MEASURE 9.1.2 Substitute higher-efficiency lamps in existing fixtures.

The low efficacy of incandescent lamps has created a market for more efficient lamps that can be used in the same fixtures. The subsidiary Measures recommend two different types of higher-efficiency lamps:

- ***screw-in fluorescent lamps*** (Measure 9.1.2.1) provide major improvements in efficacy and service life
- ***tungsten halogen lamps*** (Measure 9.1.2.2) provide only modest improvements in efficacy and service life, but they are less expensive. They may be the only option in some applications.

Other Replacements for Incandescent Lamps

Two other types of direct replacements for conventional incandescent lamps are worth mentioning because they have been promoted under the banner of energy conservation. Both of these are probably dead ends in terms of energy conservation:

- ***self-ballasted mercury vapor lamps*** use an internal tungsten filament to serve as a ballast. This type of lamp is no more efficient than incandescent lamps of comparable wattage, and it suffers serious lumen degradation. Its advantage is longer life, typically about 12,000 hours. It reduces labor cost for lamp replacement, but not energy cost.
- ***krypton-filled conventional incandescent lamps*** may improve energy efficacy by 5 to 15 percent, depending on wattage. The heavy krypton gas retards filament evaporation, allowing the filament to be operated at a somewhat higher temperature. The cost premium is high in relation to the small efficiency improvement. For applications where small lamps are needed, screw-in fluorescent lamps are a much better choice, from the standpoints of efficacy and service life. For applications where large lamps are needed, halogen or HID lamps are a much better choice.

(Krypton is also used in the small filament capsule of halogen lamps, where it serves an important purpose. It is more economical in halogen lamps because of the small amount used and the greater relative efficiency improvement.)

MEASURE 9.1.2.1 Substitute screw-in fluorescent lamps for incandescent lamps.

RATINGS

New Facilities	Retrofit	O&M
	B	

SUMMARY

Radically improves lighting efficiency. Easy, quick, and fairly cheap, but not foolproof. Be careful to avoid junk brands.

SELECTION SCORECARD

Savings Potential	$ (1 of 4)
Rate of Return	% % (2 of 3)
Reliability	✓ (1 of 3)
Ease of Retrofit	☺ ☺ ☺ (3 of 3)

Screw-in fluorescent "lamps" are actually complete fixtures packaged on a standard lamp base. They include a fluorescent tube, a starter, and a ballast. The fluorescent tube itself may be permanently attached to the ballast or it may be separately replaceable. A large variety of configurations are available, including units with integral reflectors and various types of globes or diffusers. See Figure 1.

The best screw-in fluorescent lamps are somewhat less efficient than the best conventional fluorescent fixtures, but they are still three to four times more efficient than ordinary incandescent bulbs of similar light output. In applications such as the example shown in Figure 2, they can significantly reduce electricity cost. They last about 10 times longer, but they cost about 20 times more.

No special steps are needed to replace incandescent lamps with screw-in fluorescent units in most situations. In some cases, a minor modification of the fixture is needed. However, there are many situations where screw-in fluorescent replacements cannot be used.

Some screw-in fluorescent lamps have magnetic ballasts and some have electronic ballasts. In units made

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Fig. 1 Three basic types You can select a bare lamp, or a lamp with a reflector, or a lamp with a diffuser.

by reputable manufacturers, electronic ballasts are more efficient. They add some problems, and they eliminate others. See Reference Note 55, Fluorescent Lighting, for details about fluorescent lamps and ballasts.

The newest types of screw-in fluorescent fixtures use tubes of small diameter and high brightness. These were originally called "PL" fixtures (after Philips Lighting, who introduced them), and they are now called "compact fluorescent" fixtures. Older types of screw-in fluorescent fixtures, still being offered, use a conventional circular tube of large diameter that is mounted on a screw-in ballast.

Limitations

Screw-in compact fluorescent lamps were designed as replacements for incandescent lamps. However, they cannot be substituted in these common situations:

- ***fixtures too small for the lamps.*** The need for a ballast, which is mounted at the screw base, makes the units too fat for many existing fixtures. Also, screw-in units are too long for some fixtures.

  Some table lamps that use harps to hold the shades may be adapted to accommodate the lamps by using harp extenders.
- ***need for high light output.*** The largest compact fluorescent lamps cannot match the light output of the largest incandescent lamps.
- ***need for dimming.*** Compact fluorescent lamps should not be used with conventional lighting dimmers. Doing so shortens their life, reduces their efficiency, and may create a fire in the fixture.
- ***frequent switching.*** The filaments and starters of fluorescent lamps wear out with frequent on/off switching.
- ***need for instant light.*** Most compact fluorescent fixtures have preheat starters, which take a second or two to work. After starting, the lamps require a few seconds to reach full brightness. Lamps that use mercury amalgams (explained below) require almost a minute to reach full brightness.

There are some other, less common situations where you should not use compact fluorescent lamps. These include extremely low temperatures, a need for very good color rendering, sensitivity to acoustical noise, and sensitivity to electrical interference. See "How to Select Compact Fluorescent Lamps," below, for more about these factors.

Energy Saving Potential

The following table compares the energy consumption of ordinary incandescent bulbs to the energy consumption of some typical compact fluorescent lamps that might be used to replace them. The figures indicate a typical saving of about 70%. Few other energy conservation measures offer this much potential for savings.

Incandescent		Fluorescent			Wattage
Watts	Lumens	Watts	Lumens	Type	Reduction (%)
25	230	9	400	bare lamp	64
40	460	11	600	bare lamp	72
60	890	15	900	bare lamp	75
60	890	17	950	with diffuser	72
75	1,200	20	1,200	bare lamp	73
75	1,200	23	1,550	bare lamp	69

However, this simple comparison does not tell the whole story. You need to make an energy savings analysis for each potential lamp substitution. For example, much incandescent lighting in commercial facilities is done with downlights and other shrouded fixtures. The lateral light distribution pattern of bare compact fluorescent lamps is inappropriate in such fixtures, so you may have to use fluorescent reflector lamps that are less efficient.

How to Select Compact Fluorescent Lamps

Replacing incandescent lamps with compact fluorescent lamps is a simple operation, but you need to be careful in selecting the substitute lamps. The following are the important criteria.

■ Lumen Output

Start by finding out whether the illumination levels provided by the present lighting match the requirements of the activities. Calculate any increases or reductions in the lumen output that are appropriate. Then, search the catalogs to find lamps that provide the output you need.

Screw-in fluorescent lamps are available in a range of sizes to replace the most common incandescent bulb sizes. See Figure 3. The output of the fluorescent units was somewhat limited at first, but output continues to be increased.

Experience indicates that manufacturers exaggerate the effective light output of compact fluorescent fixtures. For example, if a compact fluorescent lamp promises "as much light as a 75-watt bulb," a person probably will not be able to see as well as with the original 75-watt bulb. This may be due to differences in color rendering, or to exaggerating the lumen output.

On the other hand, where fixtures are largely decorative, as with downlights in lobbies, compact fluorescent fixtures tend to produce an illusion of greater brightness than their lumen output suggests.

Light output deteriorates with age. Provide enough reserve capacity to provide adequate lighting at the end of the replacement cycle. The best compact fluorescent lamps lose about 20% of their light output at the end of normal service life.

■ Wattage Input and Efficacy

After you find the lamps that can provide the desired lumen levels, select among them for the lowest input wattage. In other words, select the highest efficacy.

Be skeptical of the efficacy figures published for compact fluorescent fixtures. Experience indicates that the actual efficacies of cheap compact fluorescent fixtures may be less than half that of better units. Reliable comparisons of the products of different manufacturers are not available, so it is reckless to acquire units from any but the best manufacturers. (We said "best," not "most popular." One of the largest vendors of compact fluorescent fixtures produces cheap junk.)

These are efficacies for compact fluorescent fixtures derived from the published figures of one major manufacturer:

Watts	Lumens/Watt	Type
9	44	bare lamp
11	54	"
15	60	"
20	60	"
23	67	"
17	55	diffuser lamp
18	61	"
18	44	reflector lamp

Note that *these efficacy figures include the effects of the ballast, whereas this is not true of ratings for conventional fluorescent lamps.*

■ Reliability and Service Life

Some units presently on the market have poor reliability. Screw-in fluorescent lamps can be produced by marginal manufacturers, and units of poor quality can be made substantially cheaper than units of good quality. The market has not shaken out the poor

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Fig. 2 A good place to retrofit screw-in fluorescent lamps The ceiling of this lobby is a forest of downlights. Screw-in fluorescent lamps provide adequate illumination. Bare lamps provide the best efficiency in the existing reflector fixtures. Their appearance is satisfactory at this distance. Their longer service life greatly reduces the amount of labor required for maintenance.

products. On the contrary, because compact fluorescent lamps are perceived as expensive (compared to incandescent lamps), the lower cost of the poor quality units has allowed them to flood the market. The rated life of most compact fluorescent lamps is 10,000 hours. However, the rating does not guarantee quality. Some units of low quality last only a few hours or a few weeks.

Purchase compact fluorescent lamps only from manufacturers of good reputation. If you are going to install large numbers of lamps, make some calls to experienced users of compact fluorescent lamps to find which units are best.

If the unit allows the fluorescent tube to be replaced, the life of the ballast is rated separately. A life of 50,000 hours is commonly claimed for ballasts. Take such numbers with a grain of salt. Not enough time has gone by to allow such figures to be verified by field experience.

The life of a magnetic ballast declines with higher operating temperature. The operating temperature is increased if the unit is installed with the ballast above the lamp, and if the fixture is poorly ventilated. The life of an electronic ballast declines as the number of switching cycles increases.

■ Lamp Dimensions

You may have trouble finding models of compact fluorescent fixtures that fit many incandescent fixtures. Figures 1 and 3 show the problem. Compact fluorescent fixtures are all much wider at the base than incandescent lamps. Most are substantially longer, although shorter compact fluorescent tubes are entering the market. Manufacturers are achieving shorter lengths by bending the tubes into hairpin and corkscrew shapes.

■ Light Distribution Pattern

The light distribution pattern of the lamps affects the overall efficiency of lighting. For example, a bare compact fluorescent lamp radiates most of its energy in a direction perpendicular to the tube. If such a lamp is installed in a recessed downlight with an absorptive interior, most of the light is absorbed inside the fixture.

Compact fluorescent lamps are available with integral reflectors or diffusers to improve light distribution, as shown in Figures 1 and 4. For example, they are available with parabolic reflectors to minimize light loss when installed in downlights. The combination of greater light source efficiency and lower light losses can increase the overall efficiency of the fixture by a factor of 10 to 30 (that's not a misprint) when these lamps are installed in highly absorptive fixtures.

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Fig. 3 A range of light outputs The maximum size of screw-in units with bare lamps continues to grow. Units are available that substitute for the most common incandescent lamp sizes. However, beware of exagerrated claims about "equivalent" light output.

Ability to Replace Fluorescent Tube Separately

The ballasts in screw-in fluorescent lamps may last several times longer than the tubes. Some units allow the lamp to be replaced separately from the ballast. For example, see Figure 4. Units that allow the tube to be replaced separately may have better long-term economics. This is illustrated by the economic example given below.

Color Characteristics

The color rendering of fluorescent lamps is different from the color rendering of incandescent lamps, and this may be important in some applications. Fluorescent lamps emit light strongly in a few narrow bands of color that are created by the mercury vapor in the lamps. These color spikes are superimposed on a broader light spectrum produced by the phosphors.

The perceived white color of the fluorescent lamp is not the result of a continuous light distribution spectrum. Instead, it is the result of selecting the phosphors to produce the illusion of white light. This causes the lamp to distort the colors of illuminated objects. Human vision corrects for this, so people do not notice it, except in certain color-critical applications.

For more about lamp color in general, see “Color Rendering Index” and “Lamp Color” in Reference Note 52, Comparative Light Source Characteristics. For more details of fluorescent lamp color, see Reference Note 55, Fluorescent Lighting.

Starting and Operating Temperatures

All fluorescent lamps, including compact units, operate at peak efficiency only if the glass tube is near a particular temperature. The tube temperature is determined by the environment of the lamp and by the lamp’s heat output. The optimum temperature is about 105°F (40°C). The lamp usually starts at a lower temperature than this, and then warms up to a temperature that may be well below or well above the optimum temperature. If the space is kept at normal indoor temperature and the fixture is well ventilated, the lamp will stabilize near its optimum temperature. If the lamp is used outdoors, or if it is installed in a poorly vented ceiling fixture, its efficiency suffers seriously.

Fluorescent lamps require a minimum ambient temperature to start reliably. Compact fluorescent lamps have higher current densities, shorter arcs, preheat starting, and other features that allow them to operate at lower temperatures than conventional fluorescent lamps. Different models of compact fluorescent fixtures claim starting temperatures from -20°F to 32°F (-29°C to 0°C).

The product literature does not make it clear how much efficacy suffers at lower operating temperatures. Some manufacturers use an amalgam of mercury with another metal to stabilize the mercury vapor pressure inside the lamp. This keeps the lamp efficacy high over a wider range of temperature. A disadvantage of this method is that the lamp may require as much as a minute to reach full brightness as the mercury separates from the amalgam.

Screw-in fluorescent fixtures that use conventional circular lamps should be used only at normal indoor temperatures.

Acoustical Noise

Units of good quality emit little noise. Cheaper units may be noticeably noisy. Refer to Measure 9.2.4 for more about this.

Power Factor

Low power factor is a potential problem with magnetic ballasts, but generally not with electronic ballasts. Measure 9.2.4 gives the details.

Radiated Electromagnetic Noise

This is a potential problem with units that have electronic ballasts. For example, problems have been noted with remote control units and security scanners. Refer to Measure 9.2.4 for details.

Compact lamps are smaller and they draw less current than conventional fluorescent fixtures, so they have the potential of emitting less electromagnetic radiation. This does not mean that they actually make less noise. Cheaper units that lack adequate input filtering may cause the power wiring to act as an antenna, causing trouble at some distance from the lamps.

Harmonic Distortion

Harmonic distortion in compact fluorescent fixtures worries electric utilities, who have been using incentives and penalties to promote lower harmonic distortion. Units are commonly rated in terms of “total harmonic distortion” (THD). At present, a THD of 20% is considered acceptable. Some cheaper units may have a

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Fig. 4 Reflector fixture with separately replaceable lamp The ballast may last several times longer than the lamp. A unit like this should be made of glass, rather than plastic, because the ultraviolet radiation from a fluorescent lamp will darken plastic.

THD much worse than this. See Measure 9.2.4 for details.

Label Fixtures to Deter Backsliding

When a lamp burns out, it is easy to replace it with the wrong type. The most effective way to prevent this is to label the original fixtures with the lamp types to be used. Measure 9.7.3 explains how to label fixtures to minimize these failure modes.

An Economic Example

Compact fluorescent fixtures are good devices in their own right, but they are also a fad, which causes people to use them uncritically. The economic benefit they provide may not be as great as widely assumed, so it is worthwhile to examine a typical case.

Assume that 23-watt compact fluorescent lamps are used to replace 75-watt incandescent lamps, resulting in a saving of 52 watts per lamp. Assuming a 10,000-hour life and an electricity cost of 8 cents per kilowatt-hour, each lamp replacement saves $42 in electricity cost during its life.

During the unit's lifetime, it saves replacement of ten incandescent lamps costing $0.50 apiece, for an additional saving of $5.00. The compact fluorescent lamp costs $18. Thus, the facility saves $42 for a net investment of $13.

This is a good ratio, but variations in the assumed factors could make the economics much worse or much better. There is great variation in electricity rates. The example did not include demand charges, which are a major factor is some locations, but not in others. The example did not include labor cost for lamp replacement, which is much lower for compact fluorescent fixtures. The rate of return, as opposed to total savings, depends on the number of hours that the lamps operate each year.

If the fluorescent tube can be replaced separately, the typical replacement tube cost is about $5. Therefore, lamps with replaceable tubes may have considerably better long-term economics.

It is worth stressing that cheap junk units, which infest the market, will not last long enough to pay off. Buy for quality, not for price.

ECONOMICS

SAVINGS POTENTIAL: *50 to 75 percent of lighting energy, depending on how closely the needed lumen levels can be matched by the fluorescent lamps.*

COST: *Good screw-in fluorescent lamp assemblies cost from $15 to $30, depending on wattage, features, and quantity purchased. Replacement tubes alone cost about $5, for the more common types. The cost is reduced by the cost of all the incandescent lamps that would have burned out during the life of the fluorescent lamp. This is typically $5 to $10.*

PAYBACK PERIOD: *Less than one year, to many years. Refer to the economic example above.*

TRAPS & TRICKS

SELECTING THE LAMPS: *The continued popularity of junk units shows that buyers are not selecting wisely. Even the best equipment is too new to have a reliable performance record in real applications. Take care to select the proper lamp wattage and configuration for each application. Check with previous users about service life and problems.*

MAINTAIN THE BENEFIT: *Don't forget to label the fixtures.*

MEASURE 9.1.2 Substitute higher-efficiency lamps in existing fixtures.

The low efficacy of incandescent lamps has created a market for more efficient lamps that can be used in the same fixtures. The subsidiary Measures recommend two different types of higher-efficiency lamps:

- ***screw-in fluorescent lamps*** (Measure 9.1.2.1) provide major improvements in efficacy and service life
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Other Replacements for Incandescent Lamps

Two other types of direct replacements for conventional incandescent lamps are worth mentioning because they have been promoted under the banner of energy conservation. Both of these are probably dead ends in terms of energy conservation:

- ***self-ballasted mercury vapor lamps*** use an internal tungsten filament to serve as a ballast. This type of lamp is no more efficient than incandescent lamps of comparable wattage, and it suffers serious lumen degradation. Its advantage is longer life, typically about 12,000 hours. It reduces labor cost for lamp replacement, but not energy cost.
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RATINGS

New Facilities	Retrofit	O&M
	B	

SUMMARY

Radically improves lighting efficiency. Easy, quick, and fairly cheap, but not foolproof. Be careful to avoid junk brands.

SELECTION SCORECARD

Savings Potential	$
Rate of Return	% %
Reliability	✓
Ease of Retrofit	☺ ☺ ☺

Screw-in fluorescent "lamps" are actually complete fixtures packaged on a standard lamp base. They include a fluorescent tube, a starter, and a ballast. The fluorescent tube itself may be permanently attached to the ballast or it may be separately replaceable. A large variety of configurations are available, including units with integral reflectors and various types of globes or diffusers. See Figure 1.

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Limitations

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However, this simple comparison does not tell the whole story. You need to make an energy savings analysis for each potential lamp substitution. For example, much incandescent lighting in commercial facilities is done with downlights and other shrouded fixtures. The lateral light distribution pattern of bare compact fluorescent lamps is inappropriate in such fixtures, so you may have to use fluorescent reflector lamps that are less efficient.

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Replacing incandescent lamps with compact fluorescent lamps is a simple operation, but you need to be careful in selecting the substitute lamps. The following are the important criteria.

■ Lumen Output

Start by finding out whether the illumination levels provided by the present lighting match the requirements of the activities. Calculate any increases or reductions in the lumen output that are appropriate. Then, search the catalogs to find lamps that provide the output you need.

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Experience indicates that manufacturers exaggerate the effective light output of compact fluorescent fixtures. For example, if a compact fluorescent lamp promises "as much light as a 75-watt bulb," a person probably will not be able to see as well as with the original 75-watt bulb. This may be due to differences in color rendering, or to exaggerating the lumen output.

On the other hand, where fixtures are largely decorative, as with downlights in lobbies, compact fluorescent fixtures tend to produce an illusion of greater brightness than their lumen output suggests.

Light output deteriorates with age. Provide enough reserve capacity to provide adequate lighting at the end of the replacement cycle. The best compact fluorescent lamps lose about 20% of their light output at the end of normal service life.

■ Wattage Input and Efficacy

After you find the lamps that can provide the desired lumen levels, select among them for the lowest input wattage. In other words, select the highest efficacy.

Be skeptical of the efficacy figures published for compact fluorescent fixtures. Experience indicates that the actual efficacies of cheap compact fluorescent fixtures may be less than half that of better units. Reliable comparisons of the products of different manufacturers are not available, so it is reckless to acquire units from any but the best manufacturers. (We said "best," not "most popular." One of the largest vendors of compact fluorescent fixtures produces cheap junk.)

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Note that *these efficacy figures include the effects of the ballast, whereas this is not true of ratings for conventional fluorescent lamps.*

■ Reliability and Service Life

Some units presently on the market have poor reliability. Screw-in fluorescent lamps can be produced by marginal manufacturers, and units of poor quality can be made substantially cheaper than units of good quality. The market has not shaken out the poor

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Fig. 2 A good place to retrofit screw-in fluorescent lamps The ceiling of this lobby is a forest of downlights. Screw-in fluorescent lamps provide adequate illumination. Bare lamps provide the best efficiency in the existing reflector fixtures. Their appearance is satisfactory at this distance. Their longer service life greatly reduces the amount of labor required for maintenance.

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■ Lamp Dimensions

You may have trouble finding models of compact fluorescent fixtures that fit many incandescent fixtures. Figures 1 and 3 show the problem. Compact fluorescent fixtures are all much wider at the base than incandescent lamps. Most are substantially longer, although shorter compact fluorescent tubes are entering the market. Manufacturers are achieving shorter lengths by bending the tubes into hairpin and corkscrew shapes.

■ Light Distribution Pattern

The light distribution pattern of the lamps affects the overall efficiency of lighting. For example, a bare compact fluorescent lamp radiates most of its energy in a direction perpendicular to the tube. If such a lamp is installed in a recessed downlight with an absorptive interior, most of the light is absorbed inside the fixture.

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Fig. 3 A range of light outputs The maximum size of screw-in units with bare lamps continues to grow. Units are available that substitute for the most common incandescent lamp sizes. However, beware of exagerrated claims about "equivalent" light output.

■ **Ability to Replace Fluorescent Tube Separately**

The ballasts in screw-in fluorescent lamps may last several times longer than the tubes. Some units allow the lamp to be replaced separately from the ballast. For example, see Figure 4. Units that allow the tube to be replaced separately may have better long-term economics. This is illustrated by the economic example given below.

■ **Color Characteristics**

The color rendering of fluorescent lamps is different from the color rendering of incandescent lamps, and this may be important in some applications. Fluorescent lamps emit light strongly in a few narrow bands of color that are created by the mercury vapor in the lamps. These color spikes are superimposed on a broader light spectrum produced by the phosphors.

The perceived white color of the fluorescent lamp is not the result of a continuous light distribution spectrum. Instead, it is the result of selecting the phosphors to produce the illusion of white light. This causes the lamp to distort the colors of illuminated objects. Human vision corrects for this, so people do not notice it, except in certain color-critical applications.

For more about lamp color in general, see "Color Rendering Index" and "Lamp Color" in Reference Note 52, Comparative Light Source Characteristics. For more details of fluorescent lamp color, see Reference Note 55, Fluorescent Lighting.

■ **Starting and Operating Temperatures**

All fluorescent lamps, including compact units, operate at peak efficiency only if the glass tube is near a particular temperature. The tube temperature is determined by the environment of the lamp and by the lamp's heat output. The optimum temperature is about 105°F (40°C). The lamp usually starts at a lower temperature than this, and then warms up to a temperature that may be well below or well above the optimum temperature. If the space is kept at normal indoor temperature and the fixture is well ventilated, the lamp will stabilize near its optimum temperature. If the lamp is used outdoors, or if it is installed in a poorly vented ceiling fixture, its efficiency suffers seriously.

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The product literature does not make it clear how much efficacy suffers at lower operating temperatures. Some manufacturers use an amalgam of mercury with another metal to stabilize the mercury vapor pressure inside the lamp. This keeps the lamp efficacy high over a wider range of temperature. A disadvantage of this method is that the lamp may require as much as a minute to reach full brightness as the mercury separates from the amalgam.

Screw-in fluorescent fixtures that use conventional circular lamps should be used only at normal indoor temperatures.

■ **Acoustical Noise**

Units of good quality emit little noise. Cheaper units may be noticeably noisy. Refer to Measure 9.2.4 for more about this.

■ **Power Factor**

Low power factor is a potential problem with magnetic ballasts, but generally not with electronic ballasts. Measure 9.2.4 gives the details.

■ **Radiated Electromagnetic Noise**

This is a potential problem with units that have electronic ballasts. For example, problems have been noted with remote control units and security scanners. Refer to Measure 9.2.4 for details.

Compact lamps are smaller and they draw less current than conventional fluorescent fixtures, so they have the potential of emitting less electromagnetic radiation. This does not mean that they actually make less noise. Cheaper units that lack adequate input filtering may cause the power wiring to act as an antenna, causing trouble at some distance from the lamps.

■ **Harmonic Distortion**

Harmonic distortion in compact fluorescent fixtures worries electric utilities, who have been using incentives and penalties to promote lower harmonic distortion. Units are commonly rated in terms of "total harmonic distortion" (THD). At present, a THD of 20% is considered acceptable. Some cheaper units may have a

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Fig. 4 Reflector fixture with separately replaceable lamp The ballast may last several times longer than the lamp. A unit like this should be made of glass, rather than plastic, because the ultraviolet radiation from a fluorescent lamp will darken plastic.

THD much worse than this. See Measure 9.2.4 for details.

Label Fixtures to Deter Backsliding

When a lamp burns out, it is easy to replace it with the wrong type. The most effective way to prevent this is to label the original fixtures with the lamp types to be used. Measure 9.7.3 explains how to label fixtures to minimize these failure modes.

An Economic Example

Compact fluorescent fixtures are good devices in their own right, but they are also a fad, which causes people to use them uncritically. The economic benefit they provide may not be as great as widely assumed, so it is worthwhile to examine a typical case.

Assume that 23-watt compact fluorescent lamps are used to replace 75-watt incandescent lamps, resulting in a saving of 52 watts per lamp. Assuming a 10,000-hour life and an electricity cost of 8 cents per kilowatt-hour, each lamp replacement saves $42 in electricity cost during its life.

During the unit's lifetime, it saves replacement of ten incandescent lamps costing $0.50 apiece, for an additional saving of $5.00. The compact fluorescent lamp costs $18. Thus, the facility saves $42 for a net investment of $13.

This is a good ratio, but variations in the assumed factors could make the economics much worse or much better. There is great variation in electricity rates. The example did not include demand charges, which are a major factor is some locations, but not in others. The example did not include labor cost for lamp replacement, which is much lower for compact fluorescent fixtures. The rate of return, as opposed to total savings, depends on the number of hours that the lamps operate each year.

If the fluorescent tube can be replaced separately, the typical replacement tube cost is about $5. Therefore, lamps with replaceable tubes may have considerably better long-term economics.

It is worth stressing that cheap junk units, which infest the market, will not last long enough to pay off. Buy for quality, not for price.

ECONOMICS

SAVINGS POTENTIAL: *50 to 75 percent of lighting energy, depending on how closely the needed lumen levels can be matched by the fluorescent lamps.*

COST: *Good screw-in fluorescent lamp assemblies cost from $15 to $30, depending on wattage, features, and quantity purchased. Replacement tubes alone cost about $5, for the more common types. The cost is reduced by the cost of all the incandescent lamps that would have burned out during the life of the fluorescent lamp. This is typically $5 to $10.*

PAYBACK PERIOD: *Less than one year, to many years. Refer to the economic example above.*

TRAPS & TRICKS

SELECTING THE LAMPS: *The continued popularity of junk units shows that buyers are not selecting wisely. Even the best equipment is too new to have a reliable performance record in real applications. Take care to select the proper lamp wattage and configuration for each application. Check with previous users about service life and problems.*

MAINTAIN THE BENEFIT: *Don't forget to label the fixtures.*