1. Summary

Aircraft warning lights are lighting devices used to make tall structures more visible to aircrafts, during both daytime and nighttime. These devices should have specific features, in terms of light intensity, beam pattern and light colour defined by international regulations and national standards. The proposed paper provides an overview of the most important guidelines defining lamp types, location and operation of lighting devices. Some layout examples are also included depicting common light configurations on structures.

1.1 Introduction

Aircraft warning lights (AWL) are lighting devices installed on any permanent or temporary structure which could pose a potential hazard to air navigation. Lighting systems, often called obstruction lights, are designed with different shapes, colours and light intensity to produce an acceptable level of safety: the final purpose is to prevent a risk of collision for aircraft flying near the structures. Recommendations on obstruction lighting systems, technical standards and functional features, may vary according to terrain features, weather patterns, geographic locations and the overall layout of the structures that need to be lit.

In general there is no single standard defining minimum mandatory requirements governing design and installation of obstruction lighting; on the other hand the most common and widespread regulations are ICAO’s (International Civil Aviation Organization, a specialized agency of the United Nations,) and FAA’s (Federal Aviation Administration, an agency of the United States Department of Transportation).

1.2 ICAO and FAA regulations


The introduction clearly states that Annex 14 contains the minimum aerodrome specifications for aircraft of certain varying characteristics. Minimum means member States (i.e. 189 of the United Nations members and the Cook Islands) may impose more stringent conditions if necessary; this of course applies also to lighting systems.
Within the more than one hundred and eighty member States of ICAO there are many different systems of jurisprudence. It is a function of ICAO to facilitate the adoption of international air law instruments and to promote their general acceptance.

FAA standard is described in the “Advisory Circular AC 70/7460-1K, Obstruction Marking and Lighting”. It is a regional regulation for the safety of civil aviation within the United States, anyway it has become a de facto standard for its widespread adoption also outside US.

As an example, ARAMCO (Arabian American Oil Company) standard guidelines acknowledge and incorporate in great measure FAA’s recommendations for aviation obstruction marking and lighting.

It’s important to notice that between ICAO’s and FAA’s standards there are many points in common, some differences (e.g. lights location and combination) and sometimes where one regulation lacks details, the other fills the gaps: in detail FAA’s is a very pragmatic regulation, in addition to general principles, provides examples and clear practical rules also where ICAO remains generic.

Hereafter, we provide a brief explanation of ICAO main recommended practices for obstruction lights.

### 1.3 Lamp types

A first distinction made in regulations is related to lamp types.

According to ICAO, standard light units are distinguished by a set of parameters: light intensity, beam pattern, light color, flash rates.

ICAO divides lamps into three main groups:

- **Low intensity obstruction lights**: these lights should be used where the object height above the surrounding ground is lower than 45 m.
- **Medium intensity obstruction lights**: should be used where the object height above the level of the surrounding ground is higher than 45 m.
- **High intensity obstruction lights**: these lights should be used to indicate the presence of an object if its height above the level of the surrounding ground exceeds 150 m.

In detail, the regulation describes different lamp types within the above three groups.

Low intensity obstacle lights, on fixed objects, are fixed-red lights divided in two types:

- **Type A**: with minimum intensity of 10 candelas.
- **Type B**: with minimum intensity of 32 candelas.

There are two other types of low intensity obstacle lights, Type C and D used on security vehicles and other vehicles.

Medium intensity obstacle lights are divided into three types:

- **Type A**: white color flashing lights with intensity of 20,000 candelas during daytime, 2,000 during nighttime.
- **Type B**: red color flashing lights with minimum intensity of 2,000 candelas.
- **Type C**: red color fixed lights with intensity of 2,000 candelas.

Finally high intensity lights are divide in two types:

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1 ICAO definition of the intensity required for obstacle lights takes into account the background luminance of the site. Intensity requirements are defined according to three background luminance values: “Above 500 cd/m²”, “50 - 500 cd/m²”, “Below 50 cd/m²”. Here, to simplify the description, minimum required values are described.
- Type A : white color flashing lights, with minimum intensity of 200.000 candelas during daytime, 20.000 candelas during twilight and 2.000 candelas during nighttime.
- Type B : white color flashing lights, with minimum intensity of 100.000 candelas during daytime, 20.000 candelas during twilight and 2.000 candelas during nighttime.

Moreover, regulations provide details for every characteristic of each type of obstacle lights, defining vertical beam spread, intensity at given elevation angles, flashing intervals and flashing duty cycles.

1.4 Location and combination of obstacle lights
Description on how to place visual aids on the objects includes guidelines on how many lamp levels to be used according to the given structure and type of obstruction light to be used for each level.

A first general recommendation states that number and arrangement of low, medium or high intensity aircraft warning lights at each level to be marked shall be such that the object is indicated from every angle in azimuth. This means that the number of light units recommended depends on the diameter of the structure.

A dimensional guideline can be retrieved in FAA’s document:
- up to 6m of diameter, 3 lights are required;
- more than 6 m of diameter, at least 4 lights are required.

![Figure 1- Number of light units in respect of the diameter of the structure](image)

Regulations on what type of obstruction lights to use refer to the obstacle dimensions and on the need for daytime, nighttime marking or both.

In general some freedom is allowed in choosing lights and light combination for daytime and nighttime use, especially when lighting could cause environmental concerns or dazzle pilots in the vicinity of aerodromes.
High-intensity obstacle lights are intended for day as well as night use, ensuring that the lights do not create disconcerting dazzle.
Medium-intensity lights are intended for day and night use, Type B and C are usually recommended for nighttime and Type A for day use.
Low-intensity obstruction lights are intended for night use only and, if not in combination with other types, should light objects whose height above the surrounding ground is less than 45 m.

Regarding location of lights to be placed on the object, the regulation suggests that one or more low-, medium- or high-intensity obstacle lights shall be located as close as possible to the top of the object. Top light shall be so arranged as to at least indicate the points or edges of the highest object in relation to the obstacle limitation surface.
In the case of an extensive object or of a group of closely spaced objects, top lights shall be displayed at least on the point edges of the highest objects in relation to the obstacle limitation surface, so as to indicate the general definition and the extent of the object. If two or more edges are of the same height, the edge nearest the landing area shall be marked.

![Diagram of lighting for extensive buildings](image)

**Figure 2 – Lighting of extensive buildings; A,B =45 – 90m, C,D,E < 45m**

Having said that, the recommendations describe some exceptions or particular cases. One important case to be mentioned relates chimneys or other structures of same functions; for these structures top lights should be placed sufficiently below the top so as to minimize contamination by smoke, radiations, small particles.
This advice gives some important freedom in positioning obstruction lights for the top levels, for instance, in case of chimneys or flares so common in the oil and gas premises. Furthermore, another important guideline describes the lighting of nearby structures; in fact if structures are adjacent inboard lights may be omitted when the lights are shielded in any direction by the two objects.

More in general it is recommended that lights should retain the general definition of the object; if shielded lights do not contribute to the object definition, they may be omitted.
Finally it’s worth mentioning a general principle conceived to provide an adequate level of safety: this principle states that any outage should be corrected as soon as possible. It’s a sentence that can be found in FAA’s document, not in ICAO’s guidelines, but it’s significant because it implies the need to think of a failover mechanism to provide reliability in system configuration. Regardless of a specific regulation, redundancy is a key issue especially for systems installed on flares or chimneys where accessing top levels for maintenance is critical. The use of a double system, where one spare element is ready to be switched in operation, is quite common and the best solution for redundancy instead of adding additional light elements to the standard required number.

1.5 Layout examples
In the previous paragraph it has been stated that ICAO’s regulations allow for some freedom in choosing lights and light combination for daytime and nighttime; the guidelines describe different configurations, both in terms of lamp types on each level and on daytime and nighttime lighting layouts. A common choice on which configuration to adopt, as everyone can imagine, is done according to financial resources and budget planning. Some layout examples are depicted on the following pages showing the most common configurations and some remarkable variants.
Figure 5- ICAO appendix 6: APP 6-1 Medium intensity Type A

Figure 6- ICAO appendix 6: APP 6-2 Medium intensity Type B, Low intensity Type B (night-time use only)
Figure 7 - ICAO appendix 6: APP 6-3 Medium intensity Type C (night-time use only)

Figure 8 - ICAO appendix 6: APP 6-4 Medium intensity Type A/B, low intensity Type B
1.6 Conclusions

Aircraft warning lights systems have been described. The paper outlines the most important guidelines defining lamp types, location and operation of lighting devices. Some layout examples have been included depicting common light configurations on structures.

2. References