Wall-o-Lite. (Photos courtesy of Kino Flo, Inc., Sun Valley, CA.)

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Table 3.13 Kino-Flo Fixture Specifications

Ballast	*Maximum Amperage (A)*	*Maximum Voltage (V)*	*No. of Tubes*	*Type of Tube*	*Size of Bulb/ Fixture (in.)*	*Type of Stud*
12-V DC Min-Flo	0.8	12 DC	1	T-5	4, 8	Special
12-V DC standard	4.5	12 DC	1	T-12	15, 18, 24, 48	Baby
Single-tube ballast	1.2	120	1	Med. bi-post	15, 18, 24, 48	Baby
				High output	72, 96	Baby
Double-tube ballast	2.4	120	2	Med. bi-post	15, 24, 48	Baby
Four-tube ballast	4.8	120	4	Med. bi-post	15, 24, 48	Baby
Slimline Remote	1.2	120	2	Single pin	72, 96	No fixture
Wall-O-Lite[a]	10.8	120	10	T-12	48	Junior
Rear Transmission Panels (4 × 5 ft.)	2.1	220	12	Med. bi-pin	48	2-in. OD pipe hooks

[a]Has built-in ballast.

Kino Flo also makes a dimmable fluorescent system that runs on 12-V DC power (Figure 3.39D). The 6-, 9-, or 15-in. lamps are ideal in a car scene at night to give the appearance of dashboard light on the driver's and passenger's faces. These units are also ideal for tabletop and miniature photography when used with an optional AC power transformer.

Color Rendition

There are many types of fluorescent tubes, and some have better color rendition than others. Manufacturers provide two ratings to indicate the type and quality of the color rendered by their fluorescent tubes: the correlated color temperature (CCT) and the color rating index (CRI). The CCT and CRI are printed on the packaging of the tubes and sometimes also on the tubes themselves.

Both CCT and CRI are ratings relative to the color perception of the human eye, not the peculiarities of film emulsions. These ratings can be misleading in terms of the color rendering of fluorescent light on film. Experimentation, testing, and experience, rather than CRI and CCT figures, must guide the gaffer, but it is helpful to understand what these figures mean.

Correlated Color Temperature The CCT gives the effective color temperature of the tube to the human eye when the spikes in the color curve are combined together. Fluorescent lights come in various color temperatures. Daylight tubes are designed to light spaces that have supplementary daylight, such as offices with large windows. The light is color-balanced toward the blue end of the spectrum (5000K to 6500K) to blend with the window light. Warm lights, which have a color temperature closer to that of household bulbs (3000K), are for use in enclosed spaces where supplementary light comes from table lamps and wall sconces.

Color Rendering Index The CRI is a rating, from 1 to 100, of the accuracy of a light's rendering of color when compared with a perfect reference source. Daylight, for example, is a perfect 100. Again, this scale is based on how colors appear to the human eye. A high CRI indicates a nearly complete spectrum of light frequencies, but again, these numbers don't truly reflect which light looks better on film. For example, the Optima 32 (CRI 82), which has a color temperature of 3200K, has excellent color rendering on film and requires little or no color correction. A Vitalife 50 (CRI 92), on the other hand, shows a strong green spike on film that must be removed with filtration.

Types of Fluorescent Tubes

Manufacturers make two types of fluorescent tubes: standard fluorescents and full-spectrum (high-CRI) fluorescents.

Standard Fluorescents Standard fluorescent lights are manufactured to maximize lumen output and energy efficiency. They produce two to four times the light output per watt of an incandescent bulb, and they last five to 15 times longer. Because of their high energy efficiency, standard fluorescent tubes are widely used

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in office buildings, warehouses, factories, and commercial buildings. Standard fluorescents have generally low CRI ratings and require considerable color correction (Table 3.14).

Full-Spectrum Fluorescents The ugliness and inaccuracy of the color of standard fluorescents elicited complaints and even studies questioning whether extended exposure to them is healthy. By altering the chemical makeup of the phosphor coating on the inside of the tube, manufacturers developed tubes with higher CRI ratings that have a nearly continuous spectrum of color. Though the high-CRI tubes are less energy-efficient and are more expensive, their color curves are more similar to those of incandescent or daylight sources and they have better color rendition than standard fluorescents. High-CRI lamps generally require less corrective filtering (Table 3.15).

Table 3.14 Standard Fluorescent Bulbs

Lamp Name	*Correlated Color Temperature (K)*	*Color Rendering Index*
Warm White (WW)	3000	52
Deluxe Warm White (WWX), Soft White (SW)	3000	77
Cool White (CW)	4500	62

Table 3.15 Full-Spectrum High-CRI Fluorescents

Lamp Name	*Correlated Color Temperature (K)*	*Color Rendering Index*
Durotest		
Optima 32 (O32)	3200	82
Vita-Lite (VL)	5500	91
GE		
Chroma 50 (C50)	5000	90
IF 27	3000	—
GTE Sylvania		
Design 50 (DSGN50)	5000	91
Kino Flo		
Kino Daylight	5400	—

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Matching and Correcting Color Rendering

A color temperature meter gives a color compensation (CC) reading, which indicates the amount of green or magenta gel needed to balance fluorescent light with another source. A CC reading of +13 green is typical for a cool white bulb, for example. This excess green can be filtered out with a minus-green (magenta) filter. Another type of fluorescent tube might have a +3 green, which would require a quarter minus-green gel. The CC reading allows you to correct these color variations accurately (Tables 3.16 and 3.17).

Matching the Color Temperatures of Mixed Sources

There are three general approaches to matching the color temperatures of fluorescent lights, tungsten lights, HMIs, and daylight: (1) to match all the sources to daylight (5600K), (2) to match all the sources to tungsten (3200K), or (3) to match all the sources to fluorescent daylight (5600K plus green).

Matching to Daylight To remove the green from fluorescent light and balance to daylight, use daylight-balanced tubes with minus-green gel. Minus-green gel has a magenta color that decreases the strength of the green spike in a tube's color curve.

Different types of bulbs require more or less correction. With careful experimentation you can determine whether full, half, quarter, or eighth green best corrects the color rendering.

Table 3.16 Color Compensating (CC) Index and Corresponding Kodak Filter Gel

Colormeter CC Index Reading	*Nominal Equivalent Magenta Gel*	*Nominal Equivalent Green Gel*	*Exposure Change (Stops)*
−13	—	40G	$\frac{2}{3}$
−10	—	30G	$\frac{2}{3}$
−7	—	20G	$\frac{1}{3}$
−4	—	10G	$\frac{1}{3}$
−2	—	5G	$\frac{1}{3}$
+2	5M	—	$\frac{1}{3}$
+4	10M	—	$\frac{1}{3}$
+8	20M	—	$\frac{1}{3}$
+13	30M	—	$\frac{2}{3}$
+18	40M	—	$\frac{2}{3}$

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Table 3.17 Fluorescent Correction Gels

Name	*Rosco Cinegel No.*	*Lee No.*	*GAM No.*	*Nominal CC Equivalent*	*Unfiltered CC Reading*	*Exposure Change (Stops)*
Minus-green	3308	247	1580	30 magenta	+13	1
$\frac{1}{2}$ minus-green	3313	248	1582	15 magenta	+6	$\frac{1}{4}$
$\frac{1}{4}$ minus-green	3314	249	1583	7.5 magenta	+3	$\frac{1}{4}$
$\frac{1}{8}$ minus-green	3318	—	1584	3.5 magenta	+1	$\frac{1}{4}$
Plus-green	3304	244	1585	30 green	−12	$\frac{1}{4}$
$\frac{1}{2}$ plus-green	3315	245	1587	15 green	−5	$\frac{1}{3}$
$\frac{1}{4}$ plus-green	3316	246	—	7.5 green	−2	$\frac{1}{4}$
$\frac{1}{8}$ plus-green	3317	—	—	3.5 green	−1	$\frac{1}{4}$
Fluorescent 5700[a]	—	241	—	—	—	$1\frac{2}{3}$
Fluorescent 4300[b]	—	242	—	—	—	$1\frac{1}{2}$
Fluorescent 3600[c]	—	243	—	—	—	$1\frac{1}{4}$
Fluoro-Filter[d]	3310	—	1590	30 magenta	+13	$1\frac{2}{3}$
Plus-green 50[e]	3306	—	—	30 green	—	$1\frac{1}{4}$

[a]Converts a 3200K source to 5700K (cool white or daylight fluorescents).
[b]Converts a 3200K source to 4300K (white fluorescents).
[c]Converts a 3200K source to 3600K (warm white fluorescents).
[d]Corrects cool whites to 3200K and removes green.
[e]Corrects 3200K source to match cool whites.

Minus-green gel comes in rolls. When gelling fixtures that have frosted plastic panels, you can cut sheets to lay inside each fixture. For bare fluorescent tubes, you can cut the gel to fit inside the clear plastic sleeves that are widely available to protect people in public places in case of lamp breakage.

Once the green is removed, daylight fluorescents will mix with daylight and HMI sources. The scene is filmed with daylight-balanced film or tungsten film with an 85 filter on the lens.

In a room with many large windows, it is best to correct everything to daylight because the alternative, gelling the windows to tungsten, is uneconomical and time-consuming. Gels are expensive. Production managers are always reproaching lighting crews for the quantities of gel they use.

Supplemental lighting is provided by HMI lights or by portable banks of color-corrected fluorescent lights to supplement the ceiling light. Daylight-corrected tungsten lights can also be used, but they are inefficient and tend to be clumsy.

Matching to Tungsten The most common way to match fluorescent lights to tungsten color balance is to replace all the fluorescent tubes with Optima 32 tubes

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(3200K). Alternately cool white or daylight tubes can be converted to 3200K using Fluoro-filter gel. Fluoro-filter, which is orange, reduces the light's output by about one and two-thirds stops. With either treatment, daylight sources (windows and HMIs) must also be corrected to tungsten balance by applying CTO or 85 gel to the sources.

This strategy is best used when (1) the daylight sources are small and manageable (a night scene or a room with small windows), (2) tungsten lights are available for supplemental lighting, and (3) tungsten film is being used.

Matching to Fluorescent Daylight One final way to approach the problem is to apply plus-green gel (full, half, quarter, or eighth, as needed) to all the non-fluorescent sources to match them to the fluorescent tubes. The green is removed from the image by using an FLB filter on the camera lens, or the lab technicians can remove it when they print the film.

Windowgreen gel is applied to windows. Windowgreen reduces the light by three-quarters of a stop. Tungsten lights may be filtered with plusgreen 50, which is blue-green and reduces their output by one and one-quarter to two stops.

This treatment is best used when (1) there are too many fluorescent lights to gel or replace them all, (2) the lights are not easily accessible, or (3) gelling the fluorescent lights would reduce the light level to the point that it would not give an adequate exposure. Mobile banks of fluorescent tubes may be used for supplemental lighting.

Flicker and High-Frequency Ballasts

Although it is not visible to the eye, fluorescent lights flicker 120 times each second. As with HMIs, a camera will record a pulsating light level when the camera speed varies or when the camera speed and shutter angle are not compatible with the cycle of 120 discharges per second. Cameras fitted with wild, non-crystal-controlled motors record a pulsing light level because as the frame rate varies, a frame may receive one discharge more or less than the last.

High-frequency ballasts bypass the problem of intensity fluctuation by converting a 60-Hz input frequency to as much as 20,000 to 40,000 cycles per second. The period of time between the off and on pulse of each cycle is so short that the illuminating phosphors do not decay in light output. The phosphors are essentially flicker-free. High-frequency ballasts solve flicker problems on constructed sets but do not help on locations that have existing banks of fluorescents.

Some Technical Notes

As with HMIs the performance of fluorescent lights is affected by voltage and temperature, and the ballasts have special power considerations.

Effect of Voltage Shifts Voltage shifts do not appreciably affect the color temperature of fluorescents. If the voltage is too low, however, the light will go out completely or will not start. A 10% increase in power will yield a 10% increase in light output but will burn out the ballast sooner if the ballast is not made for the higher voltage.

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Effect of Temperature Fluorescent lamps are sensitive to extremes of temperature. Standard fluorescents are designed for operation above 50° F. Fluorescents operating on high-frequency ballasts will operate in temperatures below freezing. With all fluorescents, even those operating on high-frequency ballasts, the operating temperature affects both the color and the intensity of the light. In freezing conditions, the high-intensity ballast can get the tube started, but it takes a few minutes for the tube to reach to proper color and output. In hot temperatures—or if the tubes are enclosed in an unventilated space—the color will wander toward the blue-green end of the spectrum, and additional color correction may be needed.

Calculating Power Needs The wattage rating on a fluorescent tube is the power consumed by the tube alone. The ballast typically consumes an additional 10 to 20%. Thus, a 40-W tube actually consumes as much as 48 W of power (20% of 40 = 8, 40 + 8 = 48).

Computations of power for large numbers of fluorescent lights are also greatly affected by what is known as reactive current. The fluorescent fixture's reactive current increases its effective wattage. To determine the actual amperage needed, you have to add the power factor of the fixtures to their rated wattage. Reactive current and power factor are explained in Chapter 8.

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CHAPTER 5

Manipulating Light

I can't stand a naked light bulb any more
than I can a rude remark or vulgar action.
Tennessee Williams, *A Streetcar Named Desire*

To achieve the objectives discussed in the previous chapter, the electrician must know how to mold light as a sculptor molds clay. Light has five properties, each of which an electrician can manipulate. They are color, brightness, form, shape and pattern, and movement. The techniques discussed in this chapter are the tools that electricians use to manipulate and control these five properties.

Color

The lighting crew has two goals when it comes to color. The first is the technical process of matching the color temperature of the light sources to each other and to the rated color balance of the film stock. The second is essentially aesthetic: introducing color into the light. The DP uses tints to enhance the mood of the scene, to color the actors' faces and costumes, and to simulate the color of a source, such as fire or a neon sign.

Color Correction

The color of light is determined by the intensity of the various wavelengths that make up the light. The spectrum of visible light is from 380 to 760 nanometers (nm) (Figure 5.1).

As explained in Chapter 3, different light sources have different color balances. Unlike the human eye, film stock cannot adjust to its surroundings. Color rendition is always relative to the color balance of the film stock: either tungsten (3200K) or daylight (5600K). To appear white on film, the color balance of the light must match that of the film. This is accomplished by applying color correction gels, CTO (color temperature orange) and CTB (color temperature blue), to unmatched sources. The gels redistribute the spectrum by reducing the intensity of selected wavelengths in a given source. The basic concept of gelling lights is simple, but it helps to understand color correction in greater depth, starting with the Kelvin and MIRED systems of measurement.

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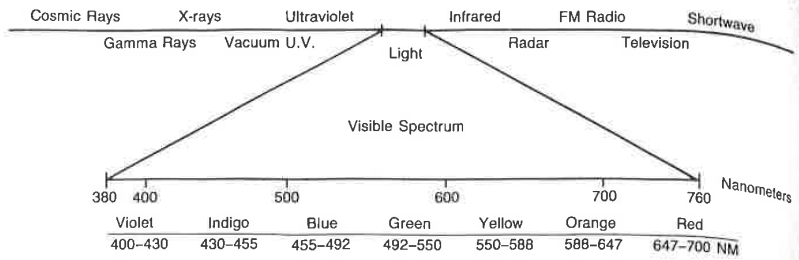

Figure 5.1 The electromagnetic spectrum and the color spectrum.

Kelvin Color Temperature Scale

All light has color. When the full range of wavelengths is combined, the result is said to be *white light*. However, every light source has its own balance of wavelengths. Because the human eye adapts to its surroundings, shifts in balance are not always apparent to the human eye unless one light source is contrasted directly with another. The light on an overcast day is actually bluer than direct sunlight. A tungsten light appears yellow compared to sunlight. White light is relative.

The color makeup of any source that has a continuous spectrum, such as an incandescent light, can be measured on the color temperature scale and quantified in degrees Kelvin. Figure 5.2 shows how the distributions of wavelengths differ for sources of different color temperatures.

The Kelvin scale is based on the idea that light is emitted when a substance is heated—for example, an incandescent filament.* How much it is heated determines the color makeup of the light. When heated a little, it glows red. Heated more, it becomes yellow, then white, then pale blue, and finally brilliant blue.

Table 5.1 shows the color temperature of various sources. You can see that household bulbs are in fact quite yellow (2800K to 2900K). Tungsten bulbs burn slightly cooler (bluer) but are still orange compared to sunlight.

The color makeup of sources that do not have a continuous spectrum—for example, HMIs and fluorescents—can also be given a Kelvin rating: the correlated color temperature. For our purposes, these sources should be measured with a color temperature meter that has both a Kelvin readout and a green/magenta scale. From these readings you can determine what color correction is needed to make the light appear white on film.

MIREDs and MIRED Shifts

When gel manufacturers quantify the effect of a color correction gel, they use microreciprocal degrees (MIRED units), rather than degrees Kelvin. This is because the change in degrees Kelvin of a given correction filter depends on the color

*Scientifically speaking, the Kelvin scale is based on a comparison of the color of a source to the color of a perfect black body when it is heated.

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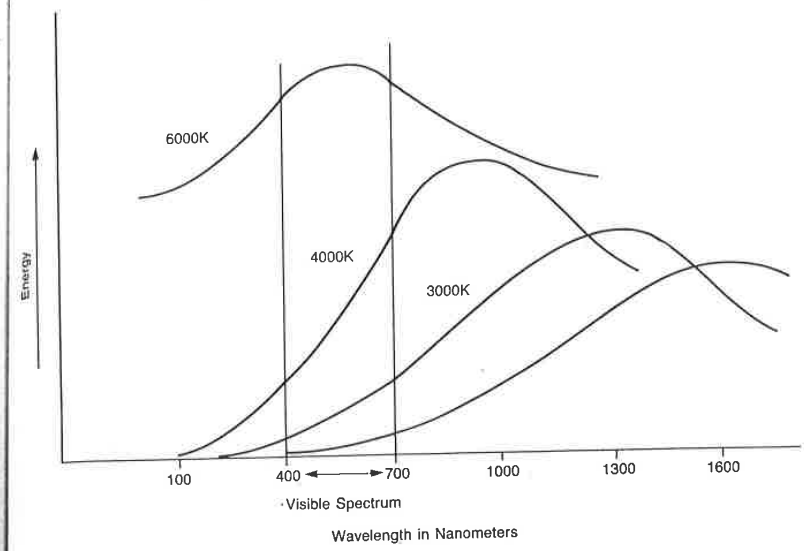

Figure 5.2 Distribution of wavelengths for different sources of light.

temperature of the light source. For example, a gel that alters a 3200K source 200K (to 3400K), when applied to a 5600K source alters the color 650K (to 6250K). MIREDs provide a linear scale on which to calculate the shift of a given gel on any source.

The MIRED value is equal to 1 million divided by the Kelvin color temperature:

$$\frac{1{,}000{,}000}{K} = \text{MIRED value}$$

Table 5.2 gives the MIRED values from 2000K to 6900K.

Note that tungsten color temperature is 312 MIREDs, and daylight is about 182 MIREDs. To correct a daylight source to tungsten, a shift of +130 MIREDs is required. To correct a tungsten source to daylight, a shift of −130 MIREDs is required.

To calculate the MIRED shift needed to get from any Kelvin temperature (K_1) to any other Kelvin temperature (K_2), use the following equation:

$$\text{MIRED shift} = \frac{1{,}000{,}000}{K_1} - \frac{1{,}000{,}000}{K_2}$$

Color Temperature Meter

A color temperature meter gives a Kelvin reading of the light hitting the cell of the meter. It is important to realize that although a cinematographer's color meter, such as the Minolta Color Meter II (Figure 5.3), is calibrated at the factory,

Table 5.1 Color Temperatures of Various Sources of Light

Source	*Color Temperature (K)*	*MIREDs*
Match or candle flame	1900	526
Sunlight, dawn or dusk	2000–2500	500–400
Household bulb	2800–2900	357–345
Tungsten halogen bulb	3200	312
Photoflood bulb	3400	294
Sunlight, one hour after sunrise	3500	286
Sunlight, late afternoon	4500	233
Blue glass photoflood bulb	4800	208
3200K lamp with dichroic filter	4800–5000	208–200
FAY lamp	5000	200
Sunlight, summer	5500–5700	182
White-flame carbon arc light with Y-1 filter	5700	175
HMI light	5600 or 6000	179 or 167
Sunlight with blue or white sky	6500	154
Summer shade	7000	141
Overcast sky	7000	141
Color television	9300	108
Skylight	10,000–20,000	100–50

Table 5.2 Kelvin Scale/MIRED Scale Conversion Table[a]

Color Temperature (K)	*MIRED Value*									
	+0	*100*	*200*	*300*	*400*	*500*	*600*	*700*	*800*	*900*
2000	500	476	455	534	417	400	385	370	357	345
3000	333	323	312	303	294	286	278	270	263	256
4000	250	244	238	233	227	222	217	213	208	204
5000	200	196	192	189	185	182	179	175	172	169
6000	167	164	161	159	156	154	152	149	147	145

[a]To find the MIRED value of 5600K, for example, read across on the 5000 row and down the 600 column.

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Figure 5.3 Minolta Color Meter II. (Photo courtesy of Minolta Corp., Cypress, CA.)

the readings of two identical meters will often vary from one another. This type of color meter is accurate for comparing the color temperatures of several light sources, but no Kelvin reading should be taken as an absolute value. When more than one meter is being used to take readings on the set, the meters should be checked side by side under the same light to determine the amount of variation between them.

Light-Balancing Scale The Minolta color meter automatically calculates the MIRED shift from the Kelvin reading. Minolta calls this shift the *light-balancing (LB) index number*. This number indicates the amount of amber or blue correction gel needed to match the source to the color temperature of the film stock, which must be preset on the meter (3200K, 3400K—which is used for some still film stocks—or 5500K). A chart on the back of the meter gives the LB reading, the Kodak gel number, and the amount of exposure change that the gel requires. MIRED shift values for standard CTO and CTB gels are listed in Tables 5.4 to 5.6.

Color-Compensation Scale The color temperature meter also gives a color-compensation reading that indicates the amount of green or magenta gel needed to balance fluorescent light with a source that has a different color spectrum. Use of the CC scale was covered in detail in Chapter 3, under "Fluorescent Lights."

Table 5.3 Light-Balancing (LB) Scale

LB Index No.	*Kodak Amber Correction Gel No.*	*Kodak Blue Correction Gel No.*	*Exposure Change (Stops)*
−112	—	80B	$1\frac{2}{3}$
−81	—	80C	1
−56	—	80D	$\frac{1}{3}$
−45	—	82C	$\frac{2}{3}$
−32	—	82B	$\frac{2}{3}$
−21	—	82A	$\frac{1}{3}$
−10	—	82	$\frac{1}{3}$
+9	81	—	$\frac{1}{3}$
+18	81A	—	$\frac{1}{3}$
+27	81B	—	$\frac{1}{3}$
+35	81C	—	$\frac{1}{3}$
+42	81D	—	$\frac{2}{3}$
+52	81EF	—	$\frac{2}{3}$
+81	85C	—	$\frac{1}{3}$
+112	85	—	$\frac{2}{3}$

Table 5.4 Daylight Color Correction Gels

Type	*Rosco Cinegel No.*	*MIRED Shift*	*Lee No.*	*MIRED Shift*	*GAM No.*	*Color Temperature Shift (K)*	*Exposure Change (Stops)*
Extra CTO	—	—	—	—	1540	20,000 to 3200 5500 to 2200	1
CTO	3407	+167	204	+159	1543	6500 to 3200 5500 to 2900	$\frac{2}{3}$
Sun 85	3401	+131	—	—	—	5500 to 3200	$\frac{2}{3}$
$\frac{3}{4}$ CTO	—	—	—	—	1546	5500 to 3200	$\frac{2}{3}$
$\frac{1}{2}$ CTO	3408	+81	205	+109	1549	5500 to 3800	$\frac{1}{2}$
$\frac{1}{4}$ CTO	3409	+42	206	+64	1552	5500 to 4500	$\frac{1}{3}$
$\frac{1}{8}$ CTO	3410	+20	223	+26	1555	5500 to 4900	$\frac{1}{4}$

Table 5.5 Neutral-Density and Neutral-Density/Daylight Correction Gels

Type	Rosco Cinegel No.	MIRED Shift	Lee No.	MIRED Shift	GAM No.	Color Temperature Shift (K)	Exposure Change (Stops)
.15 ND	3415	0	298	0	1514	0	$\frac{1}{2}$
.3 ND	3402	0	209	0	1515	0	1
.6 ND	3403	0	210	0	1516	0	2
.9 ND	3404	0	211	0	1517	0	3
1.2 ND	—	—	299	0	1518	0	4
CTO .3 ND	3405	+131	207	+159	1556	5500 to 3200	1
CTO .6 ND	3406	+131	208	+159	1557	5500 to 3200	2
CTO .9 ND	—	—	—	—	1558	5500 to 3200	3

Table 5.6 Tungsten Correction Gels

Type	Rosco Cinegel No.	MIRED Shift	Lee No.	MIRED Shift	GAM No.	Color Temperature Shift (K)	Exposure Change (Stops)
Extra CTB	—	—	—	—	1520	3200 to 6000	$1\frac{3}{4}$
Full CTB	3202	−131	201	−137	1523	3200 to 5500	$1\frac{1}{2}$
$\frac{3}{4}$ CTB	—	—	—	—	1526	3200 to 5000	$1\frac{1}{4}$
$\frac{1}{2}$ CTB	3204	−68	205	−78	1529	3200 to 4100	1
$\frac{1}{3}$ CTB	3206	−49	—	—	—	3200 to 3800	$\frac{2}{3}$
$\frac{1}{4}$ CTB	3208	−30	203	−35	1532	3200 to 3500	$\frac{1}{2}$
$\frac{1}{8}$ CTB	3216	−12	218	−18	1535	3200 to 3300	$\frac{1}{3}$

Applying Gel to the Fixture

There are several places to affix gel and diffusion: on the barn doors (Figure 5.4), in a gel frame, or on a frame in front of the light. (The grips handle this frame.) The most common way of attaching gel or diffusion to a Fresnel or open-face light is to clip it on with clothes pins, sometimes called *C-47s* or *bullets*. When gel is attached to the barn doors, be on the lookout for light reflecting off the back of the gel and bouncing onto the walls of the set. Encircle the barn doors with black wrap to block gel-reflection spill.

It is sometimes tempting to double a gel—for example, to double a quarter CTO when a half CTO is required. However, keep in mind that each additional layer doubles the thickness of the polyester base between the source and the subject. Triple and quadruple layers of the gel base introduce odd colors into the light, making it appear muddy. It is better to use the proper correction if possible.

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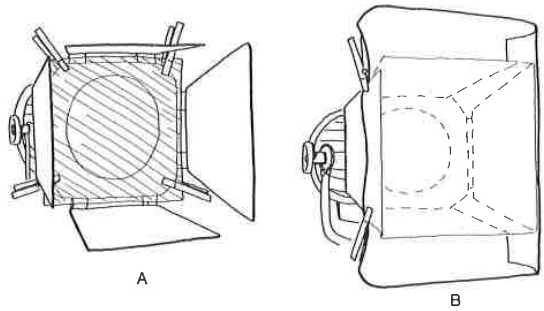

Figure 5.4 (A) Gel or diffusion attached inside the barn doors lessens the problem of light bouncing off the shiny polyester and spilling onto the scenery. However, the heat intensity will eventually melt the color out of the gel, and the gel may need to be replaced from time to time. (B) When attached to the outside of the barn doors, the gel will not melt. The effect of diffusion materials is more pronounced when they are attached on the outside because they effectively enlarge the face of the fixture. However, this renders the barn doors ineffective; flags must be used to control the light. (Equipment courtesy of Hollywood Rental, Sun Valley, CA.)

Color-Correction Gels

Almost all correction gels come in increments of full, half, quarter, and eighth correction. Depending on the thickness of the gel, it will absorb some amount of light. Gel comes in rolls 48 or 54 in. wide and 22 or 25 ft. in length and in sheets 21 in. × 24 in. or 20 in. × 24 in. When gel is cut from the roll, the cut pieces should be labeled. Figure 5.5 shows a good way to organize the cut gels by size and color.

Converting Daylight Sources to Tungsten Daylight correction gels are orange, and they change daylight sources to tungsten color temperature (3200K). Use 85 gel to correct sunlight and HMI sources (5600K) to tungsten. Use full CTO or extra CTO to correct skylight to tungsten, or for a warm yellow look, use it to convert a 5500K source to 2800K.

The grips apply daylight correction gel to windows to convert the exterior daylight to 3200K. When the outside of the window is accessible, gel can be stapled or taped over the outside window frame, which hides the gel more easily. When stapling gel, apply a square of gaffer's tape to the gel and staple through the tape to prevent the gel from ripping. The key to gelling windows is to keep the gel tight and free of wrinkles. Daylight correction is also available in 4-ft. × 8-ft. sheets of Plexiglass™. Using Plexiglass eliminates some of the problems of polyester gel, which tends to wrinkle and move in the wind.

The gel can be attached from the inside with snot tape (for example, 3M transfer tape) or by carefully taping around the edge of the gel with tape that matches the color of the window frame. This works best with the black metal

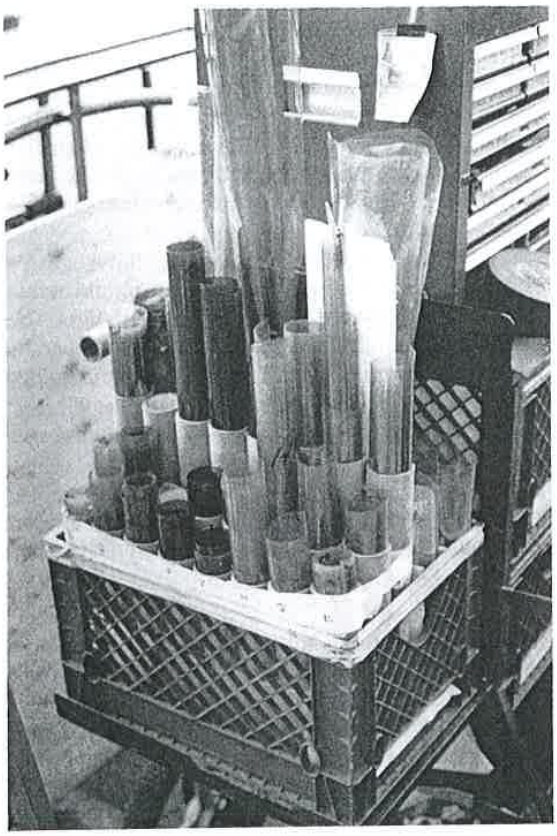

Figure 5.5 Cut gel and diffusion should be marked with a permanent marker and stored according to size and type of gel. Photo by author.

window frames of high-rise office buildings. Another fast method is to spray water on the windows and apply the gel with a squeegee. This method will not last all day, but it saves so much time that it doesn't matter if it must be redone.

Neutral-Density and Combination

Neutral-Density/Daylight Correction Gels

Neutral-density (ND) gels decrease the intensity of the source without altering the color. ND-3 reduces the intensity one stop, N-6 two stops, N-9 three stops. Combination CTO/ND gel and Plexiglass is commonly used to reduce the light coming in through windows.

Converting Tungsten to Daylight Tungsten correction gels, called *CTB* or *booster blue*, change the color temperature of a tungsten source to that of daylight. In a room with lots of windows, it would be better to gel the lights than the windows. However, tungsten lights are very weak on the blue end of the spectrum. A full CTB gel cuts light transmission by 85%, or about two stops. A 2k light is reduced to the output of a 1k light. Obviously, this is an extremely inefficient use of equipment. HMI and FAY fixtures provide daylight-balanced light that is cleaner, brighter, and a more efficient use of power.

Dichroic Filters A dichroic filter, *dike*, is a glass filter that fits onto the front of some open-face lights and converts 3200K light to 5600K light. The filter reduces light output by two stops. Dichroic filters convert the color temperature by optically canceling out certain wavelengths of light. The filter is easily identified by its strange red/blue reflective appearance—like gasoline in a water puddle.

Before the dichroic filter came along, the MacBeth filter was used. It is simply a blue glass filter.

Carbon Arc and Fluorescent Color-Correction Gels The techniques for color correcting arc lights and fluorescent lights are covered in Chapter 3.

Ultraviolet and Infrared

The wavelengths below the bottom of the visible spectrum are ultraviolet (UV). At the other end of the light spectrum, above the highest visible wavelength, is infrared (IR) radiation, which we feel as heat.

All lighting fixtures produce some level of IR and UV radiation. HMI globes are very strong in the UV wavelengths, which are filtered out by the fixture's lens. Gel manufacturers also make UV gel, which can be used to filter out UV radiation.

HMIs are low in IR radiation and are therefore relatively cool. Tungsten lights, on the other hand, are very high in IR radiation. In fact, they lose 90% of their energy as heat. Clear heat-shield gel is sometimes used to protect colored gels from the direct heat, which causes gels to loose color.

Coloring Light

Color is apparent in light when only a part of the visible spectrum is represented. A deeply colored gel effectively narrows the range of wavelengths to those of a specific color. For example, a red gel transmits only the wavelengths around 650 nm.

Color Chips and Gray Scale

When the film laboratory makes a print or video transfer from a developed negative, the timer or colorist adjusts the exposure and colors of the print to make them look natural. When a DP introduces colors into the lighting, he must take steps to prevent the timer from removing the color in the lab. To give the lab a reference at the head, or beginning, of each film roll, the AC films about ten seconds