B+N

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R+D activities

05.03.2022.

R+D activities at B+N Referencia Ltd

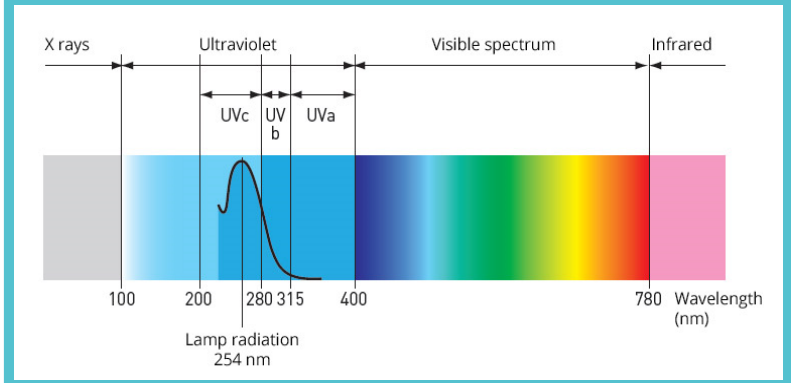
- Our R&D department was established in 2016
- Currently consists of 20 developers and technicians
- Development focus: improving hygiene and increasing efficiency
- At the end of 2019, our in-house developed autonomous cleaning robot, ROBIN R3000 was completed
  - Ideal for cleaning large halls and wide corridors
  - It autonomously cleans an area of 1000-1500 sqm in one shift
  - First series already in operation at our partners

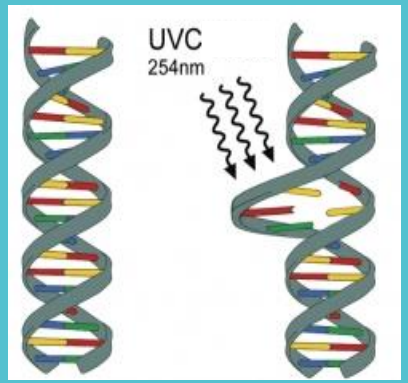
UVC devices

- UVC disinfection
  - Mobile UVC disinfection device - serial production started in Q2 of 2021
  - Autonomous UVC disinfection robot - prototype in Q2 of 2022

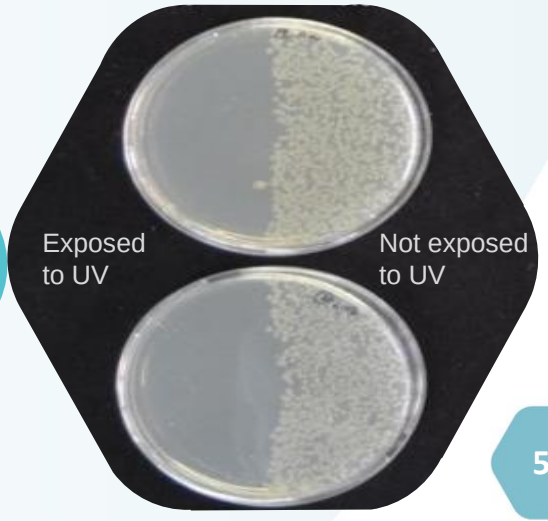
UVC disinfection

- UV light is between 100-400 nanometres wavelength.
- And the wavelength between visible light and X-rays, in the range of 200-280 nanometres (UVC), has a germicidal effect.
- UVC light is able to inactivate viruses, bacteria, spores and fungi by damaging their genetic material (DNA/RNA).
- Direct UVC light can damage human eye and skin.





E. coli cell culture can be inactivated by exposed of proper UV dose (left side of plates)



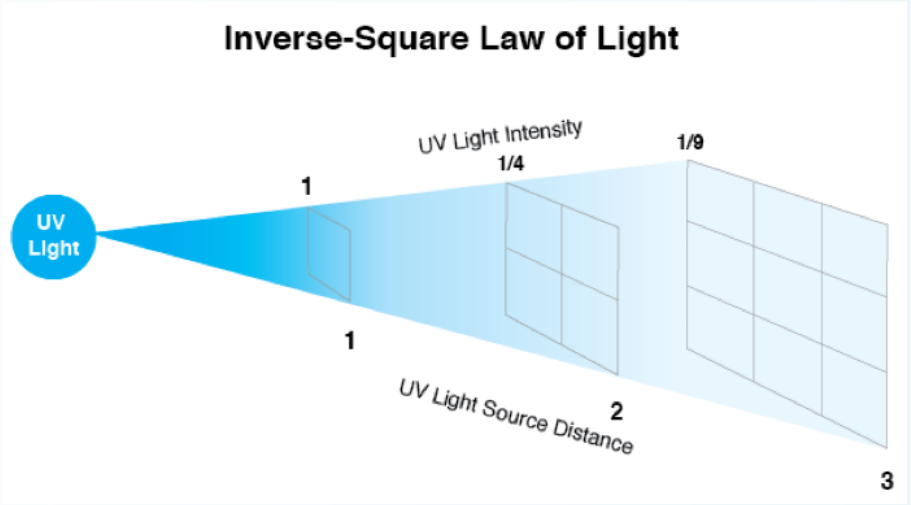
https://www.sciencedirect.com/science/article/pii/S2468067218300452#b0055

UV Safety

- Direct UV radiation can be harmful to the human skin and eyes
- Appropriate safety procedures and wearing of protective equipment are mandatory

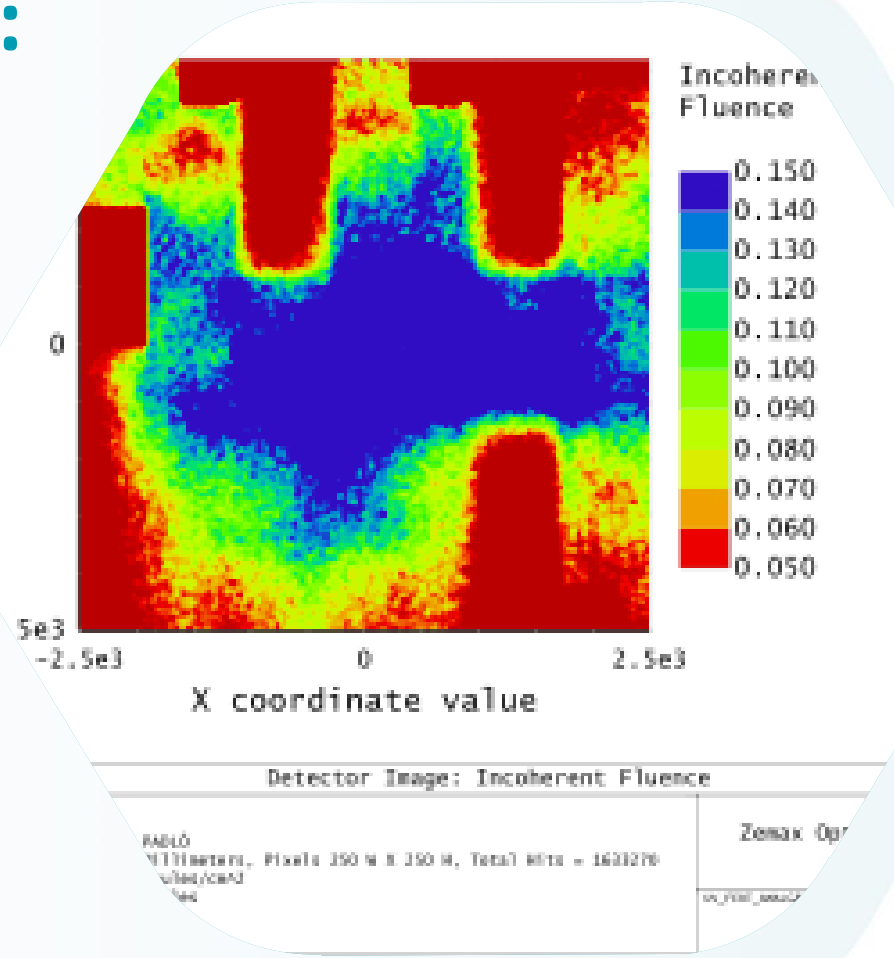
UV intensity and dose

- Intensity is inversely squared related to the distance
- UV light is filtered out by most materials, so its effectiveness is minimal on shaded surfaces
- The inactivation dose of many pathogens is known from the literature, and the dose and time required to achieve the desired disinfection effect can be calculated from intensity

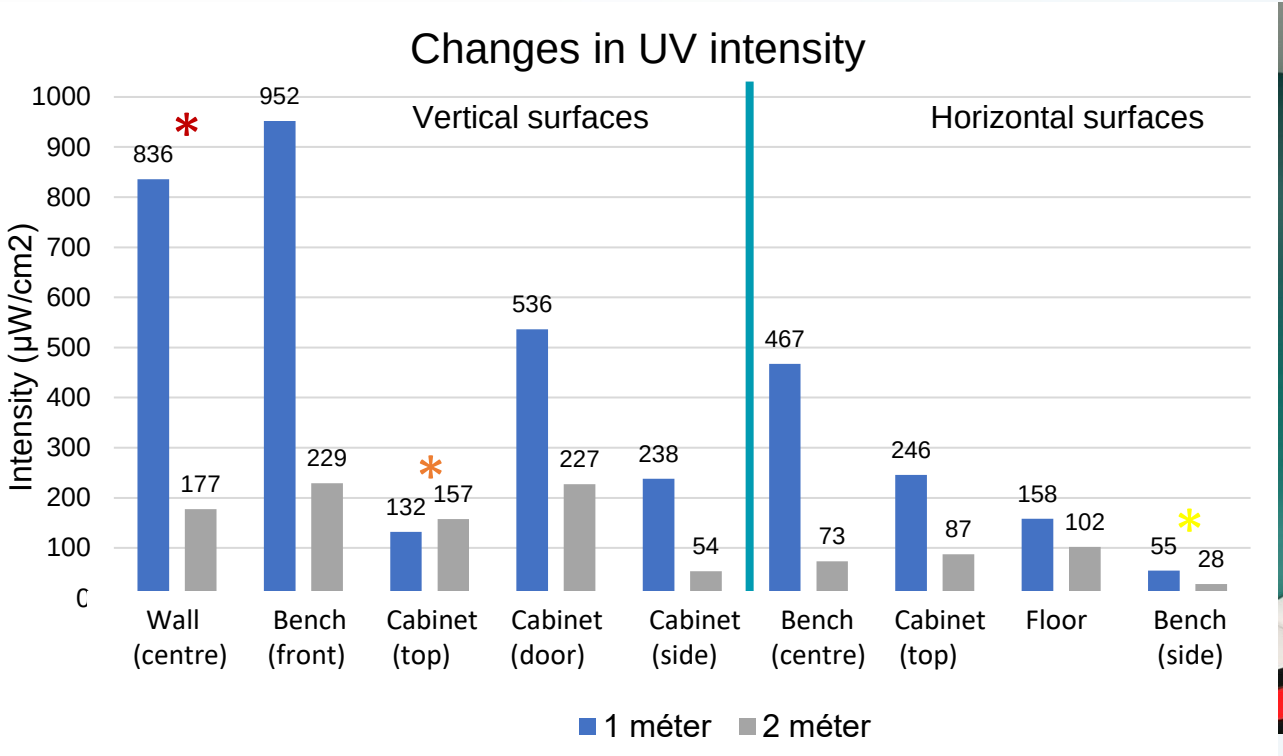


UV dose in practice: reflection, shading effects

- The reflectivity of iradiance from the ceiling slightly increases the dose on horizontal surfaces (floor in animation)
- On shaded surfaces the change is minimal



UV intensity and distance (case study)



+ Besides distance, angle of incidence and shading also affect intensity

Ideal UV disinfection process

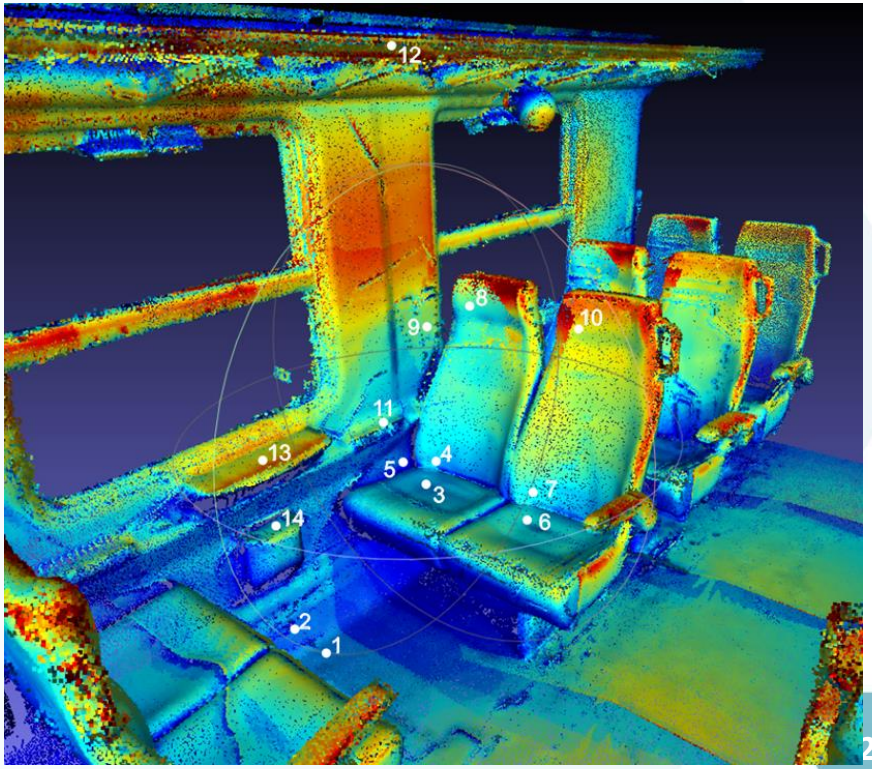
- UV light disinfection introduction process:
  - Room measurement, determination of required dose and application time (3D model)
  - Process development, site application instructions
  - Process validation, UV dose measurement (radiometer, dose indicator stickers)
- UV light application considerations
  - Regular monitoring (following operation instructions, dose measurement)
  - UV light source lifetime consideration
- Introduction of UV disinfection devices can achieve a significant reduction in hospital-acquired infections
  - Additional disinfection step to a stable hygiene system
  - Long-term monitoring required

Mobile UVC disinfection device

- Optimised for fast and efficient disinfection of public transport (trains, buses, trams)
- The right dose of UV-C light kills 99.9% of pathogens in a short time
- Adjustable arms allow optimisation of UV radiation for different angled surfaces
- Easy to move and navigate between rows of chairs
- Long, 2 hour run time, easily replaceable battery
- Disinfects a train carriage in 20-25 minutes
- After disinfection, the room is ready to use

3D modelling

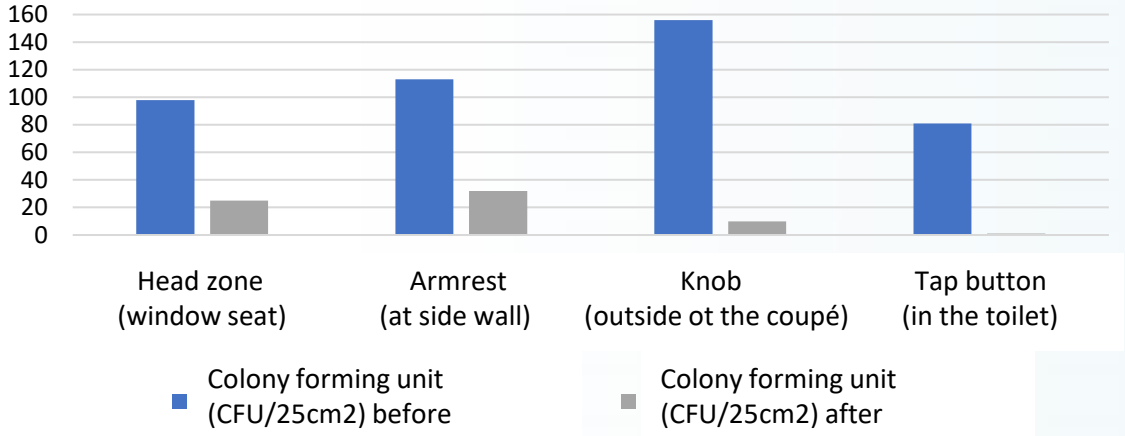
	Measurement point	Measured intensity (µW/cm²)	Calculated intensity (µW/cm²)
1	Floor at the side wall of the train	235,8	300
2	Side wall at the floor	204,3	265
3	Seat horizontal surface (at side wall)	173,5	316
4	Seat back surface, lower corner (at side wall)	195,6	340
5	Side wall at seat, lower corner	180,7	150
6	Seat horizontal surface, corner (centre)	248,8	383
7	Seat back surface, lower corner (centre)	244,4	400
8	Seat back surface, upper corner (at side wall)	306,2	384
9	Side wall at back surface	203,9	239
10	Seat back surface, upper corner (centre)	395,6	600
11	Armrest at the corner (side wall)	256,8	445
12	Front of luggage rack	180,3	330



Application of UVC disinfection device

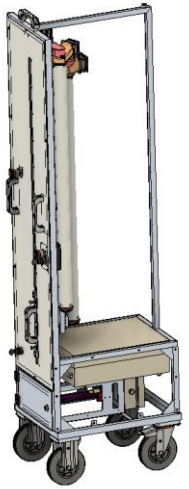
- We achieved a dose of about 1. 5-2 times higher than the targeted dose with an irradiation time of 45 sec/row on most surfaces.

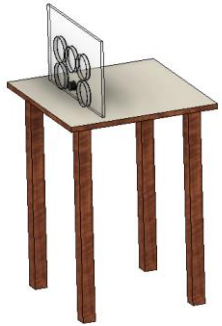
Measurement point	Measured dose (mJ/cm^2) (sticker)	Reduction by disinfection (%)
Head zone, centre, window seat	37,5	74
Armrest at side wall	25	72
Knob (outside of the coupé) (1 meter)	50	94
Tap button in the toilet	25	99

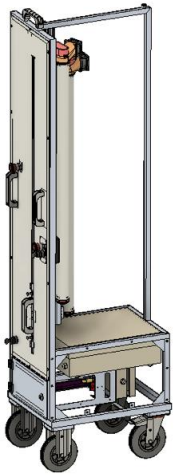


Disinfection efficiency of UVC device in experimental conditions

- Accredited conditions
  - Bacteria: *Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus, Enterococcus fecalis, Salmonella typhimurium*
- Vertical setting:
  - For all species, 1 min irradiation of petri dishes placed at 1 m resulted in a minimum 99.9% reduction in bacterial counts at an average UV dose of 29.27 mJ/cm2.
- Horizontal setting:
  - For all species, 1 min irradiation of petri dishes placed at 1 m resulted in a minimum 90% reduction in bacterial counts at an average UV dose of 5.40 mJ/cm2 UV for all species.







Pros and Cons

UV disinfection	Manual disinfection	H2O2 / O3 gas disinfection
– Shaded areas are not reached	+ The disinfectant can be applied to surfaces	+ The gas can reach everywhere
+ Chemical-free method	– Chemical method	– Chemical method
+ Consistent disinfection quality per cycle	– Quality depends on the operator	+ Consistent disinfection quality per cycle
+ Area can be used immediately after treatment	– There is contact/drying time after treatment	– Significant contact time after treatment
+ Room must be closed	+ Only basic health and safety requirements	– Room air must be separated
+ Short treatment time, depends on room size, little labour requirement	– Treatment time is considerable, high labour requirement	– Long treatment time, high labour requirement
+ Technological time depends on room size, 15 minutes can be sufficient	– Technological time: depends on room, >30 min	– Technological time: depends on room, >120 min
• $$ - $$$$$ • Light source lifetime	• $	• $$$$ • Device lifetime

Summary

- Usingof UVC devices is a particularly fast and effective method for disinfecting highly touched surfaces in hospitals, public transport, schools and nurseries
- However, the physical properties of irradtion it is necessary to optimise the application for the area
- Our UVC disinfection devices have been developed and introduced with these considerations.