

Self-Luminous EXIT Signs Installation at EEO

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Executive Summary

As part of the Pilot Energy Management Opportunity (EMO) Implementation Programme using innovative energy efficient equipment, Energy Efficiency Office (EEO) of Electrical and Mechanical Services Department (EMSD) has completed a pilot project using self-luminous EXIT signs at their offices located in 111 Leighton Road. The work covered the supply and installation of six self-luminous EXIT signs to replace the existing EXIT signs at EEO. The new EXIT signs do not require any power supply and regular testing requirements as stipulated in the latest COP for Fire Services Installation and Equipment and Inspection, Testing and Maintenance of Installations and Equipment published by FSD 1998. The self-luminous EXIT signs contain some radioactive tritium gas (H-3) in glass tubes and the emitted Beta rays are converted to the visible light via the fluorescent coating inside the gas tubes. The declared life of the new EXIT signs is 15 years. The total cost of this pilot project was \$14,400 and the estimated payback period is less than 2 years taking into account both energy and maintenance cost of the original EXIT signs.

1 Introduction

It is a legislative requirement (Fire Services Ordinance, CAP. 95) for all building owners to provide illuminated EXIT signs for all approved exit routes inside their buildings. EXIT signs shall be internally illuminated bearing the word “EXIT” in English and Chinese of not less than 125mm high. They shall be connected to both mains and emergency power supply. If the building is not equipped with an emergency generator, the EXIT signs shall be provided with secondary battery in according with British Standard 5266: Part 1. Other than EXIT signs illuminated by electric operated lamps, self-luminous signs designed to British Standard 5499: Part 2 have also been permitted for use in buildings or premises which are under single ownership or a central management in Hong Kong (FSD Circular Letter No. 2/2000 for EXIT and Directional Signs dated 12 April 2000 referred).



Fig. 1: Conventional EXIT sign using 18W T8 fluorescent lamp & power pack

Conventionally, most EXIT signs in Hong Kong are self-contained maintained type emergency luminaires complete with a single 18W T8 fluorescent lamp, an electromagnetic ballast, a starter and an emergency power pack. The emergency power pack is actually an integrated converter/inverter unit completed with a battery charger, a sealed, rechargeable, maintenance free, nickel cadmium battery unit, a power failure detector and an automatic changeover relay. The EXIT signs are normally powered from the mains (circuit power is about 31W each) and backup by the battery in case of power failure for a minimum of 2 hours of continuous operation. They are operated round the clock and the annual energy cost for each EXIT sign is about HK\$244.

Proper maintenance of the conventional EXIT signs is essential to ensure reliable operation of the EXIT signs during power failure or fire. They shall be maintained in efficient working order at all time and shall be inspected by a registered fire services contractor at least once in every 12 months. Furthermore, the latest COP for Inspection, Testing and Maintenance of FS Installation and Equipment also requests owners of EXIT signs to carry out voltage test every week and discharge test every month as an additional safety measures. All test results should be entered in a register. These extra requirements have imposed tremendous difficulties and additional maintenance cost for EXIT signs and emergency lighting using conventional self-contained type fluorescent luminaires.

2 Existing EXIT Signs Installation in EEO

The existing EXIT signs installation at EEO consists of six numbers conventional 18W 600mm self-contained maintained fluorescent luminaires complete with emergency power packs. They were installed on top of each entrance doors in the office areas for compliance with the FSD requirements. Fig. 2 and 3 show the original EXIT sign used in EEO and its internal components.



Fig. 2: The original EXIT signs used in EEO

One of the EXIT sign removed was tested in EEO for its energy performance using a Fluke 41B Power Analyser. The test results and all recorded electrical parameters were shown in Table 1 for reference. The total circuit power for the EXIT sign was found to be 31W (including ballast loss, lamp power and charger power). The annual energy consumption would then be 272kWh, which is about \$244 energy cost based on a tariff rate of \$0.9 per kWh. It is worth noted that THD (Total Harmonic Distortion) current of the EXIT sign is almost 40%, even though its power factor at 0.92. This is normal for all

fluorescent lighting circuit with power factor correction capacitors.

Table 1: Test results of the original EXIT sign using 18W T8 fluorescent lamp

			Voltage	Current
Frequency	49.94Hz	RMS	220.9V	0.16A
Power:		Peak	308.6V	0.24A
Watts	31.00W	DC Offset	0.3V	0.02A
VA	34.00VA	Crest Factor	1.4	1.54
Vars	3.00var	THD Rms	1.66%	37.07%
Peak W	78.00W	THD Fund	1.66%	39.91%
Phase	8° lead	HRMS	3.7V	0.06A
Total PF	0.92	KFactor		6.15
DPF	0.99			



Fig. 3: Internal components of a conventional EXIT sign

A temperature test using a thermocouple thermometer indicated that the internal temperature inside the EXIT sign box was 36°C at a room temperature of 23°C. This internal temperature is much higher than the optimum conditions for T8 fluorescent lamps (25°C) and nickel cadmium battery (20°C) and has adverse effect on the luminous flux output (-10%) and operation life (-50%) of the battery.

3 New Self-Luminous EXIT Signs Installation in EEO

Figure 4 shows one of the newly installed self-luminous EXIT signs used in EEO. These self-luminous EXIT signs are self-powered by the low-energy radioactivity of tritium gas hermetically sealed within glass tubes. They were installed in EEO since April 2001.

Tritium (Hydrogen-3) is actually an isotope of hydrogen. It can be man-made, but it is also a naturally occurring substance that is produced by cosmic ray action and by the decay of natural radionuclides in rocks and soil. It is colourless, odourless, lighter than air. It is present in air and water all over the earth and is regularly ingested and breathed by everybody. All humans contain trace amount of tritium and several other naturally occurring radioisotopes. Tritium is not a stable isotope and is said to be radioactive (half-life 12.3 years). As the tritium nucleus decays it emit an electron, causing energy to be released in the form of Beta radiation. A new nucleus is then formed with two protons and one neutron thereby becoming a form of non-radioactive helium. Tritium beta

emissions are very weak and are easily stopped by thin layers of any solid material including our body's skin. Since tritium gas cannot penetrate the skin, the radiation exposure might be received through the lungs where it mixes with the body fluids. Tritium is not absorbed by the bone marrow or other body organs and instead is expelled from the body through urination in a very short period of time.



Fig. 3: New self-luminous EXIT sign installed at EEO

The light source in the tritium EXIT sign consists of 17 borosilicate glass tubes, internally coated with phosphor and energised with tritium emissions. As the tritium decays, it emits low-level Beta radiation that stimulates the phosphor, causing it to emit visible light. This beta radiation is completely contained within the gas tubes. Therefore, in a normal usage situation, there should have no risk of radiation exposed from the tritium EXIT sign.

The technical specifications of these self-luminous signs are basically as follows:

- (a) The EXIT sign shall comply with British Standard 5499: Part 2 or other standards acceptable to the Director of Fire Services.
- (b) The EXIT sign shall be internally illuminated by light sources using energy from the Beta radiation of Tritium (H-3) gas in glass tubes via fluorescent coating inside the tubes. The minimum luminance at the faceplate shall be 0.5 cd/m^2 .
- (c) The housing shall be made of impact-resistance and flame retardant materials.
- (d) The faceplate shall be made of clear polycarbonate to produce even and diffused illumination of the legend.
- (e) The legend shall be in both English and Chinese, conforming to EXIT sign requirement in Sec. 5.10 of the COP for Minimum Fire Service Installations & Equipment.
- (f) The housing shall be securely sealed against weathering and fixed by security screws to prevent from being stolen and unauthorised access to the light sources.
- (g) The guaranteed effective life shall be 15 years from the date of manufacture.
- (h) Labels in English and Chinese shall be affixed to sign indicating the hazard level, supplier details, expiry date and method of disposal in according to Radiation Ordinance (CAP. 303).
- (i) Agreement shall be made by the supplier to remove and dispose of the EXIT signs 10 years after the installation in accordance with the Radiation Ordinance.

The total supply and installation cost for this pilot project was \$14,400. The anticipated energy saving per year is about \$1500, which is equal to the total annual energy

consumption for the six original EXIT signs. Disregarding the maintenance cost, the simple payback is about 10 years. However, if the costs for weekly voltage tests, monthly discharge tests, annual overhauls and parts replacement of the conventional EXIT signs are taken into account, the payback period would at least be shortened to 1.2 years.

4 Life-cycle Cost Comparison for 18W Fluorescent and Self-Luminous EXIT Signs

For new EXIT signs installations, it makes good sense to look not only at the initial costs but also at its total cost throughout its anticipated, or required, life. Individual will have their own expectation of installation life, but it is suggested that life-cycle costing should be based on the short term (5 years) for the rapid changing market, the medium term (10 years) for the average user and the long term (20 years) for those situations where change is infrequent. For EXIT sign installation, the medium term of 10 years is preferable for its lift-cycle costing calculation. Table 2 below shows the estimation of the 10-year lift-cycle cost comparison for both self-luminous and conventional EXIT signs.

Table 2: Comparison of 10-year lift-cycle cost for self-luminous and conventional 18W T8 fluorescent EXIT signs

Estimated Cost Items	Tritium Self-Luminous EXIT sign	18W T8 EXIT Sign c/w Magnetic Ballast & Power Pack
1. Material cost	\$2100	\$500
2. Installation cost	\$150 (fixing only)	\$400 (conduit & wiring)
3. Energy cost for 10 years	--	\$244 x 10 = \$2,440
4. Weekly voltage tests	--	\$20 x 52 x 10 = \$10,400
5. Monthly discharge tests	--	\$40 x 12 x 10 = \$4,800
6. Annual Inspection	--	\$50 x 10 = \$500
7. Lamp replacement	--	\$20 x 5 = \$100
8. Battery replacement	--	\$100 x 3 = \$300
10-year life-cycle cost:	\$2250	\$19,440

5 Conclusion and Discussion

The following conclusions could be drawn based on the information above:

- 5.1 The new self-luminous EXIT signs installed in EEO are in good operating conditions since April 2001.
- 5.2 The anticipated energy saving up to end of December 2001 is \$1000 for the 6 nos. new EXIT signs installed in EEO.
- 5.3 Based on an annual energy cost of \$244 and an annual maintenance cost of \$1570 for various voltage tests, discharge tests and inspection requirements for each EXIT sign, the simple payback period is found to be 1.2 years.
- 5.4 As far as energy conservation is concerned, the replacement of the existing EXIT signs in EEO by self-luminous EXIT signs is well justified. However, there are several other legislative and environmental factors that need to be considered before making the final decision.
- 5.5 The legislative requirement is basically that a building owner is required to obtain

license from the Hong Kong Radiation Board for building provided with self-luminous EXIT/directional signs carrying radioactive substances irrespective of any number of sign installed. There is, at present, no exemption granted to Gaseous Tritium Lighting Devices (GTLD). Any amounts of GTLDs used in buildings have to be licensed. The 20 MBq exemption limit for ionization smoke detectors is not applicable to GTLDs. The license fee is \$2770 for one building/premises, which also covers other radioactive equipment used in the building, such as medical equipment, ionization type smoke detectors, etc. Although Government buildings are generally exempted under the licensing requirements, engineers concerned should ensure that appropriate statutory regulations and requirements on radiation as stipulated by the Radiation Board are complied with and strictly be followed.

- 5.6 Although there will have no adverse effects to human health even if all tritium tubes in a self-luminous EXIT/direction sign were broken, engineers should ensure signs are located at physically safe positions and could easily be viewed by building occupants in case of emergency.
- 5.7 Similar to the proper disposal of fluorescent lamps and batteries removed from the conventional EXIT signs, the disposal of self-luminous EXIT signs carrying radioactive substances might have an environmental effect. Proper agreement should be made at an early stage between the EXIT signs suppliers and building owners for appropriate disposal of the signs after the designed life cycle of the signs (a 10-year life cycle is recommended).
- 5.8 Having considered all factors above, it is advisable to employ self-luminous EXIT/direction signs as far as possible for new projects and major retrofit work. They are particularly suitable for use in areas where power supply is not easily available but clear escape or directional signs are needed in these areas for evacuation purpose.