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GUIDELINES

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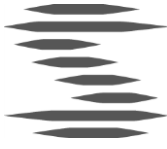
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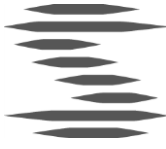
Pethra Gustavsson, cNAL

Marking of objects that may constitute a hazard to aviation and about notification of obstacles to aviation

This document offers guidelines that describe on a general level which technical solutions Svenska kraftnät advocates in connection with the Swedish Transport Agency's updated "regulations and general advice on the marking of objects that may constitute a hazard to aviation and about notification of obstacles to aviation" TSFS 2020:88.



Version	Change note	Date
0.1	First draft out for consultation	27/08/2021
1.0	Decision on first version	06/10/2021



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1 Introduction

The Swedish Transport Agency has decided on an updated regulation regarding the marking of objects that may constitute a hazard to aviation and about the notification of obstacles to aviation, TSFS 2020:88, which came into force on 1 January 2021.

This regulation has a major impact on Svenska kraftnät, as it must be applied to objects (pylons and overhead lines) of a height of 45 metres or more above ground level or water level.

The purpose of this document is to summarise the content and highlight the parts of the regulation that affect Svenska kraftnät. For more detailed information, please refer to the Swedish Transport Agency's regulation TSFS 2020:88.

2 Aircraft warning balls and aviation obstacle lighting; technical design and requirements

2.1 Area of application

These guidelines must be applied when marking pylons and overhead lines of a height of 45 metres or more above ground level or water level, and that are located outside an airport's established obstacle-limiting areas.

Installations that have been set up before this statute came into force and that have been marked in accordance with older regulations may be marked in accordance with older provisions up to and including 31 December 2025.

2.2 Marking of existing and new pylons

Svenska kraftnät has decided that aviation obstacle marking of pylons must in the first instance always be undertaken using **low-intensity light** and never with medium- or high-intensity light. The reason for this is that the choice of more intensive light sources requires monitoring in the event of faults and logging of operational deviations in a journal. Monitoring requires installation with a power supply from two independent sources to secure lighting. This alternative can be a major problem from an earthing perspective and an unnecessarily expensive solution.



Painted markings on pylons may only be selected when absolutely necessary if the lighting alternative cannot be applied or there are other special reasons. The reason for this is that maintenance of painted pylons is more complex and more labour-intensive (e.g. shutting down the line) than maintenance of lighting. A decision to paint the pylons must always be made in consultation with the reference group member from line maintenance.

If the pylon is over 150 metres high, the pylon must be fitted with obstacle lights at the top **and** painted markings from 45 metres and above.

2.2.1 Marking with low-intensity light

Low-intensity light can be provided by means of two options:

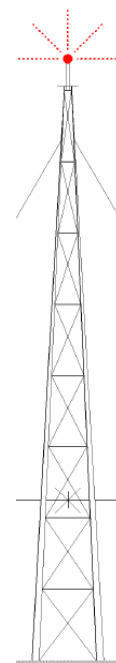
1. Grid connection with ground cable and circuit-separation transformer
2. Solar cells with LTO (Lithium Titanate) batteries

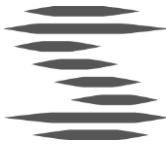
When selecting lighting, a **grid connection with a ground cable** and circuit-separation transformers must be selected in the first instance. This solution is considered to generate less maintenance than solar cells, as the batteries for solar cells need to be replaced frequently and lose capacity over time. With a grid connection, Svenska kraftnät is not at risk of power failure or power shortage, provided that all cables and connections are intact.

There are, however, situations in which grid operation with a ground cable is not preferable; e.g. if the overhead line has to pass through a nature reserve, an area with high natural values, rocky terrain, meadows or watercourses. In nature reserves, excavation for a cable must sometimes be performed by hand, which can generate high costs if it is a long way to the nearest connection point. In these cases, lighting powered by solar cells can be more advantageous. A decision on which is the best alternative should be taken in consultation with the reference group member from line maintenance, although it may also be appropriate to contact the County Administrative Board or the municipality.

When selecting solar cells, Lithium Titanium (LTO) batteries should be chosen in the first instance, as they have a longer lifespan and a lower environmental impact than other batteries.

Lights must be placed so that they mark the highest point of the pylon and be visible around the horizon. Low-intensity light must consist of a solid red light.





Lights must otherwise comply with the specifications set out in TSFS 2020:88, Appendix 3 & Appendix 8.

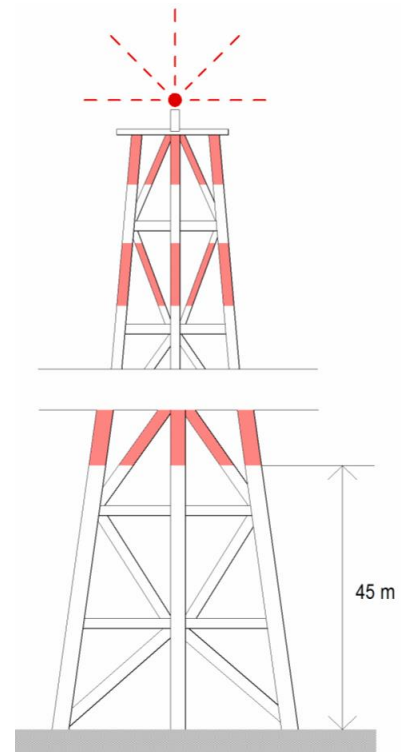
2.2.2 Marking with paint

Aviation marking of pylons with paint may only be selected if it is not possible to apply any form of lighting or if it is considered more advantageous to use painted marking for other reasons.

Before a decision is made to paint the pylons, the reference group member responsible from line maintenance must always be contacted for advice on marking alternatives.

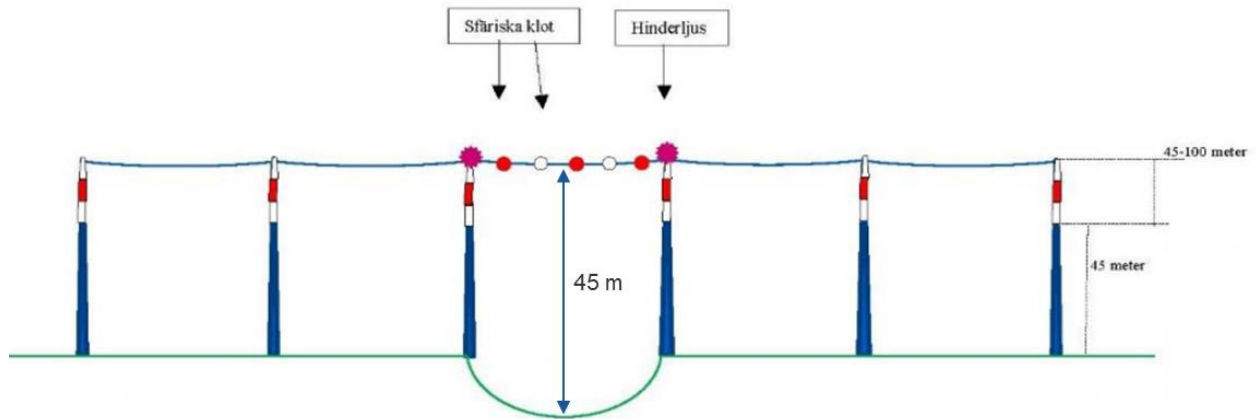
The following applies when choosing to mark aviation obstacles with paint:

- The paints must be fluorescent or of a retroreflective type.
- Marking with paint must be executed in the form of a band pattern, the colours of which must contrast with the background against which they will be seen.
- All pylon sections above 45 metres must be painted. This includes any parts that protrude from the framework rods, i.e. crossarms.
- The width of the paint fields must be proportional to the scale of the object and be in the range of 2-10 metres. The marking must be at least 2 metres, regardless of whether this means that part of the marking is at a level lower than 45 metres.
- The paint fields must be perpendicular to the object's longitudinal axis. The colours orange and white or red and white must be used in the first instance.
- The fields must have the darker colour at the ends of the marking.
- The paint fields may be achieved by means of a number of narrow sub-fields, and the gap between these may not exceed the width of the sub-field. The gap may never be greater than 0.4 metres.





2.3 Marking of overhead line



If the top line is higher than 45 metres above ground level or water level and crosses a large watercourse, valley, national or European route, the line must be marked with a warning ball with a diameter of 60 centimetres. This means that it is the greatest height of the line above ground level or water level that determines whether or not aviation marking on the line is necessary, not the height of the pylon.

The distance between the warning balls must not exceed 30 metres. Each warning ball must be of a single colour and must be installed in the sequence white and red alternately, or white and orange alternately.

Pylons that form part of a horizontal overhead line and are located where the overhead line crosses a large watercourse, valley, national or European route, must be marked in accordance with section 2.2 “Marking of existing and new pylons”.

2.3.1 Definition of road, major watercourse and valley

*“A **valley** is a large, elongated depression in the surface of the earth, which is limited by longitudinal heights, rock walls or soil-covered slopes on both sides. The valley follows a fairly straight line in a certain direction.”* The Swedish Transport Agency has no definition of the dimensions required for the depression to be defined as a valley. Nor are there any established criteria for the division and designation of different types of watercourses. A separate assessment must therefore be made on a case-by-case basis.

In adverse weather conditions, pilots often fly using VFR*, which means that they navigate and maintain distance from obstacles, terrain and other aircraft by following major landmarks such as major roads, waterways and valleys. In order to



determine whether high lines crossing these landmarks are to be marked as an obstacle, an assessment must be performed of whether it is highly likely that an aircraft would use the valley or watercourse for orientation in the event of poor visibility.

* VFR= Visual Flight Rules

The Swedish Transport Administration has a register of all roads that are classified as national or European routes that can be used to determine this need when the line crosses a road. With regard to a decision linked to large watercourses or valleys, this needs to be done in consultation with Svenska kraftnät's experts in the field of geodata, and with the reference group member from line maintenance.

2.3.2 Suspending warning balls

There are several different solutions available when suspending warning balls on an overhead line. Which alternative is best depends on the conditions:

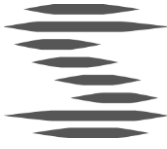
- Is there an existing line with an existing warning ball, or does a new line with a new warning ball have to be set up?
- Does the line need to be replaced or just tightened?
- Can you drive beneath the line with a mobile crane?

Some options require the line to be shut down, while others can be carried out without a shutdown. The method of suspension must be decided in consultation with the reference group member from line maintenance.

2.4 Health, environment and safety

Svenska kraftnät has produced a comprehensive inventory of the risks associated with the three main processes required to meet the Swedish Transport Agency's requirements for aviation obstacle marking.

1. Painting the framework
2. Installing obstacle lights
3. Installing/replacing aviation warning balls



In all three work processes, risks of high electromagnetic field levels, electrical risks and induction and influence can arise, depending on the work method chosen. This is because of the proximity to live equipment, which in the worst case can be fatal. It is therefore of the utmost importance that a thorough risk analysis is performed before each step and that there is an investigation into which risks may arise and what they can result in, and that a decision is made on an appropriate solution to eliminate the risk.

Those operations with the highest risk value can be performed using one of the following three alternative solutions: dead working (AUS), live working (AMS) or work with EMF protective clothing. A decision on a line shutdown must be made in order to perform the work process safely, always in consultation with experts within Svenska kraftnät. A line shutdown must always be planned in consultation with Svenska kraftnät's operations centre.



3 Summary of decisions and aviation obstacle marking requirements

Svenska kraftnät has decided that all pylons over 45 m must in the first instance be fitted with low-intensity obstacle lights, be supplied by a grid connection and be fitted with a circuit-separation transformer. Overhead lines that need to be marked as obstacles must be provided with 600 mm aviation warning balls at intervals of 30 metres.

The table below shows a summary of the aviation marking requirements for both pylons and overhead lines.

Type of installation	Criteria	Requirements
Overhead line	<ol style="list-style-type: none">1. The top or phase line is over 45 metres above ground level or water level, AND:2. The line crosses a large watercourse, valley, national or European route	<ol style="list-style-type: none">1. Spherical warning balls on line AND:2. Obstacle lights on each intersecting pylon
Pylon model I	<ul style="list-style-type: none">○ 45–150 metres high	<ul style="list-style-type: none">○ Obstacle lights in the first instance○ Painted marking as a second option
Pylon model II	<ul style="list-style-type: none">○ Over 150 metres high	<ul style="list-style-type: none">○ Painted marking AND obstacle lights