Sustainable Light at Railway Stations

7 years of policy, light design and realisation

M.M. Pigeaud, MSc

Sustainable Light at Railway Stations

7 years of policy, light design and realisation

M.M. Pigeaud, MSc.

Table of contents

LED lighting in the Delft station train hall

LED lighting on the Delft station platform

LED lighting at Amsterdam Sloterdijk station

Preface

This book is about the realisation of sustainable lighting at 400 ProRail stations in the Netherlands between 2015 and 2022. Sustainable lighting is part of the ProRail climate goals and was executed by ProRail's Lighting Programme. For the 2015 Paris Climate Agreement, ProRail had to reduce their energy consumption by 30% before 2020. Sustainable lighting contributes to this goal. LED lighting saves 50% relative to fluorescent light. And another 50% can be saved by dimming in the absence of passengers.

Lighting design has developed significantly in recent years. In the past, station lighting was mainly functional. At present we include aspects such as accessibility, glare, maintainability, social safety, architecture, wayfinding, possible nuisance to local residents, flora and fauna. As it turns out, these aspects and interests are often at odds with each other. That is why we seek the most optimal solution in consultation with the stakeholders.

With this book, the Lighting Programme wants to share the experience and knowledge gained on sustainable station lighting. How did we reach certain solutions and what lessons have we learned? We will focus on designers at ProRail and engineers and consulting partners. We hope this book will inspire professionals at municipalities, public transport companies and other owners of (semi) public spaces as well. Just like lighting fixture and controller manufacturers.

In 2020, Bureau Spoorbouwmeester described *what* we want to achieve with station lighting in a policy document titled 'Handboek Verlichting op stations' [Station Lighting Handbook]. The goal is a clean, whole and safe, sustainable and comfortable station. This book is about *how* we will achieve those goals. Based on concrete examples: what does and does not work at a specific station when it comes to designing and realising lighting plans?

We will not be focusing on the aesthetics of a lighting design or how to make it. We invite the reader to make their own judgements. To put it in the words of revered designers Ootje Oxenaar and Paul Mijksenaar: "I can't teach you what is beautiful. If I show you good designs, you will learn what is beautiful all on your own."

Maurits Pigeaud
Systems Engineer
Lighting Programme

Tjebbe Ruskamp
Programme Manager
Lighting Programme

Deventer station forecourt lighting

Introduction

'ProRail connects, improves and becomes more sustainable', is our mission. The Lighting Programme by ProRail fleshes out this mission.

Throughout the implementation of our programme, we have always sought to *connect* with all stakeholders who benefit from proper station lighting. Since it involves a multi-year programme, we were able to invest in good relationships and build mutual understanding. Not just with administrators, but end users such as visually impaired travellers, local residents and municipalities as well. On top of replacing the functional station lighting, the Lighting Programme set out to make station lighting future-proof. Which requires energy efficiency as well as pleasant light and ease of maintenance. By seeking to connect with stakeholders (such sa Visio, monument commissions, residents), we were able to generate understanding and goodwill.

For us, replacing the lights was always about *improvement*. The new fixtures, for instance, produce less stray light. This reduces nuisance to residents and is friendlier to flora and fauna. Furthermore, the new lamps last 5 times longer. This reduces nuisance to travellers and maintenance costs.

Finally, the Lighting Programme makes an important contribution to the *improved sustainability* of ProRail assets. Station lighting accounts for 30% of ProRail's total energy consumption. The Lighting Programme contributes to sustainability by realising a 50% energy savings on station lighting. And another 50% is saved by dimming the light in the absence of passengers. In view of the 2015 Paris Climate Agreement, ProRail has to reduce their energy consumption by 30%. Halving the amount of energy consumed by station lighting means that ProRail saves 15% of the total energy consumption already. With that, the Lighting Programme has realised half of ProRail's savings target.

Lighting was once a capstone in the design of a building. When the architect was done with the architectural design, the installer would get to fit the lighting installation into the building. Today, lighting science is a multidisciplinary field. Lighting is an integral part of an architectural design, supporting the architecture and concealed out of sight. Multidisciplinary light design means to take into account the architecture, social safety, contrast, glare, light nuisance, flora and fauna, ease of maintenance and administration. That is why we always opted for a multidisciplinary approach to modernising the lighting at existing stations. You will read all about it in this boos.

Amsterdam Sloterdijk station Hemboog. Not wanting to disturb the arches of the roof with fixtures, the architect opted for lampposts under the roof. To avoid glare, higher columns were applied than at regular platforms.

1 Light and station lighting

Before we proceed to an explanation of sample projects of the Lighting Programme, this chapter will provide background information on lighting science in general and station lighting in particular.

1.1 History of light

The concept of lighting is older than we can remember. It exists always and everywhere to a certain degree. Long before the invention of artificial light, the world was lit by the sun, the moon and the stars. In modern times, we live under the illusion that the world is makable. Which is sort of true for light. We have all kinds of techniques at our disposal to mould the world of light to our liking.

Just like other forms of Public lighting, station lighting began with candles and oil lamps. The invention of electricity and the incandescent lamp brought new applications. Fluorescent light provided a huge improvement in station lighting. The long history of stations shows a clear trend: always more light with less effort and at a lower cost.

The Lighting Programme marks a trend shift: not just more light, but better light. In the town of Mantgum, between Leeuwarden and Sneek, the Stichting Feel The Night foundation was very much bothered by the gigantic sea of light around the station. It could be seen from miles away across the flat Frisian countryside. Disruptive and not at all necessary, critics said. The foundation had contacted NS and ProRail several times, but was not understood. "What do you mean? Is the light not working properly? "It works fine, there is just too much of it."

After 150 years of complaints about poorly functioning lights, "the lights are out", a new voice appeared that could not be met with an answer. ProRail and NS did not budge. After all, their lights met RLN 00012. Nynke Rixt Jukkema decided to take action with a few fellow villagers. And successfully so (read more on page 13).

Meanwhile, this new awareness confronted the Lighting Programme with significant challenges. How do you protect the visually impaired, for instance, who have a legal right to sufficient – in practice often more – light, while local residents want less light? And how can this be united with the goal of saving energy to improve sustainability?

Discussions with specialists, stakeholders and target groups yielded results. Rather than light itself, visibility is the real issue.

We learned about how the human eye works. About uniformity, lack of uniformity, contrast, light colour and saturation, as well as the disturbing effects of glare and luminance. The developments and technical progress in LED lighting allowed for many desirable aspects to be realised and many disadvantages to be mitigated.

As stated above, replacing traditional fluorescent lighting by LED saves around 50% and even 75% if dimmed in the absence of passengers. Like many other stations, the ends of the platforms in Baflo and Usquert do not require so much light. A great opportunity to dim often. But once again, we hit a dilemma: nature and the surroundings demand custom work for each station, while maintenance and administration require as much standardisation as possible.

In the past years, we have gained a lot of insights in the design, realisation, administration and experience of sustainable station lighting. We believe that our Lighting Programme strikes a balance between spatial, functional and administration aspects.

The festive opening of Mantgum station.

1.2 Feel the night in Mantgum

Mantgum used to be invisible to the rail industry, but it has been on the map since 2017. Yes, it is home to a small station. Some locals knew about it and, with a bit of luck, actually knew where to find it. But at the headQuarters of NS and ProRail, not a lot of known about Mantgum. NS does not service it. Arriva does. Breakdown services had to dig deep into their lists to find anything about Mantgum at all.

However, Mantgum is home to a Nynke Rixt Jukema. An architect, she grew up in northern Friesland just off the Wadden Sea. At a young age, she developed a sense of appreciation for tranquillity and space, as well as the moon and stars at night. Mantgum has very little ambient light, contrary to the majority of the country, making it a great place for stargazing.
To preserve or regain the value of the darkness, Nynke Rixt founded the 'Feel the Night' foundation (see www.feelthenight.eu). The abundant lighting around stations bothered her. It is especially visible in rural areas, where you will see a station from miles away.

In the past, station lighting was organised according to the standards of the time: a pole with fluorescent lighting every 16 or 25 metres, the same throughout the country. Regardless of the location. The same across the entire length of the station. And the light turns on half an hour before the first train arrives and turns off half an hour after the last train leaves. That is how it goes. Day in, day out.

Nynke Rixt got in touch with NS and ProRail administrators several times, but never got anywhere. Total lack of understanding. After 150 years of complaints about defective lighting, there was now a complaint about lighting that actually works. At a certain point, Nynke Rixt was fed up, to put it into her own words. Together with 3 fellow villagers, armed with ladders and garbage bags, they decided to extinguish the light. And so they did.
As it turned out, the garbage bags were unnecessary because you can turn off fluorescent lights by twisting the lamp ninety degrees.

The next morning, the driver completely missed the station hidden in the dark. The breakdown service in Zwolle was notified, but to no avail. In the rail sector, nobody seemed to know what was going on. After a day or two, they sent someone to take a look. They found a note on the lighting column: "My name is Nynke Rixt. This is my mobile phone number and I did it." Such audacity.

Someone interfering with state property and taking the law into their own hands. The Lighting Programme was made aware of Nynke Rixt by Eelco Krakau, the Noord-Oost contract manager. "If you're going to address the lighting in the Noord-Oost region, better start in Mantgum. We've got a lady there who is set on change."

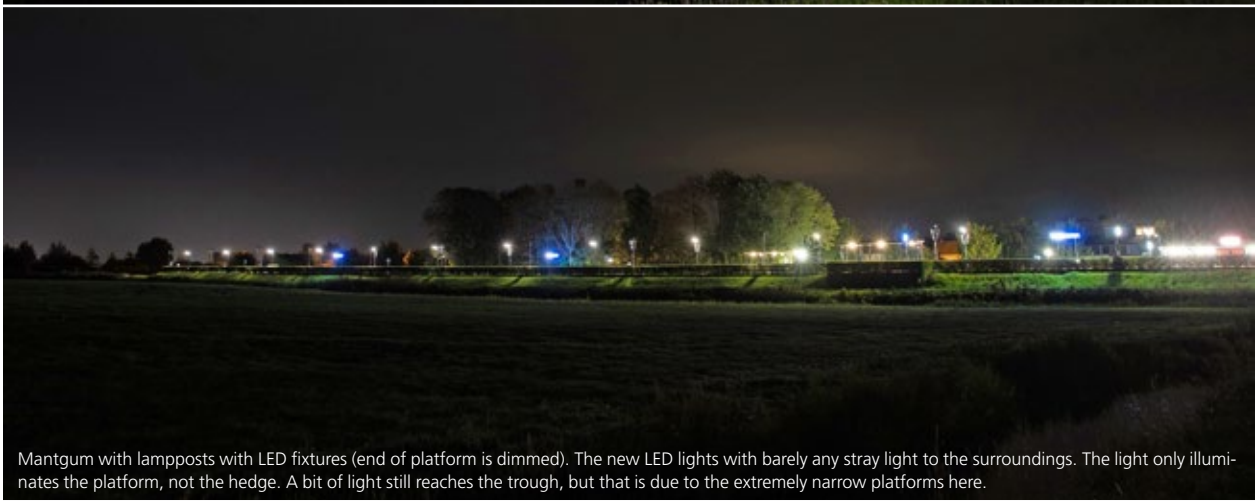
And so they did. And the additional requirement was included in the programme of requirements. Dim wherever and whenever possible and prevent light pollution. This is easy to reconcile with energy savings, but not so much when it comes to the accessibility requirement of good and consistent lighting for the visually impaired. Still, the requirements can be met by applying modern LED technologies. They allow for light to be targeted better and spread more evenly. Motion sensors ensure the light is dimmed to 30% during quiet times.

After the lighting was adjusted, the phone rang once again. "This is Nynke Rixt." Tjebbe Ruskamp, ProRail's project manager responsible for the Lighting Programme: "I was mentally preparing for more criticism."

But her question was a different one. "The people of Mantgum are pleased with the new lighting and want to celebrate this joyous occasion. How would you feel about that?"

Honestly, it was difficult for us to have a particular opinion. Around 20 new lighting columns on a board in the field. Literally. But, whatever. We decided to celebrate. Nynke Rixt: "I ran into the Frisian commissioner to the King the other day. I will give him a call. I think he will come".
She was not kidding: Arno Brok actually committed.
This changed everything. Unfortunately, Pier Eringa, our CEO of Frisian descent, was unable to make it that day. Ans Rietstra (Stiens) couldn't make it either. ProRail was represented by Astrid Bunt, Director Stations. Sieb van der Ploeg from the band De Kast said he would come sing a few songs, but had to cancel due to a big concert somewhere else. Geert Mak, who lives 2 kilometres away in Jorwend (with a view of the station) was present. He added some historic context to the celebration.

Mantgum with lampposts with the old fluorescent fixtures. In the countryside, the station can be seen from far and wide.



Mantgum with lampposts with LED fixtures (end of platform is dimmed). The new LED lights with barely any stray light to the surroundings. The light only illuminates the platform, not the hedge. A bit of light still reaches the trough, but that is due to the extremely narrow platforms here.

Weesp station. LED lamps provide warmer light than fluorescent lamps, which makes stations feel more pleasant. The light trajectory has been moved inwards, making the middle of the platform less gloomy. In Weesp, the architect applied the daylight rule in the 1970s by making the middle part of the roof transparent.

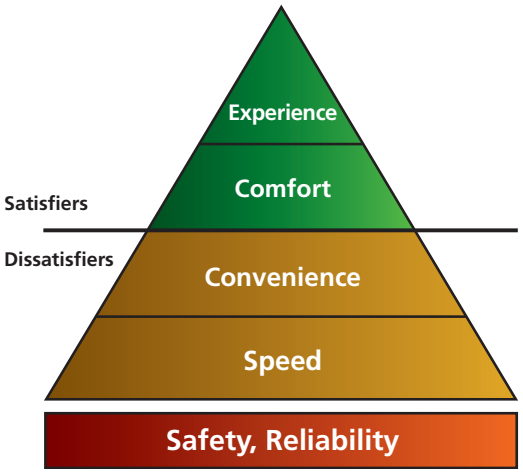
Starting in the nineteenth century, light and lighting has only grown more and more . Now, this trend has been broken with the application of less light. Plus, Mantgum, Friesland also has a reputation to uphold. Boniface was murdered in Dokkum, Mantgum revolted in the seventies against plans to terminate the station. Protests all the way up to Leeuwarden and occupations of the track kept Mantgum station open.

And now, we have rebellious, mischievous Frisians once again, who will not accept excessive light. This does give the Netherlands food for thought. Mantgum's solution has now been applied to all small stations. The Mantgum celebration became a great success.
Many enthusiastic villagers showed up. The press was widely represented. And Mantgum had put itself on the map at the ProRail and NS headquarters as well.

1.3 ProRail policy 'Light on stations'

Sustainable light is not just about artificial light, but daylight as well. ProRail has adopted the 'daylight unless' principle for good reason. Above-ground stations always have as much daylight as possible. Tunnels and passages have as many atriums or skylights as possible.
Bringing daylight to travellers underground as well. Modern designs always consider daylight entry and the use of artificial light to optimise the experience for users. When the lighting is being refurbished in existing buildings, light design and daylight must be incorporated as well. A good lighting plan can make users feel more comfortable after the renovation and experience the building more in line with the architect's intention.

Lighting should contribute to the customer value of 'movement', according to NS. First and foremost, by enhancing the sense of *safety* and by being *reliable*. Secondly, by ensuring that travellers can find their way *quickly* and *easily*. When safety, reliability, speed and convenience are not in order, travellers become dissatisfied. These 3 aspects are therefore called Dissatisfiers because they cause a negative, unsafe feeling.



Customer value model: movement

In addition to the *dissatisfiers*, there are also two *satisfiers: comfort* and *experience*. These are the aspects that contribute to the travellers' level of satisfaction. When proper lighting helps travellers see where to go with no need to worry about getting lost or tripping, this generates a sense of comfort and peace. With the additional lighting of architectural or monumental details or landmarks, travellers recognise and remember where they are more quickly. Experience is the icing on the cake. This refers to the 'wow effect' that occurs when everything is just right (light, colour, sound). Travellers feel at home, welcome and at ease.

ProRail and NS described this integral approach together with Bureau Spoorbouwmeester in 2015, in the memo 'A new light on Stations'. For the first time, LED lighting was reliable enough to be applied in stations, thanks to a guaranteed lifespan of 50,000 hours. Before that time, LED lights would often turn yellow and purple after a few years. In 2016, ProRail operational directive RLN00012 was issued, which included an LED lighting requirement for stations for the first time.

Table 3. From ProRail standard RLN00012

	Transfer area:	Horizontal on floor ≥:		Connection ≤:	Vertical on point or surface ≥:				Energy-perf.≤:	Station type:					
		E_m (lx)	U_0	(U)GR	E_{pv} transverse (lx)	E_{pv} longitudinal (lx)	E_{mv} transverse (lx)	E_{mv} longitudinal (lx)	W/m²	stop	base	base+	Mega	Cathedrals
1a	Open platform	5	0.2	55	0.5	0.5	5	1.5	0.15	x				
1b	Open platform	10	0.25	50	1	1	7.5	2.5	0.3		x	x		
1c	Open platform	20	0.3	45	2	2	15	5	0.5				x	x
2a	Ramp	5	0.2	55					0.15	x				
2b	Ramp	10	0.25	50					0.3		x	x		
2c	Ramp	20	0.3	45					0.5				x	x
3a	Covered platform	50	0.4	45	25	20	20	25	1.5	x	x	x		
3b	Covered platform	70	0.4	45	40	35	35	40	2				x	x
4a	Fully enclosed platform	100	0.4	28	50	40	40	50	3	x	x	x	x	
4b	Fully enclosed platform	200	0.5	28	100	80	80	100	6					x
5a	Platform shelter	20	0.4	45					2	x	x	x	x	x
5b	Waiting room	50	0.6	28					6		x	x	x	x
6a	Fully enclosed Stairs/Escalator	20	0.4	45					0.5	x				
6b	Fully enclosed Stairs/Escalator	50	0.4	45					1.5		x	x		
6c	Fully enclosed Stairs/Escalator	100	0.5	45					3				x	x
6d	Stairs/Escalator misc.	10	0.4	45					0.3	x				
6e	Stairs/Escalator misc.	20	0.4	45					0.6		x	x	x	x
7a	Crossing (pedestrians only)	10	0.3	50					0.25	x	x	x		
7b	Level crossing (traffic + pedestrians)	20	0.4	50					0.25	x	x	x		
8a	Passenger tunnel / Indoor passage closed	50	0.5	28					1.5	x	x	x		
8b	Passenger tunnel / Traverse closed	100	0.5	28					3				x	x
9a	Walking bridge / Indoor passage misc.	10	0.4	45					0.3	x				
9b	Walking bridge / Traverse misc.	20	0.4	45					0.6		x	x	x	x
10	Station train hall	100	0.6	28					4	x	x	x	x	x
11	Transfer general	5	0.3	55					0.15	x	x	x	x	x

The required colour rendering is ≥ R_a80 in all cases.

Clarification per transfer area:

2	Ramps for transfer: ProRail standard, not mentioned in TSI/PRM. Slopes less steep than 1:25 are considered 'false flat', illuminate these as open platforms
5a	A shelter is intended for short stays (exterior with or without a door)
5b	A waiting room is a heated indoor area (where travellers can stay longer and read a book).
6	Stairs/Escalator: Applies to stairs equipped with tactile pavings (main walkway); Illuminate stairs without tactile paving just like open platforms (e.g. stairs to P+R or bicycle parking)
6abc	Fully enclosed Stairs/Escalator: e.g. fully enclosed stairs to tunnels and indoor stairs to indoor passages
6de	Stairs/Escalator misc.: = Not fully enclosed stairs e.g. open stairs or stairs with canopy and open walls e.g. to embankments, underpasses, indoor passages and walking bridges
7a	Crossing only for pedestrians (ProRail standard, not mentioned in TSI/PRM)
7b	Overpass: overpass for traffic and pedestrians cf. TSI/PRM (harmonise light intensity at level crossing with that of adjacent public road)
11	Transfer general: Transfer areas not mentioned in this table, such as the route from platforms to buses and taxis across ProRail grounds (e.g. station square)

1.4 EU and ProRail lighting standards

In the Netherlands, lighting in the workplace is required to meet the NEN-EN12464 standard. Lighting at stations is also subject to the EU standard TSI/PRM. TSI, in turn, refers to EN12464. ProRail translated EN12464 into the RLN00012 directive. In May 2015, RLN00012 V008 was issued with the inclusion of LED lighting requirements. This marked the moment that the Lighting Programme could kick off its tender. Based on lessons learned during the programme, version 9 was released in 2016 and version 010 in 2017. Table 3 lists the main requirements in RLN00012.

The table shows the requirements for each transfer zone. An open platform requires less light than a roofed platform. A small platform has lower requirements than a large station. Below, a brief clarification to the columns:

E_m = Average illuminance in Lux

U_0 = Equivalence (E_{min}/E_m) in the light calculation or measurement

(u)GR = Glare (number from calculation)

E_{pv} = Vertical illuminance in point across or along the track.

E_{mv} = Vertical illuminance in plane across or along the track.

W/m^2 = Power per m^2 floor area;
*W/m^2 is the measure of how sustainable lighting is (also called Energy Performance or EPA). 0.15 W/m^2 on a Stop is still extremely low. To illustrate: A side platform of a Stop is e.g. 3m wide with a lamppost every 16m. An EPA of 0.15 W/m^2 then leads to a consumption of 48*0.15 = 7W per column (currently, this is often 20W). Narrower platforms therefore require even weaker fixtures to meet the EPA.*

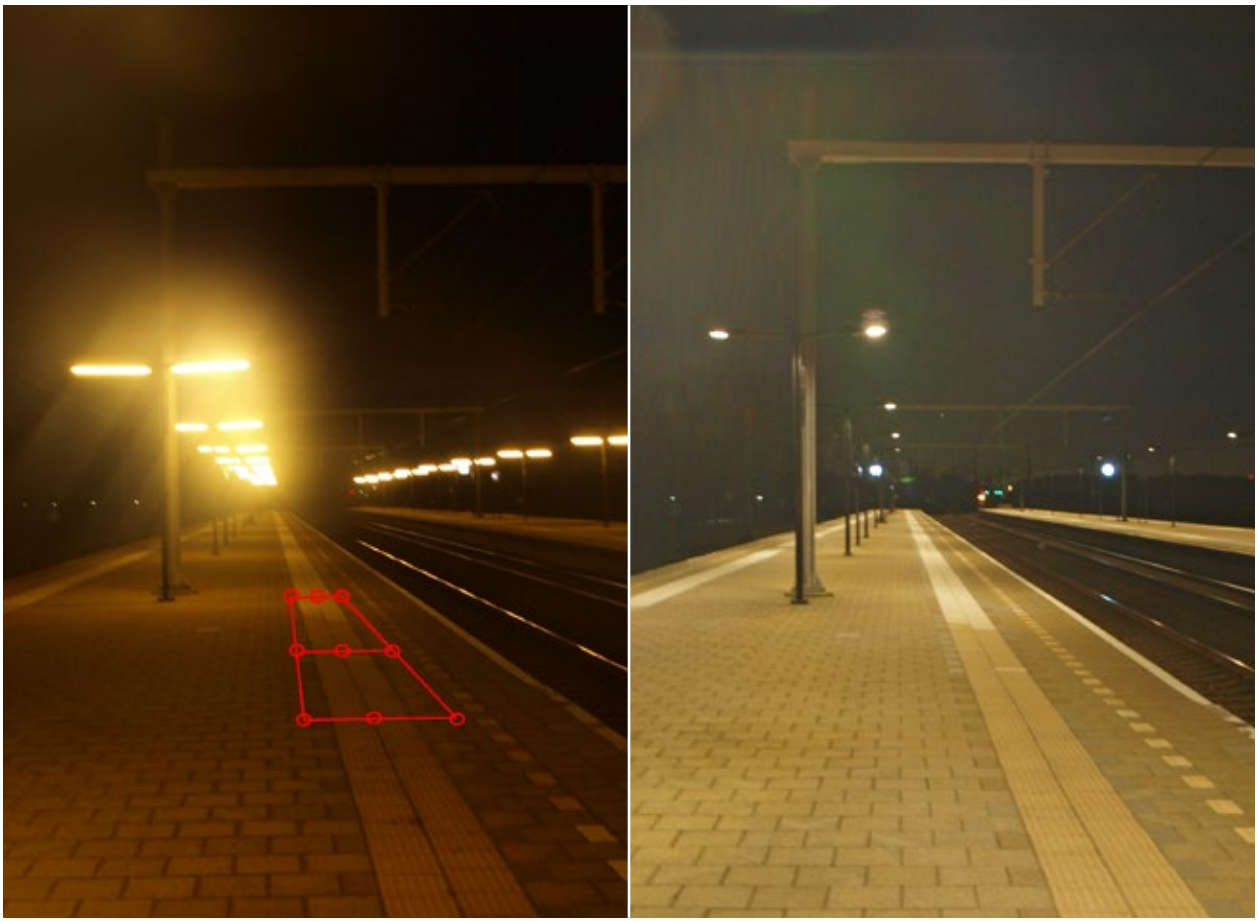
Station type: This column lists the rule (requirement) that applies to the station type. The Netherlands Has 5 station types (from Stop to Cathedral). The larger the station, the greater the lighting requirements.

Values not in the table but as a separate requirement for all LED fixtures in RLN00012:

R_a = Colour saturation of the light. A fluorescent lamp is R_a80. This means that under fluorescent light, we only see 80% of the colours relative to daylight. A sodium lamp is R_a20, which means virtually no colours are visible, only light and dark. At R_a20, a room feels ghostly and a sense of insecurity increases. ProRail requires at least R_a80, including for LED. In 2022, many indoor areas were already lit with LEDs with R_a90 .

Lm/W = The luminous efficacy of a fixture. ProRail demands 100 Lm/W. Older fixtures usually contain less efficient LEDs or generate more heat loss and often only achieve 60 Lm/W. LEDs are becoming increasingly better and 150 Lm/W is often feasible come 2022. For comparison, an incandescent lamp provides around 10 Lm/W, making it 10x less efficient than LED. A fluorescent lamp provides 50 Lm/W, making it 2x less efficient than LED.

Notes below the table:
These points are based on experiences of the Lighting Programme added in V009. Ramps are usually lit 2x stronger than platforms. However, it proved pointless to add extra lighting to every gentle slope. That is why the definition of false flat was added. Similarly, the difference between open stairs and closed stairs was added, as well as stairs inside the main walkway and small steps outside the main walkway. RLN00012 details how to design, calculate and measure all quantities. We will not address this any further in this book.



Voorschoten station, fluorescent on the left and LED on the right The 9 measuring points in red

Measuring point	Lux	Measuring point	Lux	Measuring point	Lux
1.	4.3	2.	4.1	3.	3.8
4.	7.8	5.	6.4	6.	5.2
7.	21	8.	11.9	9.	8.5

Comments:

Results

		NEN12464		Memo 4Infra (derived from NEN12464)	
Results	Calculated value	Standard:	Meets:	Standard:	Meets:
Lux avg. (E_m)	8.11	5	Yes	5	Yes
Uniformity (U_0)	0.47	0.2	Yes	0.2	Yes

The 9 lux values measured at Voorschoten station, including the average lux value (E_m) and the calculated uniformity (U_0).
The average lux value (E_m) from the measurement = 8.11 lux, which exceeds the standard of 5 lux at a stop with a wide margin. The uniformity (E_{min}/E_m) of the 9 measuring points is 3.8 / 8.11 = 0.47, which is also well above the standard of 0.2

We will explain the two main variables from Table 3. These are the average *illuminance* on the platform (E_m) and *uniformity* on the platform (U_0).

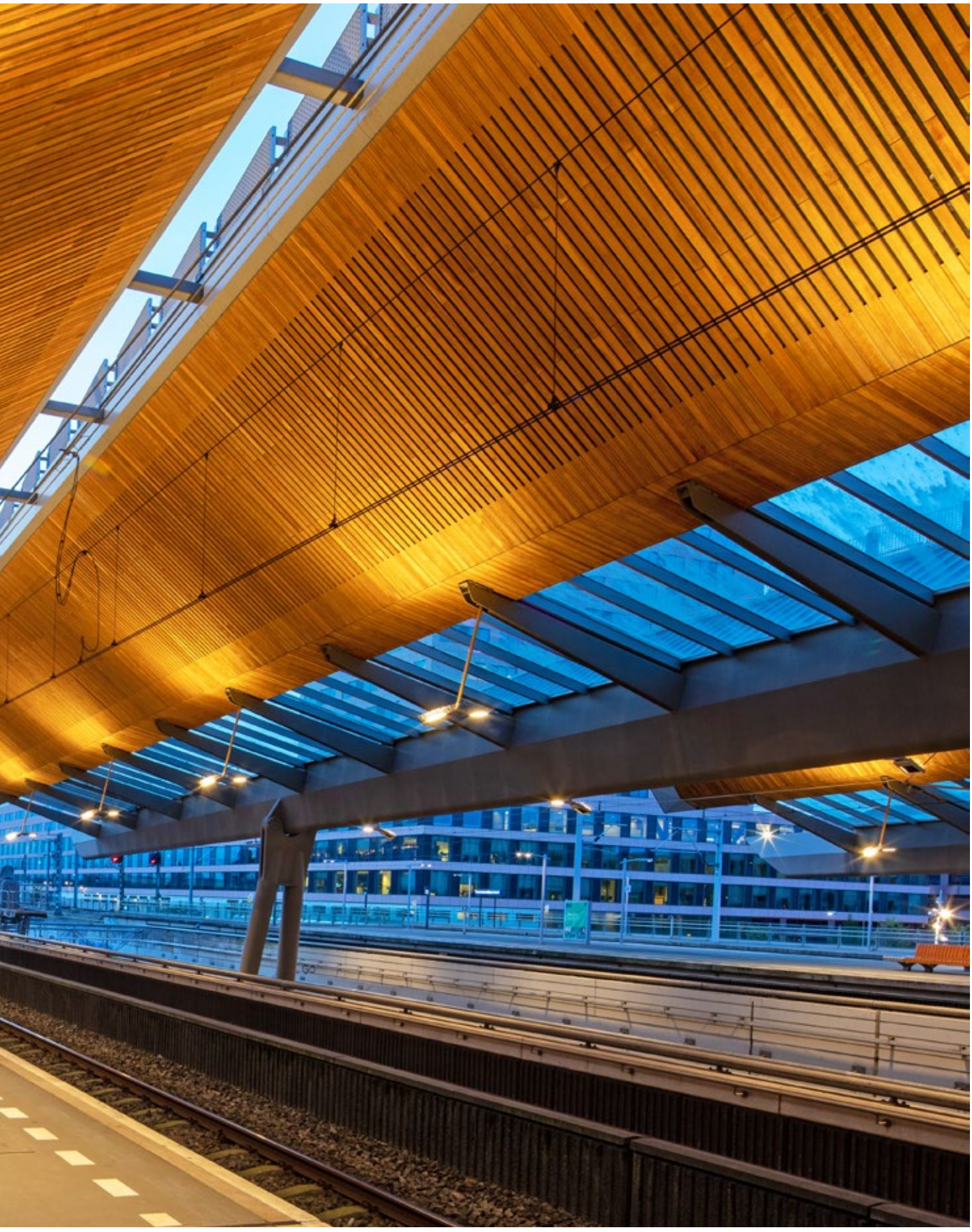
In 2015, we conducted a pilot study with LED at Voorschoten station. We replaced the old fluorescent lighting, with poor uniformity and dark spotlights between columns, by LED lighting, thereby dramatically improving the uniformity (see adjacent photos). This is because LED fixtures have better optics (lenses) that illuminate the tiles between columns properly as well. The light is only focused on the platform and not on the track or the surroundings. Because no unnecessary surfaces are illuminated, energy is saved and light pollution reduced. Because Voorschoten station is located next to the dunes, this also benefits the flora and fauna that live there. The new fixtures over the second platform, depicted on the photo on the right, are barely visible, in contrast to the old situation (photo on the left). Drivers also experience much less glare as a result of the new fixtures. At no point does the driver look straight into a fixture, except if they deliberately look to the side while driving through the station. With the old fixtures, they would see the station on the horizon kilometres away. There were even instances when drivers missed the station after the LED lights had been installed because they were not used to seeing so little light.

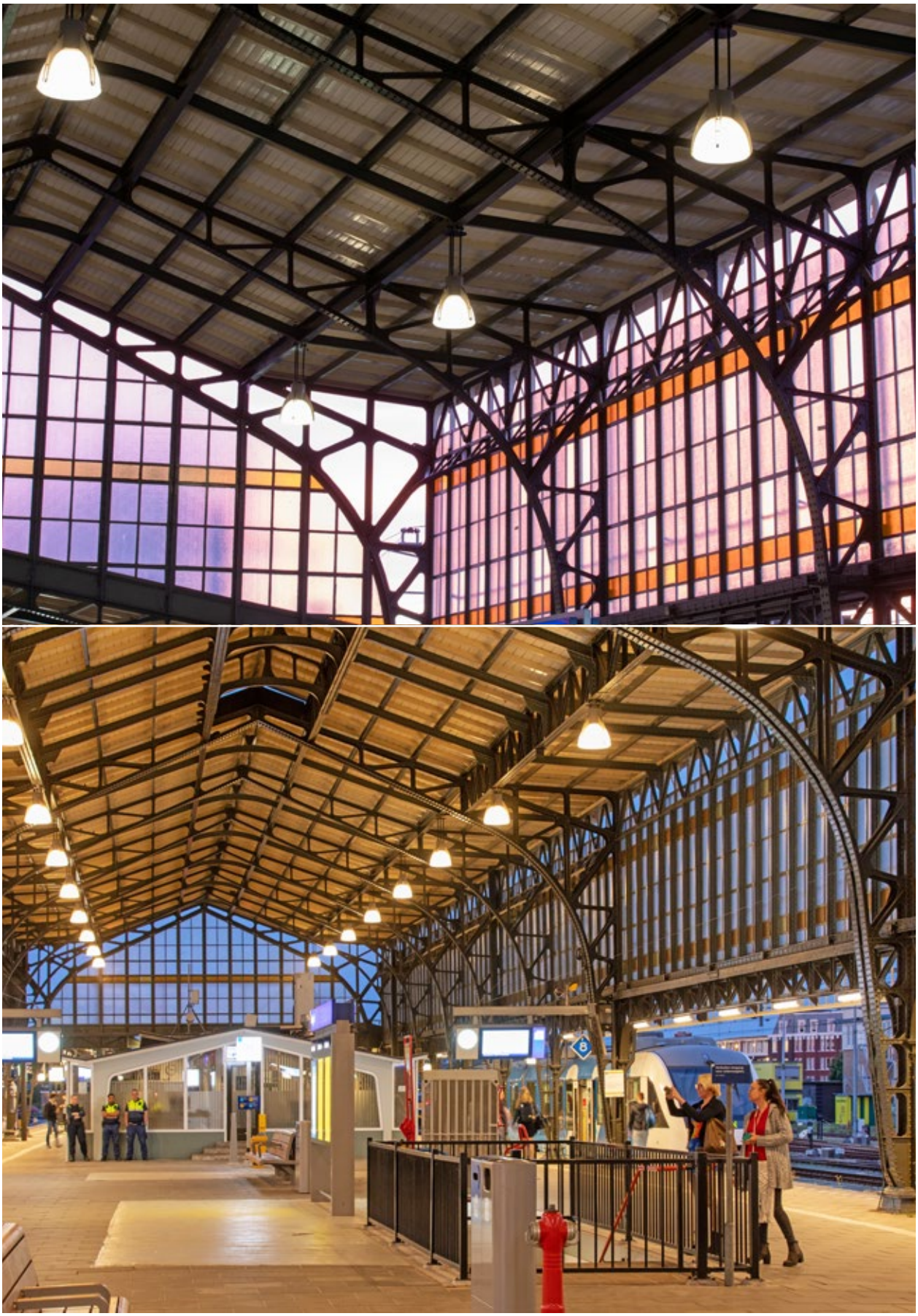
A light design is usually simulated in a Dialux model. The fixture and optic are determined based on platform dimensions, columns and lighting requirements. After realisation, actual illuminance and uniformity are measured with a light meter. The average illuminance (E_m in Lux) is to be measured in accordance with RLN00012, with a light metre at 9 measurement points around the tactile paving: 3 under the column, 3 between two columns and 3 points in between (see adjacent photo on the left). The uniformity can then be calculated by dividing the lowest lux value by the average lux value (E_{min}/E_m).

At Voorschoten station, accessibility was not the reason to apply LED. The reasons here are mainly to prevent stray light and save energy.

Of the total budget for the Lighting Programme, 40% was intended for accessibility, 40% for function maintenance (major maintenance), 10% for LED and 10% for dimming. To avoid making budgeting unnecessarily complex, we did not adjust these proportions if accessibility played more of a role at one station and major maintenance at another.

Up and down lighters Amsterdam Bijlmer Arena station after the LED replacement.





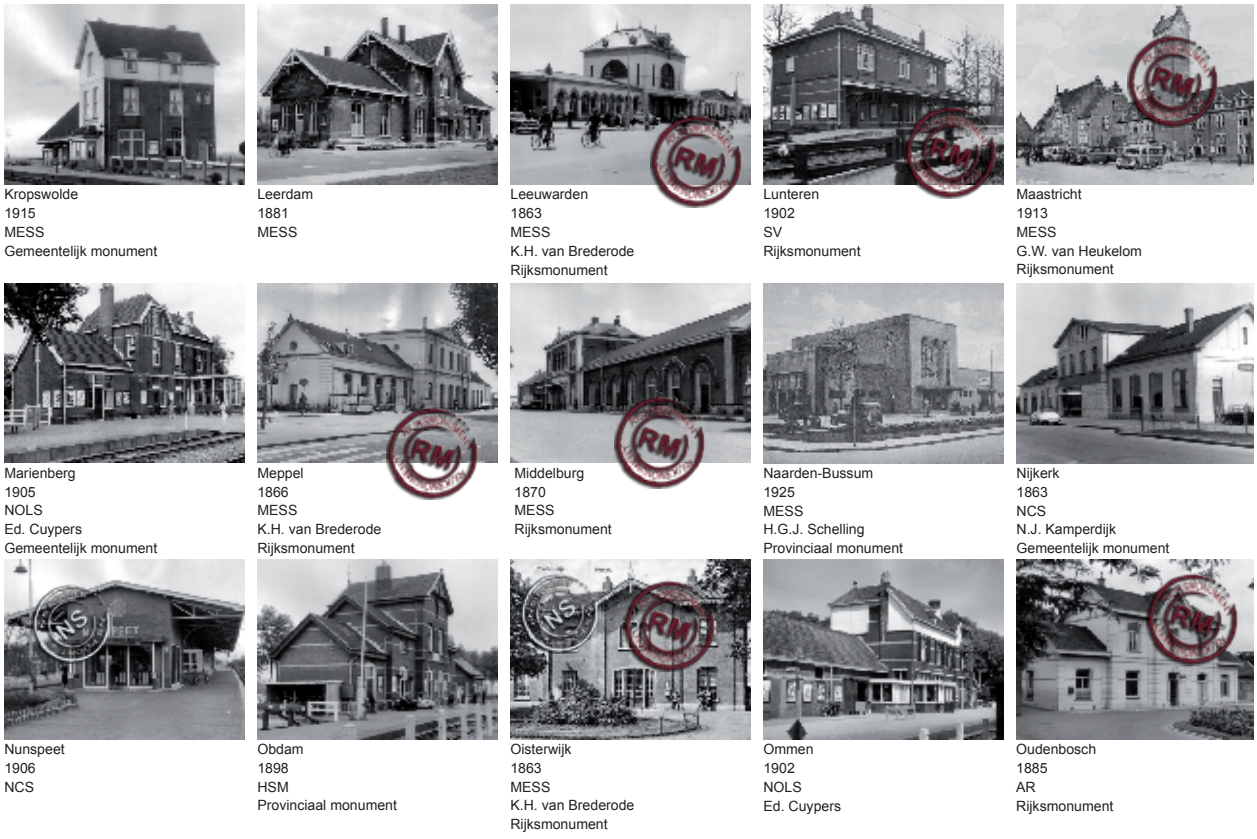
Monumental roof of Hengelo station. Existing chalice fixtures were fitted with new LED interiors (retrofit modules).

1.5 National monuments and collection stations

Several stations are national monuments. This means that permits needed to be obtained from the Monuments Committee of the municipality involved in order to replace the lighting. Several stations have been identified by Bureau Spoorbouwmeester as characteristic of their time. This is the 'Collection of Remarkable Station Buildings'. Consultation with Bureau Spoorbouwmeester is required to replace the lighting at these so-called Collection Stations. The Bureau Spoorbouwmeester website shows which stations are National Monuments and which ones are part of the collection: www.spoorbeeld.nl/inspiratie/de-waarde-van-een-collectie.

Retrofit modules were applied to the monumental roof of Hengelo station, as depicted in the adjacent photos. Retrofit was prohibited within the Lighting Programme in 2016, as suppliers could not provide a lifetime guarantee (especially in terms of heat management). Come 2022, and retrofits have become reliable with a guaranteed lifespan of 100,000 burning hours. From a sustainability and cost-savings perspective, retrofit is now a popular option.

.



A page from the book of the Collection stations, highlighting stations that are also national monuments.

An overview in the portal of the stations where dimming is applied.

The sensors and Gateway as they appear in the portal at Abcoude station.

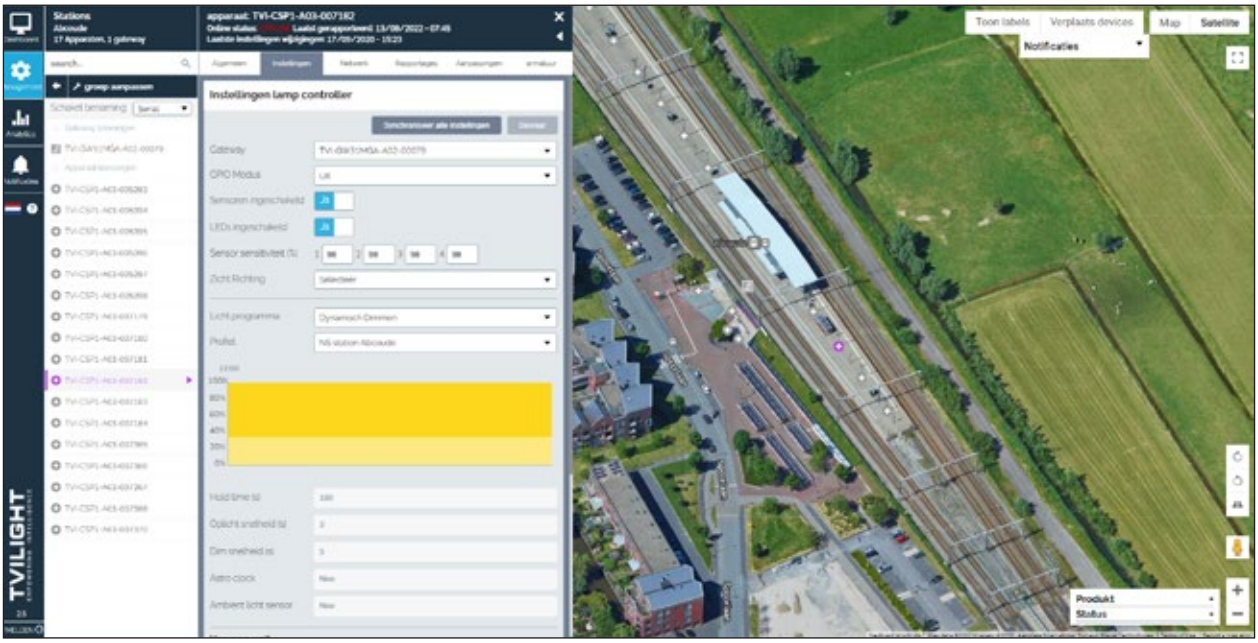
1.6 Remote dimming and monitoring

Most passengers wait for their train about 50 metres away from platform entrances (the boarding zone). Platforms are usually 300 metres long. This is because ProRail's management concession requires that in the event of a calamity, the longest Intercity must still be able to stop at every stop. If there are no passengers on the open platform outside the boarding zone, the lighting can be dimmed. The human eye perceives logarithmically. This means we do not notice a 3:1 illuminance reduction. For social safety reasons, we dim to 33% rather than 0%.

The dimming is controlled by sensors positioned on each column. When a travellers walks by the column, the sensor sends a signal to increase the lighting to 100% (comparable to a toilet where the light turns on when you enter). The sensor is coupled to the mast fixture driver with 2 Dali lines. The sensors on the columns are interconnected via a wireless mesh network (Zigbee, industrial Wi-Fi) and a Gateway (in the street cabinet or on one of the columns). The Gateway is a small PC that uses a SIM card to connect to the portal (administrator's website).

There are several such dimming systems that are also widely used on bicycle paths or in residential areas. ProRail incorporated the dimming system in one of its four framework contracts for fixtures.
The fixture supplier is Van Doorn and the manufacturer of the dimming system is TVIlight. As a one-off, we applied a similar system by Luminext at Diemen station. However, this is a more expensive alternative with a different portal. Working with different systems and portals is undesirable in view of administration activities.

The Lighting Programme has equipped the stops and base stations with the TVIlight dimming system. We do not dim at larger stations, because a completely empty platform is a rare occurrence there. At Den Haag HS, Amsterdam Centraal and Rotterdam Centraal, the open platforms outside the roof are almost always empty. Dimming is applied there to avoid nuisance to the surroundings.
At stops and base stations where night trains run (Rotterdam, Amsterdam, Utrecht route), we do not dim the lights because trains run there all night, giving the light almost no time to dim. A total of 280 stations have their columns dimmed in 2022.



This screen shows the dimming settings from 100% to 33% as well as Hold time, Illumination speed and Dimming speed.

The dashboard in the portal shows that dimming has saved 137,000 kWh over the last six months.

If we click one sensor in the portal, we can see what the settings are. The sensor dims dynamically (based on people) 24 x 7. During daytime hours, the sensor will not work because the power is disconnected from the lamp posts. If the twilight switch is overridden during the day, the lamp posts will dim dynamically.

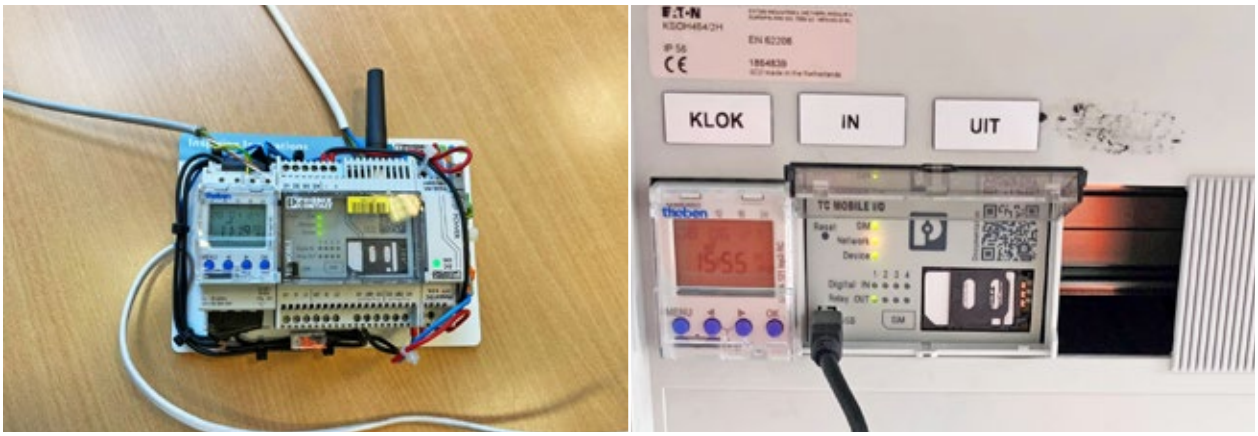
Furthermore, we see a Hold time of 180 seconds. This means the lamp remains lit at 100% for 180 seconds after a person is detected and only then drops to 33%. The Illumination and Dimming speed is 3 seconds. This means the light goes from 33% to 100% in 3 seconds when a traveller is detected, minimising the attention drawn to this process. After 180 seconds, the lamp will dim from 100% to 33%. To prevent a traveller from walking into a dark hole, adjacent (neighbouring) lamp posts are also sent to 100% when a sensor detects a traveller. Neighbouring columns can be configured via the portal as well.

A Sensor

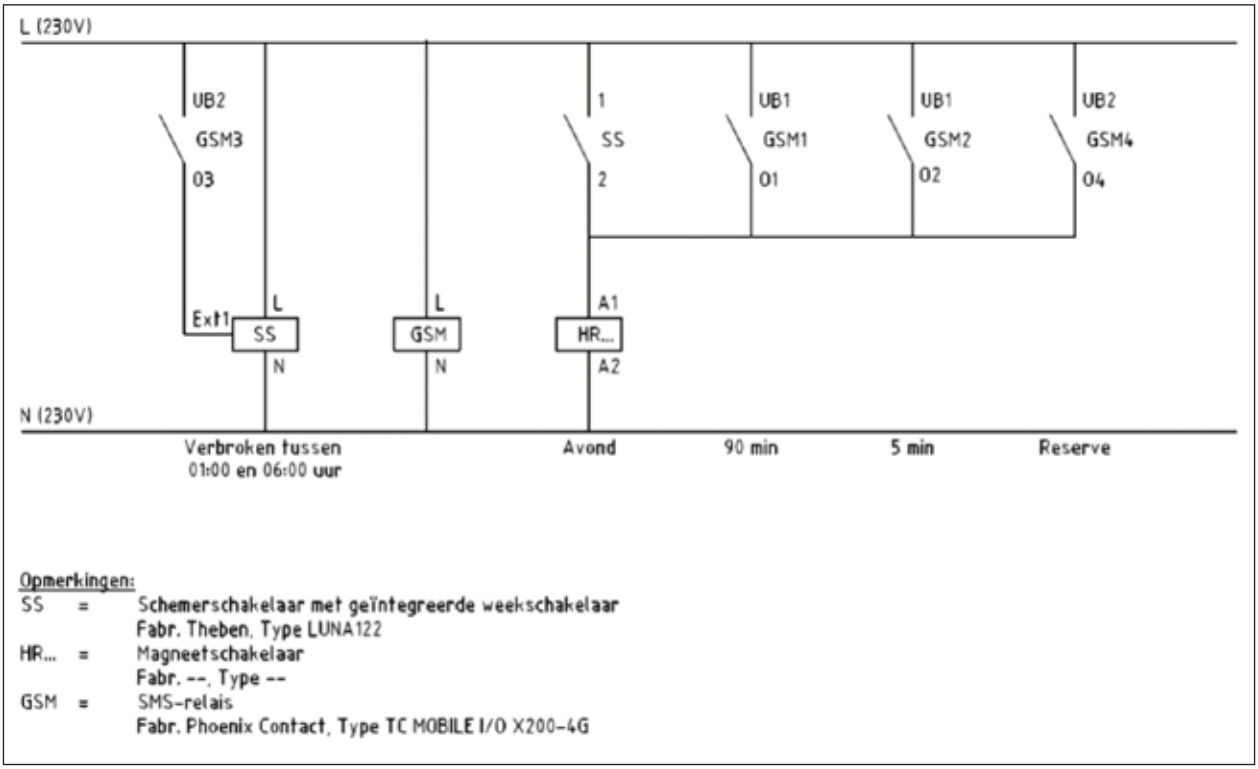
A Gateway

At stops and base stations, lamp posts are dimmed to 33% about 80% of the time. This saves us 80% x 77% = 61% energy. The LED fixture on a column has a capacity of around 10W. The consumption of the sensor and Gateway amounts to around 1W per column. At 1W per column, the dimming system therefore saves 60% x 10W = 6W. This brings the net savings to around 5W (50%) per column.

Besides saving energy, the dimming system also reduces inconvenience to the surrounding area and extends the lifespan of the LEDs by using them more efficiently. An additional advantage of the dimming system is that the administrator can see any malfunctions in the portal (remote management). The portal can also email the administrator a status report on a daily or weekly basis. This reduces the number of inspection rounds necessary and the breakdown service no longer depends on passengers for breakdown reports.



On the left, the test setup of GSM relay and timer. On the right, the built-in relay and timer at Arnhem Velperpoort station.



The circuit at Arnhem Velperpoort.

The GSM relay supports 4 signals (GSM1,2,3,4). GSM1 (call the SIM card), closes output UB1 and bridges the lighting for 90 minutes for the sweeping crew (remains closed for 90 minutes). GSM2 (SMS INSPECTION to the SIM card) closes UB1 for 5 minutes (light turns on for 5 minutes). GSM3 (SMS EVENT to the SIM card) is for events that will last for more than a couple of days (e.g. Pinkpop in Landgraaf, De Wwarte Cross in Groenlo). GSM3 turns off the timer and keeps the lights on from sunset to sunrise (to prevent people from sleeping on the platform and possibly ending up under a freight train at night). GSM4 is a backup, we do not use it.

1.7 Twilight switch and remote switching for winter measures

According to the ProRail management concession, station lighting should be switched on half an hour before sunset until half an hour after the last train and half an hour before the first train until half an hour after sunrise.

This is controlled with a twilight switch and a timer. The twilight switch is leading. If there is no or little light during the day (e.g. during thunderstorms), the twilight switch turns on the lights. The timer turns the light off between around 1 AM and 5 AM (depending on the timetable of the station). The timer therefore saves around 4 burning hours every night. The benefits are significant: less energy consumption, less nuisance to residents, flora and fauna. Plus, the lamps will last longer.

Mechanical timers used to malfunction in the past, keeping the lights on all night long. For inspection or night work, the twilight switch and timer must be manually overridden. The override will be cancelled automatically after 24 hours. With the mechanical timers, however, the override failed to cancel at times. These mechanical timers have now been replaced by electronic clocks. This has improved the reliability of the day-night-schedule.

In case of frost or snow, the gritting crew has to clear snow and spread salt well before the first train (winter measures). To carry out winter measures safely, lights must be switched on at night. To this end, NS uses remote controllers distributed among the gritting crew. These remote controllers are prone to malfunction and complex to administer. For this reason, the Lighting Programme and NS, tested a GSM relay with SIM card at Arnhem Velperpoort station in 2020, as a replacement for the remote controllers. The gritting crew can call the SIM card number to switch on the lights for 1.5 hours. The SIM card cannot be used to switch the lights off. This eliminates the risk of third parties getting their hands on the telephone number and switching off the station lights. NS is currently installing the GSM relay at all stops and base stations in consultation with the Lighting Programme.

The manual override could only be enabled by the NS in-house installer. A station or rail contractor always had to hire an NS in-house installer to shift for night work. With the GSM relay, this can be overcome. The contractor can text the GSM relay with the instruction to keep the lights on for 8 hours, for example. Inspectors and station managers doing periodic inspection rounds at stations can now also switch on the lights themselves during an inspection by calling or texting.

1.8 Delivery structure memo

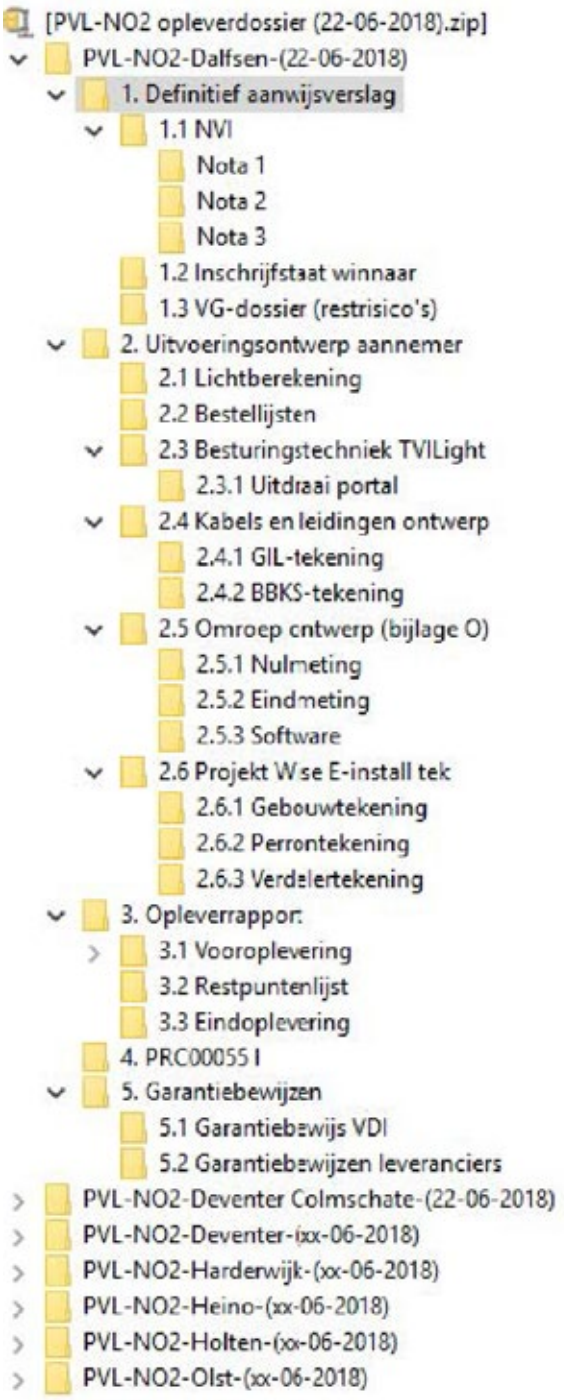
Before we started the roll-out of the Lighting Programme, we wrote the 'Delivery file structure memo'. As a result, the five contractors involved in the programme knew in advance what documents and data they had to deliver. This was intended to allow for them to flesh out their files per station during the engineering process. This was to avoid having to search hundreds of files and versions afterwards to put together a correct file.

This proved quite difficult for the first stations delivered. But maintaining and completing the file with time had become increasingly ingrained with the next stations. Once again, the advantage of a programme became apparent: with a learning organisation, you avoid making the same mistake 400 times.

We delivered the structure of the delivery files in a zip file as an empty folder structure. The contractors then completed the zip file per station. The delivery files of all 400 stations were eventually put on Sharepoint as a zip file in 2021 and 2022.

The zip file also contains all documents submitted via SAP/PLM with:

1. The region (e.g. BBKS)
2. SAP (e.g. Object data, completion profiles of the fixtures, lampposts, speakers, etc.)
3. NS data, such as E-drawings that end up in NS Projectwise.



In addition to drawings, maintenance data is also recorded for each object in the SAP database for administration purposes. In 2016, it was found that few individual objects of station installations were recorded in SAP. That is why most data was re-entered rather than changed. This includes:

1. lampposts were not yet entered in SAP.
2. Fixtures were often listed as one generic object per station in SAP (e.g. with the description 'Weesp station lighting') and not as specific objects (e.g. 'lighting post fixtures track 1 Weesp'). This made it impossible to see which type of fixture was applied at what location. To this end, we established the following naming convention per station object in the memo:

'[type equipment] [transfer zone] [position] [additional position details] [station acronym]'
for example:
'Lighting platform SP1 RTD side GVM'
'Lighting roof SP2/3 roof GV side GVM'
'Modular tube SP2/3 GVM'
ATTENTION: Do not use platform 1 and platform 2, but track 1 and track 2 instead, because only the track numbers (and not the platform numbers) are clearly marked at the station.

3. For each fixture, product make and type were recorded in SAP in the Note field (because there was no other field available).
4. The maintenance period for fixtures is now 10 years (50,000 burning hours) instead of 2 years.
5. Dimming sensors and the corresponding gateway have been added in SAP.
6. Modular Tubes (for SpoorLAN fibre optics) were added in SAP if the platform was dug open.
7. Speakers were replaced and updated in SAP when they reached the end of their lifespan.

For ProjectWise, the document '33 Tekenhandboek NS Projectwise V20 (08-05-2018).pdf' has been added as a binding contract document. This states, among other things, that a fixture list has been added in the NS maintenance drawings above the bottom corner. Before 2015, the NS in-house installer almost never added or logged this during incidental maintenance. The Lighting Programme had the fixture list added as a legend to all E-drawings (see example below for Tilburg).

ARMATUURCODELIJST

Arm. code	Omschrijving	Lamp	Fabrikant	Vermogen
G	BGP704	1xLED210-4S	Philips	166W
H	FLC240 LED 840	24xLED	WE-EF	75W
I	BGP615 DM31 830	1xLED44-4S	Philips	35W
J	BGP702 DN11 830	1xLED50-4S	Philips	42.5W

B	30-03-2021 R-472000.Q7
VOLKERRAIL	
VERLICHTING PVL-ZD19	
A	03-09-2019 P-08016
ITL	
nw. passage en renovatie Station	

Deze tekening vervangt:			
001570212	Elektrotechnische installaties Verlichting en wcd's - dak E 9005	Formaat A1x4	Schaal 1:100
		Geocode 551	Versie A
ProRail	Station Tilburg 1	As-built	
	22.050 22.250	Blad 01	

Locatie restrisico	V&G risico-omschrijving	Mogelijke oorzaak risico	Toelichting
hal	Kroonluchter valt op reizigers	Kroonluchter met lier door plafond opgetakeld maar niet goed geborgd na verwijderen van de lier.	Kroonluchter wordt opgetakeld met een takel die op de zolder staat. De kabel van de takel loopt door een sleutelgat in een UNP profiel. De kroonluchter weegt ca, 80 kg. De draagkracht van de vloer van de zolder is niet groot (gewapend beton van 100 jaar oud). Het UNP profiel is bedoeld om de vloerbelasting van het gewicht van de kroonluchter te spreiden over de zoldervloer. De kroonluchter dient daarom niet anders dan met de UNP geborgt te worden. Als de kroonluchter met de lier door de UNP naar boven is gehesen is dient: 1) de haak door het grote deel van het sleutelgat boven de UNP getrokken te worden. 2) Het UNP profiel dient daarna opzij geschoven te worden zodat de haak in het smalle deel van het sleutelgat geborgd is 3) Tussen het grote deel en het smalle deel van het sleutelgat is een verhoging aangebracht zodat de haak niet vanuit de sleuf terug naar het ronde gat kan schuiven. 4) Met de moer rond de haak dient de kroonluchter tegen het plafond getrokken te worden. 5) Pas daarna mag de spanning van de lierkabel verwijderd worden 6) Daarna kan de lier losgekoppeld worden en gebruikt worden om een andere kroonluchter te laten zekken of op te hijsen.
			

1.9 H&S Risk file (object-bound risks) per station

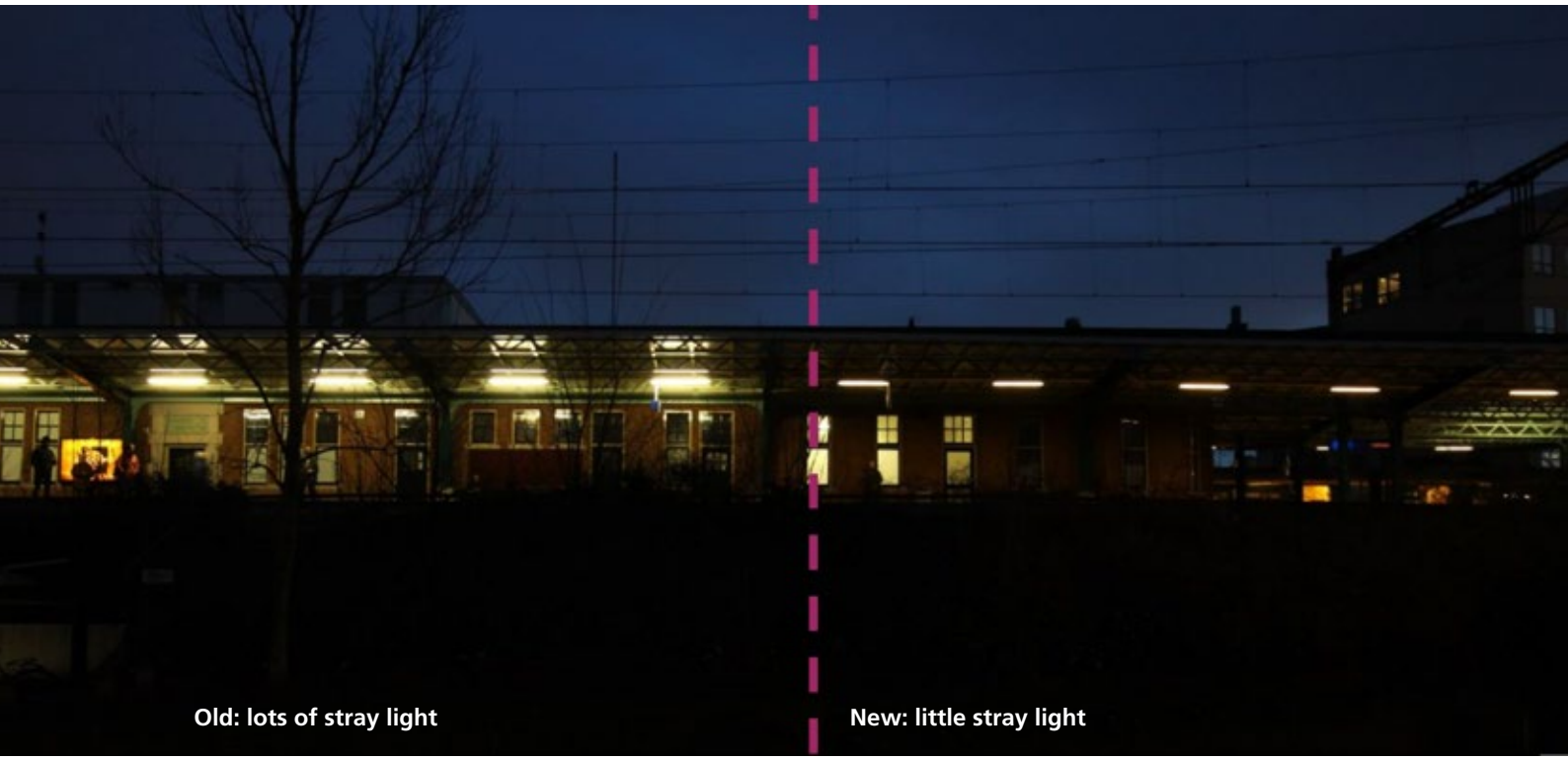
A risk file must be kept at each station according to health and safety legislation [Arbowet]. If a project makes adjustments to the station, residual risks may remain. The project team has to add residual risks to the risk file.

During the engineering phase of a project, a Health & Safety (H&S) risk assessment and plan is made prior to the project activities. The principal is required to prepare an H&S Design Phase (H&SD) plan and submit it to the contractor when tendering. The contractor will take ownership of the risk file in a risk session with the principal and develop it into an H&S plan for the execution phase (H&SE). In principle, the risks in the H&SE plan only apply to the construction phase (e.g. Risk of falling, electrocution). Sometimes, residual risks remain after completion, which must be reported to the administrator (e.g. risk of falling when washing glass roofs that require fall protection to be used). The contractor must add these residual risks to the risk file of the station.

In 2015, not a single station had a risk file. That is why the Lighting Programme attached a blank document titled 'V&G restrisico's template Station.doc' (template) to the tender documents.

In Maastricht, we installed chandeliers (see chapter 21). In the attic, 17 metres above the station train hall floor, the chandelier can be lowered with a cable for maintenance through a 10-cm hole in the floor.

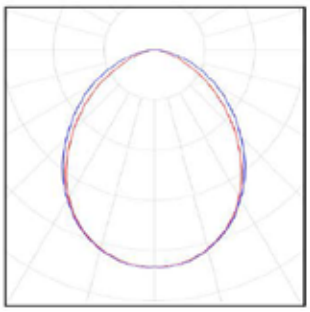
In the H&S residual risk file for Maastricht station, we explained how to safely lower chandeliers and what measures should be taken to prevent the risk of falling or the risk of falling materials (see page on the left).



View of the station from the back. The old fixtures on the left. The new fixtures with much less stray light on the right.

Disano Illuminazione - 995 Forma LED Disano 995 33W
CLD CELL sandblasted silver
Lichtuitstraling 1
Uitrusting: 1xLml3535l/995-97
Bedrijfsrendement: 100%
Lampenlichtstroom: 4378 lm
Lichtstroom armatuur: 4378 lm
Vermogen: 65.7 W
Lichtrendement: 66.6 lm/W

Kleurmetrische gegevens
1xLml3535l/995-97: CCT 3000 K, CRI 80



The data of the winning fixture. The light distribution/bundle (the optic) of the fixture on the right. The heart of the circles makes up the fixture. The majority of the luminous flux (Lm) radiates downwards and around 30% radiates to the side at a 45-degree angle.

2 Deventer, pilot with canopy and train hall lighting

Along with Haarlem, Deventer's station building is one of the best preserved monumental stations. Deventer station is elevated compared to the residential areas behind it. Residents who live to the west of the station face the bottom of the canopy. As a result, residents experienced glare from the lights in the evening. Inside the station building, colours of the building were poorly visible due to greenish mercury lamps with a colour rendering of 20%, with the requirement being 80% (R_a80).

The three photos above were made during the test of the canopy fixtures in 2015 conducted together with Koninklijke Visio.

2.1 Deventer: Test with canopy fixtures

For the national tender for framework contracts of the Lighting Programme, we conducted tests with LED fixtures under the canopy at Deventer. In consultation with a lighting consultant, we selected eight different types of surface-mounted fixtures. We put these up under a quiet section of the canopy 4 at a time. We had the fixtures assessed in 2015 by Koninklijke Visio (formerly Blindeninstituut) and a panel of visually impaired people. This allowed us to tighten the requirements of the visually impaired target group in 2016. The test resulted in the following conclusions:

1. A large luminous surface (large shade) feels less blinding
2. Less visibility from the side is more pleasant to the eye
3. To avoid glare, the luminance should be lower than 8000 Candela/m^2 (measured with a luminance camera aimed into the fixture).

We landed on the Disano fixture in 2016, with a flat shade and very little lateral projection (see fixture data on the left).

Because of the opal shade, the LEDs are hidden from the traveller's direct line of sight. This reduces the glare of the fixture. The opal shade, however, does reduce the Lumen per Watt ratio. The ProRail standard for LED is > 100 Lm/W and an incandescent lamp is 10 Lm/W. The Dialux data show that the Disano fixture consumes 65.7W and produces 4378 Lumen. This means that the efficiency of the fixture (including losses due to the opal shade) amounts to 66.6 Lm/W. The LEDs in the fixture have a higher Lm/W ratio, but the opal shades reduce the efficiency of the fixtures. We deliberately accepted the lower Lumen/W ratio in 2016, because we were prioritising stray light.

A transit is located on both sides of the fixture. It allows for power cables between fixtures to be neatly looped and strung under the shade. The fixtures were fitted with internal conduit cabling. When hundreds of fixtures are looped back to back in this way, the cross section of the internal conduit cable does need to be thick enough to carry the current of all the fixtures behind it.

Due to the elevation of Deventer station, residents living behind the station experience glare. The fixtures under the canopy are in the direct line of sight from their homes. In the photo on the left page, the old fixtures with convex shades on the left and the new LED fixtures with flat shades on the right. With a good optic, the light will only reach the intended location (the platform) and disruptive stray light is avoided.

The Deventer platform after replacement.

Tips and conclusions:
- Optics and flat shades can prevent nuisance.
- A suitable optic provides a lot of extra comfort at little cost.
- Conducting a pilot seems expensive but yields more than expected.

The fixtures with flat shades over the platform in Deventer after the LED replacement


V
3
10
8
6
4
107A
122

2014: poor colour rendering

The train hall of Deventer station, with the R_a20 mercury lamps.

2018: good colour rendering

The same train hall with R_a80 LEDs. The different colours of the masonry, the contrast of the signs and the windows are now much more visible. Faces are much easier to recognise. The new lamp has a crisper look.

2.2 Deventer: Improving the station train hall

Deventer was part of the first cluster of stations tendered with the Lighting Programme. The cluster was called 2 regio Noord Oost, NO02 for short. Four years later, NO had progressed to cluster NO45. In Deventer, we replaced old mercury lamps with a colour rendering of R_a20 in the station train hall with similar LED fixtures with a colour rendering of R_a80.

These LED fixtures were also applied in 2014, in an LED pilot at Den Haag Hollands Spoor station. Corvo fixtures with old light sources were causing a lot of outages in 2013. In anticipation of the Lighting Programme, these were replaced by LED. Wireless dimming controllers (TVIlight) were built into the fixtures (see chapter 1.6 on dimming) at the same time. Below is the Dialux data of the fixture used (Light International type Corvo). The efficiency of the fixture is 7970Lm at 94W (4x better than mercury lamps). RLN00012 requires 100Lm/W, but this fixture could not meet that standard back in 2016.

We later applied this kind of fixture (from other manufacturers as well) to monumental train halls and cannopies in Hengelo, Amersfoort, Den Bosch, Gouda and Hilversum. Those do achieve 100 Lm/W.

The adjacent bell-shaped graph describes the specifications of the optics. The LED light source is located in the centre of the inner circle. An axis was drawn around the light source every 15 degrees with the number of lumens emitted in that direction plotted on it. It shows that around a quarter of the light is emitted towards the ceiling and to the side. This makes these types of chalice fixtures very suitable for lighting a monumental ceiling or a canopy.

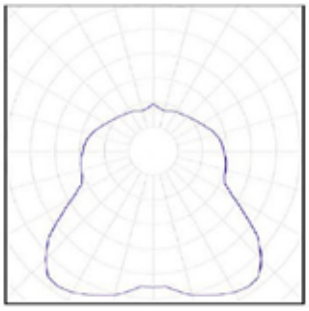
The new chalices are closed at the bottom with a transparent polycarbonate lid to prevent dust and cobwebs around the light source. The graph shows that the radiance perpendicular to the light source is slightly less than 10 degrees from the vertical. In practice, This is visible as a dark spot on the floor right below the fixture (just before the gates). This is a flaw in the lid's diaphragm and was improved in later versions.

Tips and conclusions:

- Replace mercury and sodium lamps with LED as soon as possible.
- Choose a fixture that also illuminates the ceiling.
- R_a80 (or even R_a90) yields a major improvement.

D&C - CRXL|94W|3K CRXL|94W|3K
Lichtuitstraling 1
Uitrusting: 1xLED
Bedrijfsrendement: 84.79%
Lampenlichtstroom: 9400 lm
Lichtstroom armatuur: 7970 lm
Vermogen: 94.0 W
Lichtrendement: 84.8 lm/W

Kleurmetrische gegevens
1xLED: CCT 3000 K, CRI -



The data of the winning fixture. The light distribution/bundle (the lens) of the fixture on the right. The heart of the circles makes up the fixture. The majority of the luminous flux (Lm) radiates downwards and around 10% radiates up.

Vathorst station after the LED replacement. The separate speaker posts between the lampposts are very much visible. We want to avoid such a forest of posts with the Multi Purpose post (see chapter 18).

3 Amersfoort Vathorst, test with lamp post fixtures

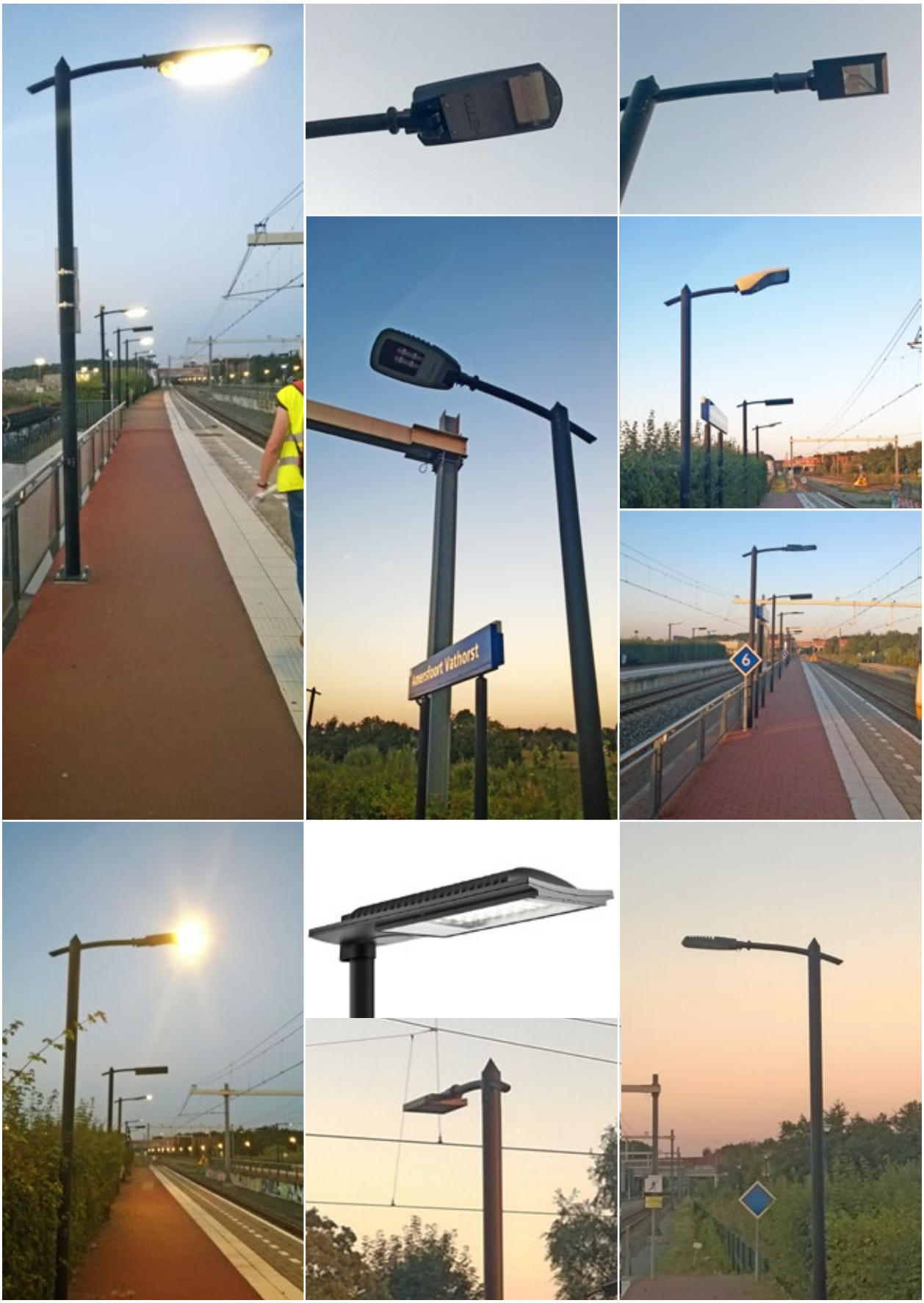
Amersfoort Vathorst station is a stop on the Amersfoort Centraal - Zwolle line. It features 2 side platforms. There are light and speaker poles on each platform.

Lighting posts sometimes bear the disadvantage of glare or a spotty light pattern on the platform. This is because they are relatively far apart. There tends to be a light source every 4 metres under a platform canopy. Open platforms, however, have a 4-metre high lamppost every 16 metres. So, a covered platform can be illuminated by 4 times as many light sources. This allows for the lamps under a canopy to be less luminous than on an open platform. Because open-platform lamps are required to be much more luminous, they often cause more glare. The Lighting Programme conducted a test in 2015 at Amersfoort Vathorst station to find out which type of fixture is still adequate and causes the least glare.

The requirement of a luminance of less than 8000Cd/m^2 is not feasible for lampposts spaced 16 metres apart. That is why the Lighting Programme does not apply the same luminance requirement to open platforms as it does to covered platforms. A lamppost with an old fluorescent fixture is especially glaring when travellers stand between the posts and look up at the fixture at a slight angle. Travellers never look straight up into the light source from under a lamppost, so glare is no issue here. To avoid blinding, visually impaired passengers often wear a cap with a sun visor.

Separate speaker posts with two speakers each are provided for passenger anouncements. The speakers are aligned parallel to the platform and rotated 180 degrees relative to each other. The two speakers should be separated by no more than 32 metres due to intelligibility. However, a post spacing (grid) of 32 metres is too much for lighting, so lampposts are spaced 16 metres apart. A separate speaker post (cf. OVS00022) is positioned between two lampposts every 32 metres (see the photo of Amersfoort Vathorst).
In order to minimise the number of obstacles on the platform, we now tend to install the speakers on lampposts every 32 metres. This eliminates 9 posts on a 300-metre side platform.

It is also possible to place one speaker on each lamppost every 16m. The advantage of one speaker per lamppost is that it looks less cluttered and the lamppost lid becomes less crowded (better for maintenance). The downside is that twice as many posts will have to be fitted with cabling for public announcements. In that case, all speakers are aimed in the same direction.



The dimensions of the casing and optics vary a great deal. The fixtures with the most LEDs (the most comfortable ones) also tend to have the largest luminous surface area and the largest casing.

Lampposts taller than 4 metres (5m) are sometimes spaced 20 metres apart. Lampposts on a side platform about 2.5 metres wide cannot exceed 4 metres in height. Should they unexpectedly fall over, 4-metre lampposts could never hit the overhead line. To prevent this risk, high lampposts were previously fitted with a post-rail connection, but this is no longer desirable given the construction, maintenance and inspection costs. On central platforms wider than 6 metres, however, 5-metre lampposts are allowed without pole-rail connections.

In consultation with lighting consultant R.J. Vos and Koninklijke Visio, the Lighting Programme conducted a pilot in 2016 at Amersfoort Vathorst station with LED fixtures on 4-metre-high lampposts spaced on a 16-metre grid. We had 2 test fixtures mounted on 2 lampposts every time, so we could see how they would interact between lampposts. In consultation with the light advisor, we selected, installed and assessed 11 fixtures. This allowed us to see how the lampposts' beams overlap and whether any dark spots emerge on the platform.

The test fixtures were usually fixtures intended to illuminate bicycle paths. They provide an oval beam on a strip of about 10 metres to the left and right of the lamppost with a width of 4 metres. An optic (lens) can be selected for each fixture to optimise the beam.

A lot of energy can be saved with optics. RLN00012 states that we want to achieve an Energy Performance of 0.15 W/m^2 on an open platform of a stop. If we light 16 metres of a 3-metre wide platform with one lamppost, this amounts to around 50m^2. At 0.15 W/m^2, this amounts to a 7W LED light per lamppost. However, if the optic is less efficient and, for example, also lights the hedge next to the platform or trough, the area becomes 16 x 5m = 80m^2. At 0.15 W/$m^2$12W is required. So, a less efficient optic requires a 60% heavier light source.

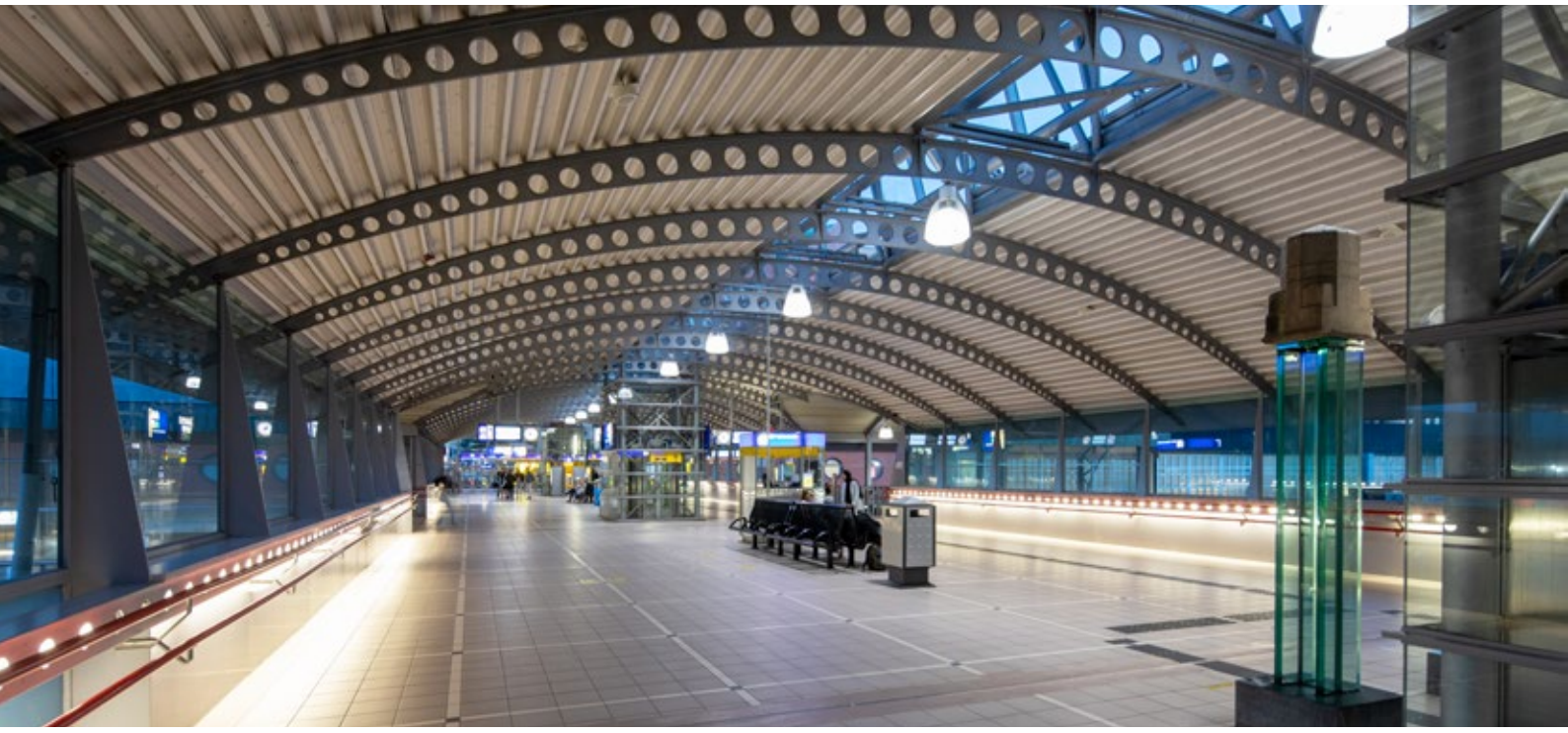
In September 2016, we conducted an inspection of the 11 x 2 LED test fixtures together with Royal Visio. Train drivers can also be blinded by the lamppost fixtures when passing through a station. For that reason, we involved train drivers in the inspection through the work group MOOS ("Met Oog Op Seinen") and included their experiences.

The fixtures were set for 20 lux on the platform (setting for large stations). This should be 5 lux at stops and 10 lux at slightly larger stations (Basic and Plus). If LED fixtures for smaller stations are dimmed 50% or 75% ex-factory, glare is decreased while energy performance and lifetime are increased.

Tips and conclusions:

1. The fixture containing the highest number of LEDs (24 pieces) resulted in the least amount of glare.
2. As the number of LEDs in a test fixture increased (4, 12, 16 and 18), the light became less blinding or unpleasant.
3. To avoid glare to Train drivers, the tilt angle should not be set to illuminate the trough.
4. Fixtures with mirrors are usually intended for architectural lighting or indirect lighting. This may cause unexpected glare from one specific angle that does not occur just a few steps to the side. That is why fixtures with mirrors are less suitable for platforms and bicycle paths where users look into the fixture at different angles.

The test lighting setup at Amersfoort Centraal, with one LED chalice in warm white (2700K). This is the same colour as the line lighting along walls. In the background, an old mercury lamp with greenish light, with a colour saturation of just 20% (R_a20), while RLN00012 now demands 80%. At R_a20, only 20% of the colours are discernible (pretty much just light and dark contrasts) and faces cannot be recognised. Difficulty recognising faces makes people feel unsafe. At R_a80, enough colour is visible to recognise faces.



The indoor passage after replacement of all chalice fixtures in the evening situation, with warm white light. The floor is uniformly lit in one colour, which has a calming effect. The optics aim more of the light upwards, making the roof look better with crisper colours.

4 Amersfoort Centraal

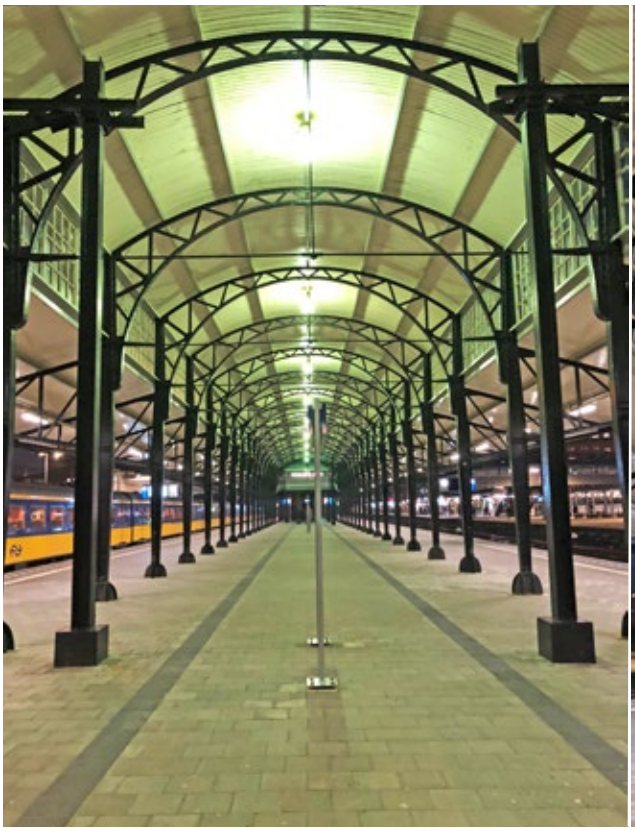
4.1 Test lighting Tunable White on the indoor passage

The indoor passage at Amersfoort Centraal was lit by the same mercury lamps as the train hall in Deventer. Light on the floor was spotty and the (train hall) roof seemed dirty grey in the evening.

Amersfoort Centraal is a Mega-type station. The indoor passage is the busiest part of the station. That is why the mercury lamps were replaced with 'breathing light' in accordance with the 2015 light vision by Bureau Spoorbouwmeester. Breathing light means that the light colour breathes along with the colour of daylight (cool white in the morning and warm white in the evening). This was visionary back in 2015, but come 2022 and almost all manufacturers offer it under the name of Tunable White. Light colour is expressed in degrees Kelvin. In the morning, daylight is around 5000K (cool white from the bright early morning) and 2700K around sunset (warm white or the yellowish light of a sunset).

When lighting also has the purpose of achieving a better atmosphere and experience, a trial is the best method. Trial lighting (with one or two fixtures) can be used to assess whether the intended effect actually occurs in practice. Adjustments can still be made based on the test, for example in the number of fixtures, suspension height, illuminance (lux), centre-to-centre distance, the optic (uniformity) or light colour.

Tips and conclusions:
- Tunable White is a good solution for busy locations with a cluttered appearance.
- But the less busy the location, the less likely Tunable White will be cost effective.



The canopy at Amersfoort Centraal with the old mercury lamps. The chalices match the architecture, but give off a greenish light and were installed too close to the canopy. As a result, the canopy is lit in spots.

The test lighting setup with just one LED chalice on a pendant. The greenish mercury lamps can be seen close to the canopy behind the test fixture.

The platform canopy with new LED fixtures on pendants in the centre of the canopy and new LED strips (light colour 3000K) above the tactile paving under the flanks of the canopy.

4.2 Trial lighting for monumental roofs with LED fixtures in 2 colours

Amersfoort Centraal has 3 platforms. Platform 2 has a monumental canopy. All 3 platforms are much longer than the indoor passage, which makes them much less busy. As a result, Tunable White is too expensive for application on the platforms.

In order to improve the visibility of the architecture and illuminate the (train hall) roof more evenly, the light designer had the new chalice fixtures suspended on a pendant in the centre of the arches. In addition, we had an LED chalice fixture developed with a gold-coloured mirror ring inside. The LED light source in the chalice has a light colour of 3000K, but the mirror ring makes for warmer light hitting the canopy at 2200K.

After the assessment of the trial lighting, all new chalice fixtures were put up under the canopy.

Tips and conclusions:

– When Tunable White is too expensive, coloured mirrors can help illuminate a monumental ceiling with warmer light than the floor.
– A fixture on a pendant lights the ceiling much more evenly than a fixture installed close to the ceiling, without much extra cost.

Above: the spotty light on a platform at Almere Centrum station in 2016. Below: The new situation with much higher illuminance and improved uniformity.

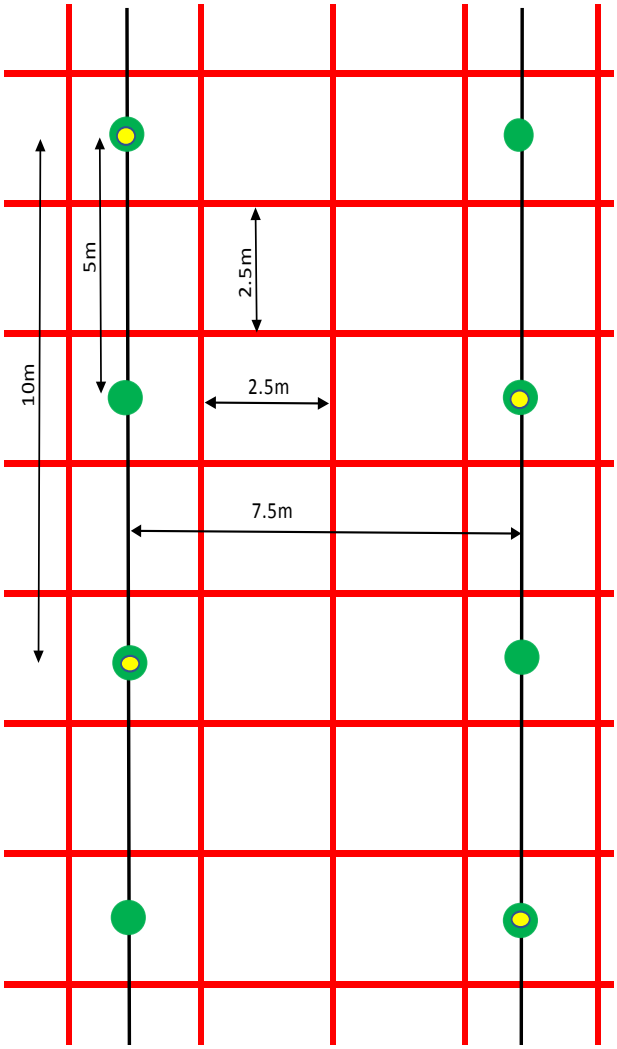
5 Almere Centrum, a new light impulse for an eighties icon

Almere Centrum is one of Bureau Spoorbouwmeester's 50 'Collection Stations'. The station was designed in the 80s by architect Peter van Kilsdonk. Each function of the building has a different colour. The construction is red, rainwater drains blue and electrical installations green. The canopy of Almere Centraal is a large red truss construction with compartments measuring 2.5 by 2.5 metres.

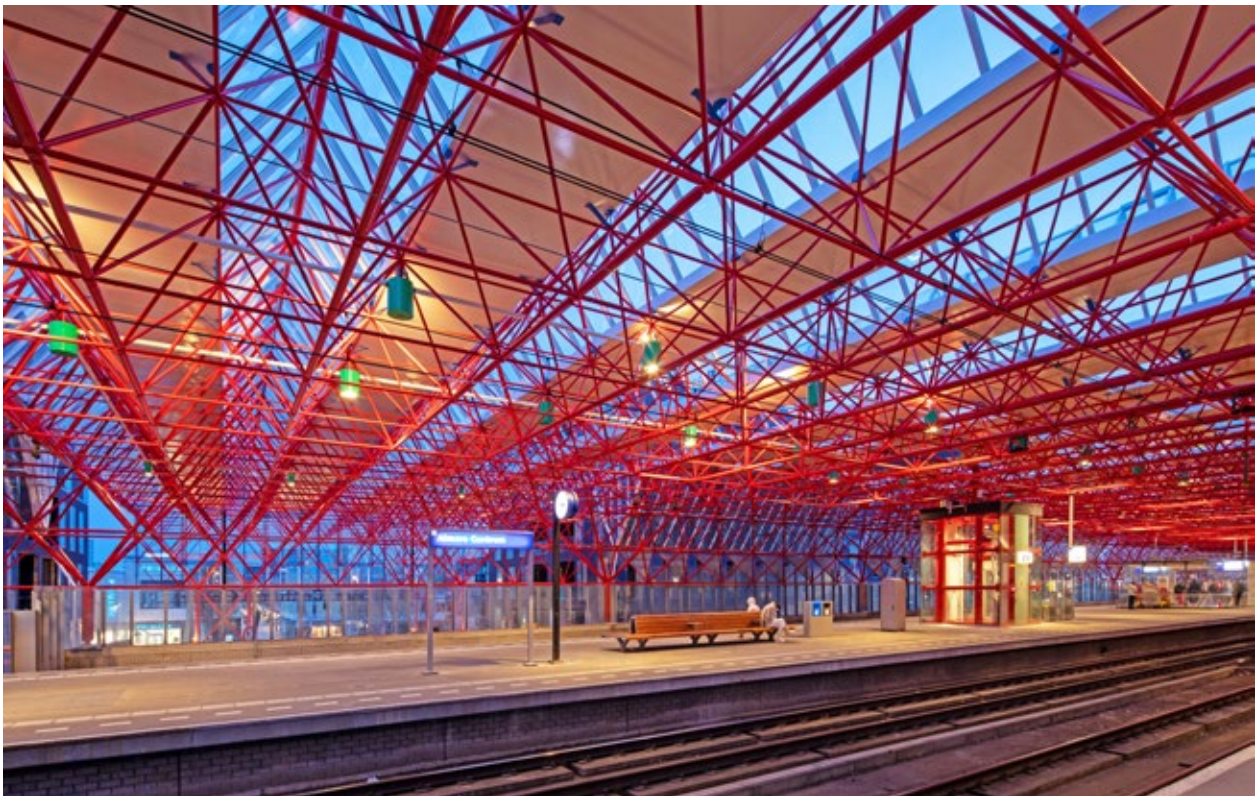
The platforms at Almere Centraal are lit by green down-lighters suspended off the canopy every 10 metres. A green speaker for public announcements is located between each pair of downlighters. The downlighters are actually spaced too far apart and, as a result, the platform did not meet the required illuminance and uniformity.

Almere Centrum is a Plus-type station. For Plus-type stations, the ProRail directive requires an illuminance (E_m) on the covered platform of 50 lux with a uniformity (U_0) of 0.5. The E_m was just 20 lux with a U_0 of 0.2. As a result, the station felt dark and unsafe at night. After converting the downlighters, the illuminance is now 55 lux with a uniformity of 0.5.

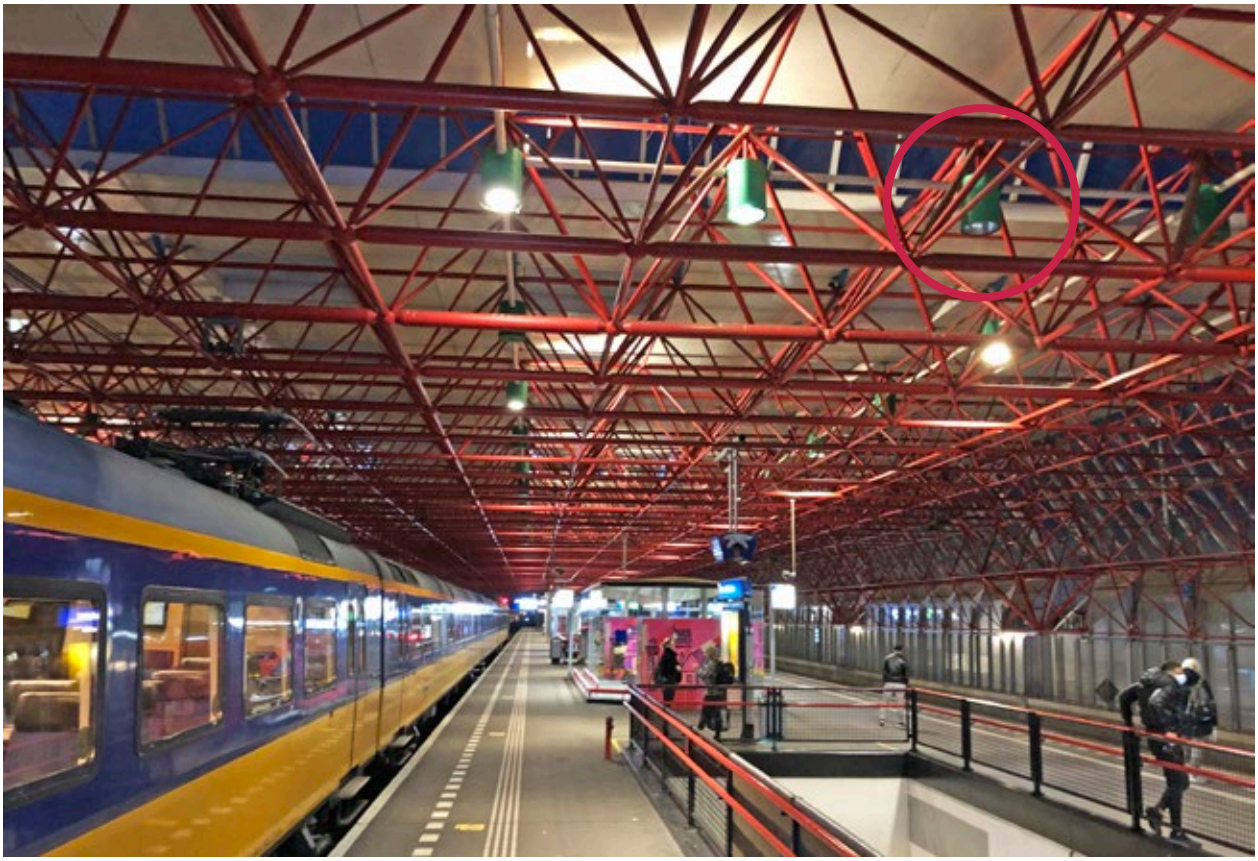
The downlighters only illuminate the platform. As a result, the truss construction of the canopy was not visible at night and loomed over the platform like a dark cloud. Spoorbouwmeester wanted to make the canopy more visible at night (just like in Tilburg, see chapter 25), with horizontally aimed spotlights shining through the truss construction. On the bottom left you can see the effect of the architectural lighting added in the canopy.



Positions of lamps and speakers relative to the red 2.5 x 2.5-metre trusses. Above the platform, there is a speaker (green sphere) every 10 metres and a downlighter (green sphere with yellow dot) every 10 metres as well. The lamps and speakers alternate for uniformity purposes.



The present lighting situation. A slightly darker spot exists under the speaker (between the downlighters). Because the illuminance is much higher, it feels more comfortable. The canopy is more visible. We installed horizontally directed LED spotlights on top of the downlighters to illuminate the trussing from the inside out (i.e. away from the platform to avoid glare).



The downlighter in the red circle above the stairs is faulty and had not yet been replaced at the time of the photo. To replace it, a scaffold had to be built above the stairs. This was done during an overnight out-of-service period.

There have been several plans to improve uniformity. There was a plan to run a red cable duct through the trusses at 6.6 m height, with an LED bar above the tactile paving in each section (every 2.5 metres). There was a plan to replace the speakers with additional LED downlighters. Spoorbouwmeester, however, wanted to preserve the original design. For that reason, we had new interiors developed for the existing downlighters with an oval beam to illuminate a 12-metre by 6-metre platform area from a height of 6.6 metres each. At first, the contractor failed to achieve 50 lux. This was due to an error in the light calculation. The LED drivers were adjusted and the average illuminance of 50 lux with a uniformity of 0.5 is now achieved.

The biannual replacement of the mercury lamps with scaffolding above the stairs was extra expensive, see photo caption in the bottom left. In the event of occasional failures, repairs were often delayed until the scheduled replacement maintenance, so the lighting above the stairs had been inadequate for quite some time prior to the LED replacement. Now, the LED downlighters only have to be replaced once every 10 years. This also provides a better guarantee that the station will remain 'safe and whole' over the years.

Tip:
- Consult Spoorbouwmeesters at an early stage.
- The visibility of a canopy or roof can be improved dramatically at relatively low cost.
- This makes for a much better social safety experience in the evening.

The spotlights in the truss was covered with a shade to prevent glare.

Alkmaar station, the old situation with the old fixtures in zone A

6 Alkmaar, easier to maintain due to fixtures from zone A to zone C

Alkmaar station consists of a side platform, a middle platform with a monumental canopy, a middle platform with a modern canopy and a modern indoor passage. The indoor passage was built over the old canopies in 2012 and was fitted with LED lighting from the start, unfortunately with a lifespan of just 5 years while 10 years is now the standard.

The canopies and open platforms had not yet been fitted with LED lighting. Cable ducts were suspended under the canopies with cables for lighting, audio and CCTV.
The cable duct with the fixtures was largely located in zone A (between the dotted line and white platform edge, see photo on the left). In this situation, faults can only be resolved in out-of-service mode. As a result, repairs of broken lamps or flickering fluorescent lamps were often being delayed too long (poor score on the 'Clean and Whole' KPIs).

In zone C (above the tactile paving),the Lighting Programme installed new cable ducts with LED fixtures underneath. As a result, the centre of the platform is illuminated more evenly and faults can be remedied during the day without decommissioning.

The monumental canopy with the new lighting

The monumental canopy with the new LED lighting under the new cable duct.

Platform 3 (the modern canopy) with the new cable duct in zone C and the old duct in zone A. You can still see the poorly painted pots on the old duct where the old fixtures used to be. These places have now been painted.

The new cable ducts were concealed by coating them in the same colour as the canopy. We did not remove the old cable ducts to prevent unnecessary issues with public announcements and cameras.

Tips and conclusions:
- Avoid fixtures in zone A or B.
- Remove them to zone C.
- Fixtures located towards the centre make for a more evenly illuminated platform.

The new lighting: the day scenario on the left, dimmed for the night scenario on the right.

7 Leeuwarden, new life for a monument with architectural lighting

7.1 Leeuwarden station train hall

Leeuwarden station is a national monument and boasts an impressive monumental station train hall, just like Groningen station. Next to the train hall, NS operates a ticket and service desk and several commercial spaces. In order to attract customers, NS always wants more light in commercial zones than prescribed by the standard. Due to the difference in illuminance between the train hall and the commercial zone, the train hall always seemed dark while meeting the standard with a margin.

In 2018, Leeuwarden was the cultural capital of Europe. For that reason, several ProRail projects in the vicinity of the station had to be completed before 2018. This included the underground bicycle parking, renewing the 150-year-old platform canopies and also replacement of the lighting in the train hall.

During the day, the train hall is illuminated at almost the same level as the commercial zone and the difference is no longer visible. We replaced the lighting in the train hall with adjustable LED lighting. The ceiling and walls are illuminated with indirect light, which improves the visibility of the paintings and masonry. During the day, the output of the indirect lighting is higher and in a lighter colour than at night.

Tips and conclusions:
- Involve a light architect, especially for monuments.
- A light architect will have to be held back at times, but do retain the foundation of their ideas.

Left: the old lighting mostly reaches the floor. The building has a gloomy and old-fashioned look. Right: the new lighting makes the monumental character of the building much more visible. (Photo: Nathalie Peters for LichtNL).

The old situation (canopy not illuminated).

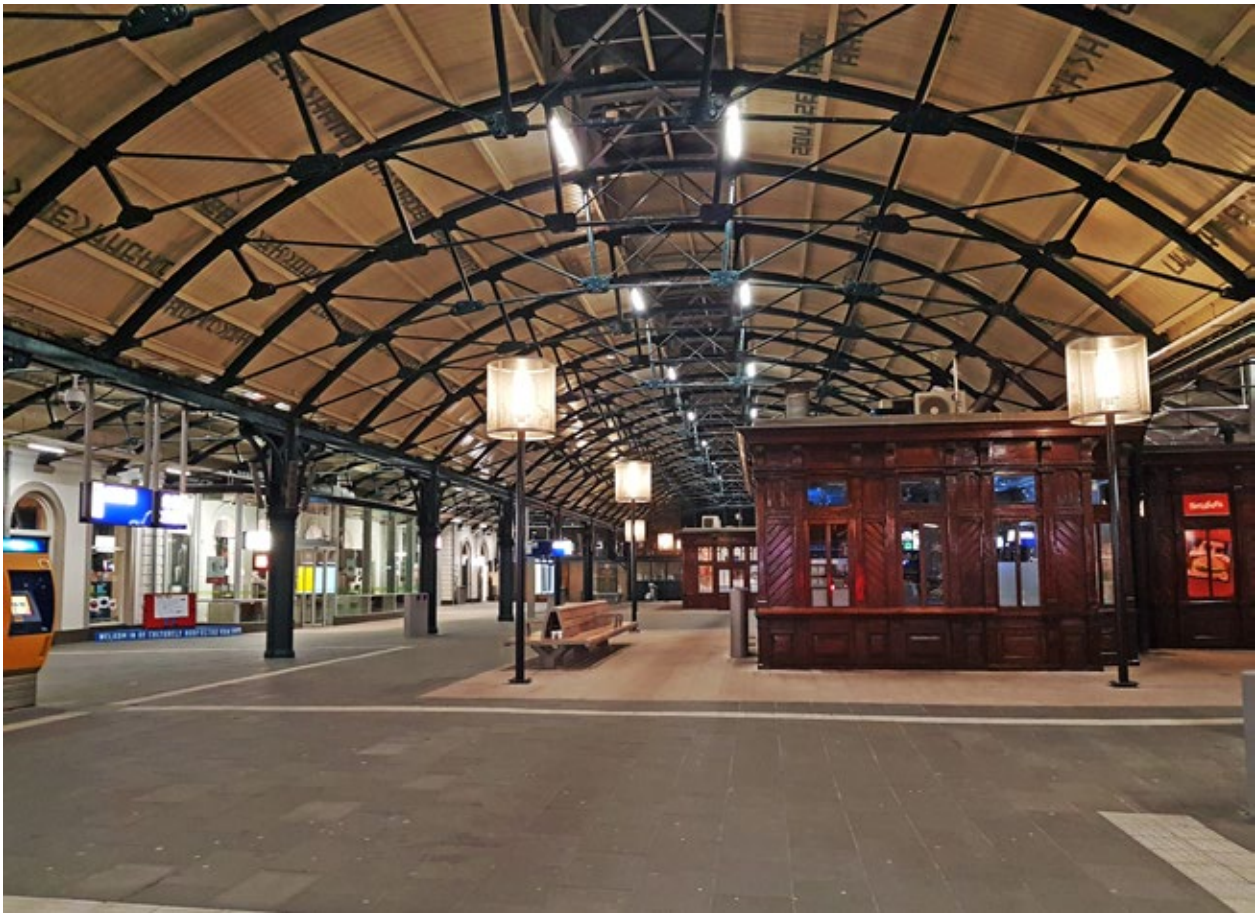
With new lighting in the day scenario, with illuminated canopy.

7.2 Leeuwarden canopy

Adjustable LED lighting was also installed under the canopy between the train hall and the platforms. A somewhat homier atmosphere was achieved by installing 'table lamps'. The monumental canopy was coated with a new layer of paint and its illumination has been improved. The canopy is covered with poems intended to draw the travellers' attention. The canopy is slightly less illuminated at night than during the day (when it is lighter outside as well, see photos).

Tips and conclusions:

- Lighting a freshly painted monumental canopy works perfectly.
- Be sure that the canopy is lit evenly without blinding the passengers.
- The poems on the canopy do not attract as much attention as expected, the effect is disappointing.
- The table lamps look great but are vulnerable (have been removed).



With new lighting in the night scenario, with illuminated canopy.

The vintage lampposts (80 x 40 tubular lampposts from 1970, also known as Douma gallows after then Spoorbouwmeester Cees Douma) were fitted with new LED fixtures. These 5-metre-high lampposts illuminate the wide platform with sufficient uniformity. The lamppost contains a dimming sensor, around half a metre below the outrigger.

The fixtures under the canopy were moved inwards (from zone B to zone C). The centre of the platform under the canopy is less dark as a result.

8 Santpoort Zuid, an old station deserves attention too

The canopy at Santpoort Zuid station is not a national monument or a Collection station, but it is a great-looking old iron canopy. The station building was designed by architect Margadant who also designed Haarlem station.

The problem was that the fluorescent lights were located under the canopy on the outer-most (train hall) roof beam in zone B and could only be replaced after decommissioning. The fluorescent lights were being replaced every 2 years, but intermediate breakdowns were often not remedied.

When renewing the surface-mounted fixtures, we placed the LED fixtures one (train hall) roof beam inwards, above the tactile paving (in zone C). Because the fixtures were moved slightly more towards the centre of the platform, the centre is now less dark as well. We installed additional fixtures above the stairs to the tunnel because the lux value was insufficient on the stairs. The canopy now looks better and the platform is less spotty.

We fitted the vintage five-metre-high rectangular lamp-posts with LED fixtures and dimmers. The five-metre posts are high enough to sufficiently illuminate the wide platform.

Tips and conclusions:
- An old station that is not a monument deserves attention just as well.
- A subtle difference can be made with small adjustments.

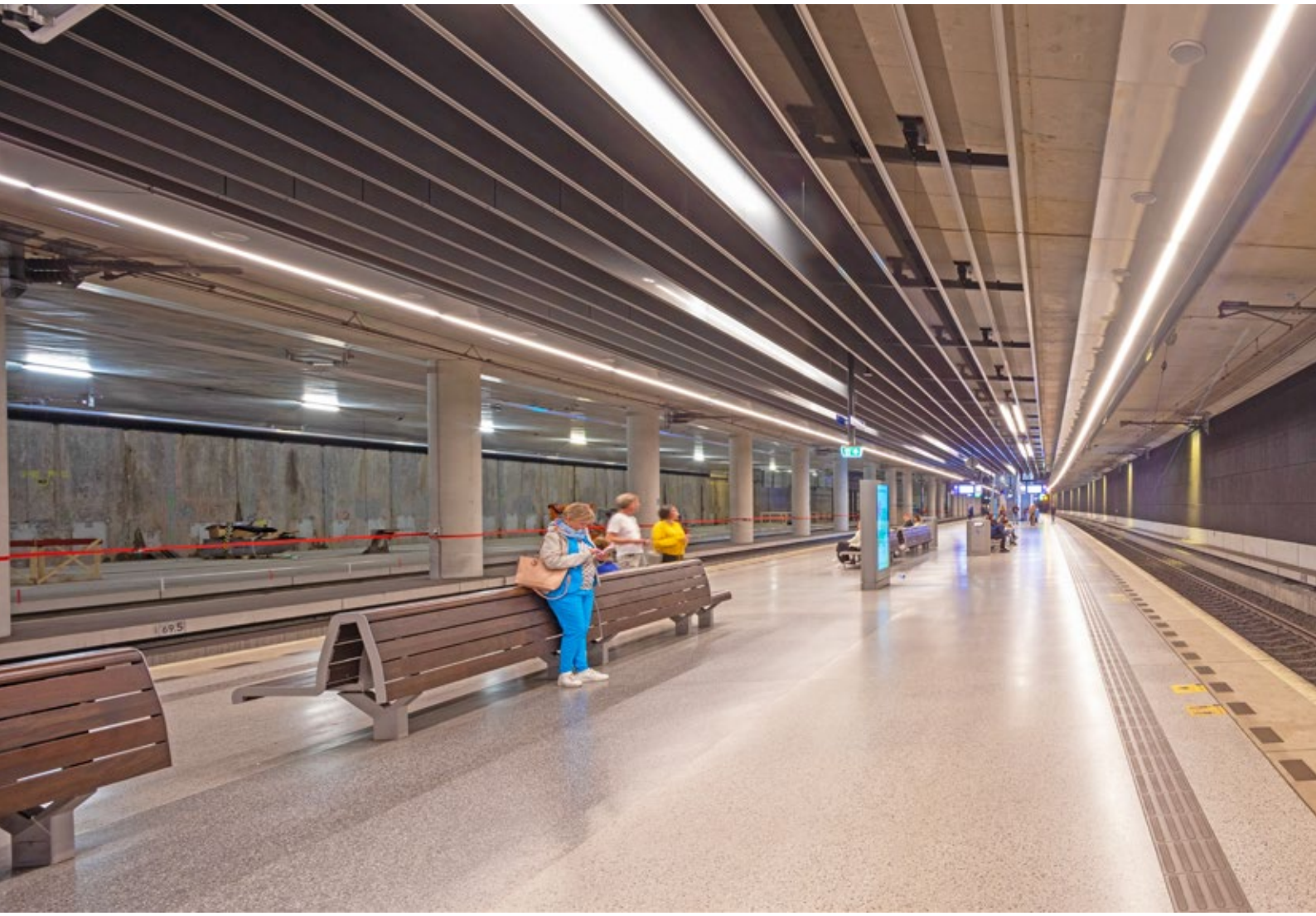
The sleek canopy at Den Helder station. Cables, ducts and pipes were concealed in the central girder (custom fixture in the girder cleaned and fitted with tailor-made LED interior).

9 Den Helder, architectural canopy lighting restored in LED

Den Helder station has a spacious canopy with concrete columns in the centre only. The columns bear a central girder where all installations (fixtures and rainwater drainage) are bundled. No cable ducts, surface-mounted cables or pipes can be seen under the canopy, creating a calmer look than many other stations. Recently painted, the canopy looks sleek and tidy. Under the central girder were fluorescent fixtures that used mirror optics to illuminate the platform and canopy. No blinding fixtures enter the travellers' line of sight.

Just like in Weesp or Alkmaar, the Lighting Programme could have installed a cable duct with functional lighting above the tactile paving. We decided against it in order to preserve the look as intended by the architect. The Programme decided to have the light strip under the central girder recreated in LED. As such, the seemingly unimportant canopy (no monument, no Collection station) is not cluttered any further and still looks sleek and tidy.

Tips and conclusions:
- Do justice to the architect's intentions.
- Discuss this on site with the contractor during a site survey.



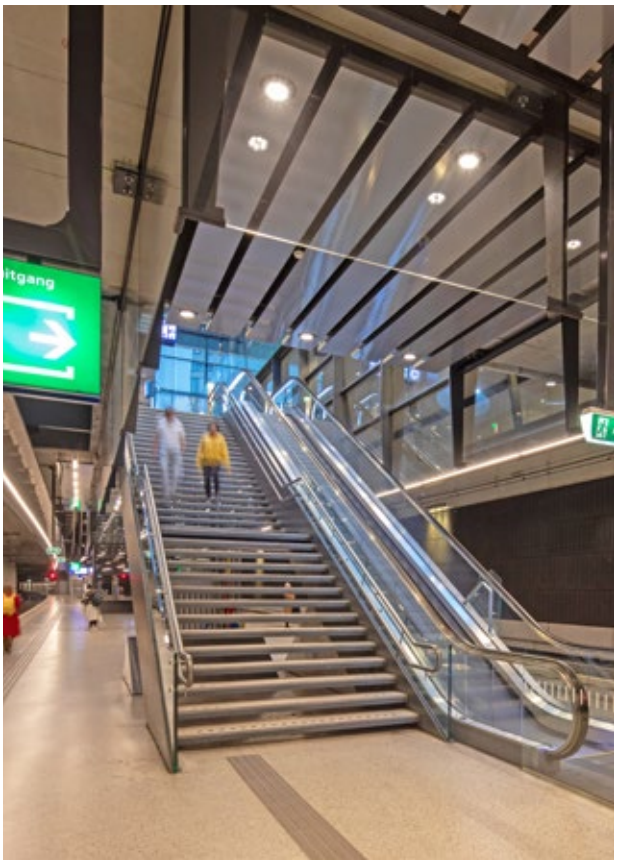
The light lines along the platform edges after replacement. The spotlights between the slats were replaced with LED as well.

10 Delft, 1000 fixtures in 52 hours

Delft station is one of the few fully enclosed (underground) stations. Other fully enclosed stations are Rijswijk, Best and Schiphol. A fully enclosed platform requires 200 Lux. That is why a continuous fluorescent light strip was fitted above the platform in Delft upon delivery in 2015. The existing light strip was converted with LED internals from the original supplier in 2019. A decommissioning of 52 hours was scheduled in 2019 to work the second tunnel tube. During this decommissioning, the station in the first tunnel tube was out of service as well with no work planned. In the space of these 52 hours, the contractor was able to convert the approx. 1000 fluorescent fixtures to LED. The work was carried out with dozens of technicians and a large number of aerial platforms simultaneously, following a script with military precision. Another decommissioning was scheduled for a few weeks later, which the contractor could use in case the task would not be completed in the first 52 hours, but as it turned out, this was unnecessary.

The train hall was already lit by LED, so no need for conversion there. A few places with insufficiently lighting remained above the stairs; extra spotlights were installed there.

Tips and conclusions:
- Always try to hitch a ride with scheduled train-free periods (TFPs).
- Let the installer join the TFP meeting.
- Have a plan B for potential delays.



There was too little light on the halfway platform of the stairs. Additional spotlights were installed (behind the slats).

The spotlights in the train hall were LED already.

Uplighters cool white and downlighters warm white at the two central platforms at Rijswijk station.

11 Rijswijk, replacement and dimming of light lines of 1174 fixtures

Rijswijk is a rather bleak station in a tunnel. There are only a handful of underground stations in the Netherlands (Delft, Rijswijk, Best, Schiphol). Fully enclosed platforms are subject to an illumination requirement of 200 lux, which is twice the amount required for above-ground stations. This standard matches that of Amsterdam's metro.

A lot of design work has been done at Rijswijk station to make the station less gloomy. Besides the functional light strip (about 470 fixtures on the 2 central platforms), the (train hall) roof is also illuminated indirectly with 704 fixtures. The intention is to illuminate the (train hall) roof more strongly during the day than at night, to give the impression of daylight. The (train hall) roof fixtures are cool white (4000K) and the platform fixtures are warm white (3000K).

The platform in the tunnel is longer than the longest Intercity that should be able to stop there in case of time-table disruptions (about 400 metres). In the regular time-table, however, only Sprinters stop at Rijswijk.

The Sprinters always stop on the south side of the platform. The platforms have an entrance building with stairs and lifts on the south side but also on the north side (the Pyramid). Travellers are nudged to the south-side entrance, as that is where the shops are located. The northern entrance is empty almost all the time.

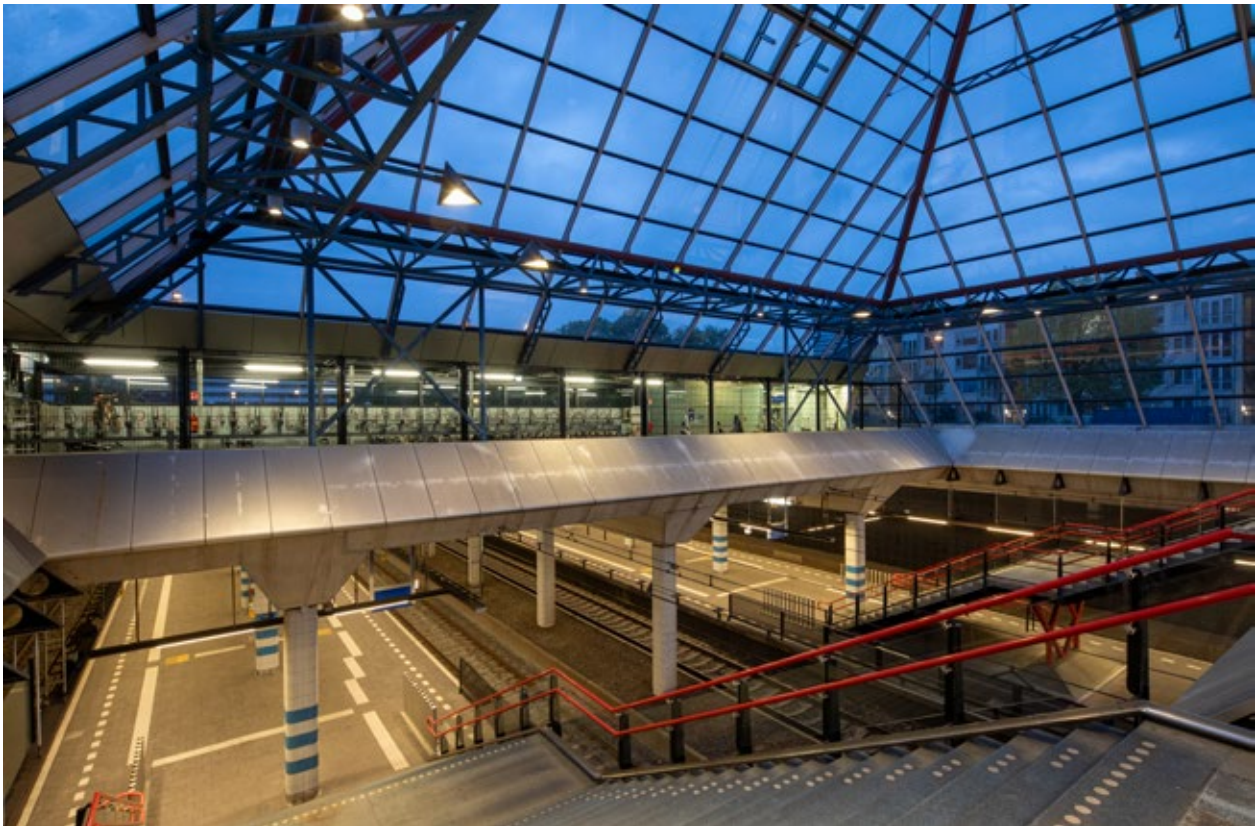
The station manager wanted to use the light to show waiting passengers where the Sprinter's stopping zone is located. We did this by keeping the lights on permanently for the first 150 metres of the platform.

In the back of the platform, sensors were placed every 30 metres and the lights are dimmed to 20% in the absence of passengers. As a result, travellers are not tempted to wait in the dark area (usually not serviced by any trains).

Should someone stroll into the dark area anyway, the light will switch to 100% 30 metres ahead of the passenger. Because it remains at 20% after 30 metres, they are not tempted to keep walking.

Sensors above the platform spaced every 30 metres

Rijswijk station with 3000K downlighters and 4000K uplighters.



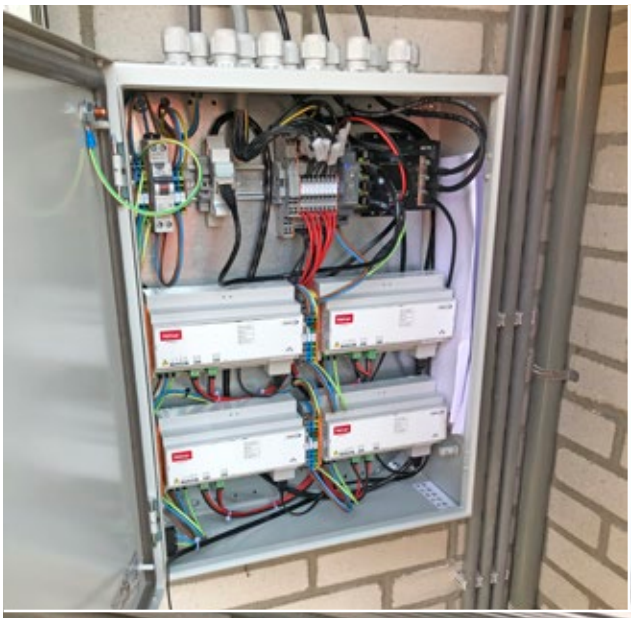
The entrance on the north side of the platforms at Rijswijk station (The Pyramid) is barely used.

After the last train, the lighting dims to 10% to avoid attracting any vandals. Should someone step onto the platform, the lights switch to 100%. This is to prevent e.g. homeless people from sleeping on the platforms (though night intercity trains pass the platforms).

The 24 sensors and the approximately 1,000 dimmable fixtures are connected to Helvar dimming controllers in the technical room using a Dali (4-wire) control cable. One Dali bus can control 128 fixtures. 9 Controllers were installed divided between 2 technical rooms.

For service purposes, a service gateway (with SIM card) was installed in the technical room, allowing Helvar to remotely view and, if necessary, correct settings during the 5-year warranty period.

Tips and conclusions:
- Working with light colours helps in a gloomy-looking tunnel.
- Light can entice travellers to go to a boarding zone.
- Light can keep unwanted visitors away from dark areas.



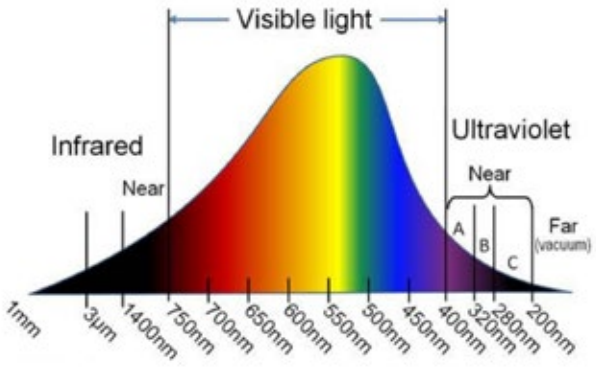
Blue light next to the lift by the southern end of the platform.

12 Rijswijk and Zoetermeer Oost, anti-suicide lighting

Rijswijk station has the highest suicide count of all stations in the Netherlands (around 2 per year on average). Rijswijk station has 2 centre platforms in a tunnel. Many intercity trains pass the tunnel. There are many places for a suicidal person to isolate themselves at the ends of the platforms. The Japanese subway tested blue light as an anti-suicide measure. No tests with blue light were conducted in the Netherlands as of yet. Rijswijk was appointed as a pilot location.

12.1 Rijswijk, intended effect of blue light at platform ends

Blue light tells our nervous system that it is morning and we need to get ready for a new day. Light in the wavelengths of 436-495nm (blue) affects alertness by producing the hormone cortisol. This substance is similar to adrenaline and readies the body for a fight, flight or fear response. Melatonin (sleep hormone) is suppressed by cortisol. Blue light is barely visible. Blue light lamps should have only one frequency (around 470 nm) and not emit frequencies in the harmful ultraviolet range.



Blue light has a wavelength of around 470 nm. but must be free of harmful Ultraviolet light. The idea is for the blue light to give a suicidal individual a cortisol boost, thereby pulling them out of their negative thoughts and increasing the odds of them calling 0800-0113 or change their mind.

Rijswijk station in 2017, the end of the platform on the north side. Travellers were able to walk into the tunnel at the end of the platform using a ramp.

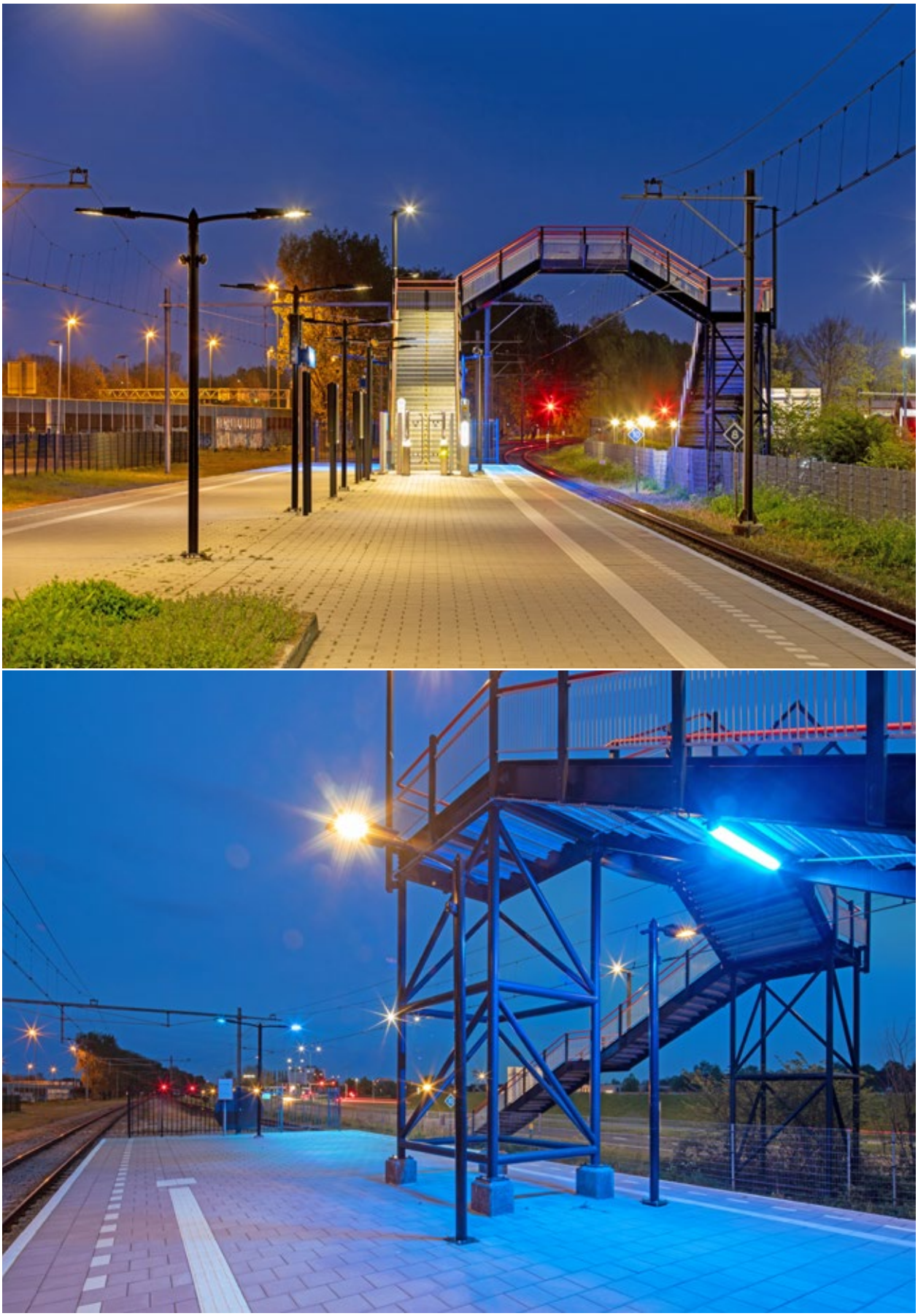
The end of the platform, right. Though daylight can be seen during the day, it turns into a gloomy place in the evening and at night.

On the Rijswijk platform, the illuminance of the blue light is 200 lux, just like the platform lighting. Blue light works best with an illuminance between 100 and 800 lux.

Fences and signs reading 'Call 0800-0113' (suicide prevention helpline) were installed in 2017. The fences should be able to open as an escape route (e.g. in case of fire). Suicidal individuals can still walk into the tunnel, but the blue lights will come on when they do. Blue lights were also installed further down the tunnel; they will switch on when someone walks into the tunnel.

Tips and conclusions:
- Blue light is a potential solution for suicide prevention
- However, hard evidence that it actually works does not exist yet.
- Still, ProRail went for it because each suicide attempt is one too many.
- Allow the blue light test to continue for as long as possible, combined with other measures.

The end of the platform on the north side upon delivery in 2019, when the blue light turns on. Fences were installed to block off the end of the platform. The fence can be opened as an escape route, but was fitted with signs about the suicide prevention line 0800-0113.



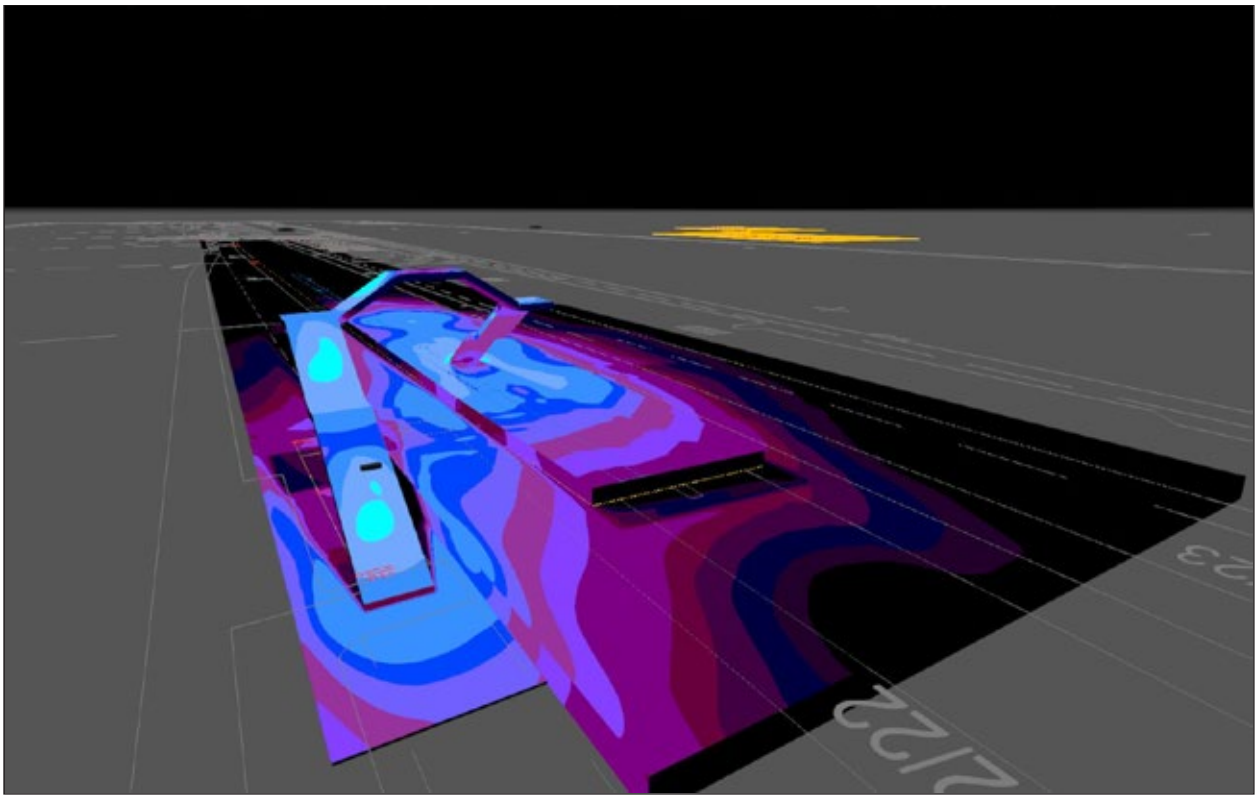
The open walking bridge near the end of the platform (after LED replacement).

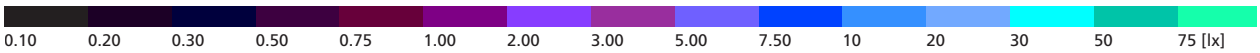
12.2 Zoetermeer Oost platform end with blue light

Zoetermeer Oost is quite a gloomy station with a poor score on the suicide statistic, just like Rijswijk. We improved the dark spots on the foot bridge by installing improved fixtures. This was not easy, because the fixtures on top of the walking bridge cannot be blinding the train drivers. For this reason, we integrated the lighting into the red tube railing on the foot bridge rather than installing lampposts.

Behind the foot bridge, there is a dark spot where suicidal individuals may isolate themselves. That is why Zoetermeer Oost station has been fitted with blue light fixtures on a lamppost behind and under the walking bridge: Fixture: Pracht, Tubis, 1909 Lm, 44W, 1285 mm., Dimmable (Blue light), RAL9005 (black).
Attention: 1909 Lm / 44W = 43 Lm/W; meaning that the light output of blue LEDs is still far removed from the 100Lm/W we require for white LEDs.

Tips and conclusions:
- Think carefully about where the dark corners are at stations and close them where possible.
- Do not blind the train driver with lighting on an open walking bridge or above the track.





The light calculation shows that the places under the open stairs around the end of the platform are now properly lit as well (10 to 20 lux, see legend under the image).

Historic cast iron lampposts at Vlissingen station fitted with custom LED fixtures and new transparent shades.

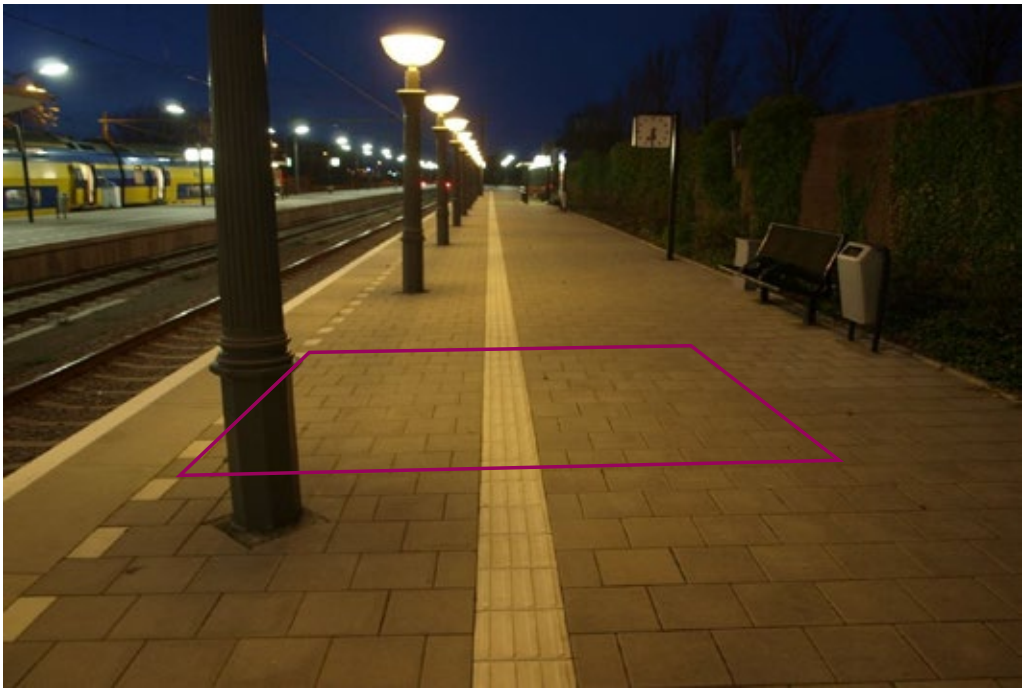
13 Vlissingen, historic cast iron lampposts converted

The Vlissingen platform features historic cast-iron lampposts. The lamps on these lampposts had no optics and illuminated the platform in circles around the lampposts.

The existing lampposts were revamped with bespoke LED conversion units. The shades were replaced by transparent plastic shades (polycarbonate), reducing the amount of stray light. A prism optic was mounted above the led source, which focuses the light across the platform, preventing it from entering the trough. The LED light source illuminates the mirror from below so travellers are not blinded.

Station: **Vlissingen** **Locatie** **Perron nummer: 1.**

Horizontale lichtmeting:	Norm:	Open perron (Basis/+)	H.o.h.	8 m



Meetpunt:	Lux:	Meetpunt:	Lux:	Meetpunt:	Lux:
1.	21,2	2.	20,1	3.	15,5
4.	21,5	5.	23,4	6.	15,7
7.	22,6	8.	23,8	9.	18

Uitkomsten			
		RLN00012 (V008)	
	Berekende waarde	Norm:	Voldoet:
Lux gem. (Em)	20,20	10	Ja
Gelijkmatigheid (Uo)	0,77	0,3	Ja

Above, the zero measurement at Vlissingen station. The old lighting was compliant the way we found it. The lampposts were converted to LED in view of energy savings and less maintenance.


2
2

The covered part of the platform also rests on the old cast-iron lampposts. No artificial light is needed here during the day, because enough light enters through the transparent skylight. A great example of the basic rule ‘daylight unless’ in RLN00012. We replaced the built-in fixtures in the existing canopy with LED built-in fixtures.

Tips and conclusions:
- Always try to preserve historic elements.
- Transparent shades on fixtures reduce loss and stray light.
- When applying transparent shades, ensure the light source is not blinding.
- Give old lampposts and constructions a second life with new technology.
- Renovation is more sustainable than new construction.


WC

14 Goes, convert indirect lighting to LED

At Goes station, the train hall was indirectly lit by fluorescent lamps behind a cove that radiates light downwards and upwards. The cove extends into the tunnel. The cove is a nice architectural addition that makes the façades of the commercial outlets below the cove more visible and also highlights the remarkable concrete structure above the cove. Thanks to the cove, the fluorescent light illuminates the floor without passengers being able to get blinded by looking straight into the light source. The principle works well, which is why we left the cove in tact. We replaced the surface-mounded fluorescent fixtures behind the cove one-on-one with equivalent surface-mounted LED bars.

We also replaced the built-in fixtures in the light rail in the middle of the hall one-by-one.

Tips and conclusions:
- Indirect lighting tends to feel calmer than direct lighting.
- If a design works well, try to renovate it one-on-one.
- This will eliminate the need to rethink indirect lighting.

Station: **Amsterdam Sloterdijk** **Locatie** **Perron nummer: 5.**

Horizontale lichtmeting:	Norm:	Overkapt perron (Mega>)

Meetpunt:	Lux:	Meetpunt:	Lux:	Meetpunt:	Lux:
1.	459	2.	493	3.	473
4.	468	5.	499	6.	468
7.	456	8.	501	9.	474

Uitkomsten			
		RLN00012 (V008)	
	Berekende waarde	Norm:	Voldoet:
Lux gem. (Em)	476,78	70	Ja
Gelijkmatigheid (Uo)	0,96	0,4	Ja

Zero measurement at Amsterdam Sloterdijk at the fully enclosed platforms at the ground level. The illuminance was 400 lux day and night because the daylight control was faulty. It should be 400 during the day and 200 lux at night.

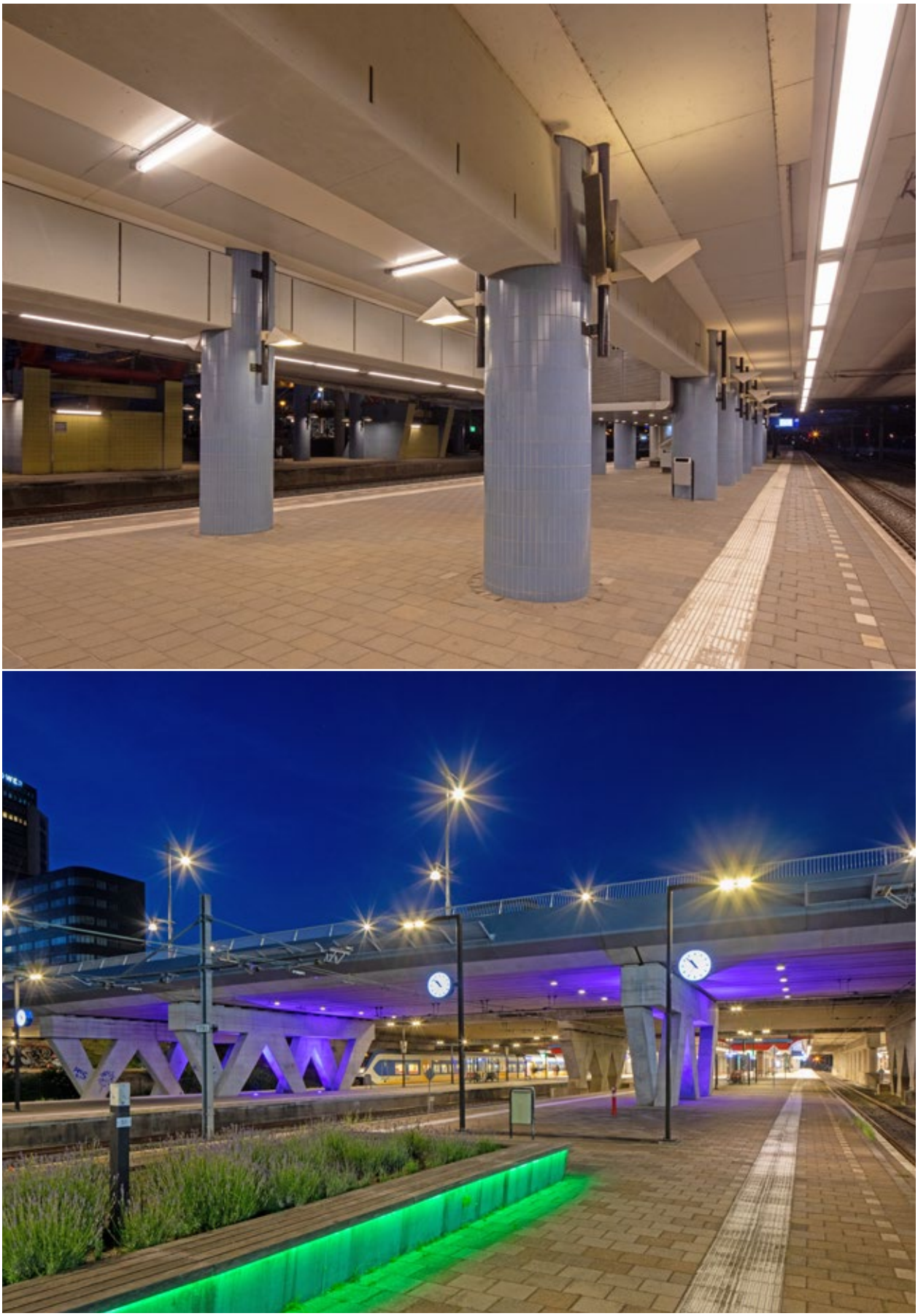
15 Amsterdam Sloterdijk, improve social safety with lighting

Amsterdam Sloterdijk is a Mega-type station. It consists of a station train hall, directly accessible from Orlyplein, with lifts, stairs and a walking bridge on the other side. There are 3 platforms (tracks 3-4, 5-6, 7-8) at the ground level, above the train hall there are 2 elevated platforms (metro tracks 1-2 and NS tracks 11-12). Platform 9-10 (Hemboog) has its own entrance from Orlyplein.

The 3 fully enclosed platforms at the ground level feel dark and socially unsafe. There was enough light but the grey concrete construction made it seem gloomy and dark. Daytime illuminance in the fully enclosed area was over 400 lux, 2x higher than the standard of 200 lux for fully enclosed platforms. Due to unstable day/night sensors, the illuminance was often 400 lux at night as well. Train drivers would be blinded when entering the station from the dark. The transition from 400 lux to the open platform with 20 lux is very intense. It looks like the end of the enclosed platform is completely dark, a place where undesirable individuals can hide.

The fluorescent fixtures were replaced by LED fixtures providing 400 lux on the platform during the day and 200 lux at night. The sensors and light controls were replaced to illuminate the platforms twice as much during the day than at night. At the transition to the outdoors, the fixtures are dimmed to create a 1:3 transition (as per RLN00012).

The fully enclosed platforms at Amsterdam Sloterdijk station with 200 lux in the evening after the LED replacement.



Light art restored.

The light line along the platform edge is located in zone B. The fixtures can only be replaced during an out-of-service period. For that reason, the light line had not been painted for a long time. The light line is also fitted with speakers for public announcements and evacuation. The Lighting Programme renewed all fixtures and speakers, and de-rusted and painted the light line during an out-of-service period.

As a result, the platform looks tidy and safe for the next 10 years. The open platforms at Sloterdijk station were once fitted with different light and colour aspects to improve the atmosphere. The light art was broken and has now been repaired sustainably. The triangular fixtures on picture above left contain uplighters to illuminate the (train hall) roof. These were often broken and have also been fitted with LED light sources. The (train hall) roof is now illuminated better and looks less gloomy.

Tips and conclusions:
- Sustainable lighting (with a long lifespan) can make significant improvements to a gloomy-looking station.
- A light line in zone B does not necessarily have to be moved to zone C if the fixtures last for 10 years.
- Go for LED with a long lifespan to preserve the improvement for a long time.
- Do not count too much on intermediate maintenance.

The spotlights between the triangles were converted to a new LED interior.

16 Amsterdam Duivendrecht, retrofits and works of light art

Amsterdam Duivendrecht is a station with 2 layers. Two tracks from Weesp to Schiphol downstairs and the tracks from Amsterdam to Utrecht and the metro tracks upstairs. The station was designed by architect Peter van Kilsdonk who also designed the stations in Almere, Zaandam, Oss and Doetinchem.

The platforms are lit by spotlights placed between two triangular partitions. The triangles are typical of Van Kilsdonk's architecture. The Lighting Programme had the spotlights between the triangles converted to LED with a new LED interior (retrofit).

There are a number of light artworks in the station, such as the slide under the stairs and the circular skylight see next page. Inside, the artworks were lit with fluorescent tubes, but those were poorly accessible for maintenance. They were often flickering, as a result of which the art had a negative effect on the experience rather than positive.

We replaced the fluorescent fixtures inside the artworks with standard surface-mounted LED fixtures. The opal plates were cleaned. The light artworks are now clean and whole and have regained their function as a landmark in the station.

Tips and conclusions:
- Bespoke fixtures are part of the architecture and cannot simply be replaced by standard fixtures.
- Light art only works when clean and whole.
- With LED, light artworks will remain whole for 10 years.
- Ensure that the artworks are cleaned at least once a year.

Light art at Duivendrecht station. The three triangle fixtures in the foreground were fitted with LED retrofits as well.


richting
Amsterdam Centraal
5
richting
Isolatorweg

17 Hengelo, retrofits in chalice fixtures

Just like in Amersfoort, Den Bosch, Nijmegen and Den Haag HS, Hengelo features a large number of chalice fixtures under the monumental canopy. In Amersfoort and Deventer, we replaced the chalice fixtures with new LED fixtures. In Hengelo, the existing glass shades were cleaned, reused and fitted with an LED retrofit unit. Because the glass shade is reused, retrofit is a more sustainable solution than replacing the entire fixture. Back in 2015, retrofit was still lacking reliability. But in 2019, the supplier was able to provide sufficient guarantees in order to convert the chalices reliably.

The fixtures are now clean and provide more light than the old light sources. Thanks to the improved colour saturation of the LED light sources (R_a80), the colours of the monumental canopy and stained glass are better represented.

The train hall at Hengelo station also contains several chalice armatures. They were converted with LED conversion units (50% of the costs of a new fixture) as well.

Tips and conclusions:
- For large numbers, it pays to develop an LED retrofit.
- Retrofitted or converted units are also subject to the demands in RLN00012.
- Retrofits are often 20% to 50% cheaper than completely new fixtures.
- However, additional installation hours are required to convert old casings.
- Gains in terms of sustainability are mostly made with the reuse of the casings/shades.

MP posts at Hardinxveld-Giessendam station

Prototype MP post at the ProRail courtyard.

'Totem pole' in Zuidhorn: an old lamppost with a lighting fixture, 2 speakers, a camera and an antenna.

18 Hardinxveld-Giessendam and Blerick, Multi Purpose posts

When we started the Lighting Programme, Bureau Spoorbouwmeester wanted us to replace all platform lampposts in the Netherlands with a model that better matches the new grey platform furnishings (the benches, pouffes and waste bins). ProRail's furnishing has been black (RAL9006) since the seventies. The new furnishing is grey (RAL9007). In addition, the old furnishing is round and elegant while the new furnishing is more angular and robust. That is why a new lamppost should be grey and rugged-looking as well.

Additional features such as speakers and antennas are being added to the current black NS4000 lampposts. The result looks like a failed totem. Spoorbouwmeester wants incorporation rather than surface mounting. All functions such as lighting, speakers, signage, measurement microphones, clocks and Wi-Fi antennas should be incorporated into the design in advance. Rather than a lamppost, it should become a Multi Purpose (MP) post.

The Lighting Programme convened several sessions with telecom experts, administrators and Bureau Spoorbouwmeester to develop a programme of requirements for the new lamppost. Broadcasting had a key requirement: only a speaker approved by ProRail could be used, otherwise it would be impossible to calculate a sound simulation. Building a separate speaker into a lamppost is not an option because the lamppost acts as a resonance chamber, which cannot be simulated in a reliable model. The following speaker boxes are permitted: the Elomet X6 and the Bosch LA1-UM20E-1 (see photo).

Bosch speaker box with 4 speakers mounted to the MP post.

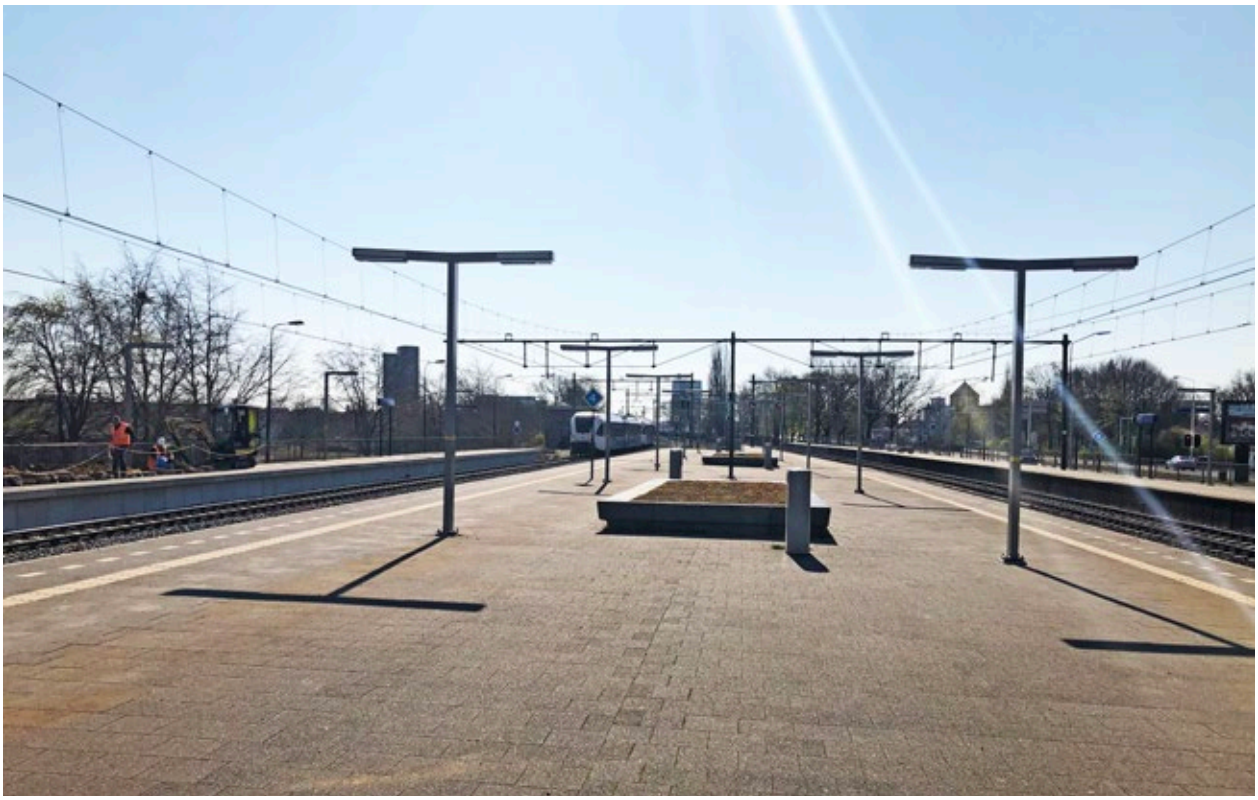
The telecom expert wants the speaker installed horizontally in the outrigger of the lamppost to direct the sound to the platform. A vertical speaker causes the sound to fan out horizontally, causing 7 dB more noise pollution to the surroundings (see OVS00082). The Elomet speaker is too large to fit in the horizontal outrigger of the lamppost. The Bosch speaker barely fits in a 100 x 200 profile. That is why we opted for an MP post constructed of a steel 100 x 200 x 4 profile. The coating of the MP post meets the coating requirements from SPC00178 of the NS4000 lamppost and bicycle racks (galvanised 90 mu and double powder coated, resistant to salt spray test, scratch test with scotch tape).

Because of the speaker, there is no more room for a fixture in the outrigger. A very flat LED fixture that can be placed under the outrigger was selected for that reason.

In consultation with a lamppost manufacturer, a prototype was built from a profile of 250 x 100 x 4. The profile is wide enough to hold 2 speakers (back-to-back) in the outrigger. It was installed on the courtyard at ProRail site De Inktpot and connected. The outrigger had been welded to the post. This caused it to become so heavy that occupational health and safety legislation prohibited installation without a crane.

We assessed the prototype together with all stakeholders and recorded modifications. The second prototype was a slightly less clunky profile of 200 x 100 x 4 and a separate outrigger. This version was installed on the courtyard at De Inkpot as well. The 200 x 100 profile only fits one speaker in the outrigger. The post was then drawn out in detail by a design firm for inclusion in SPC000178. This initial design was installed at Hardinxveld-Giessendam station.

The side platforms at Hardinxveld-Giessendam feature lampposts with one-sided outriggers. These are the standard lampposts (200 x 100) with a speaker on one side. That is why the speakers are spaced 16 metres apart. Lampposts with double outriggers were installed by the ramp. We visited Hardinxveld-Giessendam one evening with the administrators and Spoorbouwmeester. This resulted in several final adjustments to the drawings and the Multi Purpose (MP4000) post was released in SPC00178-V002. Stations where MP posts were installed include Blerick, Vorden and along the “Kolenlijn” [Coal line].

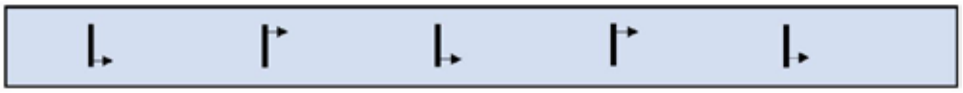


During the audit in April 2020. At the top, the dimming sensors were not yet installed.

By the final delivery in June 2020, the grey dimming sensors had been installed. Above, 2 speakers per post with double outrigger.
Based on what we know today, we would apply one speaker per lamppost on the rail side.

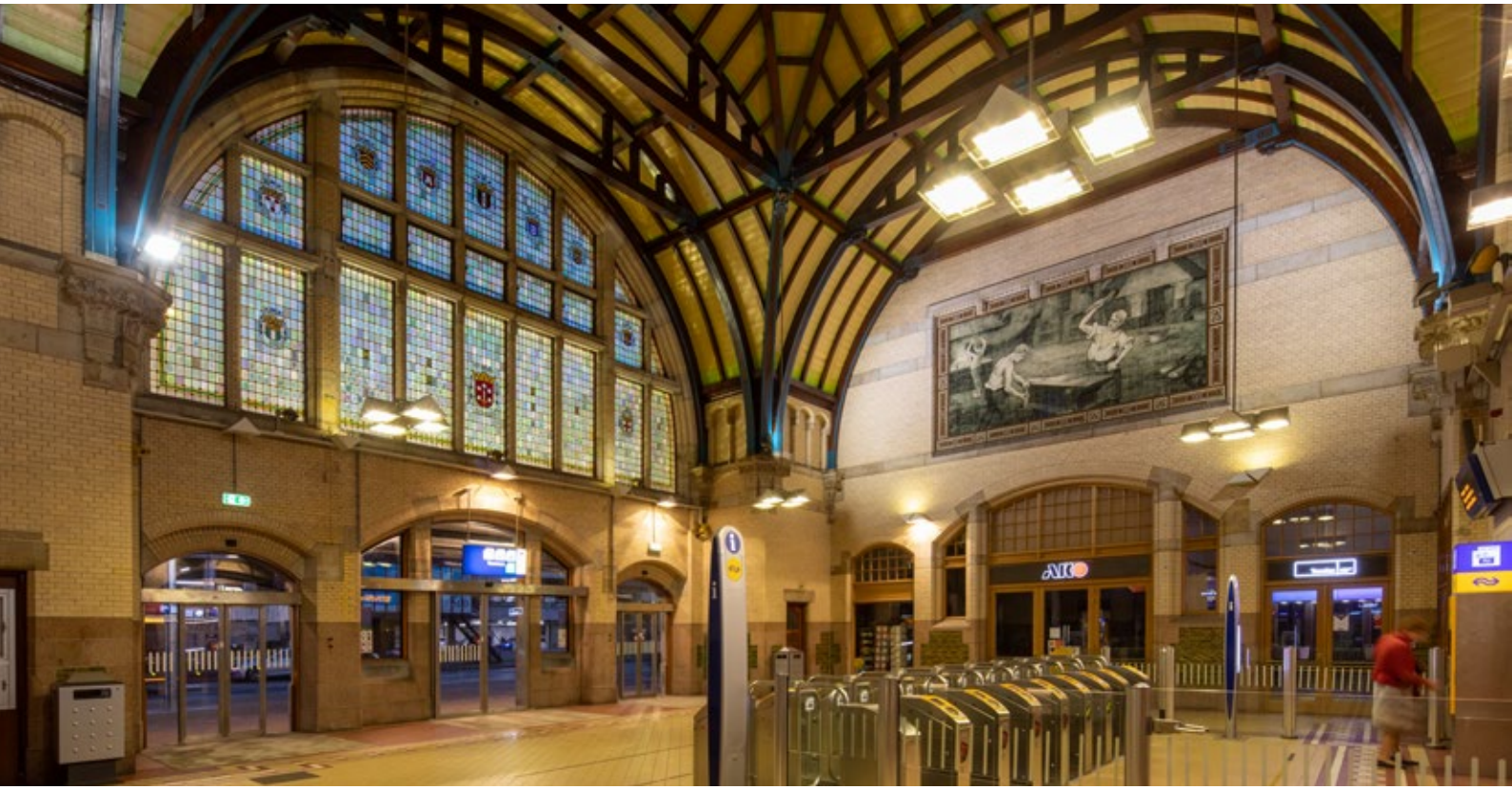
Blerick station has a very wide central platform and two side platforms. We installed 2 rows of posts with double outriggers on the wide central platform. Each post features a speaker on the left and on the right. In hindsight, we could have opted for one speaker per post by the track. In an optimisation effort, we also calculated whether it is possible to place speakers alternately (left and right) on a standard central platform of about 6m wide. According to the calculation, this will only work for platforms with a width of 6 metres or less. This was added to the OVS00178 (see the arrows in the diagram below).

Tips and conclusions:
- Developing new products is not the duty of a programme team, but it is very rewarding work.
- A lot can be achieved in concert with Spoorwegbouwmeester and the product administrator.
- A product like a lamppost involves more design decisions than one would think at first glance.
- Note that grey sensors are prescribed when using MP posts.
- MP posts are less standard than it seems, there is a huge array of options and combinations.
- Choose a cost-effective speaker projection for each platform.



The sensors on the black NS4000 lampposts are ProRail black (RAL9006). For the sensors for the grey MP4000 lampposts, the prescription is (have them ordered) grey (RAL9007).

Entrance to the entrance hall already fitted with new LED lighting.



The train hall with old fixtures. Tile tile tableaux and ceilings are unevenly lit (the new lighting has not been installed at the time of printing this book).

19 Haarlem, monumental train hall with custom Tunable White pendant fixtures

The valuation document on the monumental Haarlem station drafted by Crimson Consulting states the following:

The current station dates back to 1906 and was designed by D.A.N. Margadant. The station consists of a separate entrance building (shown here) and a separate exit building with a canopy in between. The track is elevated just like at Den Haag HS and part of the facilities are housed on a platform island. The large canopy houses not only the waiting rooms and restaurants, but also a beautiful wooden signal box. The station canopy was designed by H.W.M. Werker and is considered the highlight of his work for Hollandsche IJzeren Spoorweg-Maatschappij. Haarlem station features a lot of remarkable details both outside and in. Together with Deventer station, it remains one of the best-preserved station ensembles. The station building, the railway tunnels, the buildings on the platforms and the platform canopy form a gesamtkunstwerk reflecting the grandeur, modernity and scale of the railway company of a century ago.

Light replacement is subject to a monument permit. The permit application was submitted by the municipal Monument Commission in November 2018. It was initially rejected due to insufficient explanation of how the new lighting matches and, where possible, enhances the old architecture. Following this decision, R.J. Vos and M.M. Pigeaud fleshed out the Light Design Substantiation.

More uniform façade lighting will be installed on the canopy in front of the entrance. The half-arch window in the hall is lit from the inside to make it visible at night as well.

At the time of writing, Haarlem was not ready yet. That is why no final photos of the train hall were added.

In entrance hall A, the triangular fixtures are being replaced by 4 elegant chandeliers.

The tile tableaux are lit from below with a narrow light strip. In the tunnel, existing ducts are fitted with new indirect LED lighting.

Tips and conclusions:
- At an early stage, consult the Monument Commission of the municipality.
- Present them with a properly substantiated plan by a light designer.
- Before meeting with the Monument Commission, read the valuation documents by Spoorbouwmeester.
- Know what the characteristic and valuable details are.

Roof construction of the train hall.

Stained-glass window from the inside (this used to look very dark in the evening).

Indirect LED lighting in the passenger tunnel makes the remarkable masonry and tiles nicely visible (the lighting had already been replaced with LED).

The old uplighters at Hilversum station with horizontal pane and anti-pigeon electric wire installation.

New uplighters under the canopy at Hilversum station with slanted pigeon-proof pane. The added fixtures above the tactile paving are visible on the sides of the canopy.

20 Hilversum, custom, pigeon-proof canopy fixtures

Just like Amersfoort Centraal, Hilversum station features a historic canopy and a matching modern canopy. The canopies and platforms in Hilversum are heavily soiled by pigeon faeces and nests. The platform underneath the canopies is lit with indirect lighting through uplighters illuminating the canopy.

Due to a growing number of passengers, Hilversum has developed from a Plus station to a Mega station. The lighting did not meet the standard for a Mega-type station of 70 lux on the covered platform. To increase the illuminance around the tactile paving, we added line fixtures above the tactile paving. The line fixtures were mounted on the grey longitudinal profiles. The cables were concealed inside the profile.

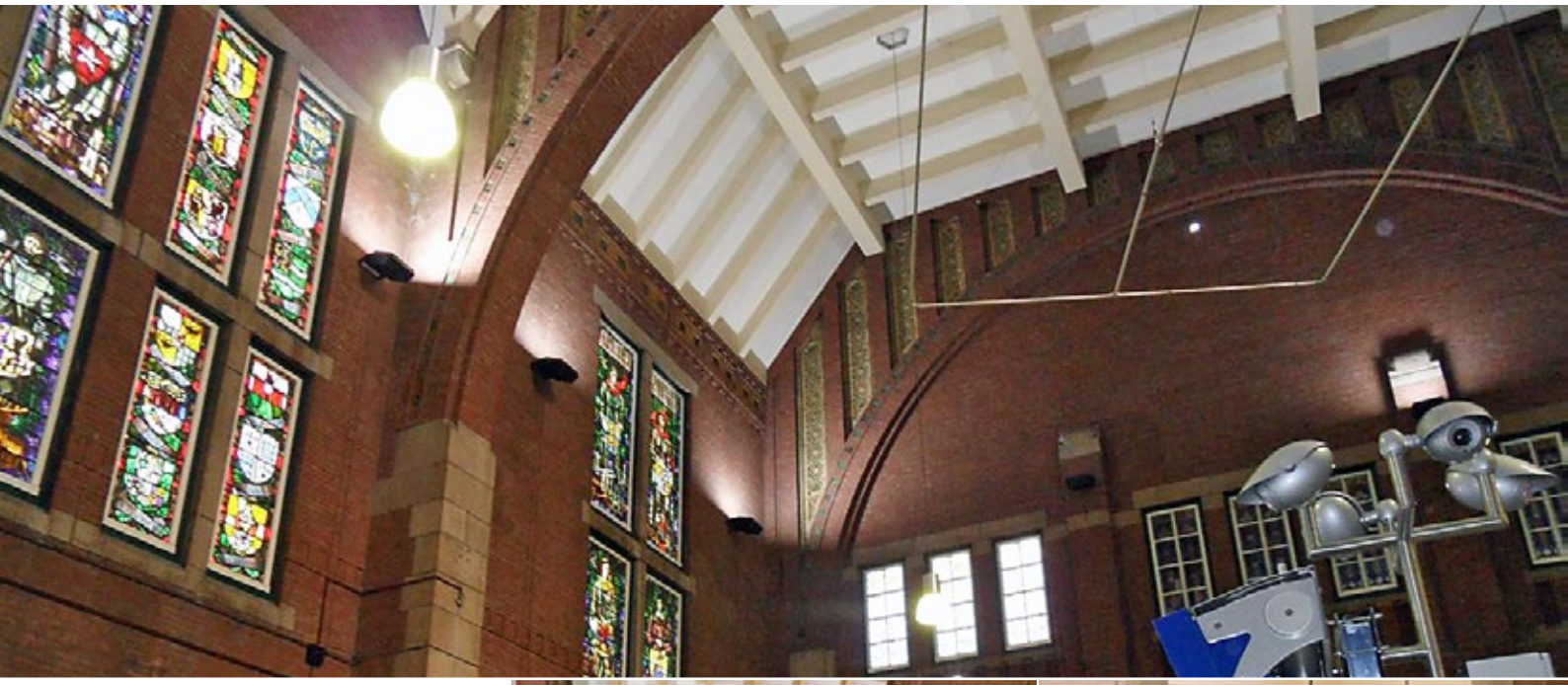
The uplighters under the canopy were fitted with pigeon pins to prevent soiling by pigeons. However, the uplighters attract mosquitoes and spiders. Spider webs accumulating around the pigeon pins were very visible in the light of the uplighters and made for a messy look at night. In fact, a dead pigeon was once found impaled on the pins, which is obviously not good for the social safety perception.

The pins were then removed and replaced by an anti-pigeon system with 2 electric conductors to give pigeons an electric shock. This system was installed along all the (train hall) roof trusses and along all the fixtures. This requires additional maintenance and the nuisance caused by pigeons returns soon after the system malfunctions.

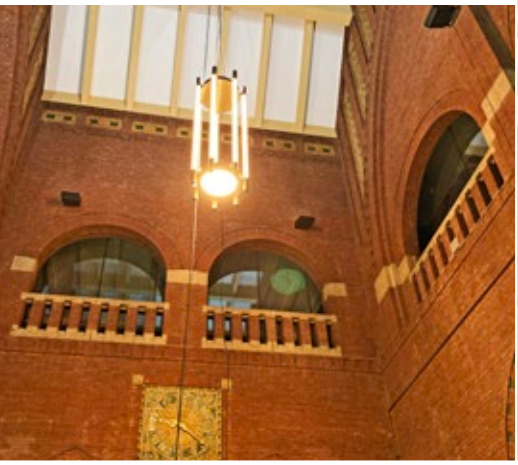
When replacing the old uplighters, we chose to skew the pane of the uplighter 30 degrees. As a result, pigeons will slide off (see photo). The uplighter beam is still directed upwards and only the pane is skewed, keeping the fixture clean.

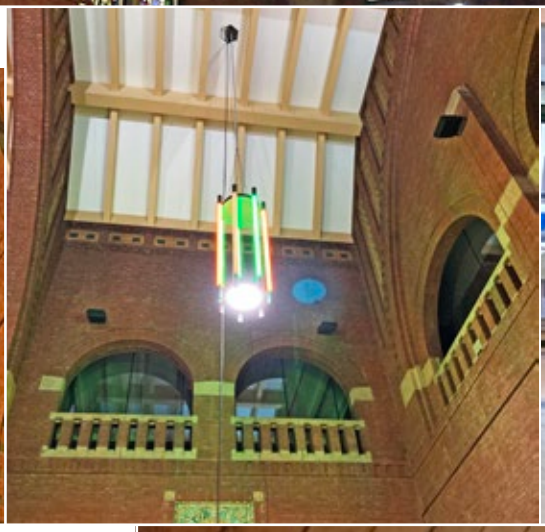
Tips and conclusions:

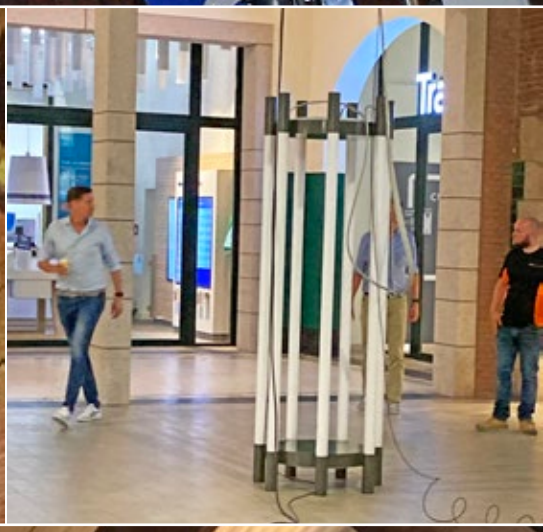
- The pigeon problem was first solved with pigeon pins and then with electric wire. When replacing the fixtures, we were able to implement a better solution by adjusting the shape of the fixture. Conclusion: Smart design works better than all kinds of additional remedies.
- When a station develops from Plus to Mega, updating the lighting to meet the standard is often impossible. Luckily, the Lighting Programme could incorporate this in Hilversum.



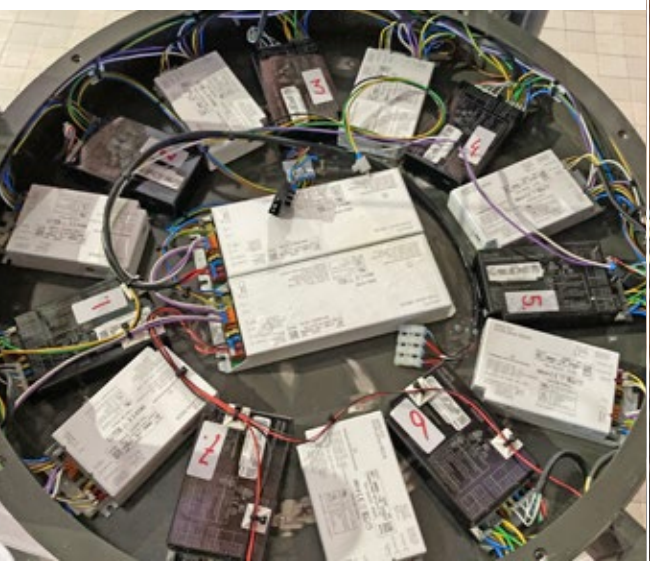
Previously spotty wall illumination.







Chandeliers with colour scenarios.



16 drivers in the chandelier. The 2 x 100W TW drivers in the centre were now installed outside the fixture in the attic.

Light controls in the attic above the train hall.

21 Maastricht, chandeliers with colour scenarios and Tunable White in the train hall

Just like the ProRail headquarters De Inktpot, Station Maastricht was designed by architect G.W. van Heukelom. The hall consists of monumental high vaults. Until now, the floor was illuminated by downlighters. Spotlights were fitted alongside the walls, but the ceiling was not being lit evenly. As a result, the train hall seemed spotty and a bit spooky at night.

Eight chandeliers were installed above the floor in the high train hall (17 metres) at a height of around 7 metres (see photo). The chandeliers feature one strong downlighter illuminating the floor and an uplighter aimed at the ceiling. Seven tubes were installed between the uplighters and downlighters to illuminate the walls. The chandeliers are Tunable White (TW; cool white in the morning and warm white in the evening, from light colour 2100K to 6000K).

The 7 tubes are colour-controllable as well. For example, a specific scenario can be selected for carnival and a different one if local football club MVV wins a match.

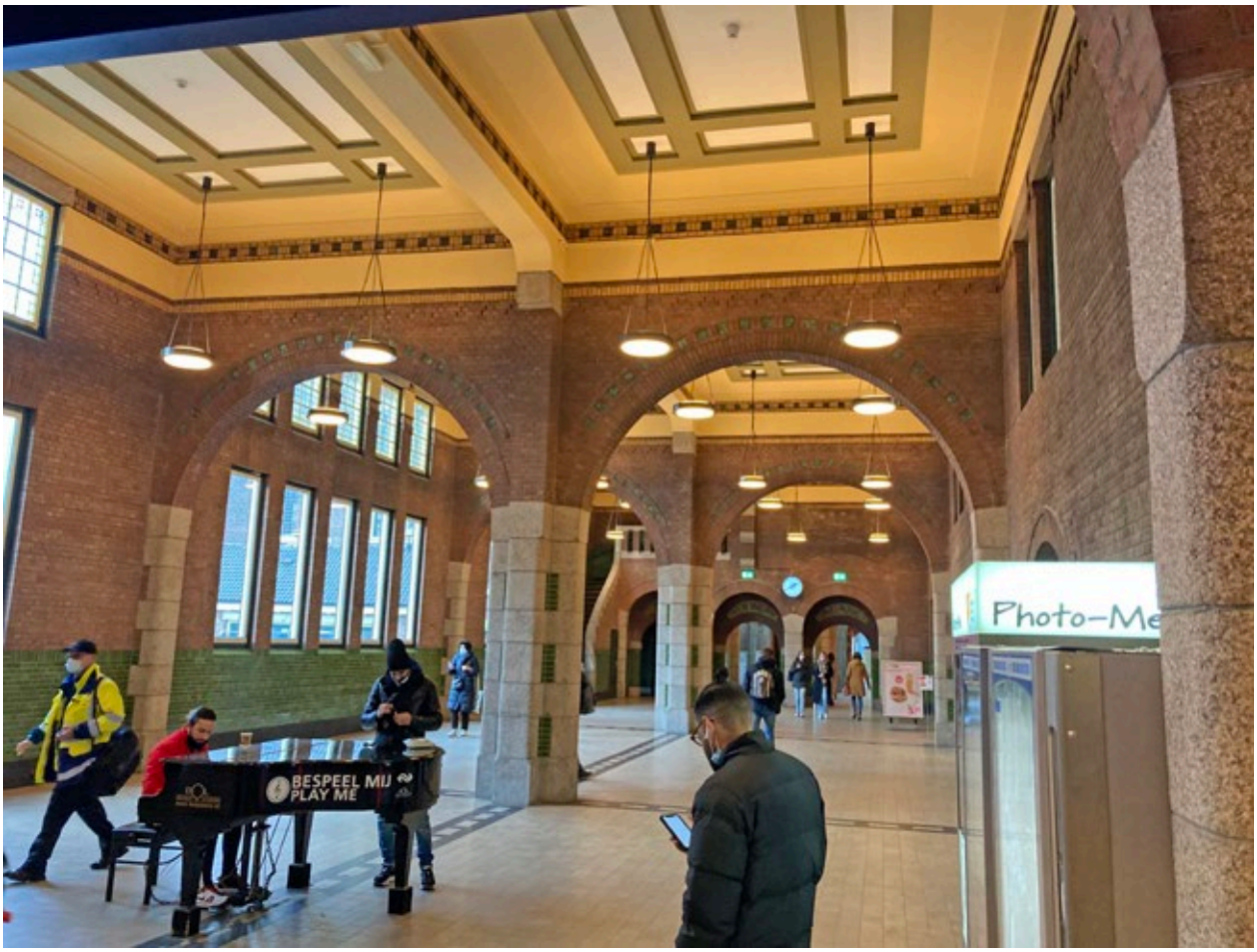
The colour-controls make the tubes very complex. Each tube contains 4 LED strips to ensure uniform light in all directions. Each LED strip consists of 2 TW colours (2100K and 6000K which can be mixed) and 4 RGBA colours (red, green, blue and amber, also mixable). Each colour has to be connected to the driver separately. The following drivers are required as a result:

– 2x 100W TW driver for the uplighters and downlighters are located on the attic outside the fixture.
– 7x 50W TW driver for the tubes.
– 7x 50W RGBA (DMX-protocol) driver to control the colour of the tubes.

This amounts to 16 drivers (900W) per chandelier.

The 8 chandeliers are lifted with a winch through 8 holes in the attic floor. Pharos controllers, the power supply and control cables were installed in an iron cabinet in the attic. The controls turned out to be more complex than anticipated. Tunable White is controlled via the Dali8 protocol. One controller is able to control 128 Dali addresses and 128 DMX addresses (colour). The 8 chandeliers contain 2 drivers for the ceiling lights and 7 for the tubes. This amounts to 8 x 9 = 72 addresses. Besides the chandeliers, there are 43 ceiling lights in the side hall with 2 drivers each (up and down), amounting to 86 drivers.

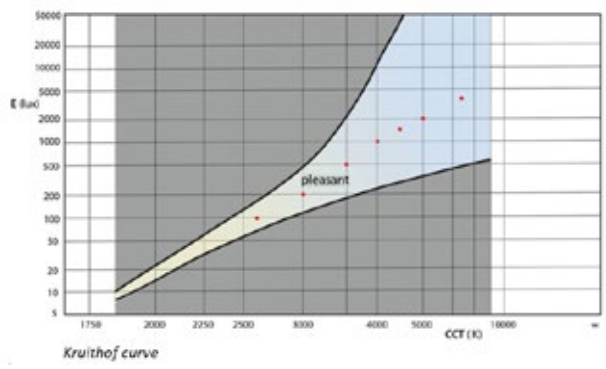
A DMX network between the 8 chandeliers was built in the attic (cat7 cable) for colour controlling the 8 x 7 tubes. Dali8 control cables between the chandeliers were also installed in the attic for the TW.



Ceiling lights with uplighters and downlighters on a thin pendant that illuminate the floor and ceiling.

The other parts of the train hall contain bespoke ceilinglights, suspended on thin pendants, that simultaneously light the ceiling and the floor. 43 Of these fixtures are located in the passage -high (6 metres), the passage low (to track 1, 4 metres high) and under the gallery (near tickets and services). The ceiling lights on thin pendants illuminate the ceiling nicely. The building and architecture are much more visible to passengers as a result. The paintwork was recently restored to the original colours, which come into their own much better now. On the adjacent photo, the ceiling lights are set to warm white (3000K).

The contractor included 2 additional Dali wires in the power cables that ran to the power outlets in the ceiling in advance. Connecting these wires to the controller in the attic allows for all fixtures to be controlled. For a small number of fixtures on the emergency power supply, the control wires had to be looped through. The TW controls can be timed. Except this does not take into account the actual outdoor light colour. In order to keep the indoor light colour the same as outdoor, a daylight sensor was connected to the TW controller in Maastricht. The sensor does not measure the daylight colour, but it does measure the lux value of the daylight. The lux values are translated to light colours in the controller (2200K – 5000K) based on the graph below (Kruithof curve). If the sensor measures 2000 lux outside during the day, the indoor light colour should be 5000K. If the sensor measures 50 lux outside at night, the indoor light colour should be 2200K.

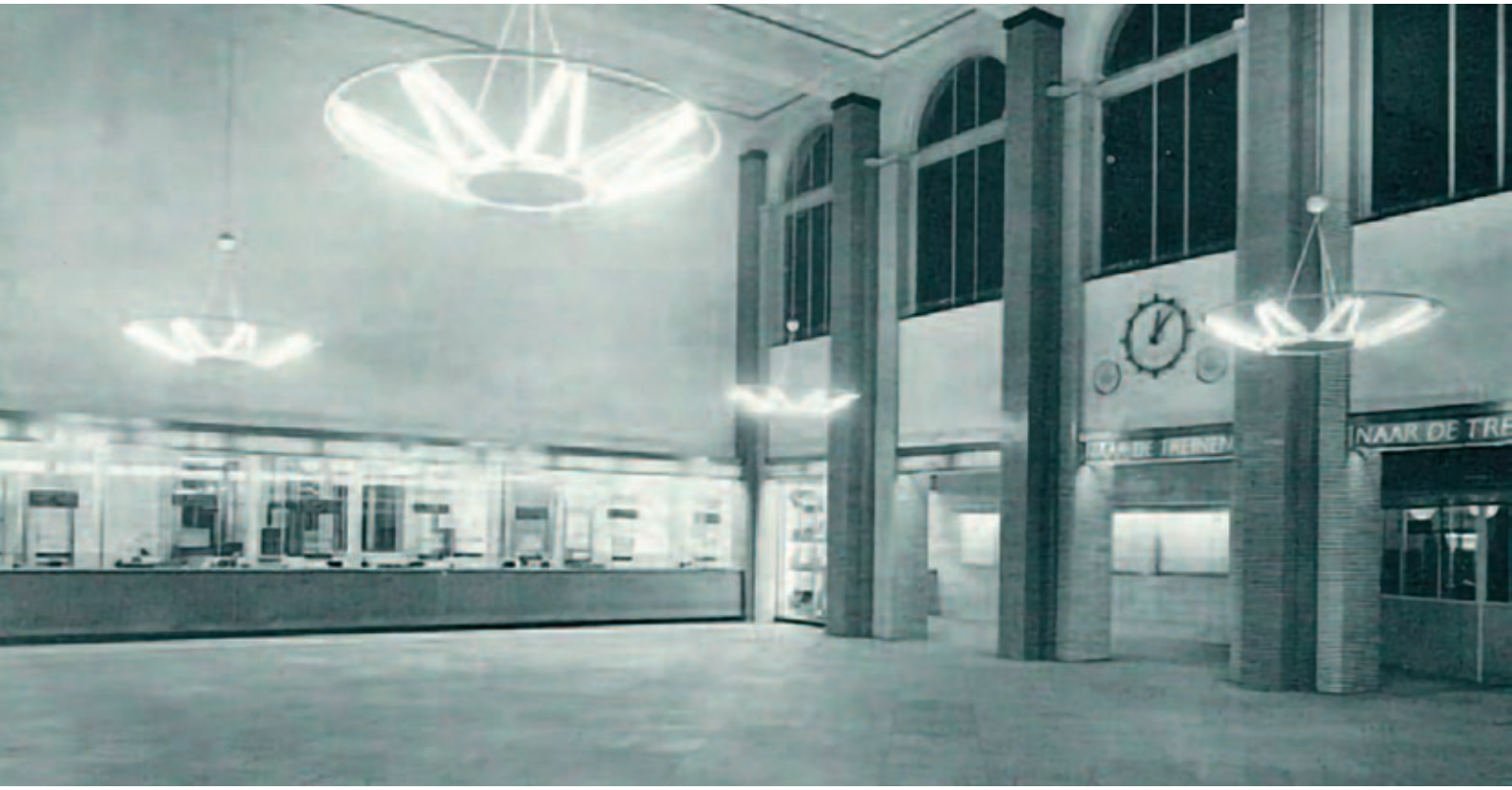


Kruithof curve

Tips and conclusions:

- Controlling Tunable White fixtures based on a daylight sensor is complex (in Amersfoort, it is simply done with a time schedule).
- The Dali wire was already included in the power cable. In the end the network contained over 128 Dali fixtures. That is why we had to disconnect part of the Dali lines and build a separate Dali network in the attic.
- DMX colour control cannot be done with 2 Dali wires, but requires a DMX or UTP cable instead. We were forced to build this in the attic in hindsight.
- A DMX splitter is required for each fork in the DMX or UTP cable. These splitters were not provided in advance, but were procured afterwards.
- The controllers have to be connected with a UTP cable to keep them synchronised. First, the plan involved a single controller in the electrical room downstairs and one upstairs. Due to the UTP cable, we installed them upstairs in the attic.
- The combination of TW and RGBA makes it very complex. This makes the fixtures and the controls less robust. RGBA is nice to have but better avoided in the future.
- We ordered a working system (bespoke) from the fixture manufacturer and had our contractor install it. The manufacturer did deliver, but did not feel responsible for delivering a working product. As a result, the ProRail Systems Engineer had to push for a lot of adjustments and delivery was delayed by a year. In the future, we should always have the contractor procure and execute the entire project (including custom work).

Current situation: the monumental train hall that seems to have a suspended ceiling due to the downlighters.



The train hall with the original chandeliers around 1950.

22 Den Haag HS, Tunable white in the train hall

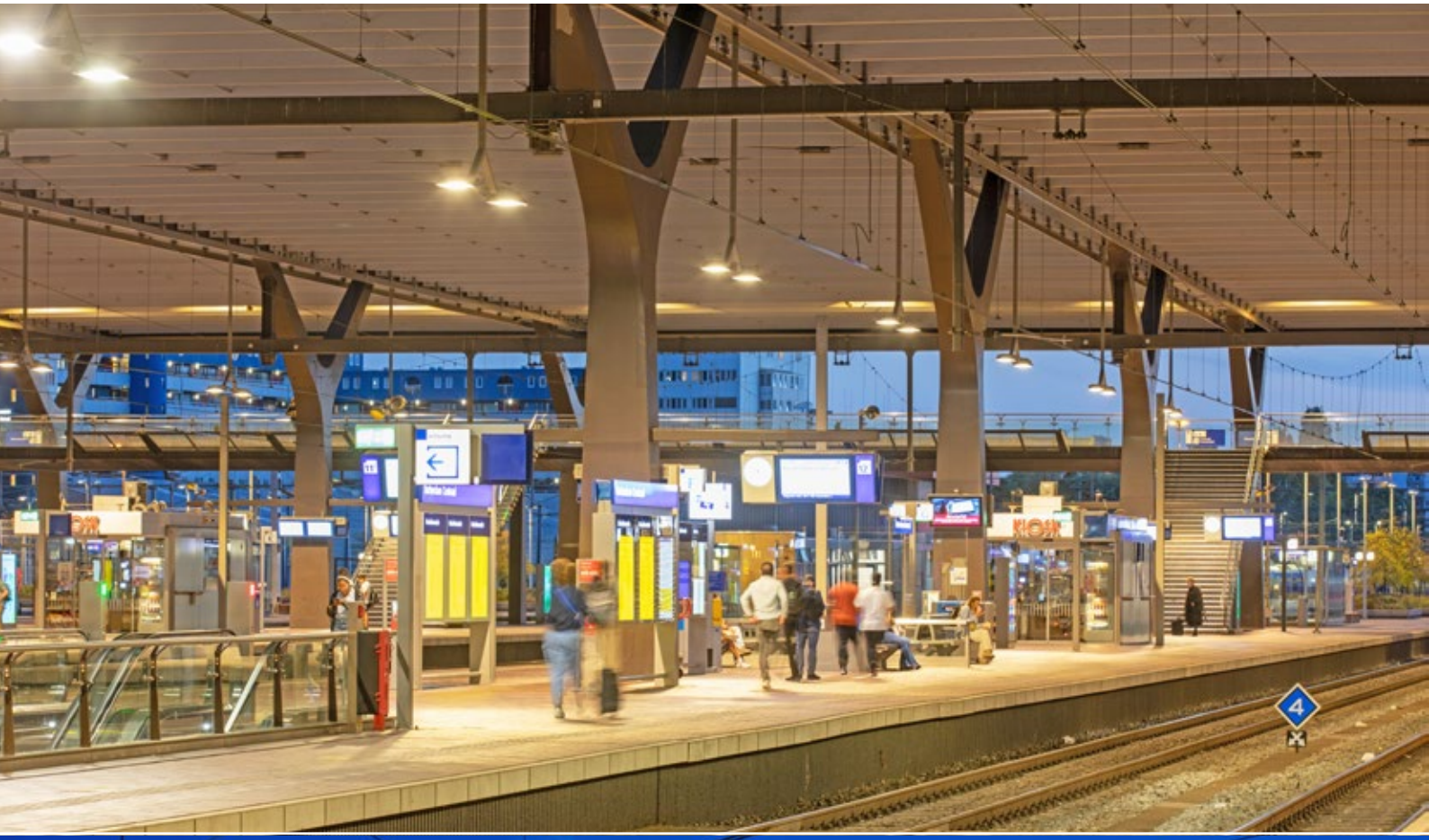
The train hall of Den Haag HS was built by architect Margadant, just like Haarlem station, though the former has been preserved to a lesser degree. The (train hall) roof of the train hall was burned in the past. A new imitation wooden ceiling was installed. A square (made of black profiles) hangs from the decorative ceiling with down-lighters and several spotlights illuminating the walls. The spotlights are often faulty or no longer aimed properly (due to vibrations of the tracks). The square with downlighters feels like a suspended ceiling, removing the height of the monumental train hall from the passenger's experience.

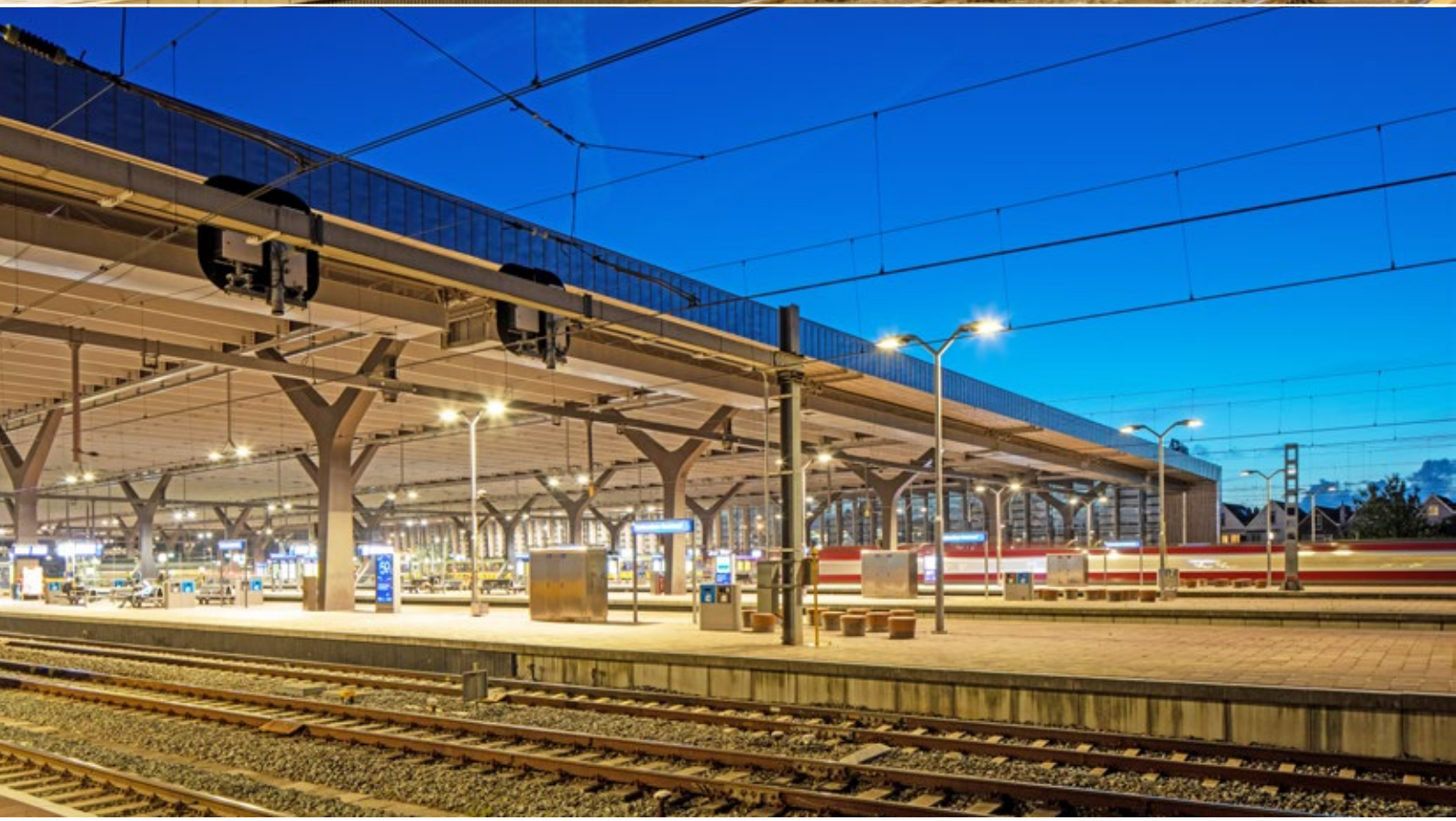
NS and ProRail asked Ruland Architecten to draft a plan for a quality impulse for the train hall and tunnel. Part of this plan is to return the lighting in the train hall to the way it was in 1950.

The square is replaced with 4 large chandeliers (with a diameter of approx. 2.5 metres). The LED tubes in the chandeliers shine in all directions, illuminating not only the floor but the walls and ceiling as well. A prototype of the chandeliers was tested in the factory in 2022. A lighting calculation revealed that the 4 chandeliers with 15 LED tubes each (2500 Lm / 25W per tube amounts to 375W per chandelier) deliver sufficient lumen output to illuminate the train hall floor at 100 lux in accordance with RLN00012.

Tips and conclusions:
- Many monumental stations got cluttered In the seventies and eighties.
- Clearing the clutter creates a sense of peace and order.
- A couple of large fixtures are much more exciting than lots of small ones.

The intended look in the visual by Ruland Architecten.





Posts outside the canopy.

23 Rotterdam Centraal, platforms and tunnel

23.1 Rotterdam Centraal, 154 floodlights on the platforms replaced

The platforms at Rotterdam Centraal suffered from a similar issue as the train hall at Den Haag Centraal. The halogen floodlights were getting too hot. The lamps were being replaced every 2 years, but the heat inside the fixture was causing a large number of breakdowns in between.

A floodlight pane snapped and fell onto the platform twice in 2015. Made of safety glass, the panes break up into fragments. This means there were no falling shards, but a trip hazard did exist above the stairs. Research revealed the cause: vibrations and heat inside the fixture. The fixtures at Rotterdam station are suspended from approximately 4-metre-long pendants (inverted lampposts) from the canopy. When a heavy freight train passes through the station, the canopy vibrates and the pendants swing along. The vibration mainly occurs when the train passes over the passenger tunnel.

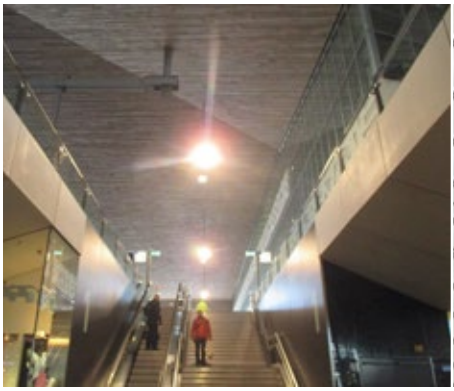
Based on this investigation, NS replaced all panes with plastic alternatives in 2016. The Lighting Programme replaced existing SIL fixtures above the stairs with LEDs that do not generate heat and panes of transparent polycarbonate instead of glass. For the replacement above the stairs, we conducted a test in 2016 with 3 different LED fixtures (1x SIL LED fixture, 1x SIL LED retrofit conversion unit, and 1x LED fixture by EWO). The conversion unit resulted in the least amount of glare. It was also the most sustainable because the original casing is reused.

In 2021, we converted the remaining 154 fixtures on the canopy with SIL LED conversion units. The plastic panes that had been applied as an emergency measure in 2016, had all burned out by 2022.

The grey-red natural stone on the platforms in Rotterdam is quite dark. Rotterdam Centraal is a Cathedral-type station, which requires an illuminance of 100 lux on the covered platform. There is some debate as to whether Rotterdam has a fully enclosed platform (standard 200 lux), but because there is a lot of daylight, we have always assumed a covered platform. The architect, however, intended for the platform to be lit at 200 lux to compensate for the dark colours. To avoid complaints, the Lighting Programme did not want for the switch to LED to lead to reduced illuminance. This is why the new LED fixtures were calculated for 200 lux on the platform floor.

The open platforms outside the canopy have lampposts with 138 SIL fixtures as well, but the standard prescribes 20 lux. In 2010, the same fixtures were installed here as under the canopy. As a result, the illuminance of 200 lux was 10x too high on the open platform. The fixtures on the lampposts outside the canopy have now been converted with LED interior, calculated for 20 lux. This has reduced the amount of light nuisance outside the canopy by a factor of 10. Due to the 10x lower lux value combined with LED, energy consumption outside the canopy was reduced by a factor of 10 as well.

Tips and conclusions:
- Use retrofits with a warranty from the brand of the original casing.
- Do not apply makeshift remedies like emergency plastic panes; they melt.
- Do not wait any longer than necessary when fixtures need to be replaced.



Blinding fixture when walking up the stairs.

This is what the fixtures look like when the lights are off.

Plastic panes from 2016, melted away in 2022.

The dark train hall at daytime. The sky lights are blocked by the floodlights.

Dark spots between the columns in the passage.

23.2 Rotterdam Centraal, Tunable White in the train hall and passage

Passengers walking from the passage to the train hall at Rotterdam Centraal during the day are often blinded by the daylight of the glass façades. For that reason, there is a need for more lighting in the tunnel and more daylight around the exit of the tunnel. In addition, there are dark spots between the columns in the tunnel and the tunnel currently feels rather frigid.

NS, the municipality and ProRail co-own the passage (tunnel) and the train hall. The team of owners commissioned the drafting of an optimisation plan in 2020 in order to bring more atmosphere and daylight into the train hall and the tunnel. The sky lights in the train hall do not work properly. Daylight is being blocked by floodlights mounted in the sky lights.

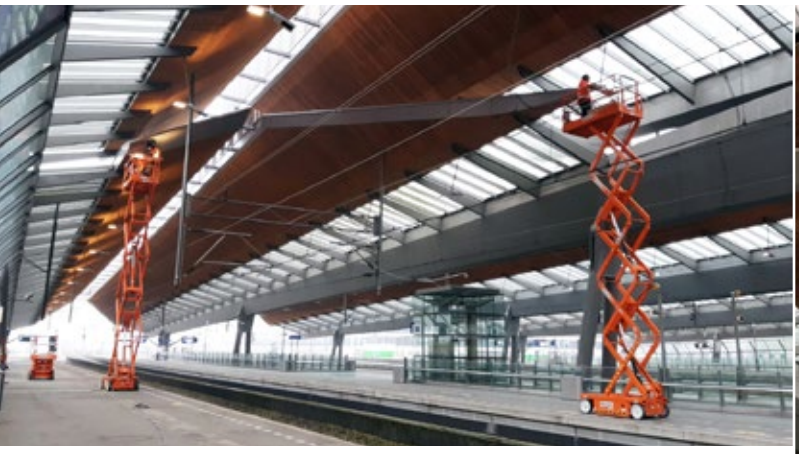
The intention is to place all floodlights outside the sky lights, allowing more daylight to enter during the day. In 2022, the principal team had not yet reached agreement on the optimisation plan, as a result of which the Lighting Programme unfortunately could not include the LED replacement. For that reason, the scope of the programme no longer includes improving the sustainability of the train hall lights.

The principal team wants to better illuminate the dark spots between the columns in the tunnel, e.g. by installing a light strip between them. In addition, Tunable White is intended to bring a sense of daylight into the tunnel.

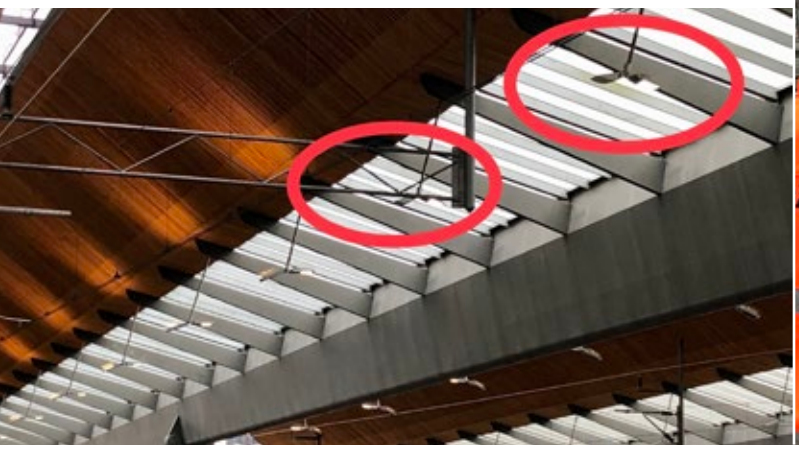
In 2022, the Lighting Programme replaced the existing fixtures in the tunnel with Tunable White LED lighting and the associated dimming controls. The floor will look less spotty because the LED fixtures have better optics than the current fluorescent fixtures. As a result, the tunnel is prepared for optimisation without having to wait for the optimisation plan.

Tips and conclusions:

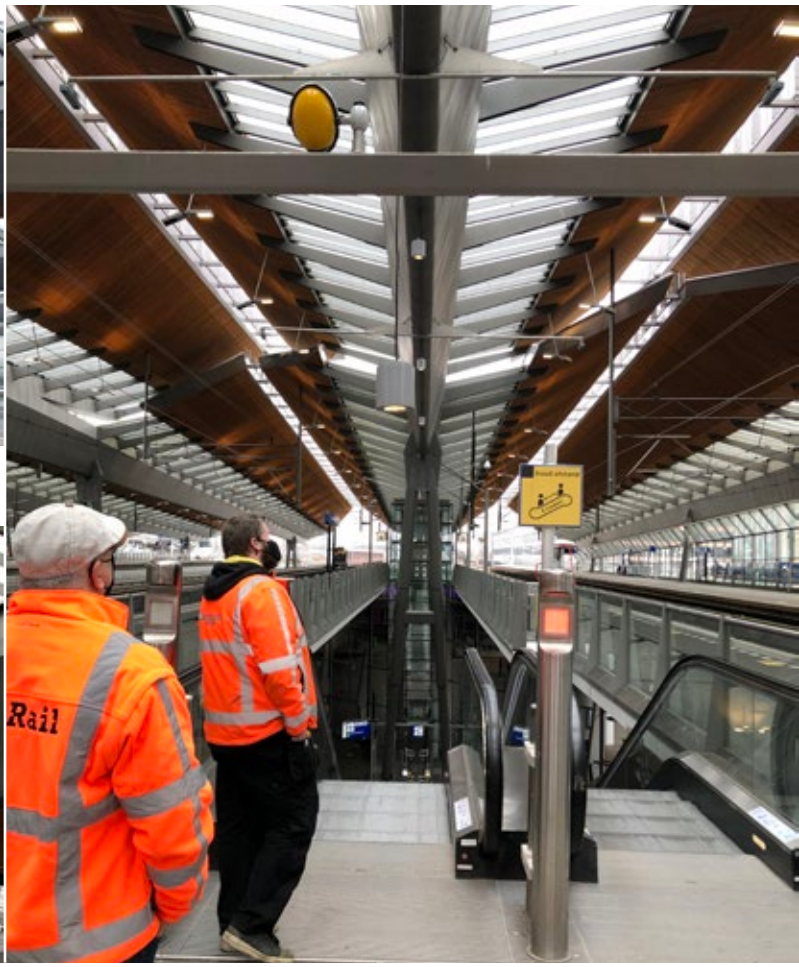
- If the scope is patially uncertain, get rid of that part, in consultation with the principal.
- We were able to use the budget for the train hall to install Tunable White in the tunnel instead.
- This gave the principal more time for the optimisation plan without holding us back.



Replacement of the 444 up and downlighters above the platforms, in an out-of-service period in week 52 of 2020, at a height of 17 metres.



Circled in red, 2 faulty uplighters at more than 20 metres above the atrium. These were yet to be replaced in early 2021 with a telescopic handler through the stairwell.



Lower the spotlight above the escalator with an hand winch; an aerial platform cannot be placed on top of the escalator.

The undulating canopy with its up and downlighters is once again clearly visible after the LED replacement.

24 Amsterdam Bijlmer Arena, saving 4 train-free periods with LED

Commissioned by ProRail and GVB (Amsterdam Metro), the installer installed the new sustainable LED lighting at Amsterdam Bijlmer Arena station. A quarter of the station is a GVB metro stop. We worked with GVB to restore the iconic lightscape as intended by architect Grimshaw & Partners.

The fixtures are difficult to reach under the 17-metre-high undulating canopy and above the high atriums. The up and downlighters hanging from pendants on the (train hall) roof cannot be replaced without decommissioning and de-energising the overhead line. The halogen lamps were being replaced every 2 years during an out-of-service period, which would cost around € 200,000. If lamps failed before that time, they could not be replaced. As a result, there was a lot of overdue maintenance in 2020.

The uplighters intended to make the undulating (train hall) roof visible at night were often dirty. With the new uplighters, the wooden acoustic (train hall) roof is once again beautifully illuminated in amber at night while highlighting the architecture a lot better.

An aerial platform cannot reach above the escalators. Thanks to an hand winch in the attic of the canopy, we can now easily lower the downlighters for maintenance and cleaning.

The new LED lights will last for more than 10 years, making the scene look as intended again for a decade to come while saving 4 out-of-service periods.

Tips and conclusions:

- Up and downlighters were left in zone A here, because LED has a 10-times longer lifespan.
- The architectural plan and suspension structure have not changed as a result.
- In hard-to-reach places, fixtures can now be lowered with a hand winch.
- Do not use an electric winch, as it often breaks down after 2 years.
- Opt for extra long lifespan (e.g. 100,000 hours). The extra cost pays for itself through reduced maintenance costs.

The situation before the LED replacement. A large proportion of the uplighters was faulty.

Old situation in Tilburg in 2016. Due to uneven lighting, the canopy looked disorderly and untidy.

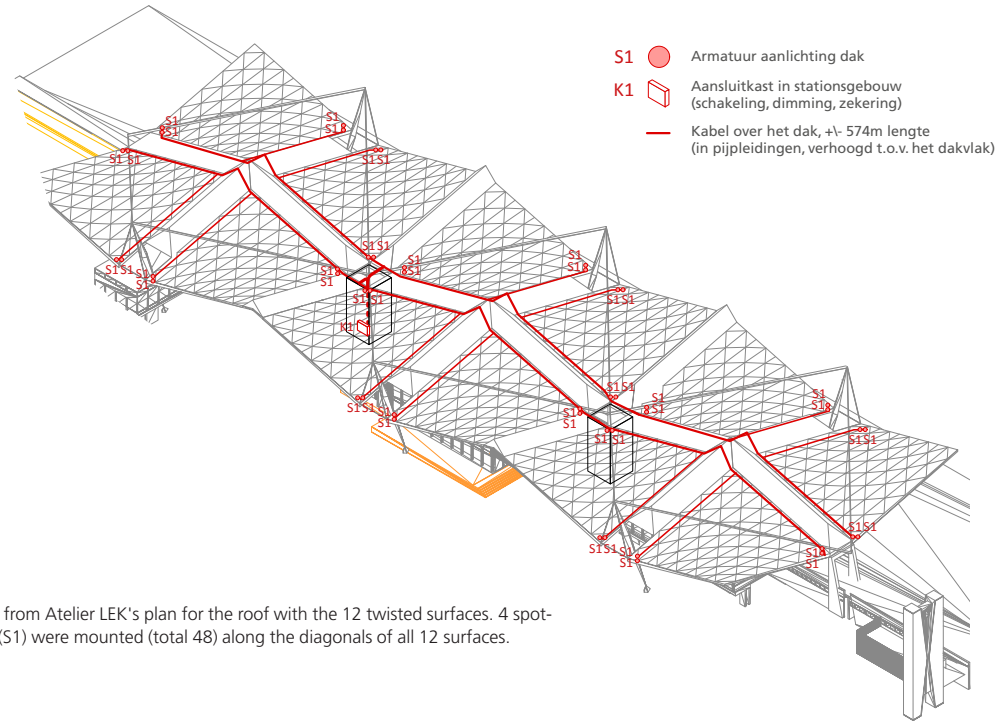


Image from Atelier LEK's plan for the roof with the 12 twisted surfaces. 4 spot-lights (S1) were mounted (total 48) along the diagonals of all 12 surfaces.

25 Tilburg, architectural lighting undulating canopy

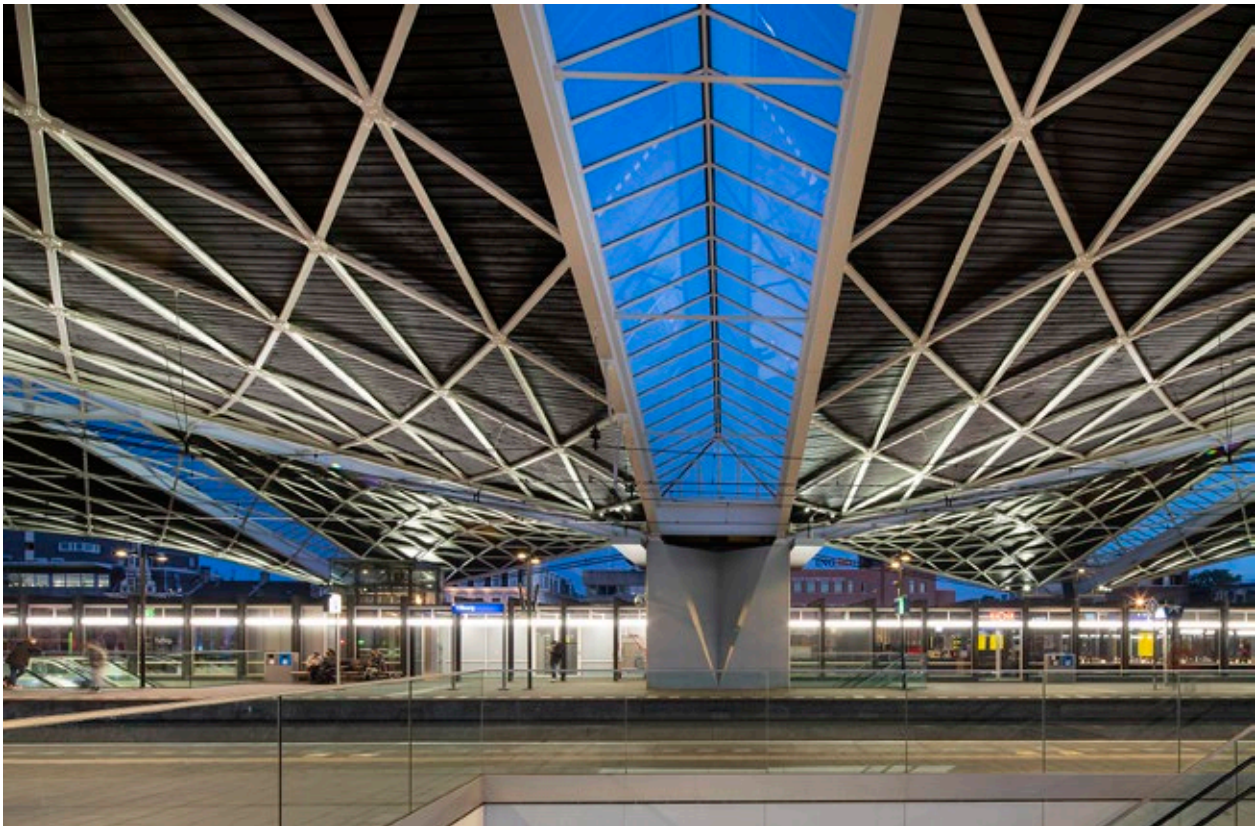
In 2020, the station environment in Tilburg underwent a major quality improvement. The old tunnel was too narrow for the large streams of travellers and was widened for that reason. The new tunnel has also become a new connection between districts. Residents can pass through the tunnel without checking in or out. The lighting on the covered platforms, however, needed to be improved. The illuminance was too low (40 lux, which should be 70 lux on a Mega-type station) and the canopy lighting was spotty and uneven. This made for a disorderly and untidy view.

The canopy has been repainted in the original colours: white rafters under black roof boarding. To make the canopy more visible, the municipality and Bureau Spoorbouwmeester wanted to add architectural lighting.

The canopy is composed of 12 twisted rectangles. Glass sky lights are located between the rectangles. The glass has been renovated and cleaned when painting the canopy. The canopy covers the side platform and the central platform. The canopy was lit from lamp posts on the platform here and there at night, but in other places it felt like a dark cloud looming over the platform. The lighting architect from Atelier LEK (Licht en Kleur) worked with the municipality, ProRail and Spoorbouwmeester to draw up a plan to make the canopy more visible.

Together with Atelier LEK, the municipality, NS, Spoorbouwmeester and the contractor, we installed and assessed a test lighting installation with 4 spotlights under a (train hall) roof surface. Atelier LEK suggested we choose between 3 types of spotlights: 40W, 75W and 110W. we assessed the 75W version in the test. To emphasise the contrast between the white rafters and the black background of the canopy, Atelier LEK opted for light colour 5500K (cold white). The test also involved assessing whether this should be warm white (3000K) or cool white (4000K). From platform 1, we also assessed the potential of causing glare to train drivers. Based on the test, we went with the 75W spotlight in the colour 5500K used in the test. We did decide, however, to make the anti-glare shades twice as long as in the test (see the photo below). In addition, it was decided to make the spotlights dimmable in order to prevent light nuisance to local residents, and to dim the roof to 30% of the regular strength after rush hour. The installation of 4 spotlights on the central platform next to the stairs required an out-of-service period.

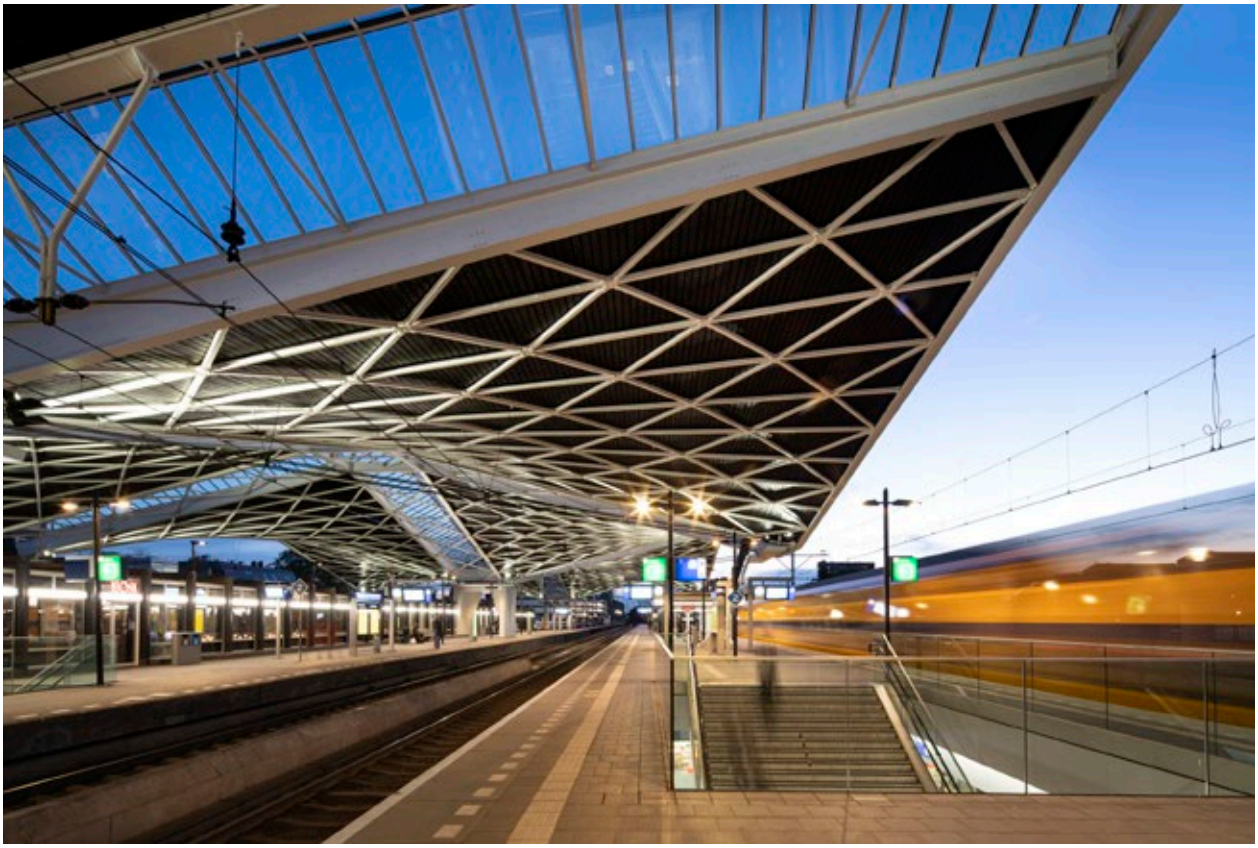
Tilburg station at night, after placing the architectural lighting (48 spotlights) (light designers Atelier LEK / photographer Frank Hanswijk).



The architectural lighting from the platform creates a beautiful perception of the building. The roof is lit much more evenly lit from below.
We can also see how the shades block a direct view of the spotlights from all directions (light designers Atelier LEK / photographer Frank Hanswijk).

Originally, the architect did not want to disrupt the shape of the canopy with fixtures. That is why there are lamp-posts on the platform under the canopy (see the photo below). We fitted the lampposts with new LED fixtures to once again illuminate the covered platform with the required 70 lux on the floor. LED lamppost fixtures on an open platform of a stop are usually around 1000 Lumen (about 10W). We had to achieve 7000Lm (70W) under the canopy in Tilburg. To reduce the risk of blinding with such light intensities, we opted for fixtures with 48 LEDs (compared to the usual 12). Because the lampposts are higher than usual (5 instead of 4 metres), less glare occurs.

Tips and conclusions:
- Always perform a test for architectural lighting.
- Assess the test with Spoorbouwmeester, the architect and the local residents.
- Choosing the medium wattage and whitest colour for the test turned out well.
- Dimming after rush hour makes the light acceptable to the surroundings.



The 5-metre posts with LED fixtures and 70 lux on the floor under the canopy (photographer Frank Hanswijk).

Signify Solar fixtures and panels during commissioning at Hilversum Sportpark (the author in the centre).

26 Hilversum Sportpark and Blerick, Solar masts

26.1 Temporary Solar masts Blerick ramp

At Blerick station (see chapter 18), the lighting was replaced. The existing ramp and stairs were scheduled to be relocated in 2 years later. There was no lighting for the existing stairs and ramp. The Lighting Programme installed temporary lighting for the existing stairs and ramp. When installing lampposts, the excavation work for the foundations and cables is the most costly (around €200 per metre of cable trench). To save on expensive excavation work in Blerick, we installed temporary Solar masts by InfraMarks (see the photo below). The masts feature a solar panel and a battery and work without a power cable. The concrete base is very heavy to prevent the post from being blown over with the panel. The box with the battery and controls is positioned on top of the concrete base. We considered leasing the solar masts, but if the duration of 'temporary' is unknown, it is better to buy and resell later.

Temporary Solar posts along the stairs and old ramp at Blerick station.

26.2 Permanent Solar masts at Hilversum Sportpark

Signify has developed a mast fixture with integrated battery and solar panel for use in India. The panel on the fixture for India is too small for sufficient daytime charging in the Netherlands. For Europe, Signify created solar panels that are fitted around an existing post like a collar. They are virtually dirt-proof due to their vertical position. The round shape of the panels means they catch little wind, preventing the lamppost from blowing over. We tested this on platform 2 at Hilversum Sportpark (see photo on the left).

On a dark December day with only 4 hours of sunlight, the panel will reach just 30% of its capacity. On a summer day, the sun provides 1000W/m^2. A good solar panel can covert 200W/m^2 into electricity. The solar panels around the post are 2 metres long and 0.2 metres wide (0.4m^2). This means that in the 4 sun hours per winter day, a yield of 60W/m^2 x 4 hours x 0.4m^2 = 96Wh can be achieved. ProRail requires LED fixtures with a yield of at least 100 Lm/w. The 7W Solar fixture is better with a yield of 150 Lm/W. As such, a 7W fixture can burn for almost 14 hours with 96Wh of generated energy. Dimming to 50% after 8 PM further increases the number of burning hours. Platform lighting switches off half an hour after the last train until half an hour before the first train (usually between 1 AM and 5 AM). This means that lampposts on platforms burn 4 hours less per night than public lighting. Therefore, the number of burning hours per night in winter from 5PM until 1 AM and from 5 AM until 8:30 AM is 8 + 3.5 = 11.5 hours per night (= 11.5 x 7 = 80Wh). We calculated that we are able to generate 96W per day in winter. This will do for a consumption of 80Wh per night. Signify calculates very conservatively and therefore applies a 640Wh battery (instead of the calculated 96Wh).

Tips and conclusions:

- Solar masts with a panel on top are prone to be blown over.
- Vertical solar panels seem inefficient, but are preferred due to their resistance to dirt.
- The battery of the Signify Solar posts is 8x too large.
- We will continue to monitor the Signify posts with the monitoring system.
- We see good potential for Solar lampposts for platform extensions, for example.
- Solar fixtures with integrated battery and panel are the challenge for the future.

The new post was placed while the old remained to be uprooted.

Removed the pole-rail connection (earth network between the old lampposts).

The old cable was dug up next to the old post.

27 Eindhoven and Breda Prinsenbeek, removing poor ground cables

27.1 Eindhoven

At Eindhoven station, the old lampposts outside the canopy were replaced. The old lampposts were spaced according to a 16-metre grid. The existing cables could be reused as per request. However, on the open central platform on the south side, the insulation value of the power cables turned out to fail NEN3140 (management standard) during the zero measurement.

NEN3140 prescribes that the resistance of the cable in the event of a short circuit must not be too high and that the insulation resistance between the conductors is sufficient. In old cables servicing platforms with long cable routes, the circuit resistance may increase and the insulation resistance decrease rapidly. If the circuit resistance is too high, the fuse will not trip when the last lamppost is energised (short circuit). If insulation resistance is too low, a short circuit may occur in the cable. The NEN1010 new construction standard is even a bit stricter than the management standard, so the new lampposts with old cables would certainly not comply with that. That is why the old cables in Eindhoven were replaced after all. They turned out to be lead-sheathed cables from 1950.

Replacing ground cables is expensive (about €100,000 per stop with 2 side platforms), as the platform has to be dug open (often during a nighttime out-of-service period). Opening up the south side of the two central platforms at Eindhoven station costed around EUR 90,000. Luckily, this could be done without decommissioning due to the width of the platform and the low number of passengers it services. Because there were many side branches with old pole rail connections to the central cable trench though, more digging was required than the trench alone.

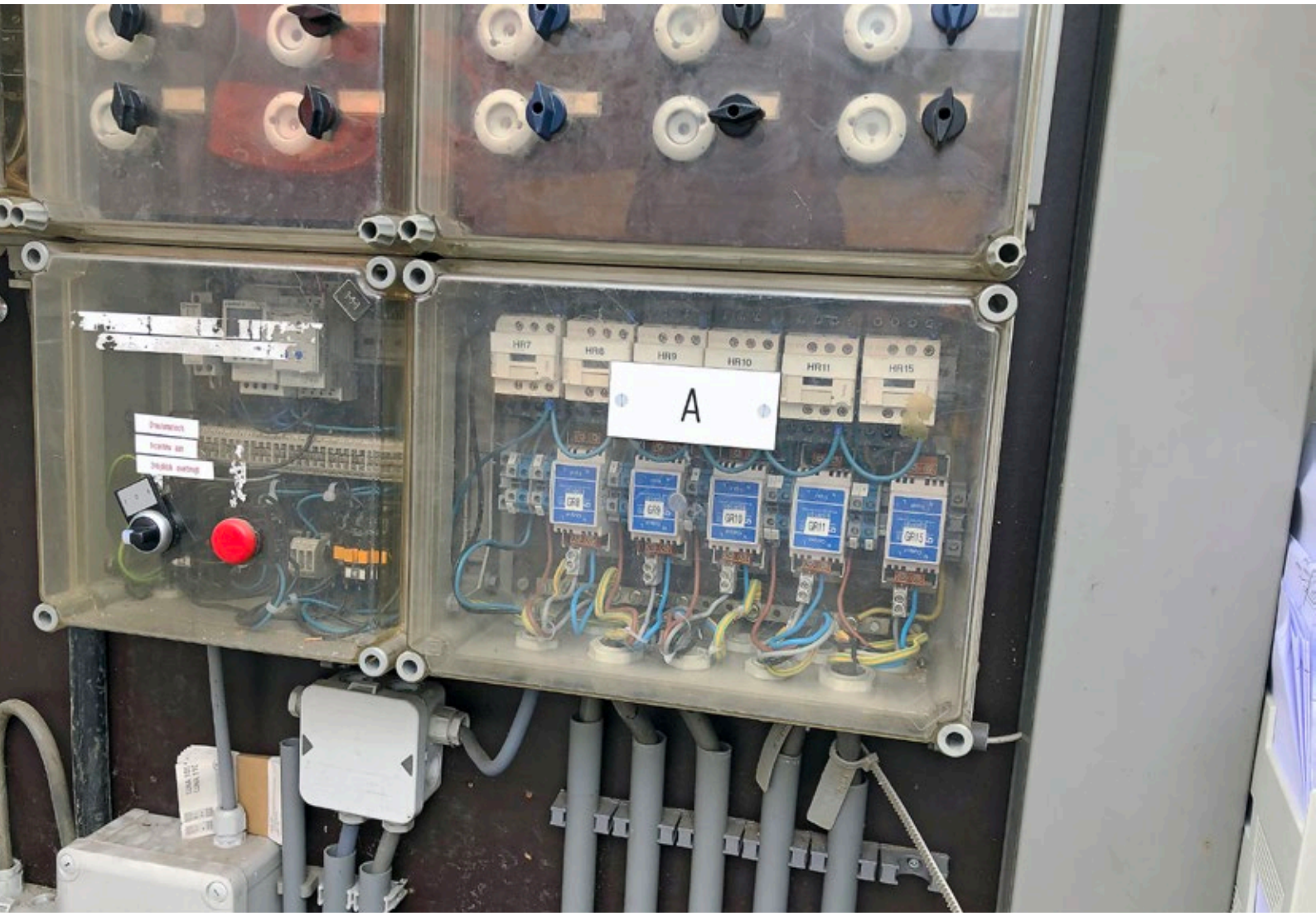
27.2 Breda Prinsenbeek

At Breda Prinsenbeek station, the installation was also found non-compliant with NEN3140 after completion. This project involved reusing poles and cables from 1988 and replacing fixtures only. Old NEN3140 reports show that part of the installation had been inadequate prior to the LED replacement as well. Such failures are often located in the open terminal strips or cables in the lampposts. This type of failure tends to be resolved by replacing the open terminal strips with closed, water-resistant lamppost boxes and new cables in the poles. To get the station up to par, it was decided, in consultation with station manager, to remedy the failure and replace part of the cables. To avoid replacing good cables, the failure was localised first. The switch board is located on side platform 1. Side platform 2 is powered via a track crossing. We then had the NS in-house installer:

1. disconnect the track crossing.
2. measure the platforms separately, the failure revealed itself in platform 2.
3. Next, disconnect the last post and measure whether the fault was resolved.
4. When the fault remained, the disconnected the second-last post.
5. Eventually, the cable between the final 5 posts on platform 2 was found to be faulty.
6. This piece of ground cabling (4 x 16m = 64m) was replaced.
7. opening up 2 side platforms and renewing the cables costs around € 100,000.
9. In this case, the problem was solved for just € 18,000.

Tips and conclusions:

- It pays to search for NEN3140 or NEN1010 errors (rather than replacing everything in one go).
- For example, ground cables from 1980 are often suitable for reuse (leave them in).
- However, always replace cables from 1950 (tend to have a lead jacket).



Following the experience in Olst, the switchboard in Blerick was fitted with 5 inrush peak limiters as well. The old fuses at the top. The black and red button on the left are for manual override (for daytime testing of the light).

28 Olst, Inrush peak limiters (nation-wide afterwards)

Olst station was one of the first stations where LED lighting was commissioned in 2017. It turned out that more than 20 LED fixtures were switched on one group. Each LED fixture has its own driver (electronic transformer). And those drivers have a drawback, which is a high inrush current. During the first (tens of) milliseconds, it may be so high that the circuit breaker 'sees' the inrush current as a short-circuit current and will therefore trip. The more fixtures are connected on a single circuit breaker, the larger the peak grows and the likelier the circuit breaker will trip.

Some fixture suppliers specify as a guideline that only 10 fixtures can be connected to one circuit breaker. Just like in Olst, 20 or more fixtures are connected to a single circuit breaker at many of our stations.

The solution to this problem can be found in:
- Fewer fixtures on a single circuit breaker. But that demands a lot more power cables, making it an expensive solution.
- Including an inrush peak limiter in the power circuit. An inrush peak limiter attenuates the current during the first 300 milliseconds to a value that does not trigger the circuit breaker. After that time, the inrush effect of the drivers has diminished far enough and the inrush peak limiter can pass the current unattenuated once again.

We opted for prescribing the Camtec ESB101 inrush peak limiter.

By the way, an 'old-fashioned' fuse (fuse cartridge) is less affected by this, as it has a different tripping characteristic. A modern circuit breaker is more sensitive. For stations with fuses in the switchboard and little free space in the cabinet (such as at Eindhoven Centraal and Valkenburg stations), it was decided to keep the fuses and not go down the route of the peak limiter.

Fuse cartridges are not a bad solution, apart from the fact that, once triggered, a fuse is broken and has to be replaced. Furthermore, they need to be replaced periodically as they age and the tripping current value becomes less reliable.
In the control tower at Schiphol Airport, circuit breakers are even banned because they fail too quickly when electronics are switched on, posing unnecessary risks to continuity.

Tips and conclusions:
- Always apply an inrush peak limiter to circuits containing more than 20 LED fixtures.
- To prepare for expansion, use a peak limiter on every group with LED lighting.
- The inrush peak limiter consumes around 1W. This is easily compensated for by the use of LED.
- Do not place inrush peak limiters too close to each other as they will become too hot.
- In the case of fuses, an inrush peak limiter is not necessary as long as the relay is suitable for the inrush peak and contacts do not merge.

Fuse

Circuit breaker

The prescribed Camtech inrush peak limiter

Eleq touch-safe splash-proof junction box in lamppost at Helmond station.

Sogexi touch-safe enclosed junction box at Oss station.

29 Bilthoven, long cable routes and excessive circuit resistance

A new car park was built in Bilthoven near the end of the central platform. The power supply of the car park was connected to the platform. The street cabinet with the switch board was on the other side of the central platform. In the event of a short circuit (or earth fault) in the last lampposts, the current will remain too low due to the long cable length and will not trip the circuit breaker or fuse (circuit resistance too high).

This means the last lamppost may be energised without tripping the fuse. To prevent this dangerous situation, the circuit impedance (resistance) is tested annually in accordance with management standard NEN3140.

The circuit impedance/resistance in the most common situations on platforms may not exceed 2.4 Ohm (for an installation circuit breaker with 16 ampere B-characteristics).

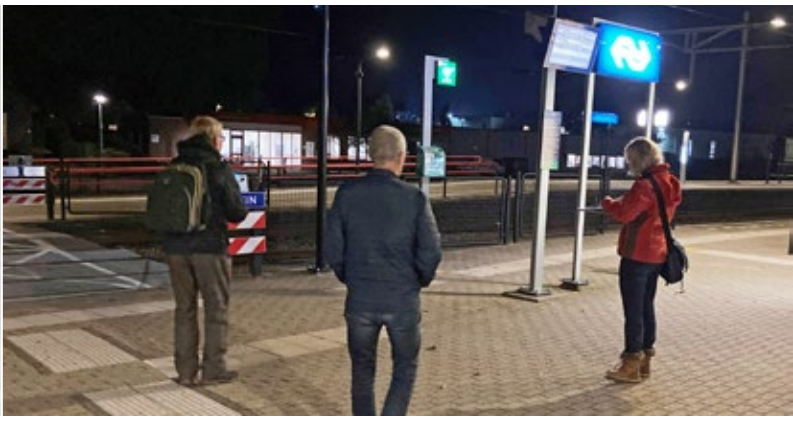
In Bilthoven, we shortened the cable lengths by installing an additional street cabinet close to the car park at the end of the central platform. A thick cable was installed to power that cabinet. The cabinet houses the installation circuit breakers for the car park and the cable routes are not too long anymore. The excavation work in the central platform made this an expensive adjustment (around € 30,000).

At some small stations where no cables were replaced, the final NEN3140 inspection showed that the circuit impedance was slightly greater than 2.4 ohm after the LED replacement. In consultation with the inspection authority, 12 amp instead of 16 amp fuses were used to ensure that the fuse would still trip in the event of a short-circuit at the last lamppost. This is possible because the power consumption of the LED lighting is much lower than that of the old lighting.

To prevent short circuits and earth faults in the lampposts, we also replaced the open terminal strips in all lampposts with closed, water resistant, touch-safe lamppost boxes with a local fuse (e.g. by Eleq or Sogexi, see adjacent photo).

Tips and conclusions:
- Excessive circuit impedance can be solved with an additional intermediate switch board (shorten cable routes).
- Excessive circuit impedance can also be solved with a lower fuse (if possible in terms of total current consumption of the lighting).
- Prevent short circuits in lampposts with touch-safe lamppost boxes and refrain from using open terminal strips.

No dark spots are visible on the pedestrian crossing.



A visually impaired person crossing the track independently (by themselves). If they find themselves halfway when the lights and bells turn on, they have to keep walking straight until they reach the platform without panicking or tripping.

The evaluation in Weesp. Each visually impaired participant took an eye measurement test before the evaluation round to measure how much residual vision the person still has.

Test in the tunnel at Weesp station

30 Evaluation with Visio at Bedum, Usquert, Olst, Weesp, Lage Zwaluwe

In February 2022, we evaluated the LED lighting at Olst station together with Royal Visio, Oogvereniging and a panel consisting of visually impaired people. There are over 100 types of visual impairment. Prior to walking the route, Visio performed an eye measurement on each panel member to determine the type of visual impairment. Each panel member was taken along the route from the bus/taxi to the train. For each transfer area along the route, questions were asked.

The evaluation was carried out in Olst because we were able to test the lighting on a central platform and a side platform there. One important element was to test whether visually impaired people would feel comfortable when using the pedestrian crossing in the dark (alone). The pedestrian crossing at the stop Olst is subject to a minimum requirement of 10 lux (and the platform is 5 lux) with a uniformity of 0.3. Measurements of the lux values in 9 location revealed that the uniformity (average lux value divided by the lowest measurement point) is even higher than 0.3. Similar evaluations were carried out in the stations of Bedum, Usquert, Weesp and Lage Zwaluwe.

Tips and conclusions:
- There are hundreds of types of visual impairment.
- The number of seniors with visual impairment is growing.
- Travellers over the age of 60 need 4x more lux than young travellers (source: Visio).
- With at least 5 lux, the platforms at a stop are sufficiently lit.
- Visually impaired passengers are more likely to be bothered by too much light than too little.
- Glare due to e.g. billboards must be avoided for the visually impaired.
- Uniformity is more important than high illuminance (lux value).

IMPRINT

Author
M.M. Pigeaud, MSc.

Photography
Henk Snaterse;
Light designers Atelier LEK, photographer Frank Hanswijk (3 photos Tilburg);
Nathalie Peters (photo of the train hall in Leeuwarden).

Cover
Station Amsterdam Bijlmer ArenA (photo Henk Snaterse)

Publisher
ProRail B.V.

Design and layout
Inpladi bv


ProRail