TECH PAPER
NAVIGATION, SIGNAL LIGHTS & CONTROL SYSTEMS, 24 V OPERATION ON NAVIGATION LIGHTS, VOLTAGE LOSS COMPENSATION DETAIL DESCRIPTION

TRANBERG®

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INTRODUCTION

This paper discusses the use of 24 volt lanterns on larger vessels, the superior benefits of this, and the few possible practical compensations needed.

Besides providing an executive summary, we provide several examples to prove this. The physical laws that are involved are also shown and demonstrated

For additional information, please contact Tranberg Technical Department.

SUMMARY

The use of 24 volt lanterns is by far superior to 230 volt lanterns. The reason for this is that the filament inside the 24 volt lamp is stronger and withstands more shocks and vibrations. This is an undisputable benefit when it comes to critical lights as navigation lights on a vessel.

As the current through a supply cable to a 24 volt lantern is nearly 10 times as high as to that of a 230 volt lantern, one must keep in mind a possible voltage drop over the length of the supply cable. This is particularly important when the cable is over 50 meters and the cross-section is less than 1,5 mm².

By reducing the voltage to a lantern lamp by as little as 5 to 10%, significant increases in lifetime expectancies of the lamp may be obtained. Tranberg lanterns are approved by Det norske Veritas (DnV) and other bodies, and generally exceed the requirements to light output. In other words, a small reduction in supply voltage does not conflict with the approvals to our lanterns.

Investing in a 24 volt lantern system is a cost-effective solution.

RESISTIVITY IN CONDUCTORS

Any conductor has an inherent resistance, and typically this resistance is reverse proportional to the conductor size (AWG or mm²). There are also other factors that has influence to the resistance, such as temperature and impurities in the metal (typically copper), but we will not discuss these as they play a relatively small part in the topics covered by this paper.

The resistance is named R, and measured in Ohm (Ω). The formula to calculate the resistance in a given conductor is as follows:

$R = \rho \bullet (L/A)$.

Where ρ (Rho) is a constant called resistivity and this is related to the material and the temperature of the conductor. L is the length (in meters) of the conductor. Note that if a cable is 50 meters long, one conductor runs 50 meters to a lantern and another one 50 meters back, totalling to 100 meters. The letter A in the formula is the area of the cross-section (in square millimetres).

Example 1: ρ for a copper is 0,0172. In this example our copper cable has a cross-section area of 1mm², and a total conductor length of 100m.

The resistance in the wire is found as follows:

$R = \rho \bullet (L/A) = 0{,}0172 \bullet (100/1) = 1{,}72\ \Omega$

HOW TO CALCULATE A VOLTAGE DROP

Ohm's law defines the correspondence between resistance (R), voltage (U) and current (I).

The formula is as follows:

$U = R \bullet I$

Going back to our example above, we found the resistance to be 1,72 Ω. If we continue, and imagine we send a current of 1 ampere (A) through the cable, the corresponding voltage drop (U) will be:

$U = R \bullet I = 1{,}72\ \Omega \bullet 1\ A = 1{,}72\ V$

WHAT IS A VOLTAGE DROP?

A voltage drop is simply a difference in voltage measured at two points. Typically this is measured near the source and near the consumer, e.g. a lantern. On very long cables, especially with a high current and a small conductor cross-section, this may reduce the voltage to a level where the consumer does not operate safely.

CALCULATING POWER

Power is a continuous conversion of energy and measured in Watt. The letter P is used to indicate power. The formula for calculating power when we know both the current through a entity as well as the voltage across is as follows:

$P = U \bullet I$

Example 2: A light bulb has a voltage across it of 24 volts and 1,67 ampere flows through it. The power dissipated in the light bulb is:

$P = U \bullet I = 24\ V \bullet 1{,}67\ A = 40\ W$

24 V OPERATION ON NAVIGATION LIGHTS - VOLTAGE LOSS COMPENSATION

ESTIMATING THE RESISTANCE OF A LIGHT BULB

The resistance in the filament inside a light bulb may be found. Again we use the formula and data from above, and find that:

U = R • I → R = U / I

R = U / I = 24 V / 1,67 A = 14,3 Ω

Example 3: If we assume that the light bulb is 230 V, while keeping the power at 36 W, we find the following

P = U • I → I = P / U

I = P / U = 40 W / 230 V = 0,17 A

R = U / I = 230 V / 0,17 A = 1352 Ω

USING 24 VOLT LIGHT BULBS ON LANTERNS

From examples 2 and 3, we see that the filament inside a light bulb has a higher resistivity with increasing voltage. The filament material is the same, no matter the operating voltage. With respect to the formula we introduced early in this document, we can assume that in order to achieve a higher resistance, the filament needs to be longer, and/or the cross-section area needs to be reduced.

Typically, the filament for a light bulb as shown in example 3 is both longer and thinner than that of example 2. The result is that the filament inside a 40W, 230V light bulb is very fragile, and withstands far less vibrations and shock than a 40W, 24V light bulb. This may not be a problem for a general purpose lamp, but when it comes to the demands of durability and criticality as set forth in a navigational lantern on a vessel, it really does matter. This is why Tranberg have been a front-runner on 24 volt navigational lanterns, and why we continue to be a leader in this technology.

VOLTAGE DROP

As seen in examples 2 and 3, the current in a 24 volt light bulb is nearly 10 times higher than in a 230 volt light bulb, where both light bulbs have the same rated power. We will now see if this has any influences on voltage drops in the supply cable.

Example 4: A 40W, 24 volt lantern is supplied from a 50 meter long cable, where the conductor have an area of 1,5 mm².

R = ρ • (L/A) = 0,0172 • (50+50) / 1,5 = 1,15 Ω

I = P / U = 40 W / 24 V = 1,67 A

U = R • I = 1,15 Ω • 1,67 A = 1,92 V

Similarly, if we extend the cable to be 100 meters, we find that the voltage drops increases to:

R = ρ • (L/A) = 0,0172 • (100+100) / 1,5 = 2,29 Ω

I = P / U = 40 W / 24 V = 1,67 A

U = R • I = 2,29 Ω • 1,67 A = 3,82 V

VOLTAGE COMPENSATION:

In order to obtain the correct 24 volt at the light bulb inside the lantern, we need to increase the supply voltage, or compensate for the voltage drop. Hence, the supply voltages to the three cases in example 4 theoretically becomes:

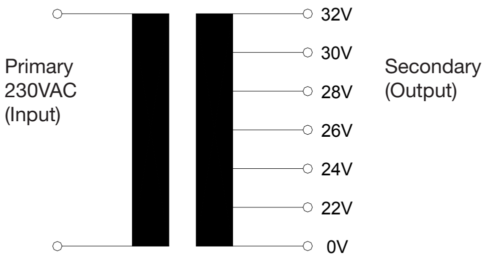
Case 1: U = 24 V + 1,92 V = 25,92V
Case 2: U = 24 V + 3,82 V = 27,82V

Tranberg solves this by using two identical and powerful transformers, one for the main power supply and one for the emergency power supply. The transformers have a 230 V primary (input) and a selection of secondary (output) voltages, typically 22 V, 24 V, 26 V, 28 V, 30 V and 32 V. These different outputs are used as required to compensate for a potential voltage drop.

For the three cases above, we would recommend the following feeding voltages:

Case 1: U = 24 V (voltage drop is negliable when using a Tranberg TEF 2870 lantern)
Case 2: U = 26 V

Transformer for lantern controllers :



The feeding is done at the switching module or individual switch by using the selected voltage.

CONCLUSION:

The 24 volt navigation light system is far superior that a 230 V system, due to life time expectancies of the light bulbs. This is particularly important for navigation lanterns on a vessel. The voltage drop in the cables to the lanterns, especially when these are of a greater length and/or small areas, is compensated by using different feeding voltages from the transformer.

NOTICE

Please refer to Tech Paper TTP 1000.That document is an abbreviated version of this document.

DISCLAIMER

In this paper we have not taken into the effect of capacitive or inductive loads, as they will create an offset between current and voltage. When dealing with pure resistive loads as found in a regular light bulb there is no capacitive or inductive loads involved. The capacitive and/or inductive effects of a supply cable to a lantern are also so small it may be omitted completely. The resistance calculation above is therefore a pure DC resistance.

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