APEC PROJECT EWG 3/99

COLLOQUIUM ON TECHNICAL ISSUES OF MINIMUM ENERGY PERFORMANCE STANDARDS

SEOUL, KOREA, 6 TO 8 OCTOBER 1999

DISCUSSION PAPER – BALLASTS FOR FLUORESCENT LAMPS

Prepared by Lloyd Harrington

Energy Efficient Strategies Pty Ltd, Melbourne, Australia

September 1999

(Appendices updated October 1999)

Note: The main body of this paper is the same as circulated before the colloquium. Report tables and Appendices have been updated with data presented at the colloquium.

Background - Trade Implications of Energy Programs

There is a significant amount of trade in energy-using equipment between APEC economies. A study of trade in air conditioners, refrigerators, electric motors and lighting products found that trade in ballasts among APEC economies was worth about US$ 500-600 million in 1996 (APEC 1998).[1] While this was the least valuable of the 4 product categories studied, ballasts were one of the most common products imported and exported (due to their low unit value), with some 380 million units imported and exported from APEC annually.

Much of this trade is affected in some way by minimum energy performance standards (MEPS). Imports in 1996 into APEC economies that have mandatory MEPS programs for ballasts accounted for 79% of the value of intra-APEC ballast trade. In recent years, a number of additional APEC economies as well as Europe have begun to seriously consider MEPS for ballasts. Energy labelling for ballasts is currently undertaken by some economies although it is not very widespread within APEC at this stage. Europe have a voluntary program of labelling which is operated by CELMA, the European lighting manufacturer's association. This program is being considered for adoption in some APEC economies like Australia and New Zealand.

A traded product must comply with mandatory requirements in all the markets where it is sold, and the authorities in each market will usually ask for evidence that it does so. This means that a ballast exporter may need to have each model tested several times to demonstrate that it complies with the MEPS requirements in all the markets where it is sold and that the information any energy label in each market is correct (where applicable).

The cost and time needed to comply with different energy efficiency programs can add significantly to the cost of traded ballasts, and can constitute a barrier to trade, especially if local testing is mandated as a pre-requisite for import. It is still likely that the benefits from lower energy use will outweigh the energy program costs, but the cost-effectiveness of energy efficiency programs for APEC economies as a group would be higher if the compliance costs were minimised.

Compliance costs for traded ballasts would be lowest if the following conditions were met:

1. All economies defined ballast product classes in the same way;
2. All markets had identical MEPS requirements for each product class (MEPS for ballasts are typically expressed as watts loss for ferromagnetic systems, but more sophisticated definitions are required for electronic units or rapid start types);
3. Alignment of test procedures for the measurement of ballast efficacy;
4. All authorities accepted the same energy test results as proof of compliance with the MEPS requirements, thus avoiding retesting;
5. All energy labels were identical, so that the one label could be placed on the product as it left the factory, irrespective of where it was ultimately sold.

Clearly, these conditions are not likely to be met in the near future nor are all of these necessarily desirable. For example, point 2 may result in sub-optimal conditions in

[1] Motors trade was worth US$ 2,500 – 3,000 million, refrigerator and freezer trade US$ 1,000 – 1,100 million, discharge and fluorescent lamps US$ 400 – 600 million and air conditioners US$ 3,000 – 3,300 million. The study was carried out before Peru, Russia and Vietnam joined APEC.

some economies, while point 5 may have some problems with respect to language. However, there are several practical options centred around points 1, 3 and 4 for reducing energy program compliance costs, to the benefit of all APEC economies participating in ballast trade.

Recent Review of Energy Test Standards and Regulations

The APEC Energy Working Group recently commissioned a review of energy efficiency test standards and regulations in APEC member economies (APEC 1999). This surveyed a wide range of energy-using products, including fluorescent lamp ballasts, and detailed the differences in product classifications, MEPS requirements, energy test standards and labels between APEC economies.

Findings

The appendices attached to this discussion paper summarise the findings of the review with regard to fluorescent lamp ballasts. These confirm that the energy program conditions affecting ballast trade do impose costs higher than the "ideal minimum", because:

1. There are a number of different test procedures for the determination of ballast energy consumption and hence MEPS requirements which are fundamentally different in their approach - this requires re-testing for different economies (see Appendix 1). This is (at least in part) due to the different technology types that are available in some markets (different approaches are required for electronic units or rapid start types) and the lack of a suitable international standard for the measurement of fluorescent lamp ballast efficiency;
2. Those economies with MEPS requirements for ballasts (listed in Appendix 2) generally set different MEPS levels, even for the same product classes (the NAFTA group has harmonised requirements for some product classes, although the timing for implementation varies). Labelling requirements also vary;

An outline of the types of programs and their related test procedures currently in operation in APEC member economies is shown in the following tables. Table 1 provides an overview of program types for ballasts for all APEC member economies.

Table 1: Summary of Labelling and MEPS programs by APEC Economy

	Australia	Brunei	Canada	Chile	China	Hong Kong ,China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	USA	Vietnam
Energy Labelling	U				V				M	M		U			M			U	V		U
MEPS/Other	U		M		M			T	M	M		U			M		S	M	M	M	U

M = mandatory, V = voluntary, U = under consideration, S = Singapore Accelerated Depreciation, T = Japan Top Runner Program

More details of the type of specific programs for fluorescent lamp ballasts are shown in Table 2. This shows the type of program and the year of implementation (where known) and any updates where applicable.

Table 2: Fluorescent lamp ballast program types in APEC Economies

	Program Type				
Economy and Product Categories	**A. Comparison label**	**B. Endorsement label**	**C. MEPS**	**D. Industry target**	**E. Other**
AUSTRALIA	VL (2002)		M (2002)		
CANADA			M (1995)		O,BC,Q,NS,NB (a)
CHINA		V (2000)	M (2000)		
JAPAN				VH(2005) (b)	
KOREA	M(1992, 1999)		M(1992, 1999)		
MALAYSIA	(d)		M (1999, 2000, 2001)		
NEW ZEALAND	V(UC)		M(UC)		
PHILIPPINES	M (target 1999)		M (target 2000)		
SINGAPORE					VL(1996) (c)
CHINESE TAIPEI			M(1993)		
THAILAND	VL(1996)		M(2003)		
UNITED STATES OF AMERICA			M(1991, 2003?)		
VIETNAM		VL (UC)	(UC)		

Notes: M = mandatory, VL = voluntary program with low impact, VH = voluntary program with high impact UC = under consideration
Years in brackets indicate year of implementation plus updates where applicable.

(a) These are MEPS levels that are set at Provincial level in addition to national Canadian levels: applies in Ontario, British Columbia, Quebec, Nova Scottia, New Brunswick. MEPS levels are all the same but the implementation dates vary from the national date.
(b) Top Runner program for Japan sets total efficacy requirements for luminaire-ballast-lamp systems – the sales weighted average efficacy for each company’s range of products has to meet the target
(c) Singapore is the accelerated depreciation program which is available for businesses which install high efficiency products, as certified by an engineer.
(d) For Malaysia, the watts loss for the ballast has to be marked on the product.

MEPS Levels

The technical requirements for fluorescent lamp MEPS by APEC member economy are detailed in Appendix 2. The approaches for specifying MEPS vary considerably. As an example, Table 3 shows the MEPS level that would apply to a ballast for a 40 Watt linear fluorescent lamp (T12 lamp nominally 1200mm) in each APEC economy which currently has mandatory (or quasi-mandatory) MEPS for that class of product. The levels shown in terms of equivalent ballast efficiency factor (BEF) are only very approximate and have been derived for comparative purposes.

Table 3 MEPS levels for single 40W T12 linear fluorescent lamps by APEC economy

Economy	Local MEPS definition	Minimum Nominal BEF (a)	Notes
Australia	Label class B1 or better (<43W)	2.33	Light output/power normalised to 0.95 nominal lamp power for ferromagnetic and ballast lumen factor (BLF) of 1.0 for others. Lamp is nominal 38W T12.
Canada	BEF >1.805	1.805	One F40T12 lamp (also 34W/48T12/RS and 40W/48T10/RS lamps) for 120/227V, 1.75 for 347V
China	BEF>1.992 BEF>2.270	1.992 (f) 2.270 (e)	One 40W T12 lamp. (f) ferromagnetic, (e) electronic
Korea	R > 0.97	2.05 (b)	T10 40W lamp, R > 1.20 from June 2002, R is ratio of Lumen/Watt of test/reference systems
Malaysia	10W (1999) 8W (2000) 6W (2001)	2.00 (1999) 2.08 (2000) 2.17 (2001)	
New Zealand	UC		
Philippines	Label class D or better	1.92 PH 1.72 RS	Draft proposal only - values are under consideration. PH is for pre-heated ferromagentic, RS for rapid start
Singapore	No tests		
Chinese Taipei	11W 110V 7W 220V 19W RS	1.96 110V 2.13 220V 1.69 RS	For pre-heat start ballasts at 110V and 220V, RS is for rapid start ballasts at either 110V or 220V.
Thailand	6W	2.17	Draft proposal only - value is under consideration
USA	BEF >1.805	1.805	One F40T12 lamp for 120/227V only, 347V N/A

Notes: (a) Ballast efficiency factor (BEF) is a measure of ballast efficiency in terms of relative light output divided by the total circuit power (as used in North America & China). Units are relative Lumens per Watt. Except for Canada, China & USA, this is an approximation for comparative purposes only. (b) Exact value depends on the characteristics of the reference ballast and lamp used.

The MEPS levels are all expressed as ballast efficiency factor (relative Lumens per Watt of total power input). Table 3 illustrates some of the many ways in which MEPS requirement can vary, even for a single lamp type:

- Sometimes allowances are made for factors such input voltage and technology (eg preheat start versus rapid start);
- The measure of ballast watts loss is only applicable for those ballast types where the lamp power can be directly determined, such a ferromagnetic types;
- In some cases the MEPS level is defined in terms of the characteristics of the reference ballast and reference lamp (eg Korea), so knowledge, performance and documentation for this piece of equipment is critical to measurements;

Where the MEPS levels for different product configurations happen to be identical for the time being, this does not mean that they will remain so. Some economies have already announced a timetable for changes in MEPS levels for some categories in future years – as far forward as 2002 in the case of Korea. The USA is also expected to announce new ballast MEPS levels shortly to take effect in 2002-2004.

Given the range of technologies on the market, it would appear that the only universal method of determining ballast efficiency is in terms of lamp lumen output (or lamp input power where measurable) and total circuit input power. These two factors can be expressed in a variety of ways (eg ballast efficiency factor (BEF) in North America, lumens per watt, total circuit watts for a normalised lumen output) but both variables are essential for the measurement of ballast efficiency and for MEPS and labelling.

Test Procedures

Test procedures currently used to measure fluorescent lamp ballast efficacy vary somewhat across APEC economies, with three main approaches identified:

1. IEC60921 and related standards (performance standard for ballasts)
2. North American standards
3. European standard (EN50294)

The origin of the test procedures for each economy is shown in Table 4 where these are known.

The technical requirements for fluorescent lamp ballast performance are well understood and documented and these are clearly set out in international standards IEC60921 and IEC60929. These deal with issues such as marking, open circuit voltage, pre-heating conditions, lamp power and current, circuit power factor, supply current, maximum current to cathode, current waveform (harmonics), magnetic screening and impedance at audio frequencies and are widely used and generally well regarded. There is also extensive reference to standards for fluorescent lamps (IEC60081 and IEC60901) and their performance requirements.

While many of the requirements in IEC60921 & IEC60929 are critical to the correct operation of the ballast-lamp system, there is some debate as to whether all of the requirements are applicable to all ballasts and whether these requirements should be mandatory or a pre-requisite for MEPS. To some degree, this is a matter to be decided by individual economies, although it is an issue worthy of discussion.

Efficacy of ballasts is not a performance variable that is defined or specified in IEC60921 or IEC60929. This has created some problems when a test method is required to define such requirements (as is necessary for MEPS and labelling) and has resulted in a range of approaches and variations to cope with the various technologies and local requirements.

Table 4: Fluorescent lamp ballast test procedures & regulations - data sources

APEC Economy	Labelling and/or MEPS requirements	Local Test Procedures	Reference Test procedures
Australia	AS/NZS50294.2 (UC)	AS3134, AS2643, AS/NZS50294.1	IEC60921, IEC60929, EN50294
Canada	Regulations, Clause 4.1 CSA C654-M91	CSA C654-M91	North American Similar to US DOE
China	GBXXXX - still in draft form	GB/T15144	IEC60929
Japan	Regulations	JIS C8108 JIS C8117	IEC60921 IEC60929
Korea	Regulations	KS C 8102-95 KS C 8100-97	JIS C 8108 (IEC60921) IEC60929
Malaysia	Electricity Regulations 1994, Energy Efficiency Regulations	MS 141 part 2	IEC60921
New Zealand	Not determined	AS/NZS50294.1	EN50294
Philippines	Standards and labelling regulations	PNS 12-2	IEC60921
Singapore	Accelerated Depreciation Regulation	None, engineer certification	
Chinese Taipei	File of (84) energy 8446093 issued by MOEA, 26 Apr 1995	CNS 927 CNS 3888	IEC60921
Thailand	Not determined	TIS 23-2521 TIS 1506-2541	IEC82-1973 (a) IEC60929
USA	10CFR430 Subpart C	10CFR430 App Q, ANSI C78.1, C-82.2	North American Similar to Canada
Vietnam	Not determined	Not determined	

Note: (a) IEC 82 (1973) was the forerunner of IEC60921 and is now withdrawn.

There are several main technology types for ballasts. For some of these (eg ferromagnetic ballasts, instant start ballasts) the measurement of lamp power is usually a simple exercise when the system is operating at mains frequency and can be determined with a reasonable degree of accuracy using normal laboratory instruments. Once lamp power can be measured, it is a simple task to then define the efficiency of the ballast in terms of ballast watts loss (assumed to be total power less lamp input power) or in terms of the lamp power (as a de facto measure of (but not necessarily equal to) lamp lumen output) and the total circuit power. The former has been the traditional approach used in many economies until recently.

However for some types of ballasts (eg high frequency electronic and rapid start ballasts) the lamp power cannot be easily determined by direct measurement. Also for high frequency systems, the light output generally increases significantly for a given lamp input power, so measurement of lamp input power (even if possible) does not give an accurate indication of the energy service being provided. In these cases there is little option but to measure the system efficacy in terms of the system light output and the total power consumed.

The test procedures currently in use in APEC Economies for the determination of fluorescent lamp ballast efficiency appear to basically fall into one of three broad categories:

1. IEC derived test methods based on IEC60921 for ferromagnetic ballasts and/or IEC60929 for electronic ballasts - a method for the measurement of efficiency is not clearly defined in these standards and this approach has severe limitations as the lamp power cannot be directly derived, especially for high frequency electronic ballasts and/or rapid start types:
2. North American test methods which measures relative light output and total power input to derive an efficiency measure:
3. European method which measures total light output (or lamp power where measurable for low frequency systems) and total power input to derive an efficiency measure - total power measurements are also normalised to a standardised light output and/or lamp power input:

Methods 2 and 3 above are in fact quite similar and there are only small differences in approach at the margin, which could possibly be reconciled with some detailed discussion. The increased light output for high frequency systems can only be fairly compared by direct measurement of total system power and lumens

Reference Lamps and Ballasts

One thing in common to all of the test procedures used for ballasts is the requirement for the definition of reference lamps and reference ballasts for a range of lamp sizes and types. IEC standards specify suitable lamps and ballasts in great detail and ideally the same reference lamps and ballasts could be used for safety, performance and efficacy tests in all APEC Economies. This is a key point for potential alignment.

Conversion algorithms or alignment?

The development of conversion algorithms has, in effect, the same impact as the alignment of test procedures – it avoids having to retest an exported product to range of local test procedures. So really, either alignment of test procedures or development of suitable conversion algorithms provides an acceptable outcome in terms of APEC policy requirements and future directions (provided that economies accept the results of a conversion algorithm as credible).

In summary the benefits are to:

- facilitate international trade
- decrease testing and approval costs for manufacturers
- allow the free movement of the most efficient products (noting that products with a low energy efficiency may still be barred if they do not meet local MEPS levels)
- facilitate international comparisons
- assist in the diffusion of advanced energy saving technologies.

Conversion algorithms have the advantage of being able to provide a more accurate estimate of the impact of local usage patterns, better ranking of products under conditions of actual use and may also allow the retention of local or traditional test conditions. However, in cases where a particular product test procedure is clearly technically superior and already characterises products to the level that is necessary, alignment would probably be a preferable medium term option. It is only worth aligning with a standard that is technically superior and competent – aligning to a poor test procedure serves little purpose.

Given the uniform technical requirements (in terms of lamp input) for ballasts (despite the range of ballast technologies which can be used to provide these requirements), there seems to be no serious argument for development of conversion algorithms for fluorescent lamp ballasts, as it should be possible to develop an international standard that is sufficient to avoid the need for retesting in almost all cases.

Recommendations

The study made the following recommendations regarding for fluorescent lamp ballasts.

Lighting products are widely used in all sectors of the economy and there is already a huge international trade in these products and their components. Generally speaking, there is widespread use, either directly or through the adoption of local "clone" versions, of the IEC standards for the measurement of lighting performance. It appears that these standards are generally well regarded with respect to design, construction and performance of lighting components.

Despite this widespread use, the issue of efficacy is not addressed directly within any of the IEC standards for lighting, although in many cases all of the required information regarding reference ballasts and lamps and measurement of various parameters is contained in the relevant standards (or these are simple to specify). However, a methodology for the determination of efficacy is critical and the best approach is not necessarily "logical or obvious" to a non-expert in lighting performance. This is probably partly a case of lack of understanding or appreciation by the relevant IEC committees of how their standards are likely to be used on a day to day basis. It is also probably the result of a history of concentration on the performance of lighting components and their standardisation (eg construction, strength, size and dimensions, operation voltage and power, light output and so on) rather than concern with respect to lamp and ballast efficacy.

The technical difficulty for fluorescent systems is that for some ballast/lamp circuit types (mainly those without a starter and those used with high frequency ballasts) it is not possible to accurately determine that lamp power, and hence implied ballast power, directly. The approach that is taken in North America and now Europe is that the light output and total power circuit power for a test lamp or ballast is compared to a reference system. This seems to be the most reliable method of measuring lamp and ballast efficacy. This is critical for high frequency systems (where the light output for a given lamp power input increases significantly) if they are to be compared on a fair and equitable basis to low frequency systems.

There is currently no IEC standard to measure the efficacy of lamps and/or ballasts. North America, out of necessity, has developed it own approaches to the measurement of lamp and ballast efficacy which appear to be technically competent. The approach is also generally in line with the approaches for measuring the efficacy of fluorescent systems that are currently being developed in Europe.

There would appear to be an opportunity for the IEC to develop a range of new international test methods for the measurement of the efficacy of lamps and ballasts. This could be done with both the input from all the major APEC economies as well as Europe to develop a truly international test procedure for measurement of lighting efficacy. The existing methods in Europe and North America could be used as a basis for the development of the new standards. There are not likely to be many controversial issues, although minimum requirements for lumen output may generate some discussion.

As a preliminary recommendation (and subject to the normal technical caveats), APEC should consider sponsoring the development of a new series of IEC standards for the determination of energy performance and efficacy of lamps and lighting components, which would complement the current suite of IEC lighting performance standards for ballasts and lamps. Once developed, consideration could be given to using this standard as a suitable test method for future alignment within APEC.

If a series of suitable IEC standards can be successfully developed, these test methods would be already suitable for a range of purposes and conditions and they would "characterise" the product to the extent that is required in the market place. Therefore, the development of a conversion algorithm is probably not necessary or recommended for this product (if the new IEC test methods are deemed to be acceptable).

Options for Further Convergence

It is accepted that the objective of fully harmonised MEPS and energy labelling requirements for fluorescent lamp ballasts throughout APEC is not practical nor necessarily appropriate at the moment, and in any case the costs and benefits of this approach for each APEC economy would need to be demonstrated.

However, the following options for further convergence are likely to bring significant benefits, at little cost, to all APEC economies.

1. Harmonisation of core elements of testing

In this scenario, APEC economies would agree to standardise definitions and general approaches to testing where this causes minimal disruption. It would also require the development of new MEPS and labelling programs (or adjustment of existing programs) to incorporate common measurement approaches for the definition of ballast efficacy such as total circuit power and measurement of light output and/or lamp power measurements. However, there may be some technology types where some additional testing or retesting may be required. This scenario, while minimising changes required by each Economy, will still result in some significant differences and will not eliminate the need for retesting of products when exported to some destinations. This is a non preferred option as it necessitates change without the accrual of the benefits of alignment.

2. Full harmonisation of test elements

In this scenario, there would be agreement to develop an IEC international standard for the measurement of ballast efficacy (and fluorescent lamp efficacy as applicable) so that there is a common and uniform basis for the determination of ballast/lamp light output (energy service) and ballast (or total circuit) power consumption that can be utilised by all APEC member economies to define MEPS and labelling requirements. This would require agreement on all elements of the test procedure such as test conditions, equipment accuracy and methodology for a range of technology types. However, given that many of the key elements of such a standard are already specified in related IEC standards (eg reference lamps and ballasts, general conditions of test), this is considered a feasible option for consideration.

The Colloquium

Objectives

The objectives of the colloquium are:

1. To consider the material concerning fluorescent lamp ballasts in the *Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies* and add to or correct it where necessary[2];
2. To consider the benefits of, and barriers to, harmonising aspects of the energy test procedures and other protocols for fluorescent lamp ballasts
3. If the benefits are considered worthwhile, to advise on a "convergence strategy".

Issues to be considered

Participants may wish to consider the following issues in relation to their economies, and come prepared to discuss them:

1. Is the material relating to fluorescent lamp ballasts in the *Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies* accurate for your economy? In particular, participants should review the sections on fluorescent lamp ballasts for each economy (Chapter 2), Section 6.3 in Chapter 6 on *Lighting Products*, and Chapter 9, *Conversion Algorithms*.
2. Are the inconsistencies between testing and MEPS requirements seen as a problem in your economy, from the point of view of (a) government and regulators, (b) product exporters, and (c) product importers?
3. Would a greater degree of convergence be of benefit?
4. What aspects of the fluorescent lamp ballast energy testing and MEPS regime in your economy do you consider vital and should be retained?
5. What are your views on the convergence options outlined in this discussion paper?

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2 The draft report can be downloaded from www.sympac.com.au/~ees/apec - file name EWG0398TV1.PDF. Final report is expected in November 1999.

6. What is a realistic convergence timetable?
7. Do you have other suggestions?

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References

APEC 1997, *Guide for alignment of APEC member economies' standards with international standards,* APEC Sub-committee on Standards and Conformance (SCSC), APEC Secretariat, Singapore.

APEC 1998, *Overview of Trade Flows of Energy-Using Products Between APEC Member Economies,* APEC Energy Working Group, Export Council for Energy Efficiency, November 1998

APEC 1999, *Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies,* Energy Efficient Strategies and others, Draft report, July 1999. Final report expected November 1999.

Appendix 1: Summary of fluorescent lamp ballast test procedures

Test procedures currently in use in APEC Economies for the determination of fluorescent lamp ballast efficiency appear to basically fall into one of three broad categories:

1. IEC derived test methods based on IEC60921 for ferromagnetic ballasts and/or IEC60929 for electronic ballasts - a method is not clearly defined in these standards and this approach has severe limitations as the lamp power cannot be directly derived, especially for electronic ballasts and/or rapid start types: (variations used in Malaysia, Philippines, Chinese Taipei, Thailand)
2. North American test methods or variations thereof which measure relative total light output and total power input to derive an efficiency measure: (Canada, China, Japan, Korea, USA)
3. European method which measures total light output (or lamp power where measurable) and total power input to derive an efficiency measure - total power measurements are also normalised to a standardised light output and/or lamp power (Australia, New Zealand)

The three basic methods are summarised below. The sections following provide some details of the relationship to each APEC member economy.

IEC60921 – Ferromagnetic Ballasts

IEC60921 specifies performance requirements for ballasts, excluding resistance types, for use on a.c. supplies up to 1000 V at 50 Hz or 60 Hz, associated with tubular fluorescent lamps with pre-heated cathodes operated with or without a starter or starting device and having rated wattages, dimensions and characteristics as specified in IEC publications 60081 and 60901. It applies to complete ballasts and their component parts such as resistors, transformers and capacitors. It only applies to ferromagnetic ballasts – electronic ballasts are covered under IEC60929.

IEC60921 specifies aspects such as marking, open circuit voltage, pre-heating conditions, lamp power and current, circuit power factor, supply current, maximum current to cathode, current waveform (harmonics), magnetic screening and impedance at audio frequencies. The standard does not specifically cover efficacy, but data on lumen output and total circuit power measured under the standard can be used to determine this parameter if required, although the standard in its current form is not really adequate. The standard does specify a method for the determination of relative light output using a reference lamp.

The standard is primarily aimed at ensuring that ballasts are designed to provide correct electrical inputs for starting and operating fluorescent lamps. Extensive references are made to lamp data sheets in IEC60081 and IEC60901 in terms of specification of ballast requirements. Although there are some requirements regarding the light output of lamps (ballast lumen factor or BLF), the energy efficiency or energy consumption of a ballast is not a primary consideration in the standard.

The standard mandates the following performance requirements:

- various marking requirements (power factor, audio frequency impedance, low distortion);
- specification for open circuit lamp voltages for the relevant lamp;
- meet specified preheating conditions for the relevant lamp;
- maintain lamp power and current for the relevant lamp type – for lamps with a starter, the reference lamp power and current from the test ballast must be between 92.5% and 115% when compared to the reference lamp and ballast; for lamps without a starter, the arc current shall be limited to 115% and the luminous flux >90% when compared to the reference lamp and ballast;
- limits on the difference between claimed and marked power factor
- various other electrical requirements such as supply current markings, maximum current to cathode, current waveform (limits on harmonics), magnetic screen and impedance at audio-frequencies.

The standard specifies details of reference lamps, reference ballasts, power quality and calibration of test equipment. The method used is to operate a reference lamp with a ballast under test, with a reference ballast which can be quickly switched in place of the test ballast. Once operating conditions are stable with the reference ballast, the reference ballast is switched into operation. The relevant lamp characteristics can then be determined for each ballast (eg current, voltage, power, lumen output).

Issues associated with the use of IEC60921 for measurement of efficacy

IEC60921-88 appears to adequately cover general performance of ferromagnetic fluorescent lamp ballasts. It is important to note that this standard specifies a minimum light output (or lamp power input) requirement, which does not appear to present in the North American standards. The issue of efficacy is not addressed directly within the standard although all of the required information on test ballasts and reference ballasts is contained in the standard. The technical difficulty is that for some ballast/lamp circuit types (mainly those without a starter and those used with high frequency ballasts) it is not possible to accurately determine that lamp power or ballast power directly. The approach that is taken in North America and now Europe is that the light output and total power circuit power for a test lamp or ballast is compared to a reference system. This seems to be the most reliable method of measuring lamp and ballast efficacy.

IEC60929 – Electronic ballasts

IEC60929 specifies performance requirements for electronic ballasts for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz with operating frequencies deviating from the supply frequency, associated with tubular fluorescent lamps as specified in IEC60081 and IEC60901 and with other tubular fluorescent lamps for high frequency operation. It only applies to electronic ballasts – ferromagnetic ballasts are covered under IEC60921.

IEC60929 specifies aspects such as marking, operating conditions, circuit power factor, supply current, maximum current to cathode, current waveform (harmonics), magnetic screening, impedance at audio frequencies, mains transient overvoltages and operational tests for abnormal conditions. The standard essentially covers the same material as IEC60921 but is considerably more complex due to the high frequency aspect of electronic ballasts. The standard also addresses the operation of lamps designed for high frequency ballasts. The standard does not specifically cover efficacy, but data on lumen output and total circuit power measured under the standard can be used to determine this parameter if required, although the standard in its current form is not really adequate as relative light output is not adequately defined.

The standard is primarily aimed at ensuring that ballasts are designed to provide correct electrical inputs for starting and operating fluorescent lamps. The tests and requirements are similar to IEC60921 except where noted below:

- preheat time shall not be less than 0.4 seconds unless allowed on the relevant data sheet;
- various specification for starting voltage rises and substitution resistor currents;
- crest factor for open circuit shall not exceed 1.8;
- Ballast lumen factor (BLF - ratio of the light output of the test ballast to the reference ballast using the same reference lamp) shall not be less than 95% of the value declared. If the declared BLF is lower than 0.9, evidence is to be given that the performance of the lamp is not impaired;
- Total circuit power shall not be more than 110% of the value declared;
- Various requirements regarding current waveform (harmonic limitations);
- An endurance test is specified with temperature cycling (5 cycles) and open-circuit switching (1000 cycles).

The standard specifies details of reference lamps, reference ballasts, power quality and calibration of test equipment. The method used is to operate a reference lamp with a ballast under test, with a reference ballast which can be quickly switched in place of the test ballast. Once operating conditions are stable with the reference ballast, the reference ballast is switched into operation. The relevant lamp characteristics can then be determined for each ballast (eg current, voltage, power, lumen output).

Issues associated with the use of IEC60929 for measurement of efficacy

IEC60929-88 appears to adequately cover general performance of electronic fluorescent lamp ballasts. This standard verifies the ballast lumen factor against the rated value for the ballast. The issue of efficacy is not addressed directly within the standard although all of the required information on test ballasts and reference ballasts is contained in the standard. For efficiency it is subject to the same problems as IEC60921.

North American Test Methods for ballasts

The test procedure for fluorescent lamp ballasts is set out in CAN/CSA-C654-M91 for Canada and 10CFR430 Sub Part B, Appendix Q for the USA. China also sets out similar requirements under GB/T 15144. Korea and Japan both use similar approaches although some of the details are different.

For the USA all of the test conditions are externally referenced to ANSI C82.2. Reference lamps and ballasts systems are defined in the standard. The lumen output of a test ballast with an appropriate reference lamp is determined under stabilised conditions. The ballast efficacy factor (BEF) is determined as the ratio of the relative light output of the test ballast/reference lamp combination (in comparison with the reference lamp/reference ballast system) divided by the total system power. Minimum BEF values as well as a number of other performance requirements are specified in the standard. No minimum ballast lumen factor is specified in the standard. The procedure for Canada and China is essentially equivalent to that required for the USA. Japan is very similar except that the efficacy of the system is expressed as nominal Lumens per watt as opposed to relative Lumens per watt. Korea specify the ration of Lumens per watt for the test systems versus the reference system.

The standard CAN/CSA-C654-M91 (as amended September 1992) is applicable to four types of fluorescent lamp ballasts; 40T12 rapid start, 96T12 rapid start, 96T12 instant start and F32T8 rapid start, all intended to operate at 60 Hz and either 120V, 277V or 347V. It does not apply to ballast designed for operation of a temperature of lower than –17.8°C. Mandatory reference is made to the safety standard for ballasts. The test is undertaken at 25°C and the supply system voltage, stability and impedance is also specified. Lamps are mounted in a horizontal position and light output and power input is to be stable before lumen and power measurements are undertaken (generally a minimum of 15 minutes). Reference lamps and ballasts are specified in the standard for each of the main lamp types and ballast combinations.

The lumen output (or lamp input power in the case of low frequency instant lamp ballasts) and total circuit power with a test ballast and reference lamp is measured. The lumen output (or lamp input power in the case of low frequency instant lamp ballasts) and total circuit power with a reference ballast and lamp is also measured. The relative light output is defined as the ratio of the light output of the test system to the light output of the reference system (expressed as 100 when they are equal). In the case of low frequency instant lamp ballasts, the relative lamp power is defined as the ratio of the lamp power of the test system to the lamp power of the reference system (expressed as 100 when they are equal). The Ballast Efficacy Factor (BEF) is determined as the ratio of the relative light output to the total power input in Watts (except for low frequency instant lamp ballasts, where the BEF is defined as the ratio of the relative lamp power to the total input power in Watts). For example, a single F40T12 reference lamp with a relative light output of 100 (ie equal to the reference ballast/lamp system) and a total input power of say 50 Watts will have a BEF of 2.0. No minimum relative light output (or power output) is required under the standard.

The Canadian standard also mandates that ballasts must have a power factor of greater than 90%.

For regulatory purposes, the ballast type, BEF, the number and type of lamps the ballast is designed to operate and the design voltage has to be supplied.

Issues associated with the use of North American standards for the measurement of efficacy

The north American test method has been specifically developed for the determination of ballast efficacy. The method is robust and takes account of special ballast types such as electronic and rapid start where the lamp power cannot be determined easily. The test method is broadly consistent in approach with the European method (see below), however there are some differences at the margin. These include a mandatory minimum power factor requirements in the north American standards (this is contained in IEC60921 rather than EN50294) and the north American standards do not require a minimum light output as a pre-requisite for the measurement of efficacy.

There are arguments for and against the inclusion of additional performance requirements with MEPS requirements. Some would argue that these are a critical pre-requisite when specifying efficiency as they define the energy service that is being delivered to the customer. On the other hand, such performance requirements are more fully and transparently handled by a performance standard like IEC60921 or IEC60929. The problem is that these standards have a comprehensive range of performance requirements - while many are critical for correct operation, some of these may be viewed as nice but not sufficiently important to make them mandatory.

EN50294-1998 – Ballast input power method

The standard is primarily aimed at measuring the efficacy of both fluorescent lamps and/or ballast combinations. It uses the total input power method for ballast-lamp circuits together with light output (or lamp power input for low frequency systems). Test ballasts are operated with an appropriate reference lamp and the total circuit light output and input power are compared to a reference ballast and reference lamp circuit operated in parallel. The total circuit power and lamp lumen output (or lamp input power) is normalised back to standardised levels for comparison purposes.

EN50294 titled "Measurement method of total input power of ballast-lamp circuits" was specifically developed by CELMA (European Lighting Manufacturer's Association) and subsequently adopted by CENELEC for use as the test method to determine the ballast energy efficiency under CELMA's voluntary energy labelling program. It is also going to be used as the basis for European ballast MEPS which is due to be finalised in the near future (proposal is for the elimination of EEI class D by 2002 and elimination of class C by 2005).

The scope of the standard covers double and single capped fluorescent lamps and their ballasts. The EN standard states a number of exclusions in the scope which are unclear in their intention. The requirements for safety and performance of IEC60920, IEC60921, IEC60928 and IEC60929 are referenced. The standard mandates that a ballast lumen factor be declared by the manufacturer – this has to be in the range 0.925 to 1.0 for ferromagnetic ballasts and between 0.925 and 1.075 for electronic ballasts. The test method for ferromagnetic and electronic ballasts is quite different and each is described below.

For ferromagnetic ballasts, the test ballast is operated with a reference lamp. In addition, a reference lamp and a reference ballast are operated in parallel. The total input power and the lamp power are measured for each circuit. The total input power for the test ballast/lamp circuit is corrected by the ratio of the measured lamp power for the reference circuit to the measured lamp power for the test circuit, times a factor of 0.95. It is unclear why the normalised ballast lumen factor of 0.95 has been chosen for ferromagnetic ballasts (this suggests that manufacturers tend to under-run lamps on average). There is also a small adjustment made for the difference between the measured reference lamp power and nominal reference lamp power (as stated on the data sheet).

For electronic ballasts, the test ballast is operated with a reference lamp. In addition, a reference lamp and a reference ballast are operated in parallel. The total light output and the total input power are measured for each circuit. The total input power for the test ballast/lamp circuit is corrected by the ratio of the light output for the reference circuit to the light output of the test circuit (ie to a BLF of 1.0). The total power is also corrected by the ratio of the nominal lamp power (lamp data sheet) for the reference circuit to the measured lamp power for the reference (the reference ballast is always a ferromagnetic ballast).

Issues associated with the use of EN50294 for the measurement of efficacy

EN50294 has been specifically drafted to address issues of efficacy of fluorescent lamp ballasts. The general approach is good with respect to determination of energy consumption and allows comparison of a wide range of ballast and lamps types. Importantly, the test method is broadly similar in approach to that used in the North American standards.

There are a number of clauses in the CENELEC which are unclear or ambiguous and there is extensive reference made to European directive and other CENELEC standards which makes it unsuitable for use as an international standard. A number of the formulae are also questionable – in particular the adjustment to a BLF of 0.95 for ferromagnetic ballasts and 1.0 for electronic ballasts. However, despite these shortcomings, the general approach is good.

At this stage, EN50294 is only a CENELEC standard and a move has not yet been made to introduce this as an IEC standard. Australia and New Zealand are currently developing a local version of the EN50294 or use in their local ballast efficiency programs. This should provide some insight into the position adopted by the Europeans in their initial version and iron out some of the current problems. There is therefore an opportunity to develop a new IEC standard which addresses the requirements of North America and other APEC member economies, as well as Europe. The basic method is now documented and with some multi-lateral input (especially from APEC member economies) it should be possible to develop a robust and useful international standard. This standard could be developed in a manner that would make it suitable for the measurement of efficacy of both lamps and ballasts.

Australia

The existing test procedures for fluorescent lamp ballasts are AS2643 and AS3963 which are equivalent to IEC60921 and IEC60929 respectively. A new draft standard based on EN50294 for the measurement of ballast energy efficiency is being developed jointly with New Zealand (see above for details).

Canada

The test procedure for fluorescent lamp ballasts is set out in CAN/CSA-C654-M91. This is a harmonised test procedure which is used in North America (see above for details).

China

The test procedure for fluorescent lamp ballasts is set out in GB/T15144-1994. While this standard is based on IEC60929, the method of efficacy measurement is harmonised with the approach used in North America (see above for details).

Japan

The test procedure for fluorescent lamp ballasts is set out in JIS C8108 (ferromagnetic) and JIS C8117 (electronic). While these standards are based on IEC60921 and IEC60929, the method of efficacy measurement is based on a relative light out per total circuit power watts, which is in net effect similar to the North American and European approaches. The relative light output is expressed as a total nominal Lumens based on the rated light output of the reference lamp. A temperature correction based on the actual temperature of lamp operation is also included as an adjustment to the overall efficacy.

Lumens per watt = nominal lamp Lumens $\times$ relative light output $\times$ temperature correction $\div$total input power.

Korea

The test procedure for ferromagnetic fluorescent lamp ballasts is set out in KS C8102 while electronic ballasts are covered by KS C8100. KS C8102 is supposed to be equivalent to JIS C8108 which in turn is based on IEC60921 (see above for details). KS C8100 is supposed to be equivalent to IEC60929 (see above for details). Note that while Korea nominally uses IEC60921 as the basis for test, they have defined ballast efficiency for MEPS in terms of the relative Lumens per watt for the system under test versus a reference system, which is in effect similar to the North American and European systems (although the energy characteristics of the reference ballast are critical in this approach).

Malaysia

The test procedure for ferromagnetic fluorescent lamp ballasts is set out in MS 141. This standard is identical to IEC60921-1988, and only covers ferromagnetic ballasts. The only difference is the addition of a brief Appendix to determine the ballast loss test (Appendix E) which is required for local Malaysian MEPS regulations. The test method is currently under consideration.

New Zealand

A new draft standard based on EN50294 for the measurement of ballast energy efficiency is being developed jointly with Australia (see above for details).

Philippines

The test procedure for fluorescent lamp ballasts in the Philippines is PNS 12-2:1996. It is understood that this standard is equivalent to IEC60921 (see above for details).

Chinese Taipei

The test procedures and requirements for fluorescent lamp ballasts are set out in CNS927-96 (performance requirements) and CNS3888-85 (method of test). Most of the tests relate to operation and safety of the ballast. CNS927 sets out acceptance limits for tests conducted under CSN3888. These include construction and performance requirements. The performance requirements are almost identical to those set out in IEC60920 and IEC60921 (see above for details) although there are some very minor deviations for specialised product types and all product classifications are not identical. It is unclear how the ballast watts loss values for MEPS are determined for rapid start ballast types (CNS standards cited do not include a method of test for these types).

Thailand

The test procedures and requirements for fluorescent lamp ballasts are set out in TIS23-2521. This is supposedly based on IEC 82 for ballasts which was withdrawn many years ago. It is assumed that the more recent version of this standard (IEC60921) is broadly equivalent to the TIS standard (see above for details). A new standard for electronic ballasts TIS 1506-2541 has recently been released. This is broadly based on IEC60929. For verification of efficacy, the Thai system uses the nominal ballast watt loss and the rated lamp power to determine an allowable system Lumens per watt.

USA

The test procedure for fluorescent lamp ballasts is set out in 10CFR430 Sub Part B, Appendix Q. All of the test conditions are externally referenced to ANSI C82.2. This is a harmonised test procedure which is used in North America (see above for details).

Appendix 2: Summary of fluorescent lamp MEPS and energy labelling technical requirements by APEC Economy

Australia

MEPS will apply to ballasts for use with linear fluorescent lamps (T type). MEPS requirements are specified in terms of total allowable ballast and lamp circuit power for various nominal lamp powers. The MEPS level equates to an energy efficiency index (EEI) of B1 or better under the European CELMA scheme, starting in 2002. Light output for electronic systems are normalised to a ballast lumen factor of 1.0 compared to a reference ballast/lamp system while for ferromagnetic systems lamp power is adjusted to 0.95 nominal lamp power (nominally about 0.97 of rated light output). Proposed MEPS levels are summarised in Table 5.

Table 5: Proposed MEPS requirements for linear fluorescent lamp ballasts, Australia

Nominal lamp power W	ILCOS code	MEPS and B1 EEI - maximum total circuit power - watts	A3 EEI - max total circuit power - watts	A2 EEI - max total circuit power - watts
15	FD-15-E-G13-26/450	21.0	18.0	16.0
18	FD-18-E-G13-26/600	24.0	21.0	19.0
30	FD-30-E-G13-26/895	36.0	33.0	31.0
36	FD-36-E-G13-26/1200	41.0	38.0	36.0
38	FD-38-E-G13-26/1047	43.0	40.0	38.0
58	FD-58-E-G13-26/1500	64.0	59.0	55.0
70	FD-70-E-G13-26/1800	77.0	72.0	68.0

Notes: EEI of A1 is as per A3 above with the following additional requirements:

a) ballast shall be dimmable.

b) at 50% power input, light output shall exceed 25% of rated.

c) dimmable to 10% of rated light output.

Canada

Ballast MEPS in Table 6 are expressed in terms of ballast efficacy factors. The ballast efficacy factor (BEF) is determined as the ratio of the relative light output of the test ballast/reference lamp combination (in comparison with the reference lamp/ballast system) divided by the total system power. The relative light output is defined as the ratio of the light output of the test system to the light output of the reference system (expressed as 100 when they are equal). No minimum light output is specified.

The higher the BEF ratio, the higher the efficiency of the ballast under test. The standards in Table 6, which took effect in February 1995, are similar to the US standards for the same products, which took effect in 1990 (the US standards cover only 120V and 277V ballasts, not 347V).

Table 6: Energy efficiency standards, fluorescent lamp ballasts, Canada

Application for operation of:	Ballast input voltage	Total nominal lamp watts (a)	Minimum ballast efficacy factor
One F40T12 lamp (also 34W/48T12/RS and 40W/48T10/RS lamps)	120 V	40 W	1.805
	227 V	40 W	1.805
	347 V	40 W	1.750
Two F40T12 lamps (also 34W/48T12/RS and 40W/48T10/RS lamps)	120 V	80 W	1.060
	227 V	80 W	1.050
	347 V	80 W	1.020
Two F96T12 lamps (also 60W/96T12/IS)	120 V	150 W	0.570
	227 V	150 W	0.570
	347 V	150 W	0.560
Two 110W F96T12HO lamps (also 95W/96T12/HO lamps)	120 V	226 W	0.390
	227 V	226 W	0.390
	347 V	226 W	0.380
Two F32T8 lamps	120 V	64 W	1.250
	227 V	64 W	1.250
	347 V	64 W	1.250

China

Proposed ballast MEPS in Table 7 for introduction in 2000 or soon thereafter are expressed in terms of ballast efficacy factors (BEF). The proposed minimum efficacy levels (also in terms of BEF) for a ballast to meet the endorsement labelling criteria are set out in

Table 8.

The ballast efficacy factor (BEF) is determined as the ratio of the relative light output of the test ballast/reference lamp combination (in comparison with the reference lamp/ballast system) divided by the total system power. The relative light output is defined as the ratio of the light output of the test system to the light output of the reference system (expressed as 100 when they are equal). No minimum light output is specified. The higher the BEF ratio, the higher the efficiency of the ballast under test.

Table 7: Proposed MEPS Levels Ballasts, China

Lamp Type	Minimum BEF ferromagnetic	Minimum BEF electronic
18W (T8)	3.154	4.778
20W (T12)	2.952	4.370
22W (annular)	2.770	3.998
30W (T12)	2.232	2.870
32W (annular)	2.146	2.678
36W (T8)	2.030	2.402
40W(T12)	1.992	2.270

Table 8: Proposed Ballast Efficiency Levels for Endorsement, China

Lamp Type	Minimum BEF ferromagnetic	Minimum BEF electronic
18W (T8)	3.686	5.518
20W (T12)	3.458	5.049
22W (annular)	3.248	4.619
30W (T12)	2.583	3.281
32W (annular)	2.461	3.043
36W (T8)	2.271	2.681
40W(T12)	2.152	2.473

Japan

The Top Runner Program sets out minimum total efficacy levels for a range of lamp/ballast types and combinations. By 2005 all manufacturers of luminaries will be required to have a sales weighted average for each type of product sold which is greater than the Top Runner target. Manufacturers have to report shipments and efficiency levels to MITI. Manufacturers are also required to mark overall luminaire efficacy on their product literature from 2000. Top Runner targets are included in Table 9. Temperature correction factors are included in Table 10.

Table 9: Top Runner Target Values for 2005 - lamp + ballast, Japan

Fixture Type for Fluorescent Lamps	Lumens/Watt
1. Straight 110W rapid start	79.0
2. Straight 40W HF operation	86.5
3. Straight 40W rapid start	71.0
4. Straight 40W starter type	60.5
5. Straight 20W starter type, electronic ballast	77.0
6. Straight 20W starter type, magnetic ballast	49.0
7. Circular type, total lamp wattage >72W	81.0
8. Circular type, 62W< total lamp wattage≤72W	82.0
9. Circular type, total lamp wattage <62W, electronic	75.5
10. Circular type, total lamp wattage <62W, magnetic	59.0
11. Table light with CFL	62.5
12. Table light with straight FL	61.5

Table 10: Temperature Correction Factors: various lamp types- Top Runner, Japan

Lamp Wall Temp ^{o}C	Other types	HF circular - single circle	HF circular double circle	CFL double tube	CFL other types
39 ^{o}C	-	-	1.000	-	-
40 ^{o}C	-	-	1.011	1.000	-
41 ^{o}C	1.000	1.000	1.030	1.007	-
45 ^{o}C	0.998	1.024	1.080	1.019	-
50 ^{o}C	0.970	1.041	1.096	0.996	-
55 ^{o}C	0.926	1.044	1.077	0.955	0.988
60 ^{o}C	0.875	1.031	1.039	0.906	0.944
65 ^{o}C	0.821	1.006	0.991	0.855	0.886
70 ^{o}C	0.767	0.970	0.943	0.808	0.829
75 ^{o}C	0.714	0.929	0.899	0.766	0.779

Note: Part of table only, original MITI table starts at 39^{o}C and ends at 90^{o}C in 1^{o}C intervals

Korea

The requirements for ballasts are listed in Table 11. The performance of the test ballast with a reference lamp is compared with that of a reference ballast connected to the same reference lamp. The efficacy (lumens/watt) of the circuit with the ballast under test is compared with the lumens/watt of the circuit with the reference ballast in place.

The ratio of these two values is called "R" and it is used to define the energy labelling rating and MEPS for ballasts.

Table 12 provides the rating scale used for energy labelling of ballasts. Table 11 sets out the requirements for MEPS. The test standards are KS C 8102-1995 based on JIS C8108 (covering magnetic ballasts) and KS C 8100-1997 (covering electronic ballasts and based broadly on IEC60929).

For energy labelling and MEPS the ratio R is defined as:

$$\frac{\text{Lumens/Watt of the circuit with the ballast being tested and the reference lamp}}{\text{Lumens/Watt of the circuit with the reference ballast and the reference lamp}}$$

In this case, the more efficient the ballast, the *higher* the ratio R. The characteristics of the reference lamp and reference ballast are defined in the test standard.

Table 11: MEPS levels for fluorescent lamp ballasts, Korea

Application for Operation of	Minimum R value (a)	Minimum R value (b)
T10 20W lamp	0.83	0.83
T10 40W lamp	0.97	0.97
T8 32W lamp	-	0.97
Circular 32W lamp	0.97	0.97
Circular 40W lamp	-	0.97

Notes: All 220V input, (a) Until 31 December 1999 (b) From 1 January 2000

The values of R for each of the 5 efficiency gradings are summarised in Table 12. Note that a rating of 5 is the lowest (least efficient) and a rating of 1 is the best.

Table 12: Rating values for R for fluorescent lamp ballast labelling, Korea

Product	Type	5	4	3	2	1
Ballast for fluorescent lamp	For tubular 20 W (T10)	0.83-0.92	0.92-0.97	0.97-1.06	1.06-1.15	≥1.15
	For tubular 40 W (T10)	0.97-1.01	1.01-1.10	1.10-1.18	1.18-1.20	≥1.20
	Others (32W-T8, 32W & 40W circular)	0.97-1.01	1.01-1.05	1.05-1.09	1.09-1.18	≥1.18

Note: Ratings valid until 30 May 2002.

Malaysia

MEPS maximum watt loss levels are specified as follows:

By 1 January 1999: maximum allowable loss = 10 watts

By 1 January 2000: maximum allowable loss = 8 watts

By 1 January 2001: maximum allowable loss = 6 watts

These set for ballasts designed to operate 1200mm linear fluorescent lamps.

New Zealand

Details of MEPS for New Zealand are not yet finalised. While the test method will be harmonised with Australia, it is not clear whether the MEPS levels will be comparable.

Philippines

Ballasts will be tested and rated into four separate classes (A to D) based on their energy performance (loss in Watts) as shown in the following tables:

Table 13: Classification of preheated ferromagnetic ballasts, Philippines

	Preheat Maximum Ballast Loss Standard Classification			
Ballast Type	**A**	**B**	**C**	**D**
2 × 18/20 W or 1 × 36/40 W	≤ 7 W	> 7 W ≤ 8 W	> 8 W ≤ 10 W	>10 W ≤ 12 W

Table 14: Classification of rapid start ferromagnetic ballasts, Philippines

	Rapid Start Maximum Ballast Loss Standard Classification			
Ballast Type	**A**	**B**	**C**	**D**
2 × 18/20 W or 1 × 36/40 W	≤ 12 W	> 12 W ≤ 13 W	> 13 W ≤ 15 W	>15 W ≤ 18 W
2 × 36/40 W	≤ 17 W	> 17 W ≤ 18 W	> 18 W ≤ 20 W	> 20 W ≤ 30W

Details of MEPS for ballasts in the Philippines are yet to be finalised, but it is believed that the current proposal is to eliminate any ballasts with a classification of less than D.

Singapore

Scheme for 1-year Accelerated Depreciation Tax Incentive (1996) applies to Ballasts for commercial and industrial fluorescent lighting systems. The new ballast or lighting system must replace old equipment. An engineering analysis by a registered professional engineer must show that the replacement will reduce energy consumption. No energy testing is required.

Chinese Taipei

Maximum allowable power consumption for fluorescent lamp ballasts were first specified in 1993 (File of (82) energy 082044). These were updated in 1995 by File of (84) energy 8446093 issued by MOEA, 26 April 1995), taking effect 1 January 1996.

The program covers both pre-heat start and rapid start ballasts, and both 110V and 220V designs.

Table 15 indicates the maximum allowable power levels for preheat start ballasts of various configurations (note that all are for linear fluorescent lamps except one). Table 16 indicates the maximum allowable power levels for rapid start ballasts. All ballasts are required to have a power factor of not less than 90%.

Table 15: MEPS for preheat start ballasts, Chinese Taipei

Group	Description	Max Ballast Power 110V	Max Ballast Power 220V	Min Power Factor
1	FL10W	5	7	> 90%
2	FL15W	5	7	> 90%
3	FL20W	5	7	> 90%
4	FL30W	11	8	> 90%
5	FCL30W (circular tube)	8.5	10.5	> 90%
6	FL40W	11	7	> 90%

Source: MOEA (1999)

Table 16: MEPS for rapid start ballasts, Chinese Taipei

Group	Description	Max Ballast Power 110V	Max Ballast Power 220V	Min Power Factor
1	FLR20W	13	14	> 90%
2	FLR20W × 2	15	16	> 90%
3	FLR40W	19	19	> 90%
4	FLR40W × 2	20	20	> 90%
5	FLR60W	24	25	> 90%
6	FLR110W	32	33	> 90%

CNS 3888 covers preheat start ballasts. The energy testing methods are specified in chapter 4.5, 4.8 and 4.9. CNS 927-96 covers rapid start ballasts.

Thailand

To obtain an energy label, four sample units must be randomly tested at TISI from a pool of at least 10 units of the same model (same size and features). If all four tested ballasts that have losses less than 6 watts each, the model will obtain a "Safety Ballast Number 5" label. If any of the four ballasts tested has greater than 6 watts loss, a replacement can be chosen from the remaining 6 units. If the replacement ballast still has losses greater than 6 watts, the model will not receive the label.

For MEPS, a product must exceed the minimum energy efficiency level to allow sale in the market. The minimum efficiency level has not been determined. For magnetic ballasts, a maximum loss of 6W is being considered as a MEPS level and this is under consideration. For electronic ballasts, research is being conducted to consider efficiency, power factor, total harmonic distortion, radio frequency interference, crest factor, and ballast life. For verification of efficacy, the Thai system uses the nominal ballast watt loss and the rated lamp power to determine an allowable system Lumens per watt.

USA

The Regulations cover lamp ballasts for design voltages of 120 and 277 V, and intended to operate with the lamp types listed in Table 17. The minimum efficiency standards in Table 17 are expressed in terms of ballast efficacy factors.

The ballast efficacy factor (BEF) is determined as the ratio of the relative light output of the test ballast/reference lamp combination (in comparison with the reference lamp/ballast system) divided by the total system power. The relative light output is defined as the ratio of the light output of the test system to the light output of the reference system (expressed as 100 when they are equal). The higher the ratio, the higher the efficiency of the ballast under test. The standards, which took effect on 1 January 1990, also require ballasts to have a power factor if 0.90 or greater.

Table 17: MEPS for fluorescent lamp ballasts, USA

Application for operation of:	Ballast input voltage	Total nominal lamp watts (a)	Minimum ballast efficacy factor
One F40T12 lamp	120 V	40 W	1.805
	227 V	40 W	1.805
Two F40T12 lamps	120 V	80 W	1.060
	227 V	80 W	1.050
Two F96T12 lamps	120 V	150 W	0.570
	227 V	150 W	0.570
Two F96T12HO lamps	120 V	226 W	0.390
	227 V	226 W	0.390

The test procedures are specified in DOE 10CFR430.27 Appendix Q which references ANSI C78.1 and ANSI C-82.2.