1. Introduction

ENG1-10.3.2

The climate in the Arabian Gulf is extremely hot during the summer and is coupled with high humidity in the Central and Southern Sectors, very low humidity in the Northern Sector. The average annual temperature is 40°C, reaching 48°C to 55°C during the summer months and an average of 23°C during winter months.

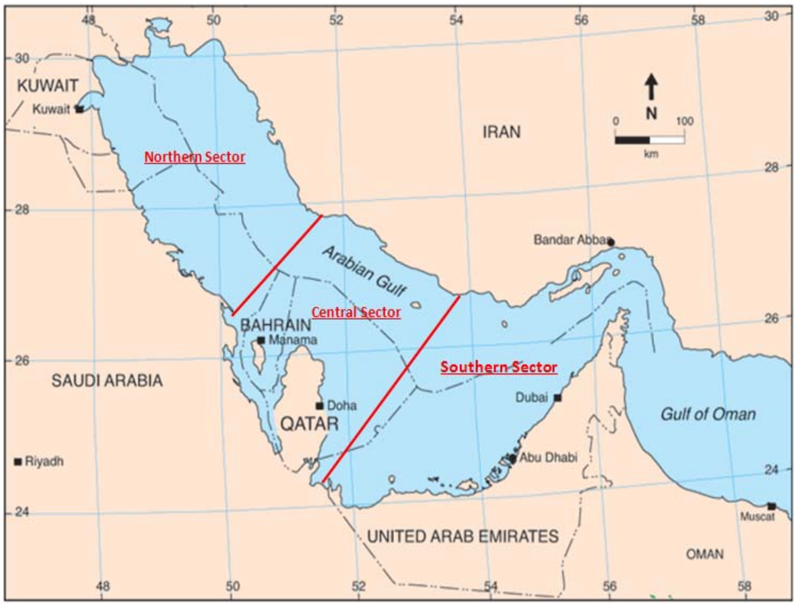
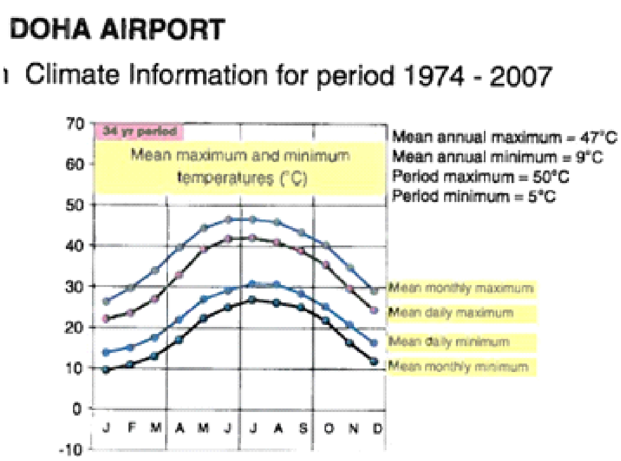


Fig.1- Gulf Overview Image

The combination of these extreme climatic conditions significantly impacts decisions taken in the provision of Aids to Navigation in the region. These high temperatures and UV levels radically affects an AtN's performance, equipment life expectancy, frequency of maintenance cycles, and operational/maintenance costs. Every AtN component is affected to a greater or lesser extent, i.e. structures, surface colour, light glazing, lenses, flashers regulators, electronics, and batteries. Shore based stations such as beacons and DGPS sites are also affected.



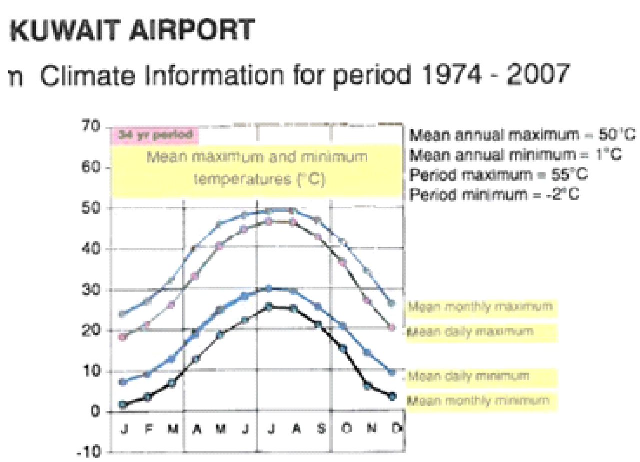


Fig.2 Climate Data 1974-2007. Source: *Admiralty Sailing Directions – NP63 16th Edition 2013*

2. The Impact of Extreme Temperatures on AtoN Equipment

This section looks at the impact extreme temperatures have on the provision of Aids to Navigation components in the Arabian Gulf. The findings are premised on MENAS' AtN operational experience of 60+ years.

a. Battery Performance

Long periods of excessively high temperatures affect a battery's performance /life span. MENAS has found this to be the case whether it is a self contained lantern or in a separate battery box sheltered from direct sunlight. As per manufacturers battery performance guideline, every 8°C (15°F) increase in temperature reduces the life of a sealed lead acid battery by up to 50%, because the battery acid is boiled, the electrodes burnout and the acid vaporises.

Battery manufacturer's generally use an average temperature of 25°C / giving a life span of 4 to 5 years to measure battery performance. However we have found as temperatures increase the battery life span reduces. For example, when the temperature rises to 48°C the battery life will last only 1-2 years. MENAS policy is to replace batteries every two years.

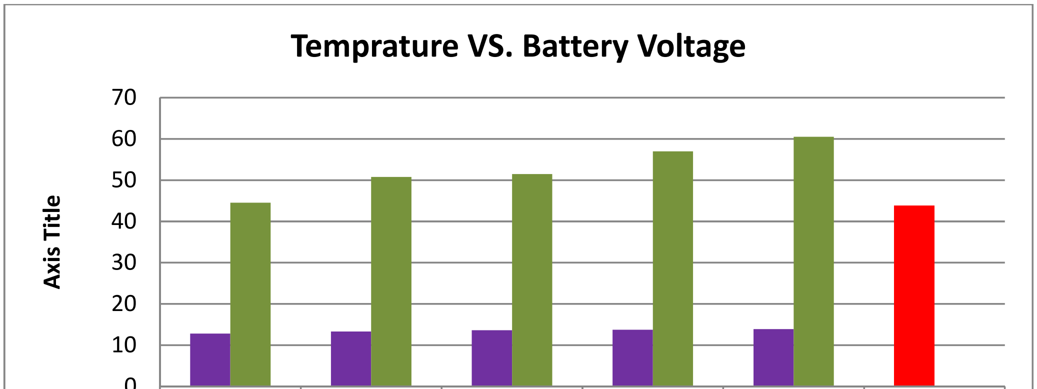
The surface colour of battery boxes also has a direct impact on the life span of batteries in the Gulf region. MENAS has observed over a 10 year period that batteries installed in black, green or red painted battery boxes have a significantly lower life span (approx 40%) less than those painted yellow or white. Therefore batteries with a life cycle of 5 years will only last 15 to 24 months in a black, green or red battery box. MENAS' long established policy is to paint all battery boxes white.

For the purpose of this paper, MENAS conducted a simple experiment to illustrate the effects extreme temperatures have on battery boxes painted different colours. See Figure 3 & 4 below.

Figure.3 Battery Box Experiment

The experiment was conducted in direct sunlight. Each battery box was painted a different colour and installed with new lead acid battery 100Ah and a calibrated thermometer. The temperature was recorded daily at 13:30 hrs over a 3 month period.

Results showed that the darker the surface colour the more temperature rises inside the box. It was noted that the difference between the average outdoor temperature and the average internal temperature inside the box was significantly higher - see Fig 4 below.



	White	Yellow	Red	Green	Black	Outdoor Temp
Voltage	12.8	13.3	13.6	13.7	13.9	43.8
Temp	44.5	50.8	51.5	57	60.5	

Fig.4 Temperature vs. different surface colours

It was also observed that battery voltage is proportionally affected when temperature increases. Batteries overcharge due to excessive heat which leads to the reduction in the life span of a battery's electro-plates.

b. Polyethylene Buoys -Degradation of Surface Colours and Material.

Excessively high temperatures and UV levels significantly impact on a buoy's surface colour and its material of manufacture.


Fig.5

The biggest impacts are the degradation of surface colour on AtNs due to the high UV levels i.e. Red surface colour fades to pink and green fades to white and the fragility of polyethylene material in high temperatures. Plastic buoys damage very easily due to the brittleness of the material in extremely high temperatures.

Manufacturers of polyethylene buoys claim they are maintenance free with a life expectancy of 10-20 years. However, this is not the case in the Gulf; given the extreme temperature and UV effect the life span of a polyethylene buoy is 5-6 years. Therefore the total operational cost will be approximately three times more than the forecast maintenance cost. This has led MENAS to change its maintenance strategy for plastic buoys in order to meet IALA standards, namely.

- Paint the effected buoys more frequently (every year)
- Replace with new buoy (5-6 years)


Fig.6

The policy of the three major AtN service providers in the Gulf (MENAS, ADPC and AMNAS) is to use steel buoys.

The above is supported by another ATN Service provider in the Gulf (ADPC – Captain AbdulAziz Al-Hammadi – AtN Manager):

Over a 3 year period we have received 44 failure notices of plastic buoys in the newly established Mussafah and Khalifa Channels, which is a very high number. The failures were attributable to the buoy towers being damaged or missing as well as the colour being totally faded.

We established that these problems were because the body of a plastic buoy is very brittle and the high temperature in our Gulf area leads to the buoy body being easily cracked and the colour fading from the buoy body - see attached images.


Fig.7

c. **Effects on Assorted Lanterns Lenses/Glazing**

The effect of high UV levels and heat on lenses and glazing reduces the transmissivity of the light and in turn its range. Another impact caused by high heat is glass cracking - see Fig 11.

MENAS has found that light transmissivity is reduced by 40% - 70% within the first 5 to 6 years of the installation. In turn this reduces the range by at least 60% of it nominal value which will have a direct impact on the performance of an AtoN. (Lenses and glazing life expectancy is normally 10 years)

To mitigate the above problems MENAS policy is to replace the lens more frequently (before the end of its life expectancy).

Fig.8

Fig.9

Fig.10

Fig.11

d. Effects on Solar Panels

Fig.12

The effects of the direct sun light (UV) and the high heat damages solar cells thus reducing performance. The life span of a standard solar panel is generally 14 to16 years with an average output of at least 70% to 80%. However in reality in the we achieve an average of 40-50% over a 10 year cycle - see Fig 15

The reduction in output of the solar panels means the charging current is insufficient, thereby reducing the battery life cycle. Units need to be replaced more frequently. The general AtoN performance and availability will be affected and operational costs will increase by at least 40%.

MENAS policy is to replace solar panels every 8 years.

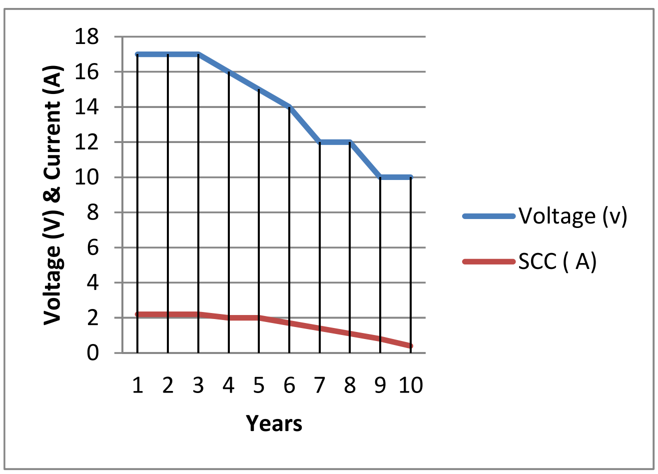


Fig. 15 Performance of 40W solar panel installed in a hot climate over a 10 year cycle.

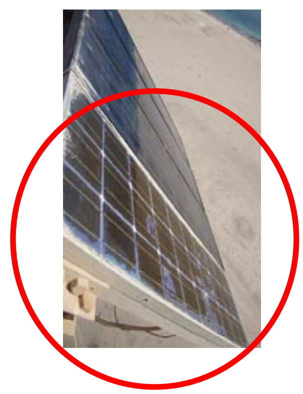


Fig.13

e. Effects on DGPS Sites

Fig.16

Marine atmospheric conditions prevailing in the Gulf are considered to be far more severe than anywhere else in the world. The variation in corrosion rate of aluminium alloys can be more than 20 years. The atmosphere at about 80 feet from the sea is approx 12x more corrosive than at 800 feet away from water. Chloride and moisture in the air depend on direction of winds, expanse of the sea, topology and temperature.

Fig 17

Effects of high UV levels and temperatures affects the protective coatings on DGPS shelters resulting in coatings peeling off and in turn an increase in temperatures inside the shelters. DGPS towers are also effected; the heat, moisture and chloride penetrates the coating causing the material to crack which leads to mast damage – See Fig.17 & 18

MENAS DGPS maintenance policies are designed to mitigate the above issues.

Fig.18

Fig.19

f. Effects on other AtoN structures

The pictures show the affect of high temperatures and humidity levels on beacon structures in the Gulf (note – not maintained by MENAS). Steel has degraded (despite being well coated) because corrosion occurred due to chloride moistures forming in the materials.

The cracks in the concrete are due to corrosion of the steel where expansion has occurred.

This makes the structure weaker, increases the risk of collapse and therefore the maintenance costs.

MENAS' maintenance strategies are designed to prevent the above from happening.

Fig.18

Fig.19

Fig.20

3. Conclusion

It is apparent from the foregoing that the extreme climate in the Gulf region, where the highest recorded summer shade temperature is 53.8°C, significantly impacts the selection of AtN materials and maintenance strategies by AtNs service provider in the region.

As an experienced AtoN service provider, we strive to provide the optimum level of services to mariners transiting the Gulf waters. However the extreme climatic conditions in the region can impact significantly on the integrity, reliability and performance of AtNs. There are also increased operational/maintenance costs required to combat the challenges of extreme heat. Therefore, we request IALA ENG Committee to further consider this case and provide guidelines for AtN service provision in extremely hot climates. We also urge IALA Industrial members to manufacture products that will operate effectively and efficiently in such climates.

4. References:

1. *MENAS Historical Data Base*
2. *GCC Metrological Offices.*
3. *Admiralty Sailing Directions – NP63 16th Edition 2013*
4. *Capt. Abdulaziz Al-Hammadi – AtoN Manager Abu Dhabi Ports Company ADPC*
5. *Photos sources: MENAS, AMNAS & ADPC photographic library.*