10546 Session 2022
SC B2 : ENVIRONMENTAL AND SAFETY ASPECTS FROM OHL (JOINT PS WITH C3)

Safe Management of Work in High-Voltage Overhead Lines in The Netherlands

Rob MEIJERS*
Qirion
The Netherlands
rob.meijers@qirion.nl

Stijn GELDERBLOM
SPIE
The Netherlands
s.gelderblom@spie.com

SUMMARY

The Netherlands has an extensive network of high-voltage cables and high-voltage overhead lines for the transport of high voltage. Despite the fact that many connections have been made underground, especially in densely built-up areas, there is still a considerable overhead high voltage network.
In total, there are approximately 4,110 kilometres route-length of high-voltage overhead line in the Netherlands at 50/110/150/220/380kV level. The total number of high-voltage pylons is 13,578 units.

Safety has become a priority in the construction and maintenance of high-voltage overhead lines. This is a result of the increasing expectation to offer employees a safe working environment; driven by respect for the employee, economic benefits, legal compliance and community values.

Furthermore, high-voltage overhead lines are expected to be designed in such a way as to minimize the exposure of third parties or public to unacceptable risks. Within a densely populated country such as the Netherlands, this is a major challenge, because the high-voltage overhead lines often run over or through inhabited areas, industrial estates or near other infrastructure.

The Netherlands has a history in which it was mainly the former Provincial Electricity Companies that did the work on the high-voltage grid themselves. Over the years, the work on the overhead connections in particular has increasingly been outsourced. Developments in recent years are also that more often foreign parties are hired to carry out work in high-voltage overhead lines. This is to ensure that the necessary work on the high-voltage overhead lines can be carried out.

This paper provides insight into the development of safe working in high-voltage overhead lines in the Netherlands. Attention is paid to the requirements imposed on the various disciplines that work in high-voltage overhead lines, for both Dutch and foreign employees. Furthermore, it provides insight into the education and training of contractors, painters, telecom workers and employees from other fields working in high-voltage overhead lines.
Additionally, the constructive adjustments to high-voltage pylons that have been made over the years, are explained after the standards have been adjusted.. These adjustments must ensure that it is possible to work more safely in the high-voltage pylons; The tightening of safety procedures that must be observed when working on high-voltage overhead lines is also discussed.

As mentioned, high- voltage overhead lines have an impact on people's lives and actions. Because the high-voltage overhead lines in the Netherlands traverse the residential areas, industrial estates and parcels in rural areas, it is important to keep the environment alert for the possible risks of contact with high voltage. The extra measures that are being taken in the Netherlands to promote safety in the area are explained.

It also provides insight into the development of incidents in overhead power lines in recent years.

KEYWORDS

Overhead Lines; Safety; Linesmen; Training; Regulations; Pylon; Environment;

1. Introduction

The Netherlands is a densely populated country with an extensive high-voltage grid at 50/110/150/220/380kV level. Despite its dense population, the Netherlands still has a significant high-voltage network above the ground of high-voltage overhead lines. In total there is approximately 4,110 kilometres route-length of high-voltage overhead line with a total of 13,578 high-voltage pylons.

Voltage (kV)	Route Length (km)	Number of Pylons
50	139	585
110	895	2.938
150	1.638	5.794
220	320	936
380	1.118	3.325

Table 1 : Overhead Lines Data

As a result of the significant growth of activities in the high-voltage grid and therefore also in the high-voltage overhead lines, more and more activities are being outsourced, with more frequent use being made of foreign parties. The Netherlands has a high safety culture, which is why high demands are made on working on and near high-voltage overhead lines.

2. Education and Training of Employees in and on High Voltage Overhead Lines

The Netherlands has a long tradition of educating and training employees in high-voltage overhead lines (hereinafter referred to as line workers).
Before the 1990s, the training and education of (new) line workers was arranged by companies themselves. The training was based on the knowledge and experience available within the company. Machinery instructions were drawn up by themselves because the equipment was designed and assembled by themselves.

A number of serious accidents (with fatalities) occurred in the early 1990s, after which the Labor Inspectorate summoned the parties involved in the construction, maintenance and management of high-voltage overhead lines in the Netherlands to increase safety when working under high-voltage loads and portals.
The main points of the policy had to be formulated in order to meet the legal minimum requirements and also to further optimize working conditions.

In response, the parties involved jointly issued a letter of intent in which they stated that they would increase safety when working in high-voltage pylons and gantries by taking the following three measures:

- Improving the training of the personnel involved, both theoretically and practically, whereby the working method and professional knowledge are also part of the training;
- Pay special attention to the safety aspects in the construction of new pylons to be built (revision NEN1060);
- Compare existing pylons with the new NEN1060 and, where economically, operationally and technically justifiable, add additional safety provisions.

From the beginning, a training and education for line workers has been set up. The training was named "Working Safely in High Voltage Lines (VHS)" [1] and is based on industry experience and not related to industry requirements.

The VHS training was given by employees of the national and provincial electricity companies and the contractor Electron (predecessor of SPIE) to the (new) line workers of these companies.

The aim of the training is to update and maintain the professional knowledge and experience of line workers. Because all Dutch electricity companies that own high-voltage overhead lines and all Dutch companies that have line workers participate in the course, either as a student or as a teacher, important information exchange takes place in the industry.
The VHS course has contributed to standardizing working methods, use of tools and materials, which has benefited safe working in high voltage pylons and gantries.
Characteristic of the course was the fact that theory and practice were given alternately during the 2 weeks of the course. The group composition preferably consisted of a mix of line workers from the various companies.

Since in practice the safety aspect is a daily concept, the task group decided that the course should be evaluated annually in order to continue to guarantee safety.
Slowly but surely, the enthusiasm of the task group waned, as a result of which the further development of the VHS course stagnated. There was a lot of repetition in the course, especially for the experienced line workers. "One learned from what one had already learned before"
In addition, network operators noticed that other parties were increasingly performing work in high-voltage pylons, such as:

- Foreign conductor assembly contractors;
- Painting companies;
- Telecom companies.

These companies were following their own training courses.

At the end of 2004, the ETN (Expertgroep Transport Netten) requested that a document be drawn up that applies to all activities in high-voltage pylons, -portals and -connections on behalf of the individual Dutch high-voltage network operators.
A task group consisting of Dutch Network Operators and Assembly Companies has drawn up the 'Eindtermen' [2] for persons who carry out work in the Netherlands in or in the vicinity of high-voltage overhead lines from 50 kV to 380 kV.
The aim of the 'Eindtermen' is to formulate uniform basic requirements with regard to safety, knowledge (theory) and skills (practice) that persons must demonstrably meet as a minimum before they are allowed to perform work on or in the vicinity of high-voltage overhead lines. These basic requirements are the same for all activities at the various high-voltage network operators throughout the Netherlands. Specifically setting these requirements ensures that only people perform work who actually have the correct basic knowledge and skills to work safely and who also demonstrably have specific professional competence.

The 'Eindtermen' also aim to achieve a transparent separation between clients and contractors.

- The client is responsible for clear, verifiable and non-discriminatory 'Eindtermen';
- The contractor ensures that employees are demonstrably trained in accordance with these 'Eindtermen'.

It should be noted, however, that meeting the requirements of the 'Eindtermen' does not automatically mean that a person is also allowed to perform work independently. Work may only be performed if the client has given an order and supervision has been arranged by an authorized person.

The following target groups are identified in the 'Eindtermen':

- Painter who works in high-voltage pylons and gantries;
- Foreman and foreman of painting work;
- Lineman;
- Foreman and assembly manager of line work;
- Administrator and project leader;
- Supervisor;
- Specialist of telecom equipment in high-voltage pylons and -gantries.

The ‘Eindtermen’ consist of 13 modules:

Basic modules:
1. Electricity Basics;
2. Basic knowledge of personal protective equipment;
3. Basic knowledge of high voltage substations;
4. Basic knowledge of high-voltage overhead lines.

Additional modules:
5. Fall protection / Working at height;
6. Start and conclusion of work for executives;
7. Start and conclusion of work for supervisors;
8. Carrying out conservation work on high voltage pylons;
9. Performing various work on high voltage connections by line workers;
10. Carrying out specific telecom activities in high voltage pylons and gantries;
11. Acting in case of incidents and accidents;
12. Risks;
13. Occupational health and environmental legislation.

Then it is described for each target group which modules (knowledge of theory and practice) and which specific additions are applicable for this target group.
The ‘Eindtermen’ contain a function/module matrix in which it is made clear which modules apply to which target group.

17 Functie/Modulematrix

Module	Functie									
	Schilder	Uitvoerder en voorman schildewerk	Lijnwerker	Lijnwerker niet klimmer	Uitvoerder Montageleider	Beheerder Projectleider	Toezichthouder	Constructie-medewerker	Inspecteur	Specialist telecom
Module 1										
1.1	□	□	□	□	□	□	□		□	□
1.2	□	□	□	□	□	□	□			□
1.3	□	□	□	□	□	□	□			□
1.4	□	□	□	□	□	□	□			□
1.5	□	□	□	□	□	□	□			□
1.6	□	□	□	□	□	□	□			□
1.7	□	□	□	□	□	□	□		□	□
Module 2										
2.1	□■	□■	□■	□■	□■	□■	□■	□■	□■	□■
2.2	□■	□■	□■	□■	□■	□■	□■	□■	□■	□■
2.3	□■	□■	□■	□■	□■	□■	□■	□■	□■	□■
Module 3										
3.1		□			□	□	□			
Module 4										
4.1	□	□	□	□	□	□	□			□
4.2	□	□	□	□	□	□	□			□
4.2	□	□	□	□	□	□	□			□
4.4	□	□	□	□	□	□	□			□
4.5	□	□	□	□	□	□	□			□
Module 5										
5.1	□■	□■	□■		□■	□■	□■		□■	□■
5.2	□■	□■	□■		□■	□■	□■		□■	□■
5.3	□■	□■	□■		□■		□■		□■	□■
5.4	□■	□■	□■		□■		□■		□■	□■
5.5	□■	□■	□■		□■		□■		□■	□■
5.6	□■	□■	□■		□■		□■			□■
5.7	□■	□■	□■	□■	□■		□■			□■
5.8	□■	□■	□■	□■	□■		□■			□■
Module 6										

Figure 1: Example of Function Matrix ‘Eindtermen’

In January 2006, the 'Eindtermen' were accepted by ETN. Anyone who works or wants to work in high-voltage pylons in the Netherlands must meet the 'Eindtermen'.
ETN is responsible for the distribution and publication of the 'Eindtermen' within the sector. Furthermore ETN is responsible for checking the certificates to be submitted by the contractors.

In recent years, several foreign companies have come to work on the high-voltage grid in the Netherlands. To enable access for these companies, it is no longer necessary to obtain a certificate in the Netherlands, but the companies must be able to demonstrate that they meet the requirements set in the 'Eindtermen'.

3. Safety Features in High-Voltage Pylons

3.1. High-Voltage Pylon Construction

In the 1991 supplement to the standard edition of NEN 1060-1987, for the first time more attention has been paid to safety provisions in high-voltage pylons. In 1995, the Dutch standard for the design of high-voltage overhead lines (NEN-1060 – Bovengrondse Hoogspanningslijnen) was further expanded with a number of regulations for additions to the high-voltage pylon construction for the purpose of working safely in high-voltage pylons for executives.

During this period, the awareness for working safely in high-voltage pylons grew, partly because a new generation of employees came to work at the companies. This generation of employees was more aware of the risks of working in the high-voltage pylons.

The main changes that have been made are:

3.1.1. Installing Handrail in the Cross-Arms

A continuous handrail must be installed in the cross-arms at a height of 0.90 - 1.10 meters above the running surface of the cross-arms. The cross-arm must be closed at the end with a closing rail also approx. 0.90 - 1.10 meters above the running surface.
This intervention is quite substantial for the pylon design, because the cross-arms generally has a tension strut that runs from the pylon body to the end of the cross-arm and is there connected to the tread of the cross-arm.

Figure 2: Cross Arms of Latice High-Voltage Towers without (left) and with (right) Handrail

3.1.2. Step Distance in the Cross-Arms

The profiles in the tread of the cross-arms had a constructive function. The profiles were placed depending on the structure and the interplay of forces on the cross-arm. It is therefore possible that the distances between the profiles were that great that in specific cases a special construction has been

installed to allow you to move in the cross-arm (walkway). This facility was only suitable for getting to the end of the cross-arm, because of the additional requirements in terms of loads, it is now also not suitable for working in the cross-arm.
The new standard prescribes that the maximum distance between the profiles in the tread must be 0.6 meters.

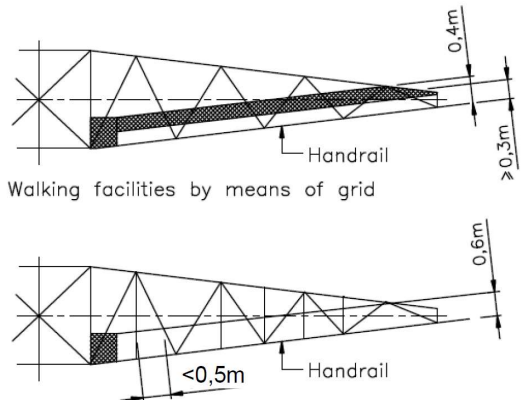

Figure 3: Walking Facilities in Cross-Arms of Latice High-Voltage Towers [6,7]

For cross-arms which bottom is more than 50 meters above the top of the foundation, a special provision for a walkway must be made.

3.1.3. Profile Distance in the Pylon Body
The steel profiles also had a constructive function in the pylon body. Particularly when painting a high-voltage pylon, this mean that the painter sometimes had to work with special to gain access to a profile.
The new standard stipulated that the profiles in the pylon body had to be placed at such a distance from each other that the employees could always stand on a profile for the purpose of work and that one or more profiles are always within "hand reach".

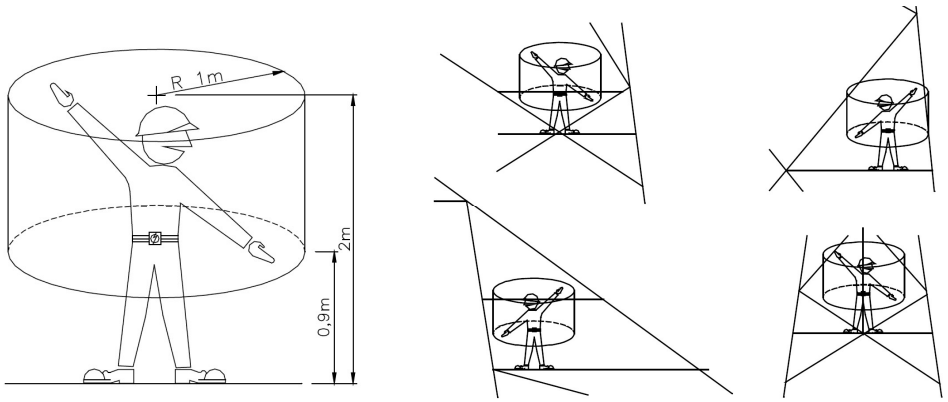

Figure 4: Notion 'Arm Reaches' [6,7]

If profiles longer than 3 meters are used in the horizontal plane, a surface of at least 30 mm must be created by means of a second profile on which the employee can stand safely.

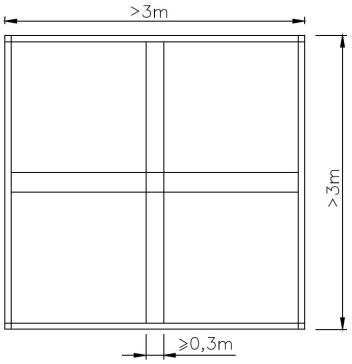

Figure 5: Safety Measures at Horizontal Joints [6.7]

3.1.4. Climbing Facility

The high-voltage pylons in the Netherlands had two different solutions for climbing into the pylon body in order to reach the traverses or top of the pylon. The first solution is a ladder construction in the centre of the pylon body. The advantage of this solution is that a pylon can be climbed at any time without the employee approaching the energized conductors.

The second solution that was applied was to place so-called climbing pins on one of the main legs of the pylon. No minimum cross-section was prescribed for these climbing pins. Disadvantages of these solutions were:

a) Because there was only one climbing facility, it could be that the employee had to climb on that side of the pylon that was still energized, while the work had to be done on the other side of the pylon. The employee had to climb from one side of the pylon to the other at the height of the cross-arm. The risks involved were that there were no specific provisions for the 'transfer' and that it was necessary to carefully consider which side of the pylon to work on;
b) The climbing pins often had a minimal diameter. It was therefore possible that heavier employees had to deal with sagging climbing pins and that in time the climbing pins could become bent with the risk of an executive slipping off. In addition, it is further specified what distance (0.25 – 0.30 metres) is required between the climbing pins;
c) There were several forms for climbing pins. The climbers only had the function of making vertical movement possible, but did not by definition provide the possibility to place the feet in particular safely. Climbing pins were installed in several pylons that made it possible to slide off the feet and/or hands.

Figure 6: "Old Type" of Climbing Pin (Climbing Bold)

The new standard includes a number of requirements for climbing facilities that should make climbing safer. The employee must be able to place his/her hands and feet safely at all times without the risk of slipping or sliding.

The adjustments included in the standard are:

a) A second climbing device had to be installed in every high-voltage pylon if the climbing device is installed on the outside of the pylon. The second climbing facility must be installed diagonally to the existing climbing facility. The choice of two climbing facilities gives the employee the opportunity to always climb on the side of the pylon on which side the high-voltage overhead line has been de-energized.
   In the Netherlands, two options have been chosen for this. The first option is to drill holes in the main leg and mount the new climbing pins in them. The second solution is a surface-mounted climbing facility, which could largely be pre-assembled before being mounted in the pylon;
b) The diameter of the climbing pins is set at a minimum of ø20mm in the new standard. The end of the climbing frames must be provided with a raised edge of at least 30mm;
c) Requirements are set for the useful width of the climbing frames (150mm) and the free space above and behind the climbing frames.

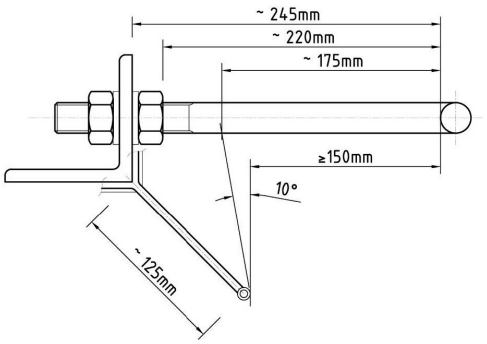

Figure 7a: Minimum Dimensions of Step Bolts (Top view) [6,7]

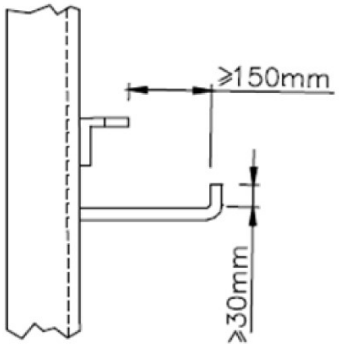

Figure 7b: Minimum Dimensions of Step Bolts (Front View) [6.7]

3.1.5. Rest Platforms / Step-Up Platforms

At tall high-voltage pylons, a climbing facility must be interrupted every 25 meters by a rest platform. If the bottom traverse of a high-voltage pylon is less than 40 meters from the top of the foundation, a rest platform does not need to be installed. This prevents employees from having to climb continuously and/or rest only with their feet on climbing pins or ladder rungs.

At the location of cross-arms, it is prescribed that a step-up platform must be installed here in connection with the climbing facility. This allows the employee to rest for a while when he reaches the traverse and to further orientate himself on the next steps to be taken.

3.1.6. Tubular Cross-Arms

In addition to the lattice high-voltage pylons, there are also a number of high-voltage overhead lines constructed from tube pylons with tubular cross-arms in the Netherlands. The generation of tubular pylons before 1995 had no special provisions for the movement of the employees on the cross-arms. In order to be able to reach the cross-arms, the employee had to climb directly onto the cross-arm from the climbing facility from the pylon body. The employee then had to move forward while sitting on the cross-arm.

The security measures introduced in 1995 are:

a) A step-up platform with a minimum width of 0.60 meters must be installed under the cross-arm. For transferring to the cross-arm, a handgrip must be fitted 0.90 – 1.10 meters above the platform.

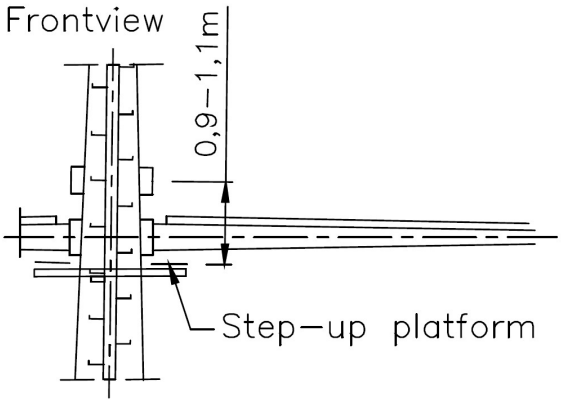

Figure 8: Step-up Platform at the spot of Cross-Arms of Tubular pylons [6,7]

b) The cross-arms must be provided with a ladder-type crawling facility on the cross-arm or stirrups on both sides of the traverse on which the employees can support both feet and hands.

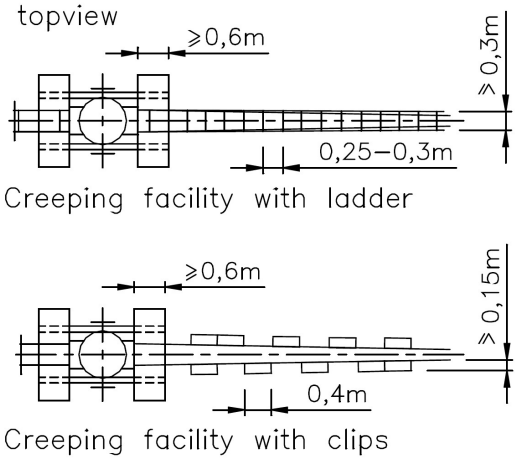

Figure 9: Two Types of Creeping facilities in Cross-Arm of Tubular Pylon [6,7]

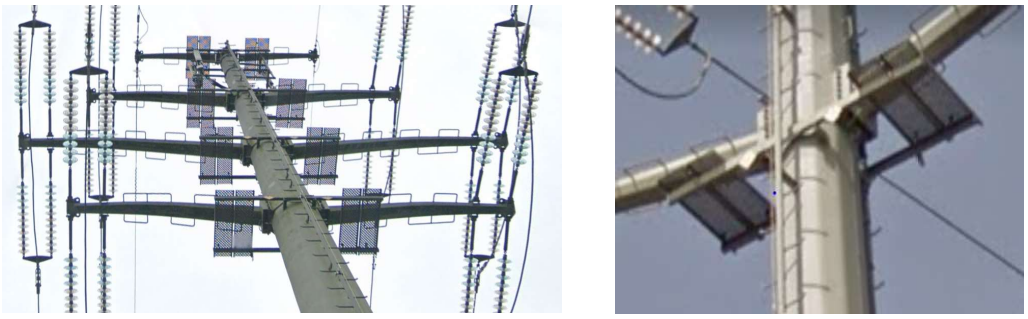

Figure 10: Clips and Step-up Platform in Cross-Arms of Tubular Pylon

Figure 11: Tubular High-Voltage Pylons without (left) an with (right) Climbing and Creeping Facilities at the Spot of Cross-Arms

In principle, the adjustments indicated in the new standard only apply to the new high-voltage pylons. Nevertheless, the network operators tested their above-ground high-voltage networks against the new standard and, where possible, adapted the existing high-voltage pylons to the new standard in terms of safety provisions.

3.2. Vertical Cable Lifelines

In general, employees in the Netherlands did not climb secured to the workplace in the high-voltagea pylons. At the workplace, the employee was secured to fall, but that did not happen during climbing. Under pressure from the then 'Labor Inspectorate' (currently ISZW), the network operators and executing companies had to look for a safe solution to be able to climb into the pylons. The basic principle was that the employee is always attached to the pylon body with at least one connection.

After investigating several options, a cable fall protection system has become standard in the Netherlands, which is mounted on the climbing facilities in the high-voltage pylons. So both on the ladders in the pylon body and on the climbing facilities on the main legs of the pylon body.
The system consists of a stainless steel wire that is attached to the pylon body with brackets at a prescribed distance from each other (in the case of a climbing ladder). The stainless steel wire has an anchor on the top of the mounted stainless steel wire, which ensures that the stainless steel wire is at the correct tension and absorbs the forces in the event of fall of the user.
The person who is going to climb has a fall protection runner, which is attached to the stainless steel wire.

The network operators jointly opted for one system in 2001, which was also purchased jointly. Assembly of the first systems started in 2002 and the entire overhead network of high-voltage overhead lines was completed in 2012. Today, a new system is installed for new construction and replacement of high-voltage pylons, as well as for the assembly of antenna sites in high-voltage pylons.

The fall protection is only used for the vertical climbing movement in the pylon. For horizontal movement in the pylon body and cross-arms, employees must secure themselves using folding hooks.

The installed systems are randomly inspected once every 6 years.
Assembly and inspection may only be carried out by trained personnel. The employees receive a certificate, that must be renewed every 3 years.

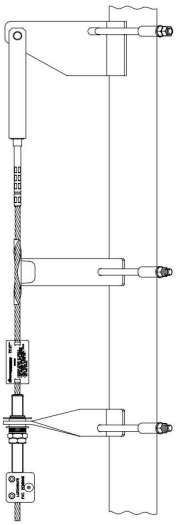

Figure 12a: Principle Vertical Lifeline System

Figure 12b: Fall Protection Runner

4. Safety Procedures for Work in High-Voltage Overhead Lines

4.1. Flagstaff Holders

In the Netherlands, it is mandatory that work in and on high-voltage overhead lines is performed without energizing. In general, this means that one of the two circuits is switched off when the work is to be carried out in the safety zone of the conductors.
For work on high-voltage installations (including high-voltage overhead lines) the BEI-BHS (Operation of Electrical Installations Branche High Voltage) applies in the Netherlands, of which TSO TenneT has drawn up the KEB (Framework document Electrical Operations). The BEI-BHS is a derivative of the NEN 3840: Working on High Voltage Installations, which is the Dutch version for high voltage installations of the EN-50110: "Operation of Electrical Installations".

The BEI-BHS states that when working in high-voltage overhead lines, the de-energized circuit must be visible and this is done by placing a green flag on the main leg of the de-energized circuit. These flags have a unique flagpole and flagpole holder, which prevents the flag from being placed on the wrong side of the pylon (i.e. on the operation side of the high-voltage overhead line). It is not allowed to climb the pylon for work in the vicinity of voltage when the green flag is not in place.

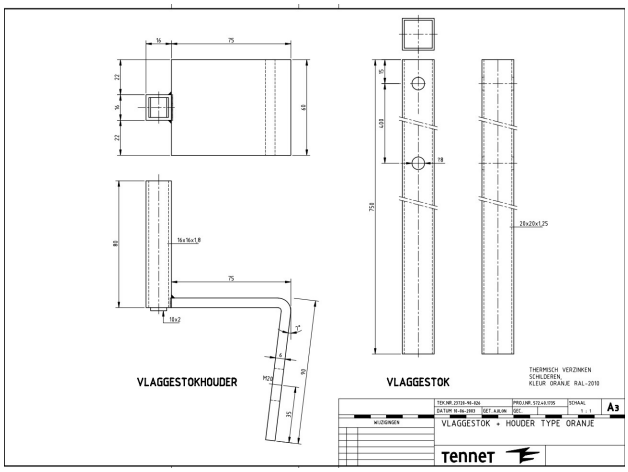

Figure 13a : Flagstaff Holder and Flagstaff

Figure 13b: Use of Flag in Tower

4.2. Rescue Set

Several, often outdated, systems were in circulation in the Netherlands for rescuing people from high-voltage pylons. Many co-executives did not know how the systems worked. The joint sector of high-voltage overhead lines (network operators, contractors, painting companies) in the Netherlands has therefore decided to jointly purchase a single rescue system and have its employees structurally train with the system.

At least 1 rescue system per pylon is available for all work on or in high-voltage overhead lines. It has been agreed that the barrel with the system will be placed under or close to the pylon during work so that it is immediately available when needed**.**

4.3. Gate Instruction

At all high-voltage substations, - connections and construction sites in the Netherlands it is mandatory for visitors and employees to follow an E-learning gate instruction. The gate instruction is about the safety rules of the network operators and following this instruction is a condition to be admitted.

The gate instruction provides insight into the network operator's safety and conduct rules and must be followed before starting work. After watching the instructional film, a test of 10 questions follows. Participants who have answered 8 questions correctly will receive a certificate by email. The gate instruction certificate is valid for 1 year.

5. Safety near High-Voltage Overhead Lines

The Netherlands is a densely built-up country. In particular in the western part of the Netherlands, the density of the buildings is greatest, but here a large part of the high-voltage overhead connections (50kV, 110kV and 150kV) has been placed underground. Nevertheless, in the Netherlands, high-voltage overhead lines cross many infrastructure and buildings or are constructed nearby. As a result, high-voltage overhead lines can have a major impact on people's living conditions. Furthermore, there is a high risk of work in the vicinity of high-voltage overhead lines.

5.1. Impact High Voltage Overhead Lines on Living Environment

5.1.1. Precautionary Policy The Netherlands

In the 1990s, a discussion arose in the Netherlands about the health risks that could arise from living and working near high-voltage overhead lines. Since no legal limit values for electromagnetic fields had been established in the Netherlands and the government took epidemiological indications seriously, the precautionary policy with regard to the health effects of high-voltage overhead lines was formulated in 2005 by the State Secretary for Housing, Spatial Planning and the Environment (VROM) in an advice to municipalities, provinces. and network operators. The advice states, among other things: “when establishing regional and zoning plans and routes of high-voltage overhead lines, or when changing existing plans or existing high-voltage overhead lines, avoid as much as reasonably possible that new situations arise in which children stay for a long time in the area around high-voltage overhead lines where the annual average magnetic field is higher than 0.4 microtesla”

The precautionary policy has consequences for:

a) Construction of new high-voltage overhead lines;
b) New buildings (homes, schools, etc.) near existing high-voltage overhead lines.

The advice only applies to new situations.

5.1.2. Cabling or moving existing high-voltage lines

An article has been included in the Energy Act 1998 (§ 3a. “Relocation or underground construction of a high-voltage overhead connection”, Article 22a) [2] which stipulates that, at the request of a municipal executive or the provincial executive, aboveground parts or moves or replaces networks intended for the transmission of electricity at a voltage level of 50 kV or higher with underground parts.

On 15 October 2018, the Ministry of Economic Affairs and Climate decided to designate those parts of high-voltage overhead lines as referred to in Article 22a of the Energy Act 1998. A total of 135 kilometres of high-voltage overhead lines within built-up areas are eligible for relocation or cabling. The decision only concerns high-voltage overhead lines of 50, 110 and 150 kV. Since 2017, a buy-out scheme has been in effect for homes outside built-up areas or for homes perpendicular to 220 or 380 kV high-voltage overhead lines [9].
The decision specifies which part of the costs for relocation or cabling will be borne by the municipality (applicant) and which part the network operator must pay, with a maximum contribution per kilometre for the municipality. It is estimated that as a result of this scheme, an average household in the Netherlands will pay a maximum of 1.37 Euro per year [11] more for the supply of electricity.

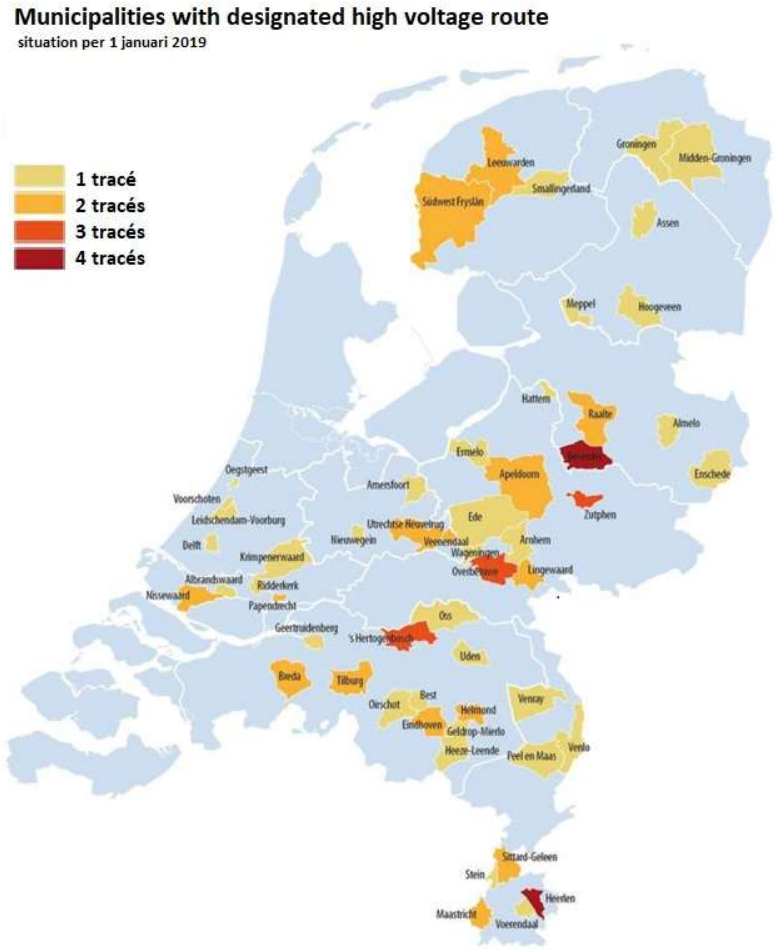

Figure 14: Municipalities with Designated High-Voltage Route [5]

5.1.3. Safety at Work under and near High-Voltage Overhead Lines

The Netherlands is a densely populated country. The high-voltage overhead lines will therefore have a major impact on activities near high-voltage overhead constructions. In order to prevent incidents occurring during work under and near high-voltage overhead lines, the network operators pay close attention to safe working under and near high-voltage overhead lines.

Because in the Netherlands, in general, agreements for high-voltage overhead lines have been concluded between the network manager and the property owner, parties who wish to carry out work under or near high-voltage overhead lines must request permission (= a written statement of approval) from the manager of the high-voltage overhead line. The procedure followed by TSO TenneT, among others, is [8]:

a) Submitting a request for permission with the addition of drawings and plans related to the work;
b) The applicant will receive a response within 20 days, stating, among other things, the permitted working and construction height;
c) A given permission is valid for a maximum of 1 calendar year;
d) If the activities change, a new application must be submitted;
e) TenneT will carry out checks on compliance with the agreements.

There is no restriction on the use of equipment for work outside the risk zone of the high-voltage overhead lines, provided they cannot fall into the risk zone of the high-voltage overhead line. If machines are needed in the zone where the business law agreement applies, permission must be obtained from the network operator.

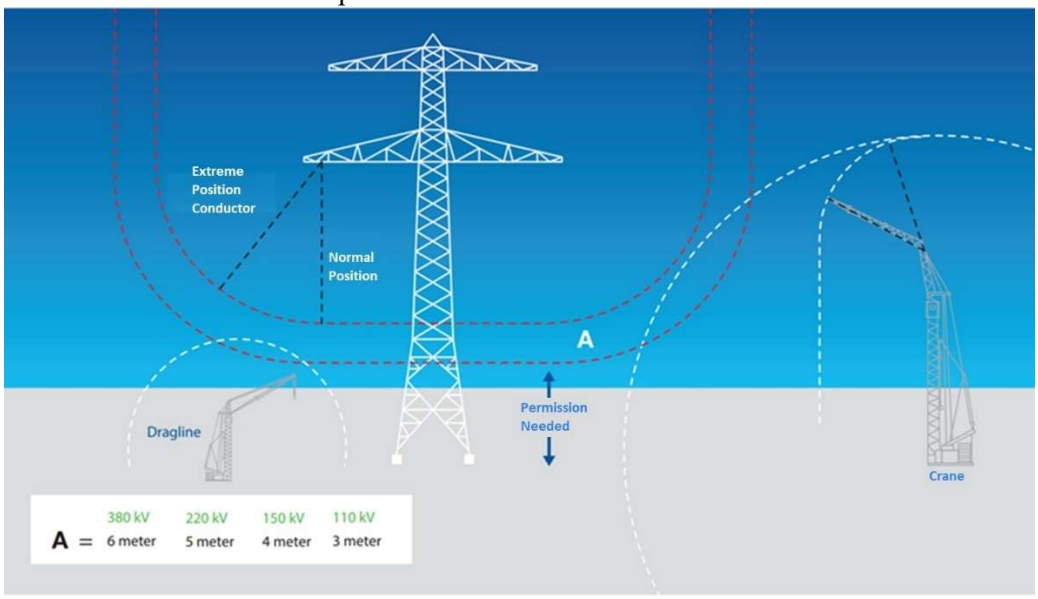

Figure 15: High-Voltage Line Risk Zone [8]

5.1.4. Safety when Working in an Agricultural Environment

The Netherlands is a densely populated country. Additonately, the Netherlands also has an intensive agricultural and cattle breeding culture. In agriculture in particular, high-voltage overhead lines are often crossed with agricultural equipment. Since most high-voltage overhead lines in the Netherlands were installed in a period between 1960 and 1990, the distance to ground level is often smaller than the distance prescribed in the current standard. As a result of the fact that agricultural equipment have grown considerably in size over the years the risks have increased.

Figure 16: Development of Agricultural Implements; 1953 (left) versus 2017 (right)

One of the solutions implemented in the Netherlands is to adapt the conductors of the existing high-voltage overhead lines in such a way that the distance from the bottom conductor(s) to ground level is

more in line with the current standard. Examples of this are high-voltage pylon elevations or the use of "suspended tensioning" (T-suspension).

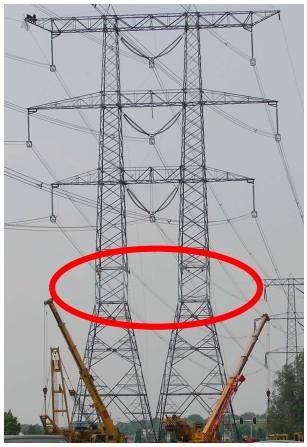

Figure 17: Extension Latice Tower

Figure 18: T-Suspension

In addition, TenneT has developed a procedure and information sheet for farmers [10], in which extra attention is requested for work in the stressed section of the high-voltage overhead line. Much attention has been paid to the minimum distance from the agricultural equipment to the conductors of the high-voltage overhead line.

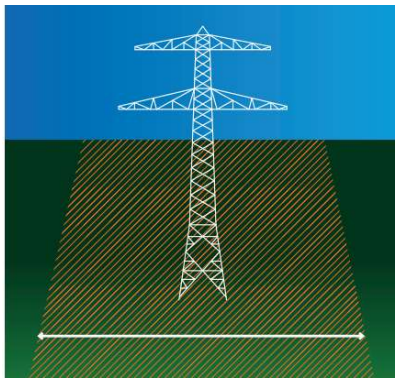

Figure 19: Top View of Loaded Strip at High-Voltage Overhead Line (shaded) [10]

5.1.5. Vegetation Under and Near High Voltage Overhead Lines

The presence of vegetation under high-voltage overhead lines entails risks. In particular the height of the vegetation can lead to short circuit of the conductors to the vegetation. TSO TenneT has drawn up a number of guidelines [9] to prevent vegetation from causing the failure of a high-voltage overhead line.

The obstructing zone (Business law zone is divided into two zones. In zone 1 it is advised to use only low growing plants. In zone 2, taller plants may be planted, but care must be taken to prevent the crown of the plants from reaching zone 1 in the event of a fall. TenneT reserves the right to take measures when planting in zone 2 to prevent falls in zone 1 from happening.

For trees in zone 3, that pose a risk to the high-voltage overhead line (such as dead trees, diseased trees, etc.), TenneT will contact the property owner to find a solution.

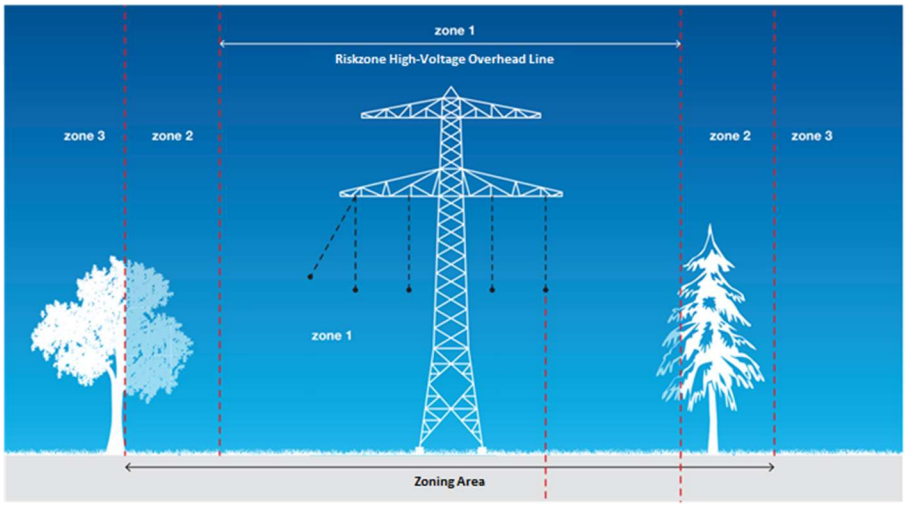

Figure 20: Zoning Area under High-Voltage Power Line to prevent Power Failure as a Result of Vegetation under a High-Voltage Power Line [9]

The area under and near high-voltage overhead lines is inspected annually for risks of vegetation on the high-voltage overhead lines. Where necessary, it is pruned/cut down to avoid the risk of power failure.

5.1.6. WIBON- law

In 2008, the Information Exchange of Underground Networks Act (WION-law) was introduced in the Netherlands, which stipulates that companies wishing to carry out earthworks must register the work and then receive information from the cable and pipeline owners about the location of cables and pipelines in the indicated area. The cable and pipeline owners must therefore indicate which measures must be taken for work near their property. The aim of the law is to prevent damage to underground infrastructure.

Because the network operators of above-ground infrastructures did not have sufficient insight into the activities under the high-voltage overhead lines, this Act was expanded with the above-ground networks on 1 July 2018 and amended in the WIBON Act (Information Exchange Act on Overground and Underground Networks) and the reporting and information obligation for high-voltage lines has been expanded. In this way, the grid operator gains insight into activities under the high-voltage lines and can announce measures in good time to prevent damage to the high-voltage lines..

6. Incidents High Voltage Overhead Lines

The measures mentioned in this paper in and near high-voltage overhead lines have been introduced in the Netherlands over the years and have since then been tightened up. The purpose of these measures is to prevent incidents in or under high-voltage overhead lines that cause injury to persons. Although high-voltage overhead lines are clearly visible and we know that coming into contact with or too close to the conductors of high-voltage overhead lines is not without danger, it seems necessary to continue to inform both operators and third parties.

The vast majority of the high-voltage overhead lines in the Netherlands are owned by TenneT. TenneT has been keeping track of reported incidents in pylons and on high-voltage overhead lines for some time now. The available data show that the measures taken appear to be successful, because the number of reported incidents involving personal injuries – both during work in the high-voltage pylons and activities under and near high-voltage overhead lines – is minimal. Although every accident with injury should be experienced as one too many, this is a positive observation.

Activities	2013	2014	2015	2016	2017	2018	2019	2020	2021
In Towers	1	0	1	0	1	1	1	1	2
Near Overhead Lines	5	0	1	0	1	0	1	2	0

Table 2 : Number of Personal Injury Incidents in Overhead Power Lines (Source : TenneT, 2022)

Since the registration in 2013 of the incidents, no fatal incidents have been reported during work on high-voltage pylons and activities near high-voltage overhead lines. With regard to work in the high-voltage pylons, based on conversations with people with long experience in the sector, it can be concluded that no fatal incidents have occurred since the early 1990s. Unfortunately, there have been casualties during activities under and near high-voltage overhead lines, but no registration of these incidents – before 2013 – has been found.

7. Conclusion

In the Netherlands, we have a long tradition of safety in and near high-voltage overhead lines. A number of developments in recent years, such as the national training requirements and the centralization of the high-voltage overhead lines at the TSO TenneT, have resulted in the development of an unambiguous policy. This has ensured that the number of incidents in the Netherlands in and around the high-voltage overhead lines has remained limited.
Educating employees, installing safety provisions in the pylons and informing the environment about the risks of high-voltage overhead lines has certainly led to a positive result in recent years.

The developments as a result of the energy transition, together with the growing amount of work, will lead to new, often foreign, players on the market and it is important to maintain the positive development with regard to safety.

BIBLIOGRAPHY

[1] Veilig Werken in Hoogspanningslijnen (VHS);
[2] Eindtermen Werken aan of in de Nabijheid van Hoogspanningslijnen (06-02-2006);
[3] Rapport Evaluatie uitvoeringspraktijk voorzorgbeleid hoogspanningslijnen, 17 december 2018 – Andersson Elffers Felix (in opdracht van Ministerie van Economische Zaken en Klimaat);
[4] Elektriciteitswet 1998; § 3a. “Verplaatsen of ondergronds aanleggen van een hoogspanningsverbinding”, Artikel 22a;
[5] Wonen in de buurt van hoogspanningslijnen – Rijksoverheid;
[6] NEN 1060 Bovengrondse Hoogspanningslijnen, 5e druk November 1995 – Nederlandse Normalisatie Instituut;
[7] NEN-EN 50341-2-15 (en) Overhead electrical lines exceeding AC 1 kV – Part 2-15: National Normative Aspects (NNAs) for the Netherlands (based on EN 50341-1:2012) ICS 29.240.20, juni 2019 - Koninklijk Nederlands Elektrotechnisch Comité Normcommissie 364011 'NEC 11/36 - Hoogspanningslijnen en isolatoren';
[8] Uw Veiligheid en de Ongestoorde Werking van de Bovengrondse Hoogspanningsverbinding, Februari 2017 – TenneT;
[9] Uw Veiligheid en Beplanting onder of nabij de Bovengrondse Hoogspanningsverbinding, April 2016 – TenneT;
[10] Uw Veiligheid in een Agrarische Omgeving bij een Bovengrondse Hoogspanningsverbinding, April 2019 – TenneT;
[11] Hoogspanningskabels kunnen onder de grond, 09 november 2018 – Nederlands Dagblad