

# 瓦斯爆鳴器驅鳥測試報告

鳥擊委員會

因為台灣的地理位置與氣候，適合各種季節性候鳥遷徙過境、留鳥棲息以及繁衍，嚴重威脅到飛行安全。本會發現美國華盛頓特區雷根機場、中國桂林、昆明、北京、澳門等機場均使用瓦斯爆鳴器執行驅鳥作業，因此自加拿大引進6具瓦斯爆鳴器（自動型2具、遙控型4具），委請空軍執行測試評估。經考量發生鳥擊事件較為嚴重、而且不干擾鄰近居民作息的軍民合用機場後，決定由嘉義機場執行。以機場跑道兩側架設瓦斯爆鳴器，評估瓦斯爆鳴器的爆鳴音響是否具有驅鳥作用，冀望有效降低軍、民航機鳥擊事件的發生；並評估系統效益性與適應性的後勤支援情況，以評估此項裝備可否有效達到驅鳥作用，以作為軍、民航單位未來採購驅鳥裝備選項時的參考。

測試時間：自2004年9月1日至2005年8月15日止。

瓦斯爆鳴器作用的原理，係將瓦斯以電擊方式點燃，使其產生5公尺內大約120分貝的爆鳴。遙控制動遙控型

瓦斯爆鳴器的有效距離為視界內2500呎；自動型發射間隔調整器的時序可以設定在40秒至30分鐘之間。瓦斯爆鳴器架設於三角架上時，利用發射管上安裝半弧形擋板，引爆後發射管可以旋轉60度方位。

## 效益性測試方面：

### 1. 評估驅鳥瓦斯爆鳴器人機介面的情況：

驅鳥瓦斯爆鳴器操作滿意度評估等級為2.11（評估分數為1-5，最佳為1），操作人員意見一致趨向滿意，功能符合需求。

因驅鳥瓦斯爆鳴器施放時，10公尺範圍內聲響音量值達110分貝，人員操作時應避免於系統周圍，並依操作手冊相關安全規定，配戴耳罩或耳塞，以維護人員聽力。

### 2. 評估測試期間鳥擊事件的頻率：

最近3年發生鳥擊事件的比較如下表：

年度 \ 月份	10	11	12	1	2	3	4	5	6	7	8	9	總計	平均鳥擊數
2002-2003	5	2	2	0	3	1	1	4	6	7	4	7	42	3.5
2003-2004	4	5	3	0	0	1	0	5	3	2	8	2	33	2.75
2004-2005	2	2	1	0	0	2	0	5	2	4	0	0	18	1.5

2005年發生鳥擊事件的頻率，比2004年與2003年發生的頻率為低。

2005年發生鳥擊事件的頻率比2004年降低57.14%，比2003年降低45.45%。

測試跑道西南邊A、B兩區域，2004年與2005年同期鳥類相調查比較如下表：

A區

年度 \ 月份	10	11	12	1	2	3	4	5	6	7	8	9	月平均數
2004	77	102	65	20	17	12	15	45	46	29	76	65	42.8 隻
2005	34	74	34	26	7	17	28	55	67	52	N/A	N/A	39.4 隻

2005年A區鳥種數量比2004年同期為低，降低比率為7.9%。

B區

年度 \ 月份	10	11	12	1	2	3	4	5	6	7	8	9	月平均數
2004	504	216	70	54	74	36	51	38	56	52	53	15	121.9 隻
2005	27	29	16	15	25	29	60	141	176	141	N/A	N/A	66.9 隻

2005年B區鳥種數量比2004年同期為低，降低比率為45.1%。

### 3. 評估瓦斯爆鳴器驅鳥能力：

瓦斯爆鳴器針對各型鳥類的驅鳥反應時間狀況：

\* 大型鳥類：平均有效反應時間為76.5秒，亦即平均驅離76.5秒後，鳥類又飛回來，達到驅離3分鐘以上的有效比率為17.4%。

\* 中型鳥類：平均有效反應時間為85秒，亦即平均驅離85秒後，鳥類又飛回來，達到驅離3分鐘以上的有效比率為35.2%。

\* 小型鳥類：平均有效反應時間為56秒，亦即平均驅離56秒後，鳥類又飛回來，達到驅離3分鐘以上的

有效比率為9.5%。

大、中型鳥類平均有效反應時間約1.5分鐘，小型鳥類平均有效反應時間約1分鐘。達到3分鐘有效驅鳥的比率，大、中型鳥類比小型鳥類的比率為高，故以有效時間來看，對大、中型鳥類瓦斯爆鳴器的驅鳥能力較為顯著，小型鳥類次之。

150公尺施放範圍內，有效驅鳥比率分別如下：大型鳥類約90%，中型鳥類約70%，小型鳥類約40%。

鳥類反應情況：

經測試發現，各種鳥類對瓦斯爆鳴器爆鳴音響的反應情況不同，因此選擇嘉義基地內數量較多的黃頭鷺、紅鳩、雲雀與白頭翁等鳥種，評估其有效範圍。

\* 黃頭鷺：有效樣本44，測試結果在150公尺範圍內，施放後有效驅鳥比率達到90%以上。

\* 紅鳩：有效樣本26，測試結果在150公尺範圍內，爆鳴後有效驅鳥比率達到69.2%以上。

\* 雲雀：有效樣本36，測試結果在150公尺範圍內，爆鳴後有效驅鳥比率達到41.6%以上。

\* 白頭翁：有效樣本21，測試結果在150公尺範圍內，爆鳴後有效驅鳥比率達到33.3%以上。

建議：依測試結果以150公尺作間隔，建議架設於南北跑道3,000呎以下，每500呎架設1具，考量南北清除區鳥類棲息頻繁，建議清除區架設4具，可達較佳效益，沿跑道兩側可考量架設16具瓦斯爆鳴器，達到最佳效益、並符合經濟效益。

## 適應性測試方面：

### 1. 評估裝備運作可靠度：

測試期間瓦斯爆鳴器共耗用5公斤瓦斯44桶，以平均每桶瓦斯可爆鳴9,350次計算，共計爆鳴411,400次。施放失效次數共9次，系統爆鳴的成功率為99.99%。系統爆鳴成功率為99.99%，系統運作可靠度高。

本體失效計3次，原因為系統在連續、快速爆鳴後，熱感應器超出臨界溫度而切斷電源；誘發性失效計4次，原因為瓦斯管破損、瓦斯管接頭處漏氣等；非失效計2次，原因為瓦斯壓力鈕無作用，經重新加壓後正常。

測試結果：

遙控型瓦斯爆鳴器，應將熱感應器納入備份件一併採購。軟管耗材可考量使用金屬軟管或其他耐用材質，並持續評估軟管的壽命成本與使用效益，以作為耗材選用的參考。

### 2. 評估裝備的維護度：

測試期間，瓦斯爆鳴器非計畫性失效計9次，耗用維修計12小時及16人工時，維護度平均維修時間及平均維修工時分別為1.33小時及1.78人工時。測試結果顯

示，系統維修時間與耗用人工時甚小。

### 3. 評估裝備耗材使用的成本效益：

瓦斯爆鳴器測試期間共耗用5公斤瓦斯44桶（自動型37桶、遙控型7桶），更換瓦斯軟管3條與軟管接頭1個，以瓦斯每桶760元計，耗材使用成本約新台幣33,440元，經評估其耗用成本低。

### 4. 評估裝備的支援度：

操作人員執行瓦斯爆鳴器爆鳴時，因爆鳴過於密集，導致瓦斯爆鳴器內的熱感應器超出臨界溫度，造成此項安全裝置無法運作，應該納入標準作業程序中，補充說明之。

訓練課程未規劃維修項目，測試期間如遇到系統故障時，僅能依標準作業手冊的故障隔離程序，執行簡易故障處置。如故障無法排除時，需由原廠提供修護資訊，惟使用單位如遇系統電子組件損壞，將無修護能量執行維修。

執行瓦斯爆鳴器與三腳支架組裝驗證，發現腳架擺放不平穩，且瓦斯桶未吊掛至適當位置時，於爆鳴過程中瓦斯管與腳架易造成相互干擾。人員需於工作執行前適當調整腳架支撐位置與高度，平均每具組裝耗費15分鐘，四具瓦斯爆鳴器將耗費一小時，對工時影響甚鉅。

## 結語：

測試結果顯示，瓦斯爆鳴器確具驅鳥效益，對鳥擊防制作為有正面效益，但僅能成為機場整體鳥擊防制措施的一環，仍需配合現有的驅鳥裝備與措施，以達防制鳥擊最大功效。如依據測試結果作有系統的規劃設置，部署自動型、遙控型瓦斯爆鳴器的方式，將可有效減輕使用單位執行驅鳥作業時人力負荷、與提升驅鳥效益。並配合鳥類調查結果，適時調整運作方式，可發揮裝備最佳效益。再配合空軍現行遙控模型飛機、鳥網、獵槍等驅鳥作為，將可有效降低機場發生鳥擊事件的機率。

## 附記：

2005年10月本會赴經濟部所轄財團法人車輛研究測試中心位於彰濱工業區的試車場，協助驅離高速周回路試車時的海鳥。示範瓦斯爆鳴器驅鳥功能後，該中心已經採購瓦斯爆鳴器2具，實施驅鳥驗證。

為了驅離候鳥過境棲息於中正機場，避免造成人員感染禽流感之風險；以及防止機場內鳥擊事件之發生，本會於2005年11月15日自加拿大進口自動型瓦斯爆鳴器12門，佈署於中正機場實施驅鳥作業。✎

本篇為2005年台灣地區鳥擊年會時，空軍測評戰研中心的瓦斯爆鳴器測試報告。

# Test Report of Using Gas Cannon to Disperse Birds

BSC-TW

Because the characteristics of its geographic location and weather, Taiwan is suitable for the transit stop, habitation and breeding of migratory birds at various seasons, thus posing serious threat to the flight safety. The BSC-TW found out that the Ronald Reagan Airport in Washington, D. C., United States, and the airports in Guilin, Kunming and Beijing, China and the airport of Macao all use LP gas scare cannons to disperse birds, and imported from Canada 6 LP gas scare cannons (2 Mark IV, automatic type; and 4 Mark V, remote control type) and entrusted ROCAF to conduct the test assessment. By considering the greater impact suffered by bird strikes and less annoying to the daily activities of the residents around the airport serving both civil and military purpose, BSC-TW decided to provide such gas cannons to Chiayi airport for testing purpose. The LP gas scare cannons are set up on both sides of the airport runway to assess whether the thunderclap-like blast of the LP gas scare cannons are effective in dispersing birds in the hope that it can effectively reduce the occurrence of bird strikes encountered by both military and civil airplanes; and to assess the effectiveness of the system and suitability as well as logistics status; so as to assess whether such equipment is effective in dispersing birds and the result will be used as a reference by both military and civil organizations for purchasing bird-dispersing equipment in the future.

Test Period: from September 1, 2004 to August 15, 2005

Year	Month	10	11	12	1	2	3	4	5	6	7	8	9	Total	Average
2002-2003		5	2	2	0	3	1	1	4	6	7	4	7	42	3.5
2003-2004		4	5	3	0	0	1	0	5	3	2	8	2	33	2.75
2004-2005		2	2	1	0	0	2	0	5	2	4	0	0	18	1.5

The frequency of bird strikes occurred in 2005 was lower than that in 2004 and 2003. In other word, the frequency of bird strikes occurred in 2005 was 57.14% lower than that in 2004 and 45.45% lower than that in 2003 respectively.

The functional principle of the LP gas scare cannon is to ignite the gas by electrical method to enable it to generate a thunderclap-like blast of about 120 db within 5 meters. The effective range of remote control LP gas scare cannon is 2,500 feet within visual range; while the time sequence of interval regulator of the automatic type gas cannon can be set between 40 seconds to 30 minutes. When the gas cannon set up on the tripod, a turning cup can be installed on the launching tube that can rotate around 60 degrees after detonation.

## Effectiveness Test:

### 1.To assess the status of man-machine interface of LP gas scare cannon for dispersing birds:

The satisfaction level of LP gas scare cannon for dispersing birds is 2.11 (with a scale of 1 to 5, the best is 1), the comments of the operators are uniform and satisfactory indicating its function meets the requirements.

As the noise volume reaches 110 db within 10 meters during the detonation of LP gas scare cannon, the operators shall stay outside of the system range and wear earplugs and muffs by following the safety rule of the operation manual to protect their hearing.

### 2.To assess the frequency of bird strike events during test period:

The number of occurrence of bird strike events over the last 3 years is shown below:

The test was conducted at area A and B on the southwest side of the runway, and the comparison of

the survey of the bird species during the same period of time in 2004 and 2005 is as follows:

Area A:

Year	Month	10	11	12	1	2	3	4	5	6	7	8	9	Monthly Average
2004		77	102	65	20	17	12	15	45	46	29	76	65	42.8 each
2005		34	74	34	26	7	17	28	55	67	52	N/A	N/A	39.4 each

The number of bird species in Area A in 2005 was lower than that in 2004, with a decrease of 7.9%.

Area B:

Year	Month	10	11	12	1	2	3	4	5	6	7	8	9	Monthly Average
2004		504	216	70	54	74	36	51	38	56	52	53	15	121.9 each
2005		27	29	16	15	25	29	60	141	176	141	N/A	N/A	66.9 each

The number of bird species in Area B in 2005 was lower than that in 2004, with a decrease of 45.1%.

### 3.Assessment of the LP gas scare cannon's effectiveness in dispersing birds:

Reaction time of various bird species to the LP gas scare cannon:

\* Large Size Bird Species: Average effective reaction time is 76.5 seconds; that is on average the bird species will return again 76.5 seconds after being dispersed, with 17.4% effectiveness of being dispersed for over 3 minutes.

\* Medium Size Bird Species: Average effective reaction time is 85 seconds; that is on average the bird species will return again 85 seconds after being dispersed, with 35.2% effectiveness of being dispersed for over 3 minutes.

\* Small Size Bird Species: Average effective reaction time is 56 seconds; that is on average the bird species will return again 56 seconds after being dispersed, with 9.5% effectiveness of being dispersed for over 3 minutes.

For large and medium size bird species, the average effective reaction time is about 1.5 minutes while that for small size bird species is 1 minute. As for being effectively dispersed for 3 minutes, the percentage of large and medium size bird species is higher than that of the small size bird species. Therefore, in terms of the effective time, the LP gas

scare cannons are more effective in dispersing large and medium size bird species than small ones.

Within a distance of 150 meters of treatment, the effectiveness in dispersing birds is as follows: 90% for large size bird species, 70% for medium size bird species and 40% for small size bird species.

Reaction of bird species: Based on the test, the reaction of various bird species to the thunderclap-like blasts of LP gas scare cannons is different. Therefore, we chose the bird species that have more population at Chiayi airbase such as cattle egrets, red turtle doves, oriental skylarks and Chinese bulbuls to assess the effective range of gas cannons.

\* Cattle egrets: With an effective population of 44 and within a range of 150 meters, after the application of the LP gas scare cannons, the effectiveness in dispersing birds is 90%.

\* Red turtle doves: With an effective population of 26 and within a range of 150 meters, after the thunderclap-like blast, the effectiveness in dispersing birds is 69.2%.

\* Oriental skylarks: With an effective population of 36 and within a range of 150 meters, after the thunderclap-like blast, the effectiveness in dispersing birds is 41.6%.

\* Chinese bulbuls: With an effective population of

21 and within a range of 150 meters, after the thunderclap-like blast, the effectiveness in dispersing birds is 33.3%.

Recommendation: Based on the test results obtained at 150 meters spacing between LP gas scare cannons, we recommend setting up one gas cannon every 500 feet within 3,000 feet at both end of south and north runway. Considering both south and north overrun areas are frequently inhabited by bird species, we recommend setting up 4 LP gas scare cannons at the overruns to achieve better effectiveness. It can be considered to set up 16 LP gas scare cannons on both sides of runways to achieve the best effectiveness and to achieve the cost effectiveness.

## Test of Suitability:

### 1. Assessment of operational reliability of equipment:

During the test period, 44 cans of 5-Kg LP gas were used. On average, each can of LP gas can detonate 9,350 times, thus totaling 411,400 times. The LP gas scare cannon system detonated 411,400 times with 9 failures and 99.99% of success rate. The successful rate of the system detonation was 99.99% indicating high reliability of system operation.

There were 3 failures of the system. As a result of continuous and rapid detonation of the system, the heat sensor exceeded its critical temperature and cut off the electric power. Three induced failures were encountered because the hose was broken or the hose connector had air leakage, etc. Moreover, 2 non-failures were experienced because the gas pressure knob had malfunction, it resumed normal function after pressurization.

Test Result:

For remote control type LP gas scare cannons, the heat sensor shall be included in the spare parts list and purchased. Metal hose or other durable material may be considered for replacing the flexible hose. The life cycle cost and effectiveness of the hose should be continuously evaluated so that it can be used as a reference for the selection of consumables.

### 2. Assessment of the maintainability of the equipment:

During the test period, the LP gas scare cannons had 9 unscheduled failures, requiring 12 elapsed hours and 16 man-hours for repair. For its maintainability, the mean time to repair and average repair man-hour were 1.33 hour and 1.78 man-hours respectively. The test result indicates the system requires very low maintenance time and man-hours.

### 3. Assessment of the cost effectiveness of equipment consumables used:

During the test period, the LP gas scare cannons used 44 cans of 5-Kg LP gas (37 cans used by Mark IV and 7 cans used by Mark V). 3 hoses and a connector were replaced. One can of LP gas costs NTD 760, thus the total cost of LP gas was NTD 33,440, which is a low cost.

### 4. Assessment of the supportability of the equipment:

When the operator was operating the LP gas scare cannon, the detonation interval was so short that caused the heat sensor to exceed its critical temperature leading to the system out of work. This operation should be included in the standard operating procedure for guidance.

The training syllabus did not include maintenance items. When system malfunction was encountered during test period, the operator could only follow the standard operation manual to conduct simple troubleshooting. If the malfunction could not be rectified, the user had to ask the original manufacturer to provide the maintenance information. However, if the user encounters the failure of electronic components, there will be no maintenance capability to fix it.

When performing verification of the assembly of LP gas scare cannon and tripod, it was found that the tripod was not set in a stable condition and the LP gas can was not suspended at proper position, causing the LP gas hose to interfere with the tripod during detonation. The operator had to make adjustments of the support of tripod and its height before conducting the detonation. It took 15 minutes to assemble each LP gas scare cannon, thus taking a total of an hour to finish the assembly of 4 LP gas

scare cannons. It was time-consuming.

## Conclusion:

The test result indicates that the LP gas scare cannon is effective in dispersing birds and has positive effectiveness to the prevention of bird strikes. However, it can only serve as one of the links in the overall chain of bird strike prevention. It shall be used in conjunction with the existing equipment and measures for dispersing birds to achieve the optimum effectiveness. If a systematic plan is developed based on the test result to set up Mark IV and Mark V LP gas scare cannons, it will effectively reduce the manpower workload of the operators in conducting the bird dispersing activities and enhance its effectiveness. Meanwhile, the operation method may be adjusted in a timely manner based on the investigation result of bird species to achieve the best effectiveness of the equipment. When the LP gas scare cannons are used in conjunction with the bird dispersing activities being implemented by ROCAF's remote control model aircrafts, bird nets, shotguns, etc., they can effectively decrease the probability of bird strikes at the airport.

## Note:

The staff from the BSC-TW visited the Automotive Research and Testing Center, a corporate body under the Ministry of Economic Affairs, located at the Changbing Industrial Park, Changhua County, in October 2005 to assist it in dispersing the sea birds from the high speed circuit for testing vehicles. After witnessing the demonstration of the function of the LP gas scare cannon, the said center has purchased 2 gas cannons for dispersing birds.

To disperse the migratory birds inhabiting at CKS international airport to preclude the risks of people being infected by the avian flu; and to prevent the occurrence of bird strikes at the airport, BSC-TW imported 12 LP gas scare cannons from Canada on November 15, 2005 and provided them for deployment at the airport for dispersing birds. ↵

*This article was the testing report made by the Test Evaluation and Tactics Research Center of ROCAF during the annual meeting of bird strikes in Taiwan area in 2005.*

