

Service On Demand Escalator

按需求服務的自動梯

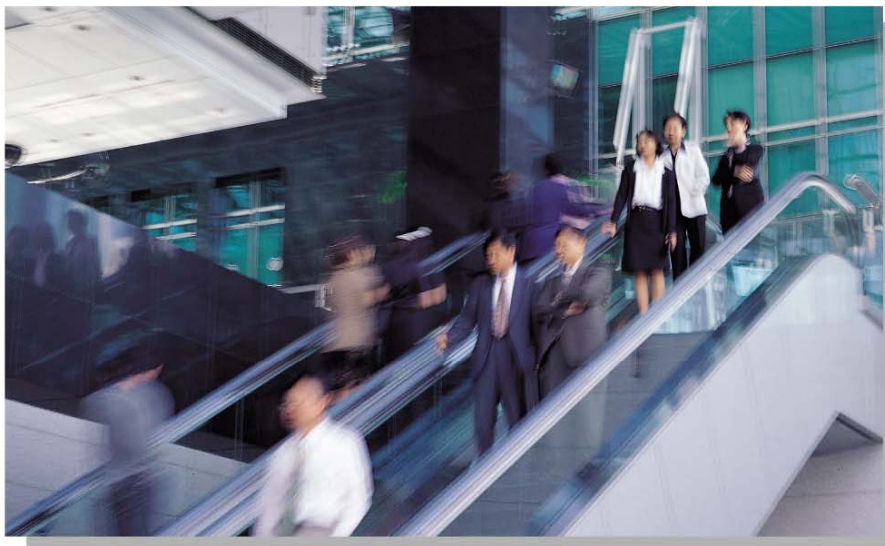
機電工程署  **EMSD**

機電工程署 能源效益事務處
Energy Efficiency Office
Electrical and Mechanical Services Department
香港九龍啟成街3號
3 Kai Shing Street, Kowloon, Hong Kong
電話 Tel: (852) 1823, 2808 3465
傳真 Fax: (852) 2890 6081
網址 Homepage: <http://www.emsd.gov.hk>
電郵 Email: eepublic@emsd.gov.hk

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Introduction

Escalators can be designed to operate only when passengers are present and either stop or slow down when no activity has been detected for a period of time. Once a passenger has been detected, the system either starts up or speeds up back to running speed. Since the operation of the escalator is determined by the presence or absence of passengers, this kind of escalator systems are known as "service-on-demand" (SOD) escalators. The SOD features for escalators are now commonly adopted in some European countries and in Japan.



This pamphlet provides basic information on the application of SOD escalators and a simple step-by-step assessment of the energy saving potential of the existing escalators.

簡介

自動梯可以設計成有乘客使用時才運行，如過了一段時間也沒有乘客，便會停下或把運行速度減慢，一旦再感應到有乘客，又會馬上啟動或加速至正常運行速度。由於自動梯的運作取決於是否有乘客，這類電梯稱為「按需求服務」的自動梯。現時歐洲一些國家及日本均已廣泛採用這種按需求服務的自動梯。

本小冊子提供有關按需求服務自動梯的基本資料，並講述如何以簡單方法評估現有自動梯的節能潛力。

Operational Principles

There are basically two types of SOD escalator:

Auto on-off control

Sensor is installed at the entry of the escalator to detect the presence of passenger. When an approaching passenger is detected, the escalator will start running and complete the travelling cycle. The escalator will stop after a period of time when no further passenger is detected.

運作原理

按需求服務的自動梯基本上分為兩種。

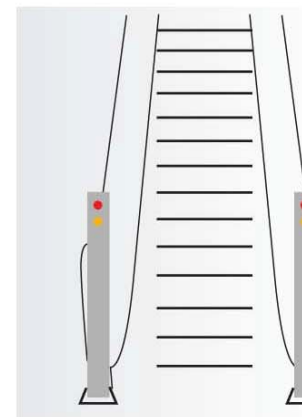
自動開關控制

在自動梯的入口處安裝了感應器，以探測是否有乘客走近。如感應到有乘客走近，自動梯便會開始運行和完成整個運送過程。如過了一段時間也感應不到有其他乘客，便會停止運行。

Normal Operation
正常運作
Speed
速度 **0.5-0.75** m/s
米/秒



Standby Operation
備用運作
Speed
速度 **0.0** m/s
米/秒



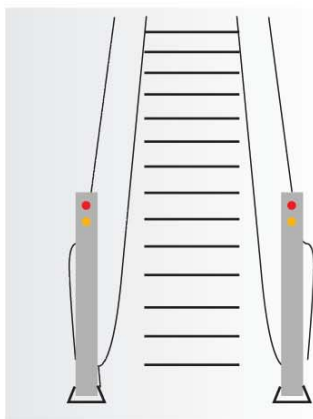
Auto two-speed control

Similar to the arrangement of **Auto on-off** controlled escalator, the **Auto two-speed** controlled SOD escalator will be actuated by the presence of passenger to run at rated speed. The Auto two-speed controlled SOD escalator will run at a lower speed (crawling speed) when it detects no passenger for a set period of time. The crawling speed is usually set at about 0.2m/s, while the rated operating speed is 0.5m/s - 0.75m/s.

自動兩速控制

與**自動開關控制**系統相似，每當有乘客出現，**自動兩速控制**的按需求服務自動梯便會將速度由慢行增加至額定速度。不過，如在一段設定的時限內感應不到有乘客，自動兩速控制的按需求服務自動梯便會把速度減慢至緩慢運行速度。緩慢運行速度通常約為0.2米/秒，而額定運行速度則為0.5米/秒至0.75米/秒。

Normal Operation
正常運作
Speed
速度 **0.5-0.75** m/s
米/秒



Standby Operation
備用運作
Speed
速度 **0.2** m/s
米/秒

Statutory Requirements on Automatic Starting/Accelerating/Stopping of Escalators

The **Code of Practice on the Design and Construction of Lifts and Escalator (COP)** published by the Electrical and Mechanical Services Department (EMSD) lays down requirements for escalators with automatic starting and speed increasing function.

The key points are summarised as follows

Automatic Starting and Speed Increasing

Escalators which start or accelerate from crawling to their rated speeds automatically by the passing of a user shall start to move or accelerate before the person walking reaches the comb intersection line. This is, for instance, accomplished by light rays if they are arranged at least 1.3m before the comb intersection line; or contact mats if the outer edge of the contact mat is arranged at least 1.8m before the comb intersection line. The length of the contact mat in the direction of travel shall be at least 0.85m. Contact mats reacting to weight shall respond before the load reaches 150N, applied to a surface of 25cm² at any point. Constructional measures shall discourage circumvention of the control elements

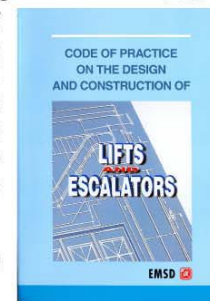
Pre-determined Direction of Travel for Escalators Start Automatically

On escalators which start automatically by the passing of a user, the direction of travel shall be pre-determined, clearly visible and marked distinctly. For example, road traffic signals shall be provided indicating to the user whether the

有關自動啟動/加速/停止的自動梯的法例規定

由機電工程署出版的《升降機及自動梯設計及建造實務守則》，列載了具自動啟動及加速功能的自動梯須符合的規定。

有關要點概述如下：



自動啟動及加速

對於由使用者經過而自動啟動或由緩慢運行加速至其額定速度的自動梯，應在使用者步至梳齒板相交線之前啟動運行或加速。如採用光束感應方法，則光束應設置於梳齒板相交線之前不少於1.30米處。如使用觸點踏墊，則踏墊的外緣應設置於梳齒板相交線之前不少於1.80米處。沿運行方向量度的觸點踏墊的長度不應少於0.85米。對重量起反應作用的觸點踏墊，在施於其表面任何一個25平方厘米的面積上的力達至150牛頓之前，便須作出反應。自動梯的結構應能防止有人繞過控制元件。

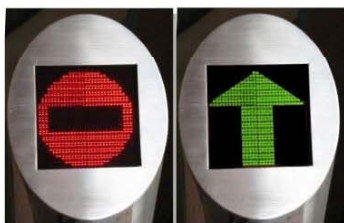
自動啟動型自動梯的預設運行方向

對於由使用者經過而自動啟動的自動梯，其運行方向應預先設定，並有清楚可見及明顯的標記。例如，應提供運輸信號，令使用者得知自動梯是否可供使用，以及自動梯的運行方向。在由使用者經過而自動啟動的自動

escalator is available for use, and its direction of travel. In such cases where escalators which start automatically by the passing of a user can be entered in the direction opposite its pre-determined direction of travel, they shall start in the pre-determined direction. The running time shall be not less than 10 seconds.

Normal Stopping, or Slowing Down Automatically Operated

It is permitted to design the control in such a way that the escalator is stopped or slowed down to its crawling speed automatically after a sufficient time (at least the anticipated passenger transfer time plus 10seconds) after the passenger has actuated a control element.



Signage indicating traffic signal of escalator

正常停止運行或減速，自動操作

允許自動梯的控制系統有這樣的設計：在乘客啟動了控制元件後，並經過一段足夠長的時間（不少於預期乘客輸送時間再加上10秒），自動梯便停止運行或減慢至緩慢運行速度。

Special Notices for Escalators Starting Automatically

In the case of escalators starting automatically, a clearly visible signal system, e.g. road traffic signals, shall be provided indicating to the user whether the escalator is available for use, and its direction of travel.

有關自動啟動的自動梯的特別告示

應為自動啟動的自動梯提供清晰可見的信號系統，例如，應提供運輸信號，令使用者得知自動梯是否可供使用，以及自動梯的運行方向。

Planning Considerations

Installation Details

The statutory requirements suggest that light rays should be installed at least 1.3m or contact mats 1.8m before the comb intersection line of SOD escalators. The sensing elements should be positioned in such a manner that the risk of vandalism and mis-use of the SOD escalator can be minimized. Barriers should be considered to be erected to



Sufficient clearance space is required for installing sensor pole and barriers
安裝感應器及欄柵需要有足夠的空間

在規劃方面的考慮因素

裝置細節

根據法例的規定，光束應設置於按需求服務的自動梯的梳齒板相交線之前不少於1.3米處，而觸點踏墊的外緣應設置於梳齒板相交線之前不少於1.8米處。裝設感應裝置時，必須盡可能將按需求服務自動梯被惡意破壞及誤用的風險減到最低。此外，亦應考

梯上，若使用者可從與預設運行方向相反的方向進入，那麼自動梯仍須按預設的運行方向啟動，而在啟動後，其運行的時間不得少於10秒。

avoid passenger by-passing the sensing elements and directly stepping onto a SOD escalator. Therefore, the designer shall check whether sufficient clearance space is available for installing the sensing elements and associated barriers for the SOD escalators.

The direction of travel shall be clearly defined with a visible signal system. For example, traffic signals shall be provided to indicate the user whether the escalator is available for use, and its direction of travel. Other than the signage required under the statutory requirements, the following signages are also recommended to alert the public:

- i) "This is an auto-start escalators"
- ii) "In service"
- iii) "Out of service"
- iv) "Danger, do not enter"(for opposite direction)

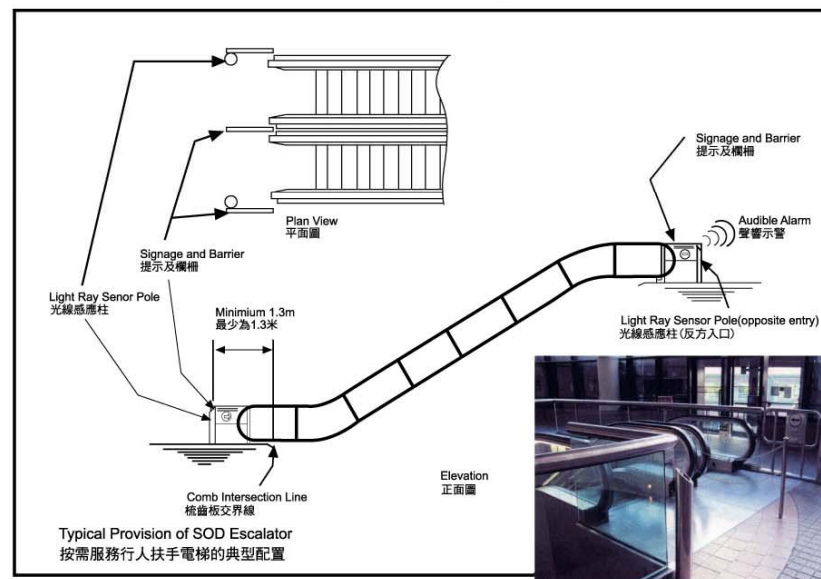
Tactile floor markings should also be provided at the entrance and exit of the escalator.

應架設欄柵，以防止乘客繞過感應裝置直接登上按需求服務自動梯。因此，設計者應查看是否有足夠空間裝設按需求服務自動梯的感應裝置及相關的欄柵。

應透過清晰可見的信號系統顯示自動梯的運行方向。例如，應提供運輸信號，令使用者得知自動梯是否可供使用，以及自動梯的運行方向。除了法例所規定的標記外，亦建議設置下列標誌，以提醒公眾注意自動梯的運作情況：


- i) 「自動啟動電梯」
- ii) 「正在運行」
- iii) 「停止服務」
- iv) 「危險，請勿進入」（於相反方向入口）

自動梯的出入口亦應設置有凹凸紋的地面標記。



Typical Provision of SOD Escalator
按需求服務行人扶手電梯的典型配置





Apart from the sensors (either light rays or contact mates) installed at the entry of the SOD escalators, sensors shall also be installed at the exit of the escalator to detect whether there is any passenger approaching the escalator in opposite direction. Once a passenger is detected, audible signal shall be activated to warn the passenger not to step onto the escalator. The escalator (for on-off controlled SOD) shall start in the predetermined direction for not less than 10 seconds.

Human Factors

Passengers may not be familiar with the operation of SOD escalator. Although the "Auto on-off" SOD control can save more energy, users may misconceive the idling condition as mal-function or stop of service. Whereas, "Auto two-speed" SOD control is more easily adapted by the general public.

Time Delay Setting

The COP published by EMSD requires the time delay setting shall be at least the anticipated passenger transfer time for a person travelling from comb intersection line at entry to comb intersection line at exit plus at least 10 seconds. However, factors such as usage pattern, type of users, etc. should also be taken into account for determining the time delay setting.

Minimising the time delay setting can achieve higher energy saving, however, adequate time delay can avoid frequent starting and stopping of the escalator.

除了在按需求服務自動梯的入口處設置感應裝置(光束或觸點踏墊)外，亦應在自動梯的出口處設置類似的感應裝置，以探測是否有乘客從相反方向走近。一旦於相反方向入口偵測到有乘客走近，就會發出可聽到的訊號，警告乘客不要進入自動梯。自動開關的按需求服務自動梯應按預先設定的運行方向運行最少10秒。

人為因素

乘客未必熟悉按需求服務的自動梯的運作。雖然使用「自動開關」的按需求服務自動梯可節省更多能源，但使用者可能會把空載停頓的情況誤以為是自動梯損壞或停止服務。相比之下，「自動兩速」的按需求服務自動梯較為公眾接受。

延時設定

機電工程署出版的實務守則規定，延時設定須最少為預期乘客輸送時間再加上10秒。不過，在作出延時設定時需一併考慮其他因素，例如自動梯使用情況、使用者類型等。

設定的時間愈少便愈能節省能源，但充足的延時設定可防止自動梯經常啟動和停止。

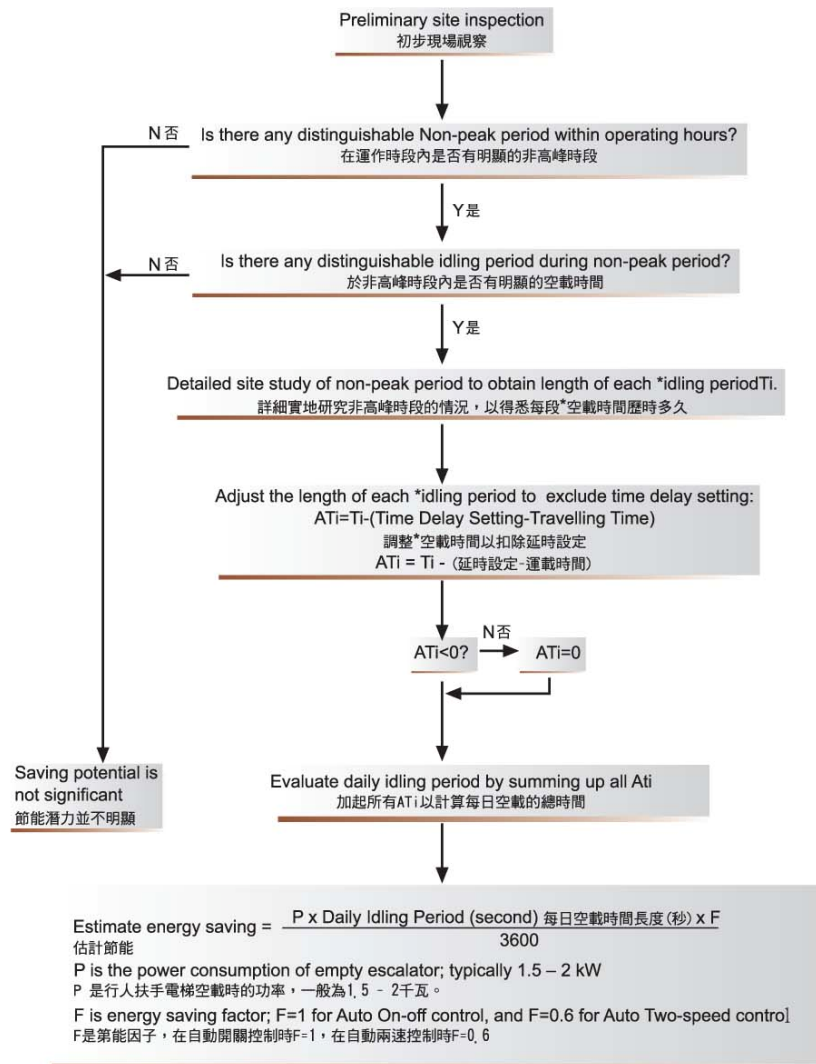
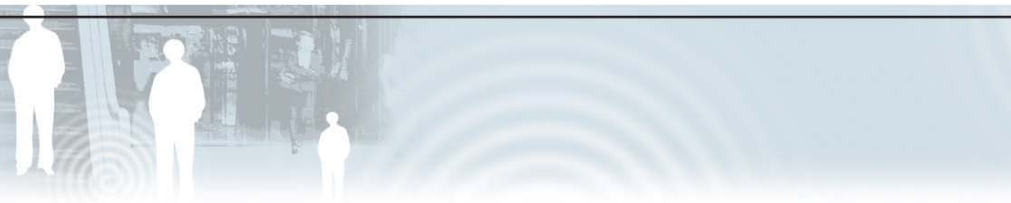
Energy Saving Potential

The application of SOD feature on escalators can save energy. However, the actual energy saved would depend on the traffic pattern and nature of applications on individual merits. Applications such as private office buildings, cinemas, theatres, long operating hours public facilities (e.g. footbridge), education institutes etc. usually have better opportunities to derive SOD savings due to the intermittent and fluctuating nature of passenger load profile. Shopping mall applications, on the other hand, will depend on the nature of retails and the arrangement of circulation routes within the mall. As an illustration of the energy saving potential, the Auto on-off control and Auto two-speed control escalators in a Government office building under our study has achieved about 52% and 14% saving respectively. For existing escalators, field studies can be conducted to evaluate the potential saving opportunity. The following flow chart can be used as a reference for planning purpose:



節能潛力

使用按需求服務的自動梯可節省能源。不過，實際能節省多少能源，則須視乎運載情況和使用地點而定。在私人辦公大樓、戲院、劇院、長時間使用的公共設施(如行人天橋)、教學大樓等，由於乘客負荷量波動和不穩定，使用按需求服務的自動梯通常可提供較佳的節能機會。至於商場，使用這類自動梯所能帶來的節能機會，則視乎商場內零售店鋪的性質及所設置的通道而定。根據我們進行的研究，在一個政府辦公大樓內的自動開關和自動兩速自動梯，可分別節省52%和14%的能源，這反映出這兩類自動梯的節能潛力。至於現有的自動梯，可於現場進行研究以評估節能潛力。以下的流程圖可在規劃時作參考之用：



9 *Idling period is referring to the time when the escalator has no passenger travelling.

*空載時間是指沒有人使用自動梯的時間。

An example using the above method to estimate the saving is included in Appendix 1 of this pamphlet

本小冊子附錄1載述運用上述方法估計節能效果例子。

Appendix 1 - Example of Energy Saving Estimation for Existing Escalator

附錄1-就現有自動梯估計節能效果例子。

The following example illustrates the estimation of energy saving based on the minimum time delay setting:

以下例子基於最低延時設定下就節能效果作出估計：

Scenario Data:
An existing single speed escalator is installed at the ground floor of an office building with a passenger transfer time of 27 seconds/trip. The escalator is operated from 08:00 to 22:00 daily and 6 days a week. The annual energy saving for retrofitting the escalator to a SOD escalator is estimated as follows:

情況數據：
在一座辦公大樓的地下安裝了一台自動梯，乘客運載時間為每程27秒。自動梯每星期運作6天，運作時間為每日08:00時至22:00時。改裝為按需求服務自動梯後每年可節省的能源估計如下：

- Step 1:**
A preliminary site investigation identified three non-peak periods which have noticeable idling time for the escalator:
- Non peak period 1: - 09:45 to 11:45
 - Non peak period 2: - 13:30 to 16:15
 - Non peak period 3: - 17:45 to 22:00

- 第一步：**
進行初步現場視察後，發現有三段有明顯空載時間的非高峰時段：
- 非高峰時段1:-09:45至11:45
 - 非高峰時段2:-13:30至16:15
 - 非高峰時段3:-17:45至22:00

Step 2:
A more detailed site study on a typical day reviews the following idling time period:

第二步
在平常日子於現場進行詳細研究，發現有以下的空載時間：

Idling time at non peak period 1 非高峰時段1內的空載時間

Start 開始	End 完結	Idling Time (second) 空載時間(秒), Ti
09:50:27	09:54:05	218
09:57:23	10:00:56	213
10:05:43	10:08:55	192
10:14:52	10:17:43	171
10:21:36	10:22:44	68
10:26:21	10:29:28	187
10:39:43	10:42:25	162
10:48:15	10:48:21	6
10:52:01	10:53:33	92
11:02:13	11:03:17	64
11:13:03	11:16:11	188
11:19:33	11:22:22	169
11:32:25	11:35:55	210
11:41:29	11:43:15	106

Idling time at non peak period 2 非高峰時段2內的空載時間

Start 開始	End 完結	Idling Time (second) 空載時間(秒), Ti
13:33:16	13:39:12	356
13:39:49	13:44:38	289
13:48:26	13:53:45	319
13:54:45	13:57:08	143
14:01:57	14:04:12	135
14:08:54	14:10:27	93
14:14:53	14:18:26	213
14:22:54	14:28:00	306
14:32:18	14:36:47	269
14:38:32	14:40:14	102
14:47:59	14:52:24	265
14:53:40	14:57:20	220
15:02:52	15:06:05	193
15:14:24	15:16:43	139
15:20:58	15:26:32	334
15:33:55	15:34:46	51
15:37:32	15:39:39	127
15:43:00	15:45:16	136
15:46:42	15:50:28	226
15:54:45	15:55:08	23
15:56:39	15:59:44	185
16:06:42	16:10:38	236

Idling time at non peak period 3 非高峰時段3內的空載時間

Start 開始	End 完結	Idling Time (second) 空載時間 (秒), Ti
17:47:20	18:07:06	1186
18:08:09	18:19:53	704
18:22:43	18:38:09	926
18:40:54	18:51:12	618
18:52:11	19:04:47	756
19:06:59	19:30:04	1385
19:30:44	19:39:48	544
19:41:36	19:42:32	56
19:43:07	19:59:20	973
20:00:36	20:16:23	947
20:18:25	20:24:50	385
20:27:37	20:52:21	1484
20:53:18	21:04:19	661
21:06:33	21:11:38	305
21:14:47	21:32:57	1090
21:33:29	21:38:51	322
21:41:12	21:41:49	37
21:44:54	21:46:34	100
21:48:36	22:09:30	1254

Step 3:

With a minimum time delay setting of 37 seconds (traveling time 27 seconds + a minimum of 10 seconds), the length of each idling period has to be adjusted by deducting 10 seconds. If the idling time is less than 10 seconds, the idling time shall be taken as zero.

第三步：

以最短延時設定為37秒(運載時間27秒+最少10秒)計算，每段空載時間須減少10秒。如空載時間少於10秒，則空載時間視作 0。

Adjusted Idling time at non peak period 1 經調整後非高峰時段1內的空載時間

Start 開始	End 完結	Idling Time (second) 空載時間 (秒), Ti	Adjusted Idling Time (second) 調整後空載時間 (秒), ATi
09:50:27	09:54:05	218	208
09:57:23	10:00:56	213	203
10:05:43	10:08:55	192	182
10:14:52	10:17:43	171	161
10:21:36	10:22:44	68	58
10:26:21	10:29:28	187	177
10:39:43	10:42:25	162	152
10:48:15	10:48:21	6	0
10:52:01	10:53:33	92	82
11:02:13	11:03:17	64	74
11:13:03	11:16:11	188	178
11:19:33	11:22:22	169	159
11:32:25	11:35:55	210	200
11:41:29	11:43:15	106	96
Subtotal 小計:			1930

Adjusted Idling time at non peak period 2 經調整後非高峰時段2內的空載時間

Start 開始	End 完結	Idling Time (second) 空載時間 (秒), Ti	Adjusted Idling Time (second) 調整後空載時間 (秒), ATi
13:33:16	13:39:12	356	346
13:39:49	13:44:38	289	279
13:48:26	13:53:45	319	309
13:54:45	13:57:08	143	133
14:01:57	14:04:12	135	125
14:08:54	14:10:27	93	83
14:14:53	14:18:26	213	203
14:22:54	14:28:00	306	296
14:32:18	14:36:47	269	259
14:38:32	14:40:14	102	92
14:47:59	14:52:24	265	255
14:53:40	14:57:20	220	210
15:02:52	15:06:05	193	183
15:14:24	15:16:43	139	129
15:20:58	15:26:32	334	324

Start 開始	End 完結	Idling Time (second) 空載時間(秒), Ti	Adjusted Idling Time (second) 調整後空載時間(秒), ATi
15:33:55	15:34:46	51	41
15:37:32	15:39:39	127	117
15:43:00	15:45:16	136	126
15:46:42	15:50:28	226	216
15:54:45	15:55:08	23	13
15:56:39	15:59:44	185	175
16:06:42	16:10:38	236	226
Subtotal 小計:			4140

Adjusted Idling time at non peak period 3 經調整後非高峰時段3內的空載時間

Start 開始	End 完結	Idling Time (second) 空載時間(秒), Ti	Adjusted Idling Time (second) 調整後空載時間(秒), ATi
17:47:20	18:07:06	1186	1176
18:08:09	18:19:53	704	694
18:22:43	18:38:09	926	916
18:40:54	18:51:12	618	608
18:52:11	19:04:47	756	746
19:06:59	19:30:04	1385	1375
19:30:44	19:39:48	544	534
19:41:36	19:42:32	56	46
19:43:07	19:59:20	973	963
20:00:36	20:16:23	947	937
20:18:25	20:24:50	385	375
20:27:37	20:52:21	1484	1474
20:53:18	21:04:19	661	651
21:06:33	21:11:38	305	295
21:14:47	21:32:57	1090	1080
21:33:29	21:38:51	322	312
21:41:12	21:41:49	37	27
21:44:54	21:46:34	100	90
21:48:36	22:09:30	1254	1244
Subtotal 小計:			13543

Step 4:
Summing up all idling durations, the daily idling duration was found to be 19,613 seconds.

第四步：
把所有空載時間加起來，每天的空載時間為 19,613秒。

Step 5:
Assume there are 52 weeks every year. The energy saving of retrofitting the escalator to incorporate SOD features is:

第五步：
假定每年有52週，把自動梯改裝使其按需求服務後，所節省的能源如下：

$$\text{Estimate energy saving} = \frac{P \times \text{Daily Idling Period (second) 每日空載時間長度(秒)} \times F}{3600}$$

估計節能

P is the power consumption of empty escalator; typically 1.5 – 2 kW
P 是行人扶手電梯空載時的功率，一般為1.5 - 2千瓦。

F is energy saving factor; F=1 for Auto On-off control, and F=0.6 for Auto Two-speed control
F是節能因子，在自動開關控制時F=1，在自動兩速控制時F=0.6

For auto on-off installation 自動開關控制：

$$\frac{2\text{kw(千瓦)} \times 19,613\text{s(秒)} \times 1}{3600\text{s(秒)}} \times 6 \text{ days/week(日/週)} \times 52 \text{ week/year(週/年)} = 3,400\text{kWh(千瓦小時)}$$

For auto two-speed installation 自動兩速控制：

$$\frac{2\text{kw(千瓦)} \times 19,613\text{s(秒)} \times 0.6}{3600\text{s(秒)}} \times 6 \text{ days/week(日/週)} \times 52 \text{ week/year(週/年)} = 2,040\text{kWh(千瓦小時)}$$