CONNECT AND PROTECT

Outdoor Cabinets for Rail Applications

Certified protection for sensitive electronics against environmental and other external influences

Outdoor Cabinets for Rail Applications

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1. INTRODUCTION: OUTDOOR CABINETS FOR RAIL APPLICATIONS

For railway systems, absolute safety and reliability are of utmost importance, as failure in sensitive equipment can have catastrophic consequences. This level of safety must also be provided by electronic cabinets installed outdoors on tracks, at train stations and signal boxes, or at level crossings. These cabinets protect electronic systems for track and signaling applications, radio-based train control systems, and the measurement and evaluation electronics of safety systems on high-speed railway lines, such as axle counters or temperature detection on the train wheels. Today, more and more electronics can also be found on the platform: Passenger information systems and comprehensive video surveillance provide information and security.

This White Paper explains in detail the most important features of outdoor cabinets for rail applications; whether on tracks, at stations, or in signal boxes:

Requirements and challenges:

- Optimal thermal performance
- Protection against environmental influences
- Security and anti-burglary protection
- Scalability and flexibility
- Integration services, simulations, and tests

These factors have a considerable impact on the safe and reliable operation of the electronics for railroad applications in the outdoor cabinet, but also on the durability and total cost of ownership of the application.

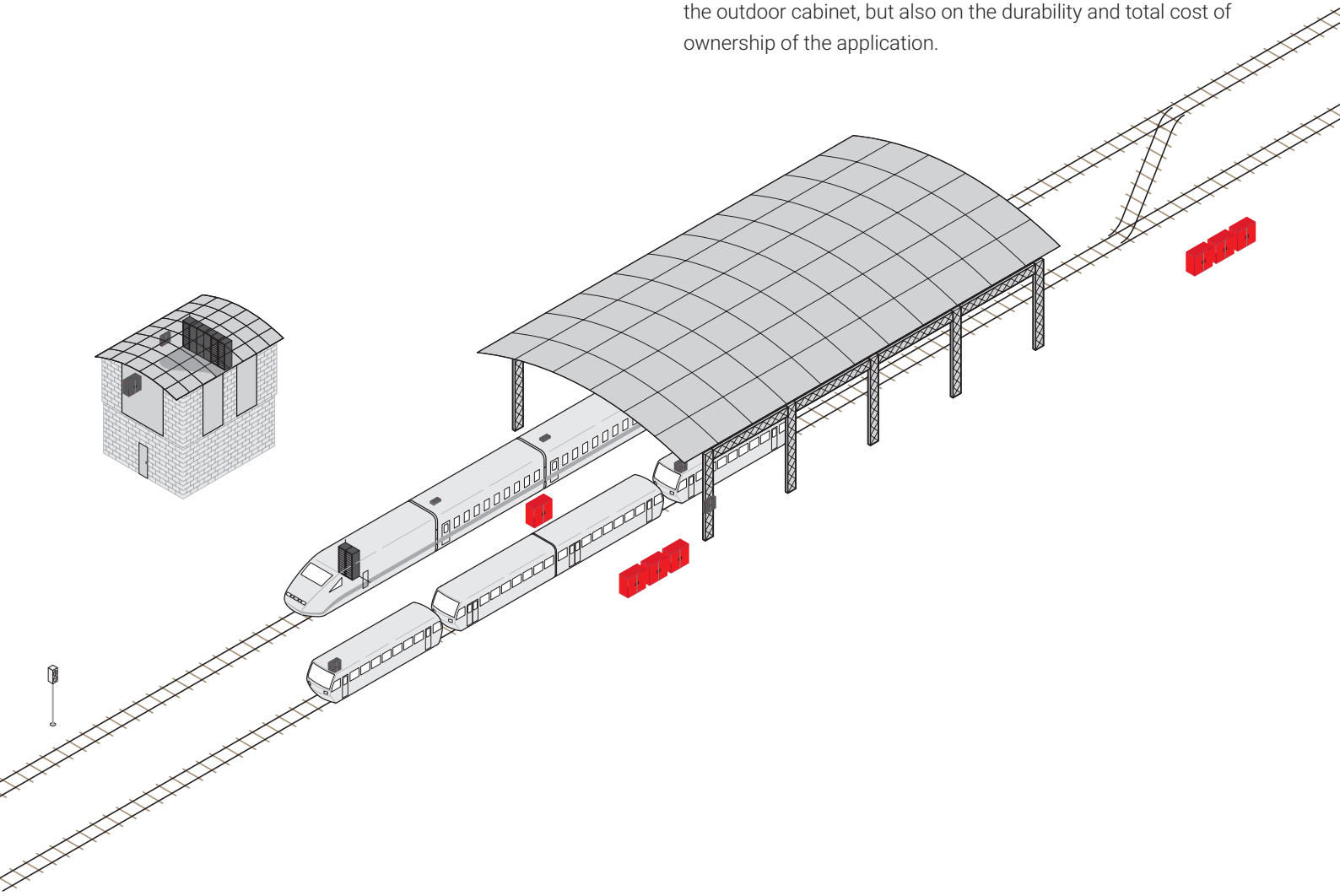

Fig. 1: Outdoor cabinet applications on the track

Outdoor Cabinets for Rail Applications

2. REQUIREMENTS AND CHALLENGES

Trains traveling at speeds of up to 300 km/h can cause high wind speeds and vibrations. In addition, outdoor cabinets are exposed to a wide variety of environmental influences like heat, cold, humidity, dust, and vandalism. In addition to international standards regarding mechanical stability, special railroad standards and certifications must also be observed such as shock, vibration, and EMC protection. Relevant certifications and standards to be met include:

IEC 61969-3	**For protection against environmental influences.** IEC 61969-3 specifies climatic, mechanical, biological, and chemical tests and basic requirements for environmental tests for enclosures in non-weatherproof outdoor areas. Security considerations, thermal management, and noise emissions are also taken into account.
EN 50125-3	**For protection against shock and vibration (1-3 m distance from the track) and wind resistance up to 180 km/h.** EN 50125-3 is specially designed for railroad applications and describes the environmental requirements for signaling and telecommunications equipment. These conditions include pressure, temperature, wind, rain, hail, and vibrations and shock events.
EN 60529	**For a protection class up to IP55.** IEC 60529 specifies the IP protection classes of cabinets and enclosures against the ingress of dust or water and for the protection of persons from hazards inside the enclosure
IEC 61587-2 and IEC 61969-3	**For earthquake security up to Bellcore Zone 4.** IEC 61587-2 specifies seismic tests for cabinets and racks. It applies in whole or in part only to the mechanical structures of cabinets and racks for electronic devices in accordance with the above-mentioned series of standards, but not to the electronic devices or systems installed within these mechanical structures. IEC 61969-3 also contains specifications regarding earthquake resistance.
IEC 61969-3 (EN 1627 and EN 1630)	**RC2 (old WK2) for protection against vandalism.** EN 1627 defines various resistance classes (RC) in terms of burglary resistance. The individual resistance classes indicate how long a product can withstand the break-in attempt of a perpetrator. A higher class means stronger intrusion protection. EN 1630 describes the corresponding test procedures.
EN 50121	**For electromagnetic compatibility.** EN 50121 specifies limit values and measurement procedures for the interference emission and immunity of electrical and electronic equipment intended for use in railway applications. The specifications are defined for the frequency range of 0 to 400 GHz.
IEC 61969-2	**For coordination measures.** Coordination measures for the construction of fixed outdoor enclosures used in non-weatherproof outdoor areas. The internal and external coordination measures are derived from IEC 60917-2. The internal coordination dimensions correspond to the mounting dimensions of the subracks according to IEC 60917-2-2 and IEC 60297-3.
IEC 60068-2-75, IEC 62262, and IK 10	**For impact resistance.** The IEC 60068 -2-75 presents three standardized and coordinated test methods to determine the robustness of a test object against impulse effects of limited strength. The number of impulses introduced is determined with regard to energy and direction. The IEC 62262 defines the IK impact resistance degree or the IK protection class. It is a measure of the resistance of cabinets for electrical equipment to mechanical stress, especially impact stress. There are ten IK protection classes that the enclosure can withstand at minimum. IK 10 is the highest protection class and corresponds to an impact energy of 20 joules.

The modular nVent SCHROFF Outdoor Cabinet is a flexible solution that ensures smooth and reliable operation of sensitive electronics in outdoor locations. It has been specially designed, tested, and certified to meet the various requirements for track-side outdoor railroad applications.

The characteristics and properties of an outdoor cabinet also have a significant impact on the total cost of ownership, the total operating costs of the application over its service life. These not only include the acquisition costs, but also the long-term energy, repair, and maintenance costs. The better the cabinet protects the application, the lower the TCO can be kept over the entire life cycle of the application. The main focus here is primarily on ensuring a specified operating temperature range so that the electronics remain functional and reliable over a long period of time, allowing maintenance and repair costs to be reduced.

Outdoor Cabinets add value by significantly reducing total cost of ownership, operational costs, improving safety, and increasing reliability and service life.

Fig. 2: Outdoor Modular Cabinet for Railroad Applications – open, with additional 19" profiles

Fig. 3: Outdoor Modular Cabinet for Rail Applications - closed

3. OPTIMAL THERMAL PERFORMANCE

The issue of cooling is especially important when installed out doors. Not only must the power loss of the installed components be dissipated, but daily or seasonal outside temperatures must also be taken into account. The thermal output of the cabinet must ensure an operating temperature appropriate to the electronics from -40°C to +60°C in an ambient temperature of -40°C to +80°C. Not only does the specified operating temperature of the electronics and the heating caused by solar radiation play a role here, but so does the heat generated by the internal electronics. Ensuring an operating temperature specified by the manufacturer for the internal electronics ensures reliable operation, extends the service life and operating life of the application, and also reduces the resulting investment in electronics.

Depending on the framework conditions, the concrete cooling requirement needs to be determined. Natural or free convection as a heat dissipation solution meets its limits when handling large amounts of heat. This is because the amount of dissipated heat (energy) has a linear relationship with the temperature difference between the inside and outside.

$$\mathbf{Q = k \cdot A \cdot (T_{Inside} - T_{Environment})}$$

Increasing the heat transfer coefficient k can help here, but this requires switching over to the forced type of convection cooling. Depending on the requirements, additional cooling components such as air-filtered fans or an air-conditioning cooling unit are now installed to achieve the optimal operating temperature.

Speed-controlled, **air-filtered fans** with thermostats represent an economic and effective means of climate control in cabinets. This active cooling through fans is an open circuit that transports ambient air into the interior of the cabinet to cool the electronics. The air supplied via air-filtered fans must be adapted to the air requirements of the components. Filter mats reliably protect the interior of the cabinet from dust. If air-filtered fans are used at very low outside temperatures, a heating unit may be required in the cabinet. The prerequisite for the use of air-filtered

fans is that the ambient temperature is below the maximum possible internal cabinet temperature. As a rule of thumb, a temperature difference of at least 5 K can be assumed. Direct air cooling is extremely reliable and has a long service life with low energy consumption.

Air-conditioning cooling units offer the highest cooling capacity and enable **cooling** of the cabinet interior, independent of the ambient temperature. An air conditioning compressor, used in the cabinet area, is tasked with transporting the heat from the cabinet to the outside, thus keeping the internal temperature in the cabinet at the desired level and within the range of the hysteresis. The fan responsible for the internal circuit permanently circulates the cabinet air. The temperature is monitored by a thermostat. This thermostat activates the compressor and the external circuit fan upon reaching the required cabinet temperature. This activates the cooling circuit and stops only when the temperature is reduced by the hysteresis value of the thermostat.

An air conditioner can only be operated on a closed, waterproof electronic cabinet. Otherwise, part of its output would be used for dehumidification instead of cooling. The selection of an air conditioning unit should be based on the maximum power dissipation in the cabinet and the desired operating point. The cooling capacity curve of the respective air conditioner needs to be observed for this purpose. When using an air conditioner, the air duct in the cabinet must be designed in such a way that no air short-circuits occur, where the air that has just been cooled is almost directly drawn in again by the unit instead of cooling the components.

To ensure an optimal operating temperature range in the cabinet, different options can be leveraged with the nVent SCHROFF Modular Outdoor Cabinet. A thermal output of up to 240 Watts can be dissipated by natural convection alone, at an average temperature in the cabinet of 90°C and an outside temperature of 80°C. This is the result of a thermal analysis using numerical methods, the result of which is a heat transfer value of 20 to 24 W/K based on the temperature under the roof or the average temperature inside the cabinet (environment according to standard IEN 61969-3, Class 1).

The standard feature of the Outdoor Modular Cabinet for railroad applications is supporting active heat dissipation using a fan kit. This kit consists of 2 fans with a thermostat, for modified cooling capacity. Using the two integrated 24V DC fans that draw cold air through the doors and blow heated air out through the external top, a thermal simulation provides for a thermal transfer of 160 W/K and an air flow capacity of 540 m³/h.

In addition to the use of fans with or without PWM control and thermostat, it is also possible to equip the cabinet with air conditioner cooling units if required. Various AC air conditioners from our own portfolio are available here. The nVent HOFFMAN V, G, and T series models are especially suited for this application area. These models come in different dimensions bearing cooling capacities of approx. 1,000 to 2,000/3,500/5,500 W. When these air conditioners are used, a specially prepared door with corresponding cut-outs is available.

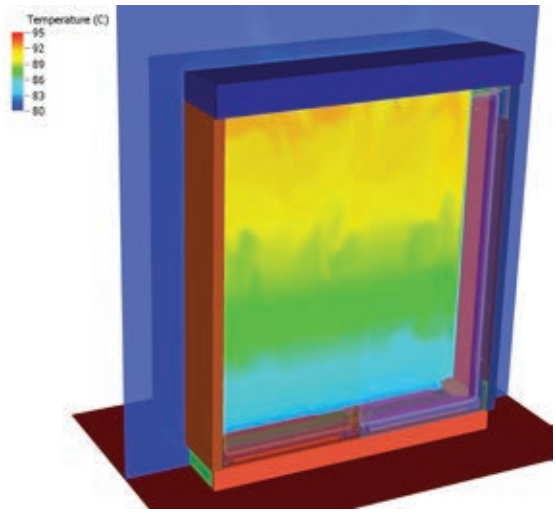

Fig. 4: Thermal simulation of the natural convection through the double wall design of the nVent SCHROFF Outdoor Modular Cabinet, thermal transfer 20-24 K/W

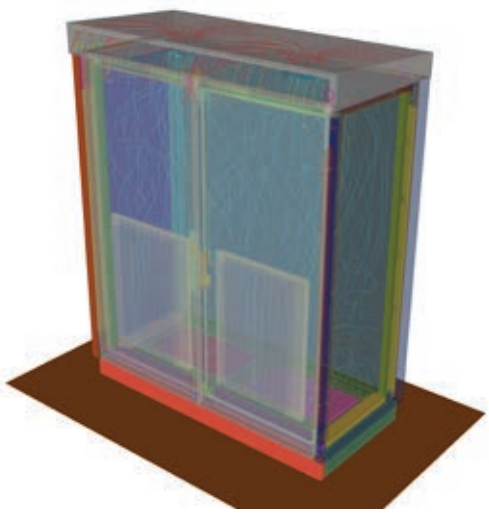

Fig. 5: Thermal simulation of the natural convection through the double wall design and the standard integrated two 24V fans and thermostat of the nVent SCHROFF Outdoor Modular Cabinet, thermal transfer 160 W/K

4. PROTECTION AGAINST ENVIRONMENTAL INFLUENCES

Outdoor use exposes electronic systems to extreme environmental conditions such as temperature fluctuations of -30 to 80°C, high humidity as well as rain, snow, hail, ice, intense solar radiation, lightning strikes, fire, storms, rockfall, dirt such as sand and dust, and electromagnetic radiation. Passing trains cause sudden differences in air pressure as well as vibrations and shocks which should not be underestimated. Depending on the speed, enormous pressure forces can develop due to the fluctuations in air pressure and affect the cabinet. In order for outdoor cabinets to withstand these mechanical influences, aspects like reinforcements on the cabinet rack must be taken into account in the design. In particular, protection against shock and vibration must be ensured at a distance of 1 to 3 m from the track. For this purpose, an outdoor cabinet must be certified according to EN 50125-3. In addition, an earthquake resistance up to Bellcore Zone 4, which corresponds to a magnitude of over 6 on the Richter scale, is of great importance, depending on the installation site. Wind resistance with values from 180 km/h up to 250 km/h, which corresponds to a Category 4 hurricane, must also be guaranteed by the structure of the cabinet. A weather-resistant powder coating or an anti-graffiti coating should protect the cladding parts from mechanical damage. Protection against unwanted electromagnetic radiation on sensitive electronics also plays a central role in railroad systems.
On the one hand, the environment must be protected from emitted radiation, and on the other hand, the electronics must be protected from penetrating radiation. Therefore, appropriate measures for grounding and lightning protection are also necessary.

Fig. 6: The interior of the nVent SCHROFF Modular Outdoor Cabinet: Aluminum profile frame, aluminum profile hinges, form-in-place gaskets for IP55 tightness between frame and inner wall, clip-on seals on the doors

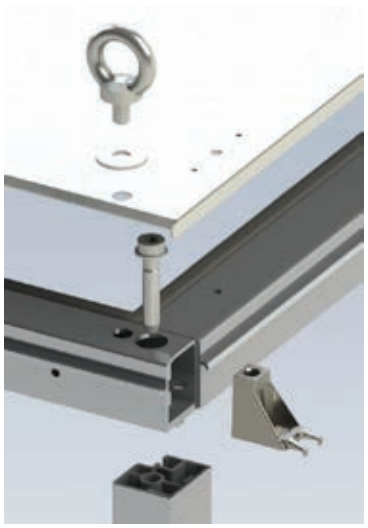

Fig. 7: Corner pieces integrated in the cabinet frame reinforce the stability and robustness of the aluminum profile frame. The lifting eyes carry a load of up to 630 kg including the weight of the cabinet.

The nVent SCHROFF Modular Outdoor Cabinet reliably protects the installed components from these environmental influences. Thanks to its aluminum frame and double-walled design, the cabinet offers rigid structural stability with a static load of 400 kg. The particularly robust design is achieved by aluminum profile hinges and corner pieces integrated in the cabinet frame. These cabinets must satisfy international standards as it pertains to mechanical characteristics such as shock, vibration, and earthquake resistance. The aim of the mechanical tests is to be certain that the cabinets will stand up to normal handling during manufacturing, storage, system construction, and operation. The static loading tests performed on cabinets include lifting tests and also rigidity tests to different requirement classes. For the shock and vibration tests carried out on cabinets, the components to be used and the load distribution are precisely specified. The cabinet is then fixed to an oscillating table and tested to one of three requirement classes (DL4, DL5 or DL6) according to the intended application. After the test, the cabinet may not show any “deformation that affects its shape, fastening or function.”

The wind test is carried out in the high-speed zone of a Jules Verne climatic wind tunnel. The cabinet is exposed to a total of four levels of wind speeds in sequential gusts at which sudden increases in speed occur in accordance with natural gusts of wind. In addition, five wind directions are tested. The Outdoor Modular Cabinet passed the wind test without damage or permanent deformations on all four tested levels and all wind directions with 250 km/h as the highest wind speed.

The tests for the seismic tolerances of cabinets are equally detailed. The seismic test is performed on a shaking table with an artificially generated waveform. During the test, the movement of the upper side of the cabinet is measured. The greatest displacement relative to the fixing point may not exceed 50 mm. Nor may there be any deformation or damage to load-bearing elements; doors must not open and covers must not come loose. At the end of the test, all locks and closures must still be functional. The nVent SCHROFF Modular Outdoor Cabinet has been subject to these tests and passed them with strong results.

Fig. 8: nVent SCHROFF Modular Outdoor Cabinet in the wind tunnel

The outdoor cabinet is equipped with all-round FIP (Form-In-Place) gaskets to ensure IP 55 tightness against penetrating fluids, e.g. rain, sand, and dust. These light-curing gaskets adapt optimally to both smooth and profiled surfaces and provide the desired protection. On the cabinet doors, this sealing effect is realized using removable clip-on seals. When replacing the outer covers, the installed components are still protected by the gaskets on the inner wall. An earthing kit with a central earthing point provides the necessary equipotential bonding. Sufficient EMC protection is ensured by the inner panels, which fully line the aluminum frame. This protection can be extended as an option.

Fig. 9: IP5X Dust Test

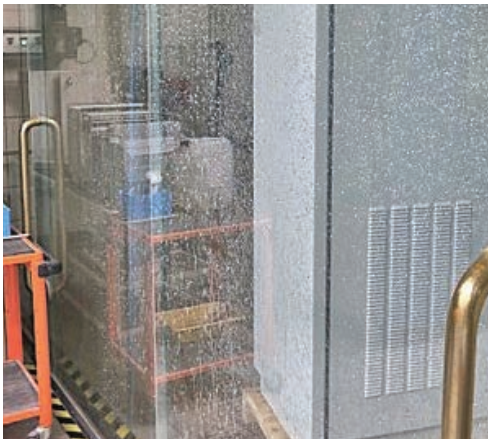

Fig. 10: IPX5 Water Test

5. SECURITY AND ANTI-INTRUSION PROTECTION

In freely accessible outdoor applications, there is also the risk of vandalism and unauthorized access. Therefore, a high degree of robustness and stability are standard features of outdoor cabinets. A stable cabinet frame and a double-walled design with modified wall thicknesses are effective measures when it comes to security and anti-burglary protection. It is also important that handles are protected against vandalism, and that screws for removing the roof, side walls, and base panels are only accessible from the inside, making access to the interior of the cabinet considerably more difficult for unauthorized persons.

The nVent SCHROFF Modular Outdoor Cabinet guarantees the desired structural stability with its aluminum frame, double-walled design, aluminum profile hinges, and reinforcing corner pieces on the cabinet frame. The outer cladding parts are made of 1.5 mm-thick, zinc magnesium-coated steel. The outside

surfaces are also powder-coated. The inner panels are made of 1 mm-thick aluminum sheet metal. All wall screws can only be accessed from inside the cabinet. The top cover, side panels, and base plinth covers can only be removed when the doors are unlocked. In addition, the aluminum hinges have very high rigidity. The cabinet base is fixed to the floor in accordance with the NEBS standard. Access to the base with the cable inlet is only possible through the inside of the cabinet when the doors are open.

The 3-point locking system ensures tightly closing doors. You can choose between different handle options: standard handle with DIN half-cylinder, vandalism-proof handle for DIN half-cylinder, and vandalism-proof handle for two half-cylinders (customized projects only).

To prove safety and anti-intrusion protection, a Modular 29 HE outdoor cabinet measuring 1300 x 1620 x 615 mm (HxWxD) was subjected to a intrusion test of resistance class RC2 and a shot test. The outer cladding parts are made of steel, the inner parts are made of aluminum. Vandalism-resistant elements of resistance class RC2 make intrusion with simple tools difficult. During the manual test, the element must withstand a break-in attempt for at least three minutes. The tester can use a screwdriver, pliers, and wedges as lever tools. The outdoor cabinet passed this test without any issues. During the shooting test, carried out with a semi-automatic Beretta N° XA042390, caliber 12/76 ½ choke, and ammunition caliber 12/70 steel pellets N°6 BATCH N°12101177, the cabinet withstood the required four blows from projectiles. No projectile perforated an outer wall.

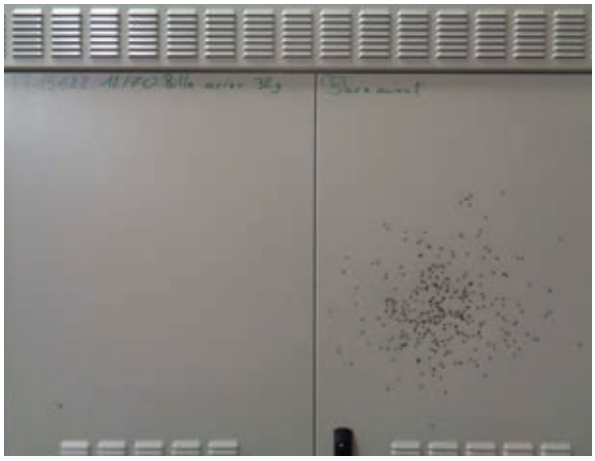

Fig. 11: Front side of the Modular Outdoor Cabinet after the shot test, no steel pellet perforated the outer wall.

6. SCALEABILITY AND FLEXIBILITY

For different areas within rail applications, it is crucial that outdoor cabinets are available in different sizes. Ideally, the cabinets are designed to be scalable in height, width, and depth, and can be easily adapted to the desired applications. An extensive range of accessories with elements for interior installation, cable routing, and cable entry, is also helpful and ensures a high degree of flexibility. Easy access to the inside of the cabinet from all sides is important for performing maintenance as well as mounting and installing electronics within the cabinet.

The flexibility of the nVent SCHROFF Outdoor Cabinet is supported by the scalability of the cabinet design and a wide range of compatible 19" accessories. The cabinet is adjustable in width from 700 to 2,000 mm, in height from 1,000 to 2,100 mm, and in depth from 500 to 1,200 mm in 50 mm increments. The construction allows access to the inside of the cabinet from all sides. The accessories for this outdoor cabinet are compatible with the extensive 19" cabinet accessories available from nVent, thanks to the optional 19" profiles.

7. INTEGRATION SERVICES

Customers' requirements for the cabinet often include the integration of additional components such as display elements, monitoring, cabling, or power supplies. These components can either be supplied by the customers or purchased and assembled via the cabinet manufacturer according to the specifications submitted.

nVent also offers this integration as a service to its customers. Components such as batteries, rectifiers, converters, and UPS devices are likewise integrated as are the requisite cabling, components for environmental monitoring (EMX), control panels and redundant cooling. nVent SCHROFF also assists its customers with testing and simulations at its own laboratories to ensure that the application requirements are fulfilled.

8. SUMMARY

Outdoor cabinets containing a suitably configured air conditioning system to cool built in electronics guarantee reliability and durability for railway applications. In addition to certified protection against environmental influences and vandalism, the flexibility and scalability of the cabinet is necessary to set up a solution modified to the customer's application.

The nVent SCHROFF Modular Outdoor Cabinet offers all the necessary features in this respect. The cabinet has been tested and certified for all relevant railroad applications on the track and thus offers safety and reliability for the proper functioning of the application over a long service life. Protection against environmental influences through a robust and tight design, a well thought-out cooling concept consisting of a double-walled construction for optimal use of natural, free convection, and additional cooling possibilities via filter fan or air-conditioning unit, the desired operating temperature range can be guaranteed in any rail environment. The protection measures against intrusion and vandalism, combined with its scalability and flexibility for adaptation to customer-specific applications, the nVent SCHROFF Modular Outdoor Cabinet is an ideal, certified solution for outdoor railway track-side applications. All of these characteristics have a major impact on the total cost of ownership and can extend the service life and reduce operating costs when cabinets are optimally adapted to the rail application, thus also reducing the TCO.

In addition to the highly flexible Modular Outdoor Cabinet, nVent also offers two other outdoor cabinets platforms, the Unibody and Comline models. These cabinets are also suitable for railway applications. The Unibody model is a cost-effective, double-walled solution for small cabinets which are used in communication applications at stations as station information monitoring systems, or for power and signal distribution. The single-walled Comline model, with its particularly light aluminum design, is suitable for wall, mast, or floor mounting and offers the necessary protection, e.g. for radio communication applications.