

# Discussion on the Optical Performance of TYH-120 Integrated beacon Light under the Backlight of Dagusha Channel in Tianjin Port and the Optimization Scheme

Guo Qiang

Tianjin Aids to Navigation Division the Navigation Guarantee Centre of North China Sea Tianjin,  
People's Republic of China

969679014@qq.com

**Abstract.** The light signal of navigation aids plays an important reference role for ship pilots, especially in the long channel manually dredged (Dagusha Channel of Tianjin Port). The stable performance of beacon lights is of great significance for ship pilots to identify the channel, determine the ship's position and avoid dangerous objects, which is directly related to the navigation safety of ships. Based on the observation of the backlight of Dagusha Channel in Tianjin Port and the analysis of the location of the navigation aids in the area under its jurisdiction, this paper introduces the optical performance of TYH-120 integrated beacon light in the channel, and puts forward a further optimization plan.

**Keywords:** beacon light, Backlight, Performance, Optimization scheme.

## 1. Introduction

A questionnaire survey was conducted among 103 pilots and 321 deck officers. The results showed that more than 87% of ship pilots were interfered by port light pollution during the process of entering and leaving the port, 46% had been seriously interfered by port light pollution, and more than 12% had taken emergency measures due to port light pollution. It can be seen that a series of light pollution, such as the backlight around the channel, has affected the stable performance of the beacon light, and has become an important factor that the management personnel of the beacon have to consider in terms of the optimization of the beacon equipment and the upgrading of science and technology.

## 2. Introduction to the structure of integrated beacon light

TYH-120 integrated beacon light is an internationally advanced solar integrated LED beacon light made in China. Its structure is composed of LED point light source, curved luminous lens, control circuit, solar panel, battery and shell. This beacon light adopts a single high brightness LED lamp bead and an intelligent power driver, and is equipped with an advanced control system. It has a constant light intensity output for different light colors. The protection level of this beacon light reaches IP67, which can achieve water tightness and air tightness.

**Table 1.** Technical Parameters of HD-120 Aids to Navigation Light

appellation	technical parameters
Effective range	4nautical miles
Vertical divergence angle	8.3±0.3degree
Light color	Available in red, green, yellow and white
Daylight threshold	300LUX(100—2000LUX adjustable)
Type of light	256species(IALA)
Remote control mode	SMS GPRS CDMA Beidou Satellite
Solar cell power	2.5W * 4
storage battery	3.7V/100AH(Li-ion Battery)
Static power consumption	3mA(GPRS); 30mA(CDMA); 2mA(Beidou)
Dynamic power consumption	1.5W(GPRS); 1.5W(CDMA); 4W(Beidou)

The beacon light uses a 32-bit ARM processor, with 256 flash types, which can be set according to the actual situation of users. At the same time, the beacon light is equipped with GPRS, CDMA, Beidou Satellite, GPS and other functional modules, which can realize the remote monitoring and control of the beacon light, and provide users with real-time feedback of the beacon light status, location information, etc. Since the beacon light uses GPS high-precision clock as synchronous signal, it can flash synchronously at the position where the lamp quality is the same and GPS satellite signal can be received. See the following table (TABLE I) for specific parameters.

### **3. Light Distribution of Aids to Navigation in Dagusha Channel of Tianjin Port**

Dagusha Channel of Tianjin Port was officially opened to navigation in 2009, and then upgraded to 100000 tons on the basis of the original 50000 ton channel. The trial navigation began on January 1, 2014. The channel is 32.5km long, 375m wide at the bottom and 14.5m deep. As of November 2022, the channel has 85 underwater buoys (non fishery buoys), 32 light beacons on both sides of the channel, 5 tangible AIS beacons, 2 radar transponder beacons. The proportion of buoys and light beacons using integrated beacon lights exceeded 74.3%. The light distance of each pair of side signs in the main channel is 0.25 nautical miles, and the light distance of adjacent pairs of side signs with the same color is 0.65 nautical miles.

### **4. Analysis of the influence of backlight on the optical performance of beacon light**

The backlight in Dagusha Channel of Tianjin Port at night mainly come from the office buildings, factories, roads, bridges, hoisting equipment near the wharf, as well as the lights of ships docked at the wharf. The light emitted is mainly white and yellow, while the beacon lights arranged in Dagusha Channel are red, green, white and yellow. When the white and yellow beacon lights are mixed with the backlight of similar colors, The factors that affect its identifiability are mainly its brightness, flash cycle and the degree of overlap with the background light. Red and green beacon lights will also face the above factors that affect its identifiability when mixed with the backlight, but they are easier to identify than white and yellow beacon lights.

According to the observation of the navigation aids management personnel, the closer the navigation aids are to the background light, the more likely the ship pilot is to be interfered when observing the navigation aids; The closer the ship pilot is to the beacon light, the less likely he is to be interfered by the background light. When the number of synchronized flashing beacon lights in front of the ship is more, the ship pilot is less likely to be interfered by the background light.

Through the observation of the area with background light (A, B, C in Figure 1, the observation distance is 1.0 nautical miles, the weather is clear, and the visibility is good), it can be seen that in the area without background light, the beacon light is very easy to identify (the light spot pointed by the arrow, A in Figure 1); In the area where there is background light, but the intensity is not enough to cover the beacon light, the beacon light can be identified through careful observation, but there is a possibility of miscalculation (the light spots indicated by the arrow, B in Figure 1); In the area with high intensity and high density background light, the beacon light is not easy to be observed, or the possibility of misjudgment by the observer is high (See C in Figure 1); During the loading and unloading period when the ship is docked at the wharf, a large number of background lights will be produced (See D in Figure 1, the observation distance is 0.5 nautical miles, the weather is clear, and the visibility is good), which will affect the ship driver to identify the navigation aids near the area, and even make the ship driver feel dizzy.



**Fig. 1** Observation state under different background lights

Aids to navigation management personnel have observed the background lights of Dagusha Channel in Tianjin Port for three consecutive years. The observation tools include but are not limited to SLR camera (Canon 500D), smartphones (iPhone X, redmi K30i). The proportion of visibility greater than 4 nautical miles exceeds 95%, and the number of observations is more than 12. Finally, seven areas with high night light intensity, long duration, and high risk of interference to the beacon lights have been designated, They are: 1. Lights of Nanjiang Expressway Bridge and buildings in the northwest, 2. Background lights around Wharf No. 4, 3. Background lights of Vopak Bohai Chemical Co., Ltd. and its surroundings, 4. Background lights of Tianjin BOMESC Offshore Engineering Co., Ltd. and its surroundings, 5. Background lights of COFCO Excel Joy Co., Ltd. and its surroundings, 6. Background lights of Tianjin LNG Co., Ltd. and 7. Background lights of Sinochem Tianjin Port Petrochemical Storage Co., Ltd. and its surroundings.(See Figure 2 for details)



**Fig. 2** Areas with more background lights

There are many strong background lights in Dagusha Channel of Tianjin Port, but the beacon lights are not always affected by the background lights within a certain range. The entry and exit routes of ships in the channel are fixed. Some buoys are easy to be interfered by the background light when the ship enters the port, but it is not easy when the ship leaves the port. Some buoys are easy to be interfered by the background light when the ship leaves the port, but it is not easy when the ship enters

the port. There are also some buoys that are not easy to be interfered by the background light no matter when the ship enters or leaves the port, although they are very close to the background light.

The Aids to Navigation management personnel have cruised the Dagusha Channel of Tianjin Port for more than 12 times at night by the ship "Haixun 15020" within three years. They have observed the Aids to Navigation within 0-1 nautical miles and 1-2 nautical miles of the above seven areas with strong background lights. They found that some Aids to Navigation are at risk of being interfered by the background lights whether the ship is entering or leaving the port. See the table below for the number of Aids to Navigation with risk of being interfered, after canceling out the overlapping navigation aids, there are finally 11 left. Although this number only accounts for 9.4% of the number of visual navigation aids in Dagusha Channel, it still increases the risk of ship driving to a certain extent, which is worth paying attention to by ship officers and further research and improvement by navigation aids management personnel.

**Table 2.** List of Aids to Navigation Easily Affected by Backlight

Backlight area	Light intensity	Number of Aids to Navigation with Interference Risk	
		(0-1 nautical mile)	(1-2 nautical mile)
Lights of Nanjiang Expressway Bridge and buildings in the northwest	moderate	4	1
Background lights around Wharf No. 4	Strong	3	2
Background lights of Vopak Bohai Chemical Co., Ltd. and its surroundings	moderate	2	1
Background lights of Tianjin BOMESC Offshore Engineering Co., Ltd. and its surroundings	Strong	3	2
Background lights of COFCO Excel Joy Co., Ltd. and its surroundings	moderate	2	2
Background lights of Tianjin LNG Co., Ltd.	moderate	1	1
Background lights of Sinochem Tianjin Port Petrochemical Storage Co., Ltd. and its surroundings	moderate	2	1

## 5. Some Suggestions on Reducing Backlight

### 5.1 Control the backlight light source

The administrative department of navigation aids shall strengthen the communication with the maritime regulatory department, and publicize the knowledge of navigation aids, light pollution and other contents to the ship pilots, the owners of the wharf and other employees; Warning signs shall be set at ports, wharves and berths where light pollution is serious; Use curtains to block the lights of the port office building, adjust the position of the lights in the storage yard, or install a sunshade, and try to avoid direct illumination of the light on the sea; The light intensity of deck lights, corridor lights and other lights of the ship shall be controlled to the minimum; When the ship enters or leaves the wharf, the operation shall be stopped temporarily, and corresponding measures shall be taken for other lights according to the actual situation; Select the background light color reasonably.

### 5.2 Improve laws, regulations and supervision mechanism

According to the current Regulation of the People's Republic of China on Aids to Navigation, the administrative department shall formulate a clear definition of the background light in key waters such as channels and docks, and define the standard of background light interference by scientific means. At the same time, the prevention and control measures on the interference of background lights shall be formulated, the supervision and management mechanism shall be established, the background lights interfering with the lights of navigation aids shall be included in the administrative punishment of maritime supervision, and the corresponding penalty rules shall be formulated.

## 6. Optimization of the structure and performance of beacon lights

Another way to reduce the impact of background lights is to upgrade the existing integrated beacon lights. One way is to increase the power of the beacon light and use a brighter flash to offset the existing background light, but this will inevitably increase the battery capacity and the area of the solar receiver. In addition to increasing the huge cost of the beacon, it will also make it difficult to replace the beacon. At the same time, the existing beacon equipment is also difficult to match the large-sized beacon light. Another way is to install the AIS module on the beacon light, In addition to allowing buoys to be recognized by visual lighting, another new way of being recognized is added.

AIS is the abbreviation of Automatic Identification System of Ships. The Automatic Ship Identification System (AIS) is a new type of navigation aid system applied to maritime safety and communication between ships and shore, ships and ships. The AIS installed on the ship can send out the static information of the ship, including MMSI, call sign and name, IMO number, length and width, ship type, etc., as well as dynamic information, including navigation status information such as the ship's position, speed, bow direction, etc. At the same time, AIS can also receive information from other ships and tangible AIS aids.

There are five tangible AIS beacons on both sides of Dagusha Channel of Tianjin Port. Their AIS equipment and beacon lights are separated, with independent power supply and feedback mode. The current working state is stable, and the ship pilot has good feedback. If an integrated AIS module is installed on the buoy light in the channel, ships sailing nearby can identify the AIS light buoy on the channel through their own AIS equipment, so as to judge the position of the ship, maintain the course and avoid dangerous objects.

## 7. Conclusion

HD-120 beacon light has been used in Dagusha Channel of Tianjin Port for more than 7 years, and its practicability and stability have been verified. However, with the development and construction of Dagusha Channel around Tianjin Port, more and more lights are used. With the opening of Dagusha 100000 ton channel, more and more large ships are available. Compared with small ships, large ships have a deep draft, which is difficult to operate and rely more on the guidance of beacon lights. Through long-term observation and record, this paper analyzes Dagusha Channel of Tianjin Port, finds out the beacons that are easily affected by the background light according to the distribution of beacons in the area under its jurisdiction, and puts forward views on how to effectively reduce the background light of Dagusha Channel and further optimize the beacon lights.

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