

A STUDY ON THE SAFETY AND PARAMETERS OF POWER DIRECT LED LAMP

Jin-Tai Kim¹ and Chung-hyeok Kim²

¹Korea Testing and Research Institute

²Ingenium College of Engineering, Kwangwoon University

E-mail: bighhs@naver.com

ABSTRACT

As energy problems emerge, high-efficiency lighting devices that can replace conventional lighting are required to save energy, and among them, LED (light emitting diode) lighting has begun to emerge as the next-generation lighting. Since LED has low power, high efficiency, long lifetime, and fast response speed, it is suitable to replace existing lighting such as incandescent lamps, fluorescent lamps, and halogen lamps. The present study proposes safety of household appliances to prevent a degraded replacement effect due to excessive luminous flux of an LED lamp that replaces a bending-type fluorescent lamp (FPL), to prevent excessive design investment for manufacturers by providing appropriate optical reference values, to identify safety issues during the installation of AC power direct LED lamps, and to standardize the optimal power supply method that can be fixed by using the LED lamp based on external converters and the LED lamp for fluorescent lamp replacement.



Ballast: A device for operating fluorescent lamps (AC input-AC output)

Fig. 1. Fluorescent lamp replacement type LED lamp – built-in converter type (the certified lamps and ballasts for fluorescent lamps can be used without modification)

Keywords: LED luminaire, LED lighting, safety standards for electrical appliances, electrical appliances safety standards in Korea, electrical safety management, safety certification, ballast, power direct, power supply, connection method

1. INTRODUCTION

1.1. Background of the Present Study

The LED lighting market has rapidly appeared due to the rapid growth of the green energy business since 2009. Furthermore, to meet the demand for energy saving, LED light sources are being replaced by traditional light sources with low energy efficiency. The light source has evolved from candles in the past, to incandescent lamps, fluorescent lamps, and LED lamps.

LED light sources have been replacing fluorescent lamps, and related luminaire are appearing in the market. In particular, the fluorescent replacement LED lamps have been actively developed to increase energy efficiency and reduce the use of mercury for environmentally friendly factors. Fluorescent lamps have been used most often in homes, offices, and industrial facilities, and recently, G13 cap's linear-type LED lamps are actively being used.

Furthermore, safety standards have been recently enacted (14.4.30) for LED lamps and linear-type LED lamps, which can replace the conventional FPL fluorescent lamps (FPL) used in homes in Korea, and certified to be distributed and commercialized.

Table 1. FPL LED Lamp Safety Standard (KC10025)

Item	Linear type (G13 cap)		FPL type (2G11 cap)	
Shape				
Power, W	20, 32, 40		36, 55	
Luminous flux standard	20 W	1100 lm → 858 lm	36 W	2590 lm → 2202 lm
	32 W	2300 lm (simulation)	55 W	4000 lm → 3400 lm
Note	The calculated luminous flux is 85 % of the luminous flux standard of KS C7601 (fluorescent lamp)			

There are different types of LED lamps. The first type is shown in Fig. 1 and it is the so-called G13/2G11 cap-shaped fluorescent lamp replacement LED lamp—built in converter, which only uses LED lamps. The second type is G13 linear type with an external converter, as shown in Fig. 2. The final type of LED lamp is shown in Fig. 3, where 220 V commercial power is supplied to the LED lamp caps of the linear type with a G13 cap and the FPL type with a 2G11 cap. [1]

Criteria for the optical characteristics of the linear type LED lamp can be found in the safety standards (KC) for the conventional fluorescent lamp replacement type LED lamp—built-in converter and the linear type LED lamp—external converter. Furthermore, the criteria for the linear type FPL LED lamps are only discussed in the safety standards of the conventional fluorescent lamp replacement type LED lamp—built-in converter (KC10025). However, as shown in Table 1, because the suggested value is defined as 85 % or higher of the standard value of the fluorescent lamp (KS C7601), rather than the actual measurement data, research needs to be conducted to determine whether fluorescent lamps can be replaced by those LED lamps or not. [2]

The fluorescent lamp replacement LED lamp can save time and money by using existing luminaires for fluorescent lamps without modification. Therefore, compared to the case where new LED luminaires need to be installed, the burden for the

installation can be relatively reduced and the existing luminaires for fluorescent lamps can be recycled without discarding them. Therefore, these luminaires have three main advantages: high efficiency, long lifetime, and eco-friendliness.

The linear type lamps are classified as:

1. The fluorescent lamp (1200 mm 32 W, 36 W, 40 W);
2. The LED lamp-external converter;
3. The fluorescent lamps replacement type (ballast compatible);
4. The power direct-type LED lamp.

Among them, the first, second, and third can be certified through the KC certification by the National Institute of technology and standards, but the fourth (the power direct-type LED lamp) has not been certified due to the lack of safety items to be tested, such as standardization of the power system when a LED lamp is used with conventional lamps and fluorescent light bulbs having the same shape as the LED lamp. As a result, due to the lack of certification standards, the demand for certification by Korean companies is increasing rapidly.

When direct-type LED lamps are supplied, it is expected that problems such as fire, electric shock, and burning accidents may arise due to misuse of lamps with different power supply methods. Therefore, this paper will study and analyse the problems

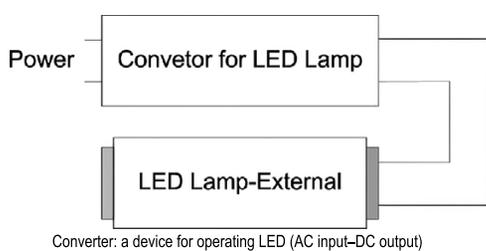


Fig. 2. Linear LED lamp – external converter type (an LED converter and an LED lamp with AC/DC50 V or lower)

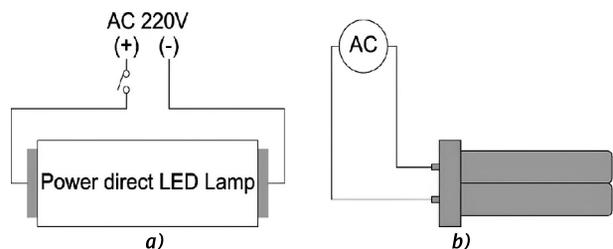


Fig 3. Power direct LED lamp (a) and FPL lamp (b) (this is a 220 V direct input method, where a converter and an LED lamp are integrated)

Table 2. Linear LED Lamp Certification Status

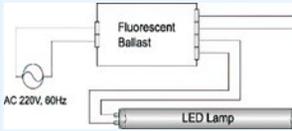
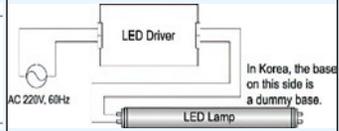
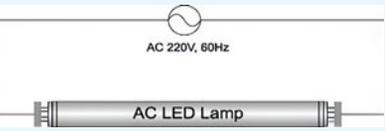
Method	Compatible ballast	External converter	220 V power direct
Circuit			
Manufacturer	20 companies	300 companies	No certified companies exist *foreign manufacturing companies cannot sell in Korea
Standard trend	Established in 2/25/2013	Established in 12/21/2010	-
Standard number	KC10025 (G13 base)	KC20001 (G13 and D12 bases)	-
International standard	IEC62776 (G13 and G5 bases)	IEC62931 (GX16t-5 base)	-

Table 3. Linear LED Lamp – External Converter Type

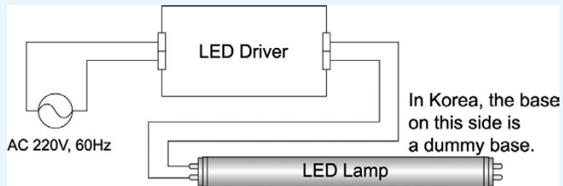
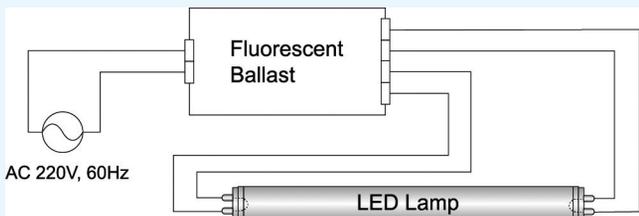
Lamp type (date of notice on safety standards)	LED converter and LED lamp below AC/DC50V used ⇒ (Notice of Electrical Appliances Safety Standards: 2010.12.21)
Structure	

Table 4. Fluorescent Lamp Replacement Type LED Lamp – Built-in Converter Type

Lamp type (date of notice on safety standards)	Certified luminaires and ballasts for fluorescent lamps are used without modification ⇒ (Notice of Electrical Appliances Safety Standards: 2013.03.25)
Structure	

of the conventional fluorescent lamps and the expected problems in the actual use of those lamps, which are summarized in Tables 2, 3 and 4.

Furthermore, safety standards for electrical appliances (KC) will be established to ensure that safe and high-quality products are distributed, and consumers can use safe products.

Therefore, with this study, it is possible to derive the safety problems that can occur when the direct-type LED lamp, which is shown in Table 4, is attached to the conventional fluorescent lamp and the luminaires shown in Table 2 and Table 3, and

to ensure safety when using them together by standardizing the optimum power supply method. Furthermore, the conventional FPL fluorescent lamps are mounted on a luminaire, and the lamp power, luminous flux, and illuminance are measured and analysed to study optimized optical characteristics that can replace the conventional lamps, based on which the domestic electrical appliance safety standards (KC) will be proposed.

Table 5 shows the connection circuit for the power direct LED lamp, which will be analysed in this work.

Table 5. Power Direct LED Lamp

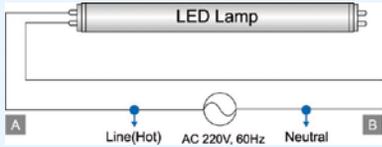
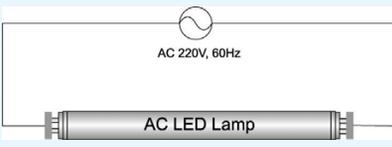
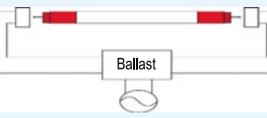
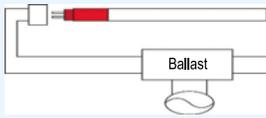
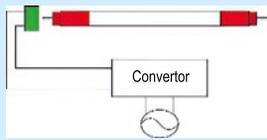
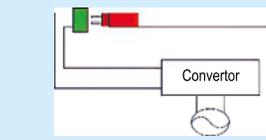
<p>Lamp type (date of notice on safety standards)</p>	<p>220 V direct input method is used and a converter and an LED lamp are integrated ⇒ Absence of safety standards</p>	
<p>Structure</p>	 <p>Input in one side</p>	 <p>Input in both sides</p>

Table 6. Direct Power LED Lamp Cross Table

Item	Power direct LED lamp	
	Connection method 1	Connection method 2
Luminaires for fluorescent lamp / LED lamp for replacing a fluorescent lamp with a built-in converter		
LED Lamp-external converter type		

2. MATERIALS AND METHODS

This study analyses the risks when the power direct-type LED lamps are installed in the conventional luminaires for fluorescent lamps and LED lamp built-in converter type and LED lamp-external converter, which are shown in Table 6, for safety investigation. Furthermore, as shown in Table 7, the risks are analysed when the LED lamp-external converter is installed in the existing luminaires for fluorescent lamps and luminaires for power direct-type LED lamps, and as shown in Table 8, the risks are analysed when the fluorescent lamps and fluorescent lamp replacement LED lamps are installed in luminaires for the LED lamp-external converter and luminaires for the power direct-type LED lamps.

Based on the analyses, problems such as compatibility, electric shock, and fire risk were derived:

1. The products that were certified by KC10025 (fluorescent lamp replacement type LED lamp-built-in converter) were analysed and the suitability for the specified luminous flux was confirmed as shown in Table 1;

2. The revised proposal was made by comparing and analysing the luminaire parameters for three FPL 36 W lamps with fluorescent lamps and LED lamps respectively;

3. The revised proposal was made by comparing and analysing the luminaire parameters for three FPL 55 W lamps with fluorescent lamps and LED lamps respectively to propose safety standards.

In addition, the reason why a luminaire with three FPL lamps was used for testing is that this type of luminaire is most common in household applications.

The optical properties were measured in accordance with Annex B of IEC60901: Single-capped fluorescent lamps–Performance specifications and illuminance simulations were analysed with a Goniophotometer (LMT, Germany) in accordance with Annex A of KS C8000: General rules for lighting equipment. The lighting method of the luminaire was measured by connecting the test ballast specified in KS C7601 (fluorescent lamp) standard as shown in

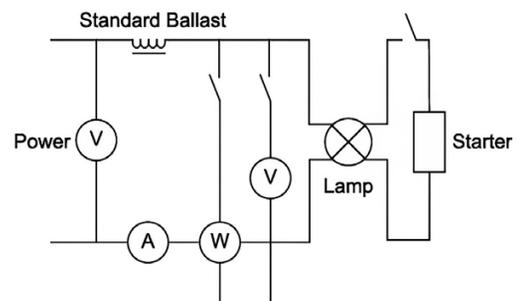


Fig. 4. Test circuit

Table 7. Converter External LED Lamp Cross Table

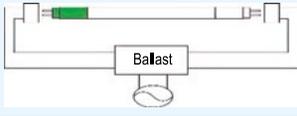
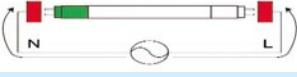
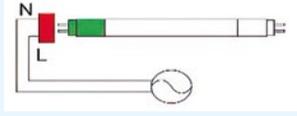
Item	LED lamp-external converter type	Note
Luminaire for fluorescent lamp		-
Luminaire for power direct LED lamp		Connection method 1
		Connection method 2

Table 8. Fluorescent Lamp and LED Lamp Built-In Converter Type Cross Table

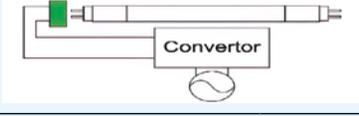
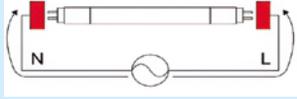
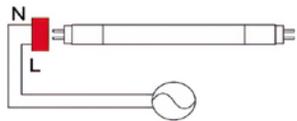
Item	Fluorescent lamp	LED lamp built-in converter	Note
Luminaire for LED lamp-external converter type			-
Luminaire for power direct LED lamp			Connection method 1
			Connection method 2

Table 9. Certified Product Analysis Results

Parameter	Unit	FPL 36 W			FPL 55 W	
		Fluorescent lamp		LED lamp	Fluorescent lamp	LED lamp
		A	B			
Luminous flux	lm	5410	5733	6558	8295	9948
Luminaire power	W	91	101	54	159	94
Luminous efficacy	lm/W	59.5	57.0	121.4	52.2	105.8
Floor surface average illuminance	lx	150	161	215	218	319

Table 10. Comparison Characteristics of FPL 36 W Fluorescent Lamp with LED Lamp

Parameter	Unit	Luminaire for three FPL 36 W lamps	
		Fluorescent Lamp	LED Lamp
Luminous flux	lm	5733	4967 (1902)
Luminaire power	W	101	42 (14)
Luminous efficacy	lm/W	57.0	117.9
Floor surface average illuminance	lx	161	160

Table 11. Comparison Luminaire Characteristics with FPL 36 W Fluorescent Lamp and LED Lamp

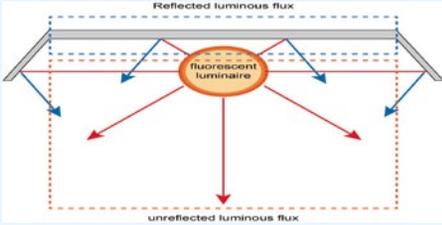
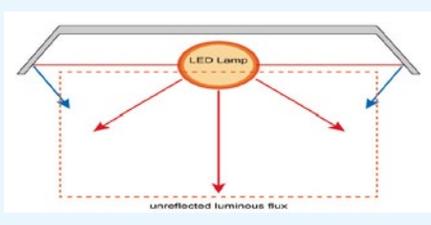
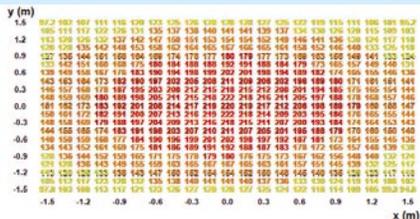
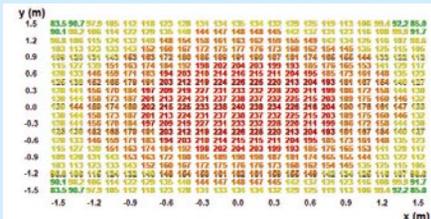
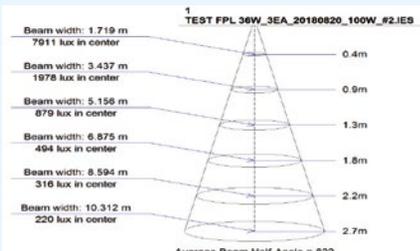
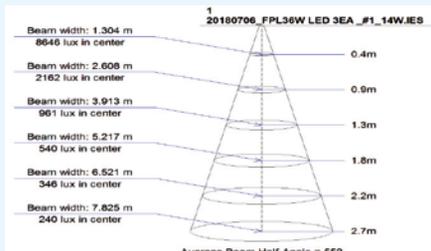
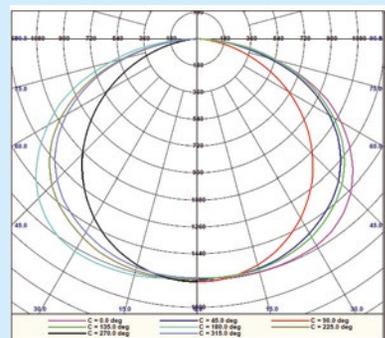
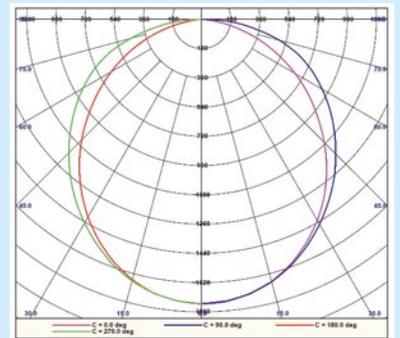
Type Item	Luminaire for fluorescent lamp (FPL 36 W×luminaire for three lamps)	LED luminaire (FPL 14 W×luminaire for three lamps)
Luminaire Operation conceptual diagram		
Illuminance distribution	 <p>Horizontal Illuminance All illuminance values in lux Table Average: 161 Table Maximum: 222 Table Minimum: 94.8 Mounting Height = 2.7 m</p>	 <p>Horizontal Illuminance All illuminance values in lux Table Average: 160 Table Maximum: 240 Table Minimum: 83.5 Mounting Height = 2.7 m</p>
Illuminance	 <p>Average Beam Half-Angle = 62°</p>	 <p>Average Beam Half-Angle = 55°</p>
Distribution curve (of luminous intensity)		

Fig. 4, and measurements were made in a darkroom at 25 °C ± 1 °C. [3]

3. TEST RESULTS

For cross-sectional analysis, safety studies were conducted for two connection methods (the first method and the second method), as shown in Table 8, and the measurement results according to IEC60901 and KS C8000 are as follows.

Product analysis showed that replacing the fluorescent lamp FPL 36 W with a KC10025 certified commercially produced LED lamp with a built-in

current converter provides a higher illuminance value of 65 lx while reducing power consumption by 47 W, as shown in Table 9. In addition, if the fluorescent lamp FPL 55 W was replaced with an LED one, the illuminance level increased by 101 lx, and the power consumption decreased by 65 W. Based on this, it can be concluded that the luminous flux of LED lamps exceeds the regulated values specified in the standard, so they need to be modified. [2]

The result of a comparative analysis of an EX-D fluorescent lamp (daylight) and an LED lamp in a three-dome luminaire designed for FPL 36 W lamps is as follows: each light source was turned on at the

Table 12. Comparison Characteristics of FPL 55 W Fluorescent Lamp with LED Lamp

Parameter	Unit	Luminaire for three FPL 55 W lamps	
		Fluorescent lamp	LED lamp
Luminous flux	lm	8295	6898 (3217)
Luminaire power	W	159	70 (23)
Luminous efficacy	lm/W	52.2	98.8
Floor surface average illuminance	lx	218	219

Table 13. Comparison Luminaire Characteristics with FPL 55 W Fluorescent Lamp and LED Lamp

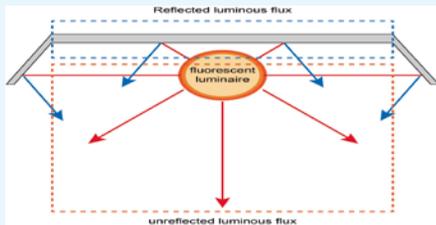
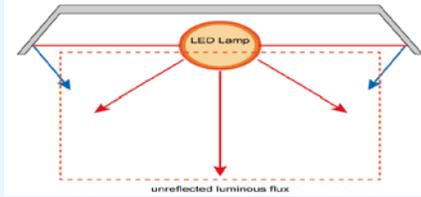
Type Item	Luminaire for fluorescent lamp (FPL 55 W×luminaire for three lamps)	LED luminaire (FPL 23 W×luminaire for three lamps)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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<tr><td>1.5</td><td>128</td><td>137</td><td>146</td><td>154</td><td>163</td><td>172</td><td>181</td><td>190</td><td>199</td><td>208</td><td>217</td><td>226</td><td>235</td><td>244</td><td>253</td><td>262</td><td>271</td><td>280</td><td>289</td><td>298</td><td>307</td><td>316</td><td>325</td><td>334</td><td>343</td><td>352</td><td>361</td><td>370</td><td>379</td><td>388</td><td>397</td><td>406</td><td>415</td><td>424</td><td>433</td><td>442</td><td>451</td><td>460</td><td>469</td><td>478</td><td>487</td><td>496</td><td>505</td><td>514</td><td>523</td><td>532</td><td>541</td><td>550</td><td>559</td><td>568</td><td>577</td><td>586</td><td>595</td><td>604</td><td>613</td><td>622</td><td>631</td><td>640</td><td>649</td><td>658</td><td>667</td><td>676</td><td>685</td><td>694</td><td>703</td><td>712</td><td>721</td><td>730</td><td>739</td><td>748</td><td>757</td><td>766</td><td>775</td><td>784</td><td>793</td><td>802</td><td>811</td><td>820</td><td>829</td><td>838</td><td>847</td><td>856</td><td>865</td><td>874</td><td>883</td><td>892</td><td>901</td><td>910</td><td>919</td><td>928</td><td>937</td><td>946</td><td>955</td><td>964</td><td>973</td><td>982</td><td>991</td><td>1000</td><td>1009</td><td>1018</td><td>1027</td><td>1036</td><td>1045</td><td>1054</td><td>1063</td><td>1072</td><td>1081</td><td>1090</td><td>1099</td><td>1108</td><td>1117</td><td>1126</td><td>1135</td><td>1144</td><td>1153</td><td>1162</td><td>1171</td><td>1180</td><td>1189</td><td>1198</td><td>1207</td><td>1216</td><td>1225</td><td>1234</td><td>1243</td><td>1252</td><td>1261</td><td>1270</td><td>1279</td><td>1288</td><td>1297</td><td>1306</td><td>1315</td><td>1324</td><td>1333</td><td>1342</td><td>1351</td><td>1360</td><td>1369</td><td>1378</td><td>1387</td><td>1396</td><td>1405</td><td>1414</td><td>1423</td><td>1432</td><td>1441</td><td>1450</td><td>1459</td><td>1468</td><td>1477</td><td>1486</td><td>1495</td><td>1504</td><td>1513</td><td>1522</td><td>1531</td><td>1540</td><td>1549</td><td>1558</td><td>1567</td><td>1576</td><td>1585</td><td>1594</td><td>1603</td><td>1612</td><td>1621</td><td>1630</td><td>1639</td><td>1648</td><td>1657</td><td>1666</td><td>1675</td><td>1684</td><td>1693</td><td>1702</td><td>1711</td><td>1720</td><td>1729</td><td>1738</td><td>1747</td><td>1756</td><td>1765</td><td>1774</td><td>1783</td><td>1792</td><td>1801</td><td>1810</td><td>1819</td><td>1828</td><td>1837</td><td>1846</td><td>1855</td><td>1864</td><td>1873</td><td>1882</td><td>1891</td><td>1900</td><td>1909</td><td>1918</td><td>1927</td><td>1936</td><td>1945</td><td>1954</td><td>1963</td><td>1972</td><td>1981</td><td>1990</td><td>1999</td><td>2008</td><td>2017</td><td>2026</td><td>2035</td><td>2044</td><td>2053</td><td>2062</td><td>2071</td><td>2080</td><td>2089</td><td>2098</td><td>2107</td><td>2116</td><td>2125</td><td>2134</td><td>2143</td><td>2152</td><td>2161</td><td>2170</td><td>2179</td><td>2188</td><td>2197</td><td>2206</td><td>2215</td><td>2224</td><td>2233</td><td>2242</td><td>2251</td><td>2260</td><td>2269</td><td>2278</td><td>2287</td><td>2296</td><td>2305</td><td>2314</td><td>2323</td><td>2332</td><td>2341</td><td>2350</td><td>2359</td><td>2368</td><td>2377</td><td>2386</td><td>2395</td><td>2404</td><td>2413</td><td>2422</td><td>2431</td><td>2440</td><td>2449</td><td>2458</td><td>2467</td><td>2476</td><td>2485</td><td>2494</td><td>2503</td><td>2512</td><td>2521</td><td>2530</td><td>2539</td><td>2548</td><td>2557</td><td>2566</td><td>2575</td><td>2584</td><td>2593</td><td>2602</td><td>2611</td><td>2620</td><td>2629</td><td>2638</td><td>2647</td><td>2656</td><td>2665</td><td>2674</td><td>2683</td><td>2692</td><td>2701</td><td>2710</td><td>2719</td><td>2728</td><td>2737</td><td>2746</td><td>2755</td><td>2764</td><td>2773</td><td>2782</td><td>2791</td><td>2800</td><td>2809</td><td>2818</td><td>2827</td><td>2836</td><td>2845</td><td>2854</td><td>2863</td><td>2872</td><td>2881</td><td>2890</td><td>2899</td><td>2908</td><td>2917</td><td>2926</td><td>2935</td><td>2944</td><td>2953</td><td>2962</td><td>2971</td><td>2980</td><td>2989</td><td>2998</td><td>3007</td><td>3016</td><td>3025</td><td>3034</td><td>3043</td><td>3052</td><td>3061</td><td>3070</td><td>3079</td><td>3088</td><td>3097</td><td>3106</td><td>3115</td><td>3124</td><td>3133</td><td>3142</td><td>3151</td><td>3160</td><td>3169</td><td>3178</td><td>3187</td><td>3196</td><td>3205</td><td>3214</td><td>3223</td><td>3232</td><td>3241</td><td>3250</td><td>3259</td><td>3268</td><td>3277</td><td>3286</td><td>3295</td><td>3304</td><td>3313</td><td>3322</td><td>3331</td><td>3340</td><td>3349</td><td>3358</td><td>3367</td><td>3376</td><td>3385</td><td>3394</td><td>3403</td><td>3412</td><td>3421</td><td>3430</td><td>3439</td><td>3448</td><td>3457</td><td>3466</td><td>3475</td><td>3484</td><td>3493</td><td>3502</td><td>3511</td><td>3520</td><td>3529</td><td>3538</td><td>3547</td><td>3556</td><td>3565</td><td>3574</td><td>3583</td><td>3592</td><td>3601</td><td>3610</td><td>3619</td><td>3628</td><td>3637</td><td>3646</td><td>3655</td><td>3664</td><td>3673</td><td>3682</td><td>3691</td><td>3700</td><td>3709</td><td>3718</td><td>3727</td><td>3736</td><td>3745</td><td>3754</td><td>3763</td><td>3772</td><td>3781</td><td>3790</td><td>3799</td><td>3808</td><td>3817</td><td>3826</td><td>3835</td><td>3844</td><td>3853</td><td>3862</td><td>3871</td><td>3880</td><td>3889</td><td>3898</td><td>3907</td><td>3916</td><td>3925</td><td>3934</td><td>3943</td><td>3952</td><td>3961</td><td>3970</td><td>3979</td><td>3988</td><td>3997</td><td>4006</td><td>4015</td><td>4024</td><td>4033</td><td>4042</td><td>4051</td><td>4060</td><td>4069</td><td>4078</td><td>4087</td><td>4096</td><td>4105</td><td>4114</td><td>4123</td><td>4132</td><td>4141</td><td>4150</td><td>4159</td><td>4168</td><td>4177</td><td>4186</td><td>4195</td><td>4204</td><td>4213</td><td>4222</td><td>4231</td><td>4240</td><td>4249</td><td>4258</td><td>4267</td><td>4276</td><td>4285</td><td>4294</td><td>4303</td><td>4312</td><td>4321</td><td>4330</td><td>4339</td><td>4348</td><td>4357</td><td>4366</td><td>4375</td><td>4384</td><td>4393</td><td>4402</td><td>4411</td><td>4420</td><td>4429</td><td>4438</td><td>4447</td><td>4456</td><td>4465</td><td>4474</td><td>4483</td><td>4492</td><td>4501</td><td>4510</td><td>4519</td><td>4528</td><td>4537</td><td>4546</td><td>4555</td><td>4564</td><td>4573</td><td>4582</td><td>4591</td><td>4600</td><td>4609</td><td>4618</td><td>4627</td><td>4636</td><td>4645</td><td>4654</td><td>4663</td><td>4672</td><td>4681</td><td>4690</td><td>4699</td><td>4708</td><td>4717</td><td>4726</td><td>4735</td><td>4744</td><td>4753</td><td>4762</td><td>4771</td><td>4780</td><td>4789</td><td>4798</td><td>4807</td><td>4816</td><td>4825</td><td>4834</td><td>4843</td><td>4852</td><td>4861</td><td>4870</td><td>4879</td><td>4888</td><td>4897</td><td>4906</td><td>4915</td><td>4924</td><td>4933</td><td>4942</td><td>4951</td><td>4960</td><td>4969</td><td>4978</td><td>4987</td><td>4996</td><td>5005</td><td>5014</td><td>5023</td><td>5032</td><td>5041</td><td>5050</td><td>5059</td><td>5068</td><td>5077</td><td>5086</td><td>5095</td><td>5104</td><td>5113</td><td>5122</td><td>5131</td><td>5140</td><td>5149</td><td>5158</td><td>5167</td><td>5176</td><td>5185</td><td>5194</td><td>5203</td><td>5212</td><td>5221</td><td>5230</td><td>5239</td><td>5248</td><td>5257</td><td>5266</td><td>5275</td><td>5284</td><td>5293</td><td>5302</td><td>5311</td><td>5320</td><td>5329</td><td>5338</td><td>5347</td><td>5356</td><td>5365</td><td>5374</td><td>5383</td><td>5392</td><td>5401</td><td>5410</td><td>5419</td><td>5428</td><td>5437</td><td>5446</td><td>5455</td><td>5464</td><td>5473</td><td>5482</td><td>5491</td><td>5500</td><td>5509</td><td>5518</td><td>5527</td><td>5536</td><td>5545</td><td>5554</td><td>5563</td><td>5572</td><td>5581</td><td>5590</td><td>5599</td><td>5608</td><td>5617</td><td>5626</td><td>5635</td><td>5644</td><td>5653</td><td>5662</td><td>5671</td><td>5680</td><td>5689</td><td>5698</td><td>5707</td><td>5716</td><td>5725</td><td>5734</td><td>5743</td><td>5752</td><td>5761</td><td>5770</td><td>5779</td><td>5788</td><td>5797</td><td>5806</td><td>5815</td><td>5824</td><td>5833</td><td>5842</td><td>5851</td><td>5860</td><td>5869</td><td>5878</td><td>5887</td><td>5896</td><td>5905</td><td>5914</td><td>5923</td><td>5932</td><td>5941</td><td>5950</td><td>5959</td><td>5968</td><td>5977</td><td>5986</td><td>5995</td><td>6004</td><td>6013</td><td>6022</td><td>6031</td><td>6040</td><td>6049</td><td>6058</td><td>6067</td><td>6076</td><td>6085</td><td>6094</td><td>6103</td><td>6112</td><td>6121</td><td>6130</td><td>6139</td><td>6148</td><td>6157</td><td>6166</td><td>6175</td><td>6184</td><td>6193</td><td>6202</td><td>6211</td><td>6220</td><td>6229</td><td>6238</td><td>6247</td><td>6256</td><td>6265</td><td>6274</td><td>6283</td><td>6292</td><td>6301</td><td>6310</td><td>6319</td><td>6328</td><td>6337</td><td>6346</td><td>6355</td><td>6364</td><td>6373</td><td>6382</td><td>6391</td><td>6400</td><td>6409</td><td>6418</td><td>6427</td><td>6436</td><td>6445</td><td>6454</td><td>6463</td><td>6472</td><td>6481</td><td>6490</td><td>6499</td><td>6508</td><td>6517</td><td>6526</td><td>6535</td><td>6544</td><td>6553</td><td>6562</td><td>6571</td><td>6580</td><td>6589</td><td>6598</td><td>6607</td><td>6616</td><td>6625</td><td>6634</td><td>6643</td><td>6652</td><td>6661</td><td>6670</td><td>6679</td><td>6688</td><td>6697</td><td>6706</td><td>6715</td><td>6724</td><td>6733</td><td>6742</td><td>6751</td><td>6760</td><td>6769</td><td>6778</td><td>6787</td><td>6796</td><td>6805</td><td>6814</td><td>6823</td><td>6832</td><td>6841</td><td>6850</td><td>6859</td><td>6868</td><td>6877</td><td>6886</td><td>6895</td><td>6904</td><td>6913</td><td>6922</td><td>6931</td><td>6940</td><td>6949</td><td>6958</td><td>6967</td><td>6976</td><td>6985</td><td>6994</td><td>7003</td><td>7012</td><td>7021</td><td>7030</td><td>7039</td><td>7048</td><td>7057</td><td>7066</td><td>7075</td><td>7084</td><td>7093</td><td>7102</td><td>7111</td><td>7120</td><td>7129</td><td>7138</td><td>7147</td><td>7156</td><td>7165</td><td>7174</td><td>7183</td><td>7192</td><td>7201</td><td>7210</td><td>7219</td><td>7228</td><td>7237</td><td>7246</td><td>7255</td><td>7264</td><td>7273</td><td>7282</td><td>7291</td><td>7300</td><td>7309</td><td>7318</td><td>7327</td><td>7336</td><td>7345</td><td>7354</td><td>7363</td><td>7372</td><td>7381</td><td>7390</td><td>7399</td><td>7408</td><td>7417</td><td>7426</td><td>7435</td><td>7444</td><td>7453</td><td>7462</td><td>7471</td><td>7480</td><td>7489</td><td>7498</td><td>7507</td><td>7516</td><td>7525</td><td>7534</td><td>7543</td><td>7552</td><td>7561</td><td>7570</td><td>7579</td><td>7588</td><td>7597</td><td>7606</td><td>7615</td><td>7624</td><td>7633</td><td>7642</td><td>7651</td><td>7660</td><td>7669</td><td>7678</td><td>7687</td><td>7696</td><td>7705</td><td>7714</td><td>7723</td><td>7732</td><td>7741</td><td>7750</td><td>7759</td><td>7768</td><td>7777</td><td>7786</td><td>7795</td><td>7804</td><td>7813</td><td>7822</td><td>7831</td><td>7840</td><td>7849</td><td>7858</td><td>7867</td><td>7876</td><td>7885</td><td>7894</td><td>7903</td><td>7912</td><td>7921</td><td>7930</td><td>7939</td><td>7948</td><td>7957</td><td>7966</td><td>7975</td><td>7984</td><td>7993</td><td>8002</td><td>8011</td><td>8020</td><td>8029</td><td>8038</td><td>8047</td><td>8056</td><td>8065</td><td>8074</td><td>8083</td><td>8092</td><td>8101</td><td>8110</td><td>8119</td><td>8128</td><td>8137</td><td>8146</td><td>8155</td><td>8164</td><td>8173</td><td>8182</td><td>8191</td><td>8200</td><td>8209</td><td>8218</td><td>8227</td><td>8236</td><td>8245</td><td>8254</td><td>8263</td><td>8272</td><td>8281</td><td>8290</td><td>8299</td><td>8308</td><td>8317</td><td>8326</td><td>8335</td><td>8344</td><td>8353</td><td>8362</td><td>8371</td><td>8380</td><td>8389</td><td>8398</td><td>8407</td><td>8416</td><td>8425</td><td>8434</td><td>8443</td><td>8452</td><td>8461</td><td>8470</td><td>8479</td><td>8488</td><td>8497</td><td>8506</td><td>8515</td><td>8524</td><td>8533</td><td>8542</td><td>8551</td><td>8560</td><td>8569</td><td>8578</td><td>8587</td><td>8596</td><td>8605</td><td>8614</td><td>8623</td><td>8632</td><td>8641</td><td>8650</td><td>8659</td><td>8668</td><td>8677</td><td>8686</td><td>8695</td><td>8704</td><td>8713</td><td>8722</td><td>8731</td><td>8740</td><td>8749</td><td>8758</td><td>8767</td><td>8776</td><td>8785</td><td>8794</td><td>8803</td><td>8812</td><td>8821</td><td>8830</td><td>8839</td><td>8848</td><td>8857</td><td>8866</td><td>8875</td><td>8884</td><td>8893</td><td>8902</td><td>8911</td><td>8920</td><td>8929</td><td>8938</td><td>8947</td><td>8956</td><td>8965</td><td>8974</td><td>8983</td><td>8992</td><td>9001</td><td>9010</td><td>9019</td><td>9028</td><td>9037</td><td>9046</td><td>9055</td><td>9064</td><td>9073</td><td>9082</td><td>9091</td><td>9100</td><td>9109</td><td>9118</td><td>9127</td><td>9136</td><td>9145</td><td>9154</td><td>9163</td><td>9172</td><td>9181</td><td>9190</td><td>9199</td><td>9208</td><td>9217</td><td>9226</td><td>9235</td><td>9244</td><td>9253</td><td>9262</td><td>9271</td><td>9280</td><td>9289</td><td>9298</td><td>9307</td><td>9316</td><td>9325</td><td>9334</td><td>9343</td><td>9352</td><td>9361</td><td>9370</td><td>9379</td><td>9388</td><td>9397</td><td>9406</td><td>9415</td><td>9424</td><td>9433</td><td>9442</td><td>9451</td><td>9460</td><td>9469</td><td>9478</td><td>9487</td><td>9496</td><td>9505</td><td>9514</td><td>9523</td><td>9532</td><td>9541</td><td>9550</td><td>9559</td><td>9568</td><td>9577</td><td>9586</td><td>9595</td><td>9604</td><td>9613</td><td>9622</td><td>9631</td><td>9640</td><td>9649</td><td>9658</td><td>9667</td><td>9676</td><td>9685</td><td>9694</td><td>9703</td><td>9712</td><td>9721</td><td>9730</td><td>9739</td><td>9748</td><td>9757</td><td>9766</td><td>9775</td><td>9784</td><td>9793</td><td>9802</td><td>9811</td><td>9820</td><td>9829</td><td>9838</td><td>9847</td><td>9856</td><td>9865</td><td>9874</td><td>9883</td><td>9892</td><td>9901</td><td>9910</td><td>9919</td><td>9928</td><td>9937</td><td>9946</td><td>9955</td><td>9964</td><td>9973</td><td>9982</td><td>9991</td><td>10000</td></tr> </table> <p>x (m)</p> <p>Horizontal Illuminance All illuminance values in lux Table Average: 218 Table Maximum: 3003 Table Minimum: 126 Mounting Height = 2.7 m</p>	1.5	128	137	146	154	163	172	181	190	199	208	217	226	235	244	253	262	271	280	289	298	307	316	325	334	343	352	361	370	379	388	397	406	415	424	433	442	451	460	469	478	487	496	505	514	523	532	541	550	559	568	577	586	595	604	613	622	631	640	649	658	667	676	685	694	703	712	721	730	739	748	757	766	775	784	793	802	811	820	829	838	847	856	865	874	883	892	901	910	919	928	937	946	955	964	973	982	991	1000	1009	1018	1027	1036	1045	1054	1063	1072	1081	1090	1099	1108	1117	1126	1135	1144	1153	1162	1171	1180	1189	1198	1207	1216	1225	1234	1243	1252	1261	1270	1279	1288	1297	1306	1315	1324	1333	1342	1351	1360	1369	1378	1387	1396	1405	1414	1423	1432	1441	1450	1459	1468	1477	1486	1495	1504	1513	1522	1531	1540	1549	1558	1567	1576	1585	1594	1603	1612	1621	1630	1639	1648	1657	1666	1675	1684	1693	1702	1711	1720	1729	1738	1747	1756	1765	1774	1783	1792	1801	1810	1819	1828	1837	1846	1855	1864	1873	1882	1891	1900	1909	1918	1927	1936	1945	1954	1963	1972	1981	1990	1999	2008	2017	2026	2035	2044	2053	2062	2071	2080	2089	2098	2107	2116	2125	2134	2143	2152	2161	2170	2179	2188	2197	2206	2215	2224	2233	2242	2251	2260	2269	2278	2287	2296	2305	2314	2323	2332	2341	2350	2359	2368	2377	2386	2395	2404	2413	2422	2431	2440	2449	2458	2467	2476	2485	2494	2503	2512	2521	2530	2539	2548	2557	2566	2575	2584	2593	2602	2611	2620	2629	2638	2647	2656	2665	2674	2683	2692	2701	2710	2719	2728	2737	2746	2755	2764	2773	2782	2791	2800	2809	2818	2827	2836	2845	2854	2863	2872	2881	2890	2899	2908	2917	2926	2935	2944	2953	2962	2971	2980	2989	2998	3007	3016	3025	3034	3043	3052	3061	3070	3079	3088	3097	3106	3115	3124	3133	3142	3151	3160	3169	3178	3187	3196	3205	3214	3223	3232	3241	3250	3259	3268	3277	3286	3295	3304	3313	3322	3331	3340	3349	3358	3367	3376	3385	3394	3403	3412	3421	3430	3439	3448	3457	3466	3475	3484	3493	3502	3511	3520	3529	3538	3547	3556	3565	3574	3583	3592	3601	3610	3619	3628	3637	3646	3655	3664	3673	3682	3691	3700	3709	3718	3727	3736	3745	3754	3763	3772	3781	3790	3799	3808	3817	3826	3835	3844	3853	3862	3871	3880	3889	3898	3907	3916	3925	3934	3943	3952	3961	3970	3979	3988	3997	4006	4015	4024	4033	4042	4051	4060	4069	4078	4087	4096	4105	4114	4123	4132	4141	4150	4159	4168	4177	4186	4195	4204	4213	4222	4231	4240	4249	4258	4267	4276	4285	4294	4303	4312	4321	4330	4339	4348	4357	4366	4375	4384	4393	4402	4411	4420	4429	4438	4447	4456	4465	4474	4483	4492	4501	4510	4519	4528	4537	4546	4555	4564	4573	4582	4591	4600	4609	4618	4627	4636	4645	4654	4663	4672	4681	4690	4699	4708	4717	4726	4735	4744	4753	4762	4771	4780	4789	4798	4807	4816	4825	4834	4843	4852	4861	4870	4879	4888	4897	4906	4915	4924	4933	4942	4951	4960	4969	4978	4987	4996	5005	5014	5023	5032	5041	5050	5059	5068	5077	5086	5095	5104	5113	5122	5131	5140	5149	5158	5167	5176	5185	5194	5203	5212	5221	5230	5239	5248	5257	5266	5275	5284	5293	5302	5311	5320	5329	5338	5347	5356	5365	5374	5383	5392	5401	5410	5419	5428	5437	5446	5455	5464	5473	5482	5491	5500	5509	5518	5527	5536	5545	5554	5563	5572	5581	5590	5599	5608	5617	5626	5635	5644	5653	5662	5671	5680	5689	5698	5707	5716	5725	5734	5743	5752	5761	5770	5779	5788	5797	5806	5815	5824	5833	5842	5851	5860	5869	5878	5887	5896	5905	5914	5923	5932	5941	5950	5959	5968	5977	5986	5995	6004	6013	6022	6031	6040	6049	6058	6067	6076	6085	6094	6103	6112	6121	6130	6139	6148	6157	6166	6175	6184	6193	6202	6211	6220	6229	6238	6247	6256	6265	6274	6283	6292	6301	6310	6319	6328	6337	6346	6355	6364	6373	6382	6391	6400	6409	6418	6427	6436	6445	6454	6463	6472	6481	6490	6499	6508	6517	6526	6535	6544	6553	6562	6571	6580	6589	6598	6607	6616	6625	6634	6643	6652	6661	6670	6679	6688	6697	6706	6715	6724	6733	6742	6751	6760	6769	6778	6787	6796	6805	6814	6823	6832	6841	6850	6859	6868	6877	6886	6895	6904	6913	6922	6931	6940	6949	6958	6967	6976	6985	6994	7003	7012	7021	7030	7039	7048	7057	7066	7075	7084	7093	7102	7111	7120	7129	7138	7147	7156	7165	7174	7183	7192	7201	7210	7219	7228	7237	7246	7255	7264	7273	7282	7291	7300	7309	7318	7327	7336	7345	7354	7363	7372	7381	7390	7399	7408	7417	7426	7435	7444	7453	7462	7471	7480	7489	7498	7507	7516	7525	7534	7543	7552	7561	7570	7579	7588	7597	7606	7615	7624	7633	7642	7651	7660	7669	7678	7687	7696	7705	7714	7723	7732	7741	7750	7759	7768	7777	7786	7795	7804	7813	7822	7831	7840	7849	7858	7867	7876	7885	7894	7903	7912	7921	7930	7939	7948	7957	7966	7975	7984	7993	8002	8011	8020	8029	8038	8047	8056	8065	8074	8083	8092	8101	8110	8119	8128	8137	8146	8155	8164	8173	8182	8191	8200	8209	8218	8227	8236	8245	8254	8263	8272	8281	8290	8299	8308	8317	8326	8335	8344	8353	8362	8371	8380	8389	8398	8407	8416	8425	8434	8443	8452	8461	8470	8479	8488	8497	8506	8515	8524	8533	8542	8551	8560	8569	8578	8587	8596	8605	8614	8623	8632	8641	8650	8659	8668	8677	8686	8695	8704	8713	8722	8731	8740	8749	8758	8767	8776	8785	8794	8803	8812	8821	8830	8839	8848	8857	8866	8875	8884	8893	8902	8911	8920	8929	8938	8947	8956	8965	8974	8983	8992	9001	9010	9019	9028	9037	9046	9055	9064	9073	9082	9091	9100	9109	9118	9127	9136	9145	9154	9163	9172	9181	9190	9199	9208	9217	9226	9235	9244	9253	9262	9271	92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(m)</p> <table border="1"> <tr><td>1.5</td><td>112</td><td>122</td><td>132</td><td>141</td><td>150</td><td>158</td><td>165</td><td>171</td><td>176</td><td>182</td><td>187</td><td>192</td><td>196</td><td>200</td><td>204</td><td>208</td><td>212</td><td>215</td><td>218</td><td>221</td><td>224</td><td>227</td><td>230</td><td>233</td><td>236</td><td>239</td><td>242</td><td>245</td><td>248</td><td>251</td><td>254</td><td>257</td><td>260</td><td>263</td><td>266</td><td>269</td><td>272</td><td>275</td><td>278</td><td>281</td><td>284</td><td>287</td><td>290</td><td>293</td><td>296</td><td>299</td><td>302</td><td>305</td><td>308</td><td>311</td><td>314</td><td>317</td><td>320</td><td>323</td><td>326</td><td>329</td><td>332</td><td>335</td><td>338</td><td>341</td><td>344</td><td>347</td><td>350</td><td>353</td><td>356</td><td>359</td><td>362</td><td>365</td><td>368</td><td>371</td><td>374</td><td>377</td><td>380</td><td>383</td><td>386</td><td>389</td><td>392</td><td>395</td><td>398</td><td>401</td><td>404</td><td>407</td><td>410</td><td>413</td><td>416</td><td>419</td><td>422</td><td>425</td><td>428</td><td>431</td><td>434</td><td>437</td><td>440</td><td>443</td><td>446</td><td>449</td><td>452</td><td>455</td><td>458</td><td>461</td><td>464</td><td>467</td><td>470</td><td>473</td><td>476</td><td>479</td><td>482</td><td>485</td><td>488</td><td>491</td><td>494</td><td>497</td><td>500</td><td>503</td><td>506</td><td>509</td><td>512</td><td>515</td><td>518</td><td>521</td><td>524</td><td>527</td><td>530</td><td>533</td><td>536</td><td>539</td><td>542</td><td>545</td><td>548</td><td>551</td><td>554</td><td>557</td><td>560</td><td>563</td><td>566</td><td>569</td><td>572</td><td>575</td><td>578</td><td>581</td><td>584</td><td>587</td><td>590</td><td>593</td><td>596</td><td>599</td><td>602</td><td>605</td><td>608</td><td>611</td><td>614</td><td>617</td><td>620</td><td>623</td><td>626</td><td>629</td><td>632</td><td>635</td><td>638</td><td>641</td><td>644</td><td>647</td><td>650</td><td>653</td><td>656</td><td>659</td><td>662</td><td>665</td><td>668</td><td>671</td><td>674</td><td>677</td><td>680</td><td>683</td><td>686</td><td>689</td><td>692</td><td>695</td><td>698</td><td>701</td><td>704</td><td>707</td><td>710</td><td>713</td><td>716</td><td>719</td><td>722</td><td>725</td><td>728</td><td>731</td><td>734</td><td>737</td><td>740</td><td>743</td><td>746</td><td>749</td><td>752</td><td>755</td><td>758</td><td>761</td><td>764</td><td>767</td><td>770</td><td>773</td><td>776</td><td>779</td><td>782</td><td>785</td><td>788</td><td>791</td><td>794</td><td>797</td><td>800</td><td>803</td><td>80</td></tr></table>	1.5	112	122	132	141	150	158	165	171	176	182	187	192	196	200	204	208	212	215	218	221	224	227	230	233	236	239	242	245	248	251	254	257	260	263	266	269	272	275	278	281	284	287	290	293	296	299	302	305	308	311	314	317	320	323	326	329	332	335	338	341	344	347	350	353	356	359	362	365	368	371	374	377	380	383	386	389	392	395	398	401	404	407	410	413	416	419	422	425	428	431	434	437	440	443	446	449	452	455	458	461	464	467	470	473	476	479	482	485	488	491	494	497	500	503	506	509	512	515	518	521	524	527	530	533	536	539	542	545	548	551	554	557	560	563	566	569	572	575	578	581	584	587	590	593	596	599	602	605	608	611	614	617	620	623	626	629	632	635	638	641	644	647	650	653	656	659	662	665	668	671	674	677	680	683	686	689	692	695	698	701	704	707	710	713	716	719	722	725	728	731	734	737	740	743	746	749	752	755	758	761	764	767	770	773	776	779	782	785	788	791	794	797	800	803	80
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Table 14. Connection Diagram Suggestion

Connection	Connection diagram
Connection method 1	<p>Example power (1-3), dummy (2-4) or power (1-4), dummy (2-3)</p>
Connection method 2	<p>Example power (1-2), dummy (3-4)</p>

Table 15. Safety Inspection of Luminaires for Fluorescent Lamp and Direct Power LED Lamp

Safety product combination	Luminaire for fluorescent lamp	
	Power direct LED lamp	
	Luminaire for fluorescent lamp + Power direct LED lamp	
	Test setup	

same area in a certain space, the illuminance from the fluorescent lamp and the average illuminance from the LED lamp were evaluated under the same conditions, and the luminous flux was calculated and analysed, as shown in Tables 10 and 11.

As a result of the analysis, the luminous flux of the LED lamp was 1902 lm, and the power was 14 W at the same average illuminance. Compared to the current standard of 2202 lm shown in Table 1, it should be reduced by about 300 lm. [4]

Below are the results of a comparative analysis of EX-D fluorescent lamps (daylight) and led lamps in a three-column lamp designed for 55 W FPL lamps.

After each light source was turned on under the same conditions in the same space as in the actual

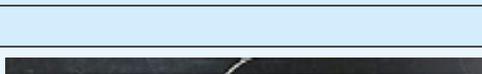
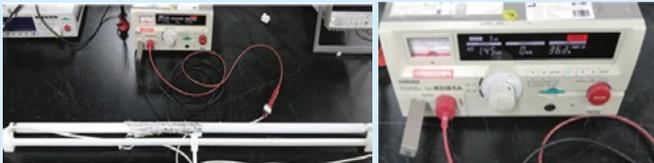
test, the point at which the illuminance from the fluorescent lamp and the led lamp are identical was evaluated, and the appropriate luminous flux was calculated and analysed. The results are shown in Tables 12 and 13.

As a result of the analysis, it was found that the luminous flux of the LED lamp was 3217 lm at the same average illuminance, and the power was 23 W. In comparison with the current standard, the value of the luminous flux should be reduced to 183 lm. [4]

A detailed connection diagram is shown in Table 14.

As a result of the cross-analysis of the luminaire for fluorescent lamp and the power direct LED

Table 16. Safety Inspection of Luminaires for Direct Power LED Lamp and Fluorescent Lamp (LED Lamp Built-In Converter)

Safety product combination	Fluorescent lamp, LED lamp built-in converter	
		
	Luminaire for power direct LED lamp	
		
	Fluorescent lamp, LED lamp built-in converter + Luminaire for power direct LED lamp	
		
Test setup		

lamp, the connection method 1 was working well and no safety problem was found. However, in the case of connection method 2, the lamp was damaged and flickered, resulting in a risk of electric shock and fire. The results of safety inspection in this case are shown in Table 15.

In the case of the connection method 1, where the luminaire for the power direct LED lamp and the fluorescent lamp were used, the lamp did not turn on and there were no safety problems occurred, and after the testing, the safety can be ensured for fluorescent lamps, as shown in Table 16. However, in the case of connection method 2, all the fluorescent lamps were damaged, resulting in the safety and electric shock problems of the lamp.

As a result of the cross test of the combination of LED lamp built-in converter and luminaire for the power direct LED lamp, the connection method 1 did not turn on the lamp and there were no safety problems occurred on the lamp and luminaire, while in case of the connection method 2, some LED lamps built-in converter were damaged, there was a safety problem occurred, and electric shock and fire risk problems were identified.

As a result of the cross test of the combination of the luminaire for power direct LED lamp and the LED lamp-external converter, the connection method 1 did not turn on the lamp, and after the testing, the lamps were normally turned on and no de-

fects or safety problems were found, as shown in Table 17.

However, in case of connection method 2, the LED lamp- external converter was damaged, smoke was generated, and a safety problem was found.

The cross-analysis of the luminaire for LED lamp-external converter and the power direct LED lamp showed that the lamps did not turn on for both connection methods. As shown in Table 18, no damages or safety problems were found, and the lamps turned on properly after the test.

4. DISCUSSION

In this study, the comparative analysis of the LED lamps, which can potentially replace the FPL 36 W and 55 W fluorescent lamps using the 2G11 cap, was conducted. Since the level of technology at the time when the existing safety certification was carried out is very different from what is currently happening, since the efficiency of the LED chip and driving part is rapidly improving due to the technology development of related companies, there is a need to revise the relevant standards in accordance with the realistic standards.

As a result of the cross-analysis according to the connection method 2 using the power direct LED lamp, the LED lamp built-in converter, the LED lamp-external converter, and the fluorescent lamp

Table 17. Safety Inspection of Luminaire for Direct Power LED Lamp and Converter External LED Lamp

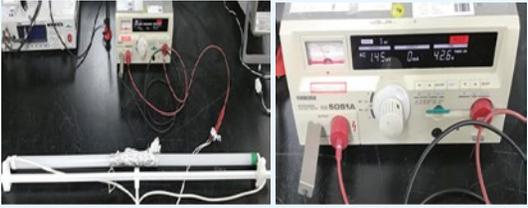
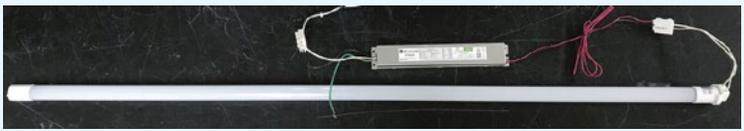
Safety product combination	Luminaire for direct power LED lamp	
	LED lamp – external converter	
	Luminaire for direct power LED lamp + LED lamp external converter	
	Test setup	

Table 18. Safety Inspection of Luminaire for Converter External LED and Direct Power LED Lamp

Safety product combination	Power direct LED lamp	
	Luminaire for LED lamp – external converter	
	Luminaire for LED lamp – external converter + Power direct LED lamp	
	Test Setup	

were damaged serious safety problems occurred, as shown in Table 19. On the other hand, the power direct-type LED lamp in connection method 1 can ensure safety without any problem such as fire, electric shock, burns even when used with different luminaires and lamps. Furthermore, to prevent a decrease in energy efficiency due to excessively luminous flux, it is necessary to revise the relevant stan-

dards to a suitable level. The standards are proposed in Table 20.

In other words, it is necessary to redefine relevant standards to use safe products, and the suggested connection method is shown in Table 21.

Further research will be required in the future to evaluate the safety and performance of the power direct type of luminaire and lamp.

Table 19. Cross-Risk Analysis Table

	Power direct LED lamp	LED lamp built-in converter	LED lamp-external converter	Fluorescent lamp
Luminaire for power direct LED lamp		Risk ↑	Risk ↑	Risk ↑
Luminaire for fluorescent lamp	Risk ↓		Risk ↓	
Luminaire for LED lamp-external converter	Risk ↓	Risk ↓		Risk ↓

Table 20. Proposed Safety Standards

Standard	Unit	FPL 36 W LED Lamp	FPL 55 W LED Lamp
KC10025	lm	2202 (85 % of KS standard)	3400 (85 % of KS standard)
Proposed standard	lm	1900 (74 % of KS standard)	3200 (80 % of KS standard)

Table 21. Direct Power LED Lamp Power Supply Connection Method

Double Cap LED Lamp		Cap
Power	Dummy	
1, 2 or 1, 4	2, 4 or 2, 3	G13, G5
2, 3 or 2, 4	1, 4 or 1, 3	



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Jin-Tai Kim,

is the Director of Institute of Electrical and Electronics Research, Korea Testing & Research Institute, Evaluator at Korea Laboratory Accreditation Scheme (KOLAS), IECEE Technical

Assessor, and he is involved in doctoral course of plasma bio display at Kwangwoon University



Chung-hyeok Kim,

Professor, Ingenium College of Engineering, Kwangwoon University, Council member, The Korean Institute of Electrical and Electronic Material Engineers