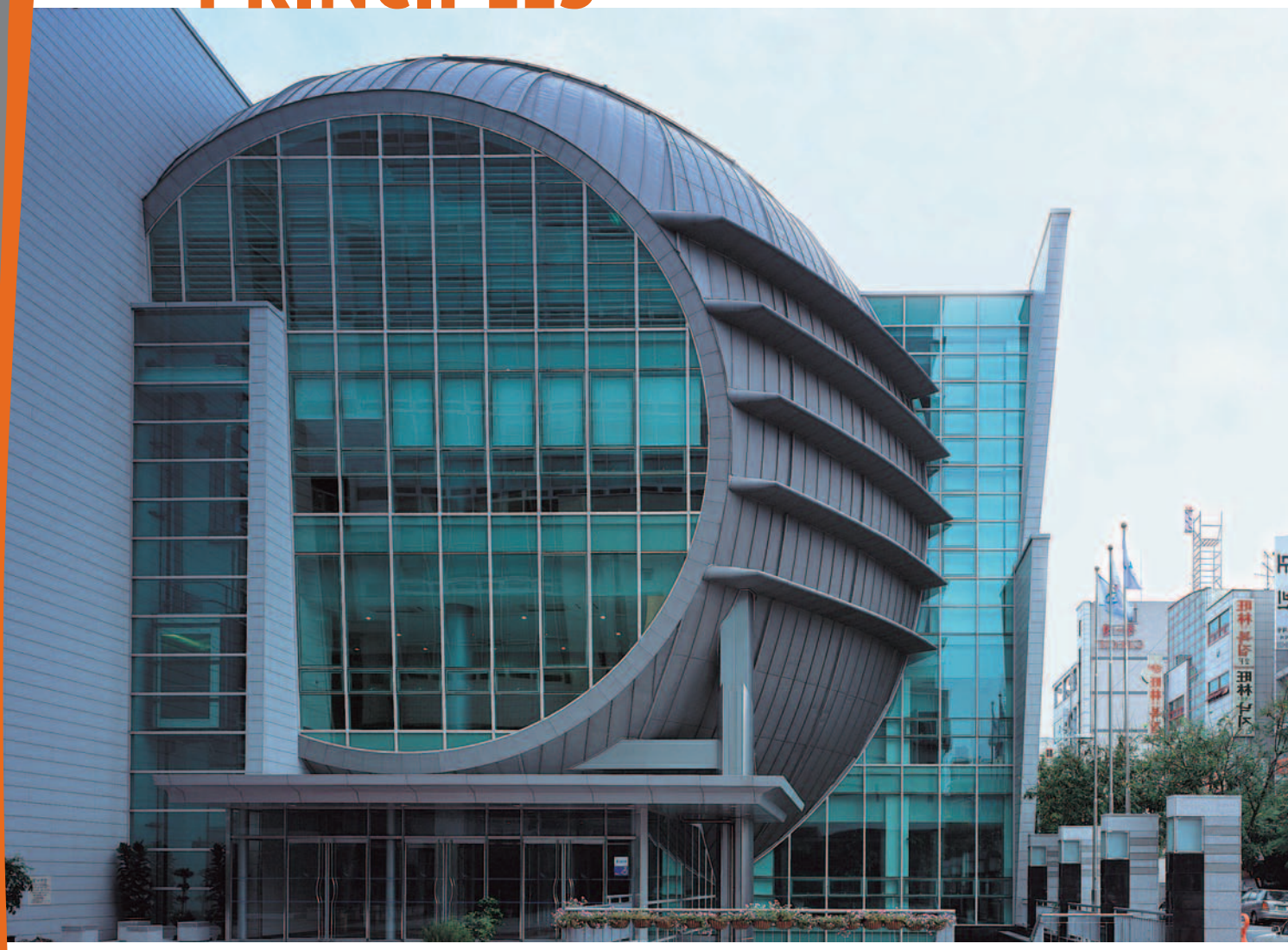
BASIC PRINCIPLES



Saeronam Church, Daejeon (South Korea) - Architect(s): Junglim Architecture Co., Ltd. - Contractor(s): LG E&C

Zinc as a building material has a long history as does VM ZINC®. Thanks to our long experience in using zinc, we recommend that you consider Umicore Building Products as a source of information and as a safety factor in the design of your project.
In this chapter, we will present building principles which should be taken into account to make your project a great success. In many cases the building basics for roofs and facades are the same. Both require managing condensation and ventilation risks. Both are also submitted to climatic stresses like wind load, atmospheric precipitation or noise pollution.

Umicore Building Products is your bridge to over a century of experience with this material. Don't hesitate to contact us.

A Umicore brand

Zinc in relation with...

Other metals

Contact between ZINC and other metals must take into account the electro-chemical reactions caused by a difference in electrical potential between the surfaces of the metals. Generally speaking, a metal with the highest potential on the electro-chemical scale decomposes a metal with a lower potential and causes its destruction after a certain time by accelerating corrosion. Therefore a certain number of contacts are acceptable whilst others must be avoided.

This electro-chemical reaction

- is accelerated in hot and humid conditions.
- is related to the electrical conductivity of the contact.
- decreases when surface treatments or natural patinas bring them closer to their standard potentials.

In the building industry, two types of contact can cause electro-chemical corrosion: direct contact and indirect contact.

Direct Contact

Direct contact can involve, among other things, fixing elements as well as metal decking and flashing. In these cases of intermittent or direct surface contacts, the basic principles in the electro-chemical table should be respected.
For example, the metal grounds for lightning conductors should be made of aluminium so that they are compatible with VM ZINC®.
Particular attention should be paid to VM ZINC® fixing elements such as clips, screws, etc.

Indirect Contact

It is more difficult to take into account indirect contacts since they develop between metals that are at a distance from each other through a conductor (electrolyte) which is active only intermittently.

For example:

- Rainwater must never flow from a high potential metal onto a metal of lower potential. The water, in this case, becomes charged with metal ions which can destroy the weaker metal.
- The metallic reinforcement contained in concrete exposed to the weather, can set off electrolytic reactions in the presence of moisture.

COMPATIBLE METALS	INCOMPATIBLE METALS
Lead There are no problems associated with this metal **Aluminium** Although a lower potential, it has a similar protective coating, thus the two metals have very similar potentials, eliminating any risk of corrosion. **Galvanised Steel** Galvanisation coats the steel with a fine film of zinc. This zinc-zinc contact poses no problem.	**Copper** **Steel (Non galvanised)**

Zinc in relation with...

Timber

■ **A low or non-acid solid, natural and non treated timber deck, that is, with a pH of between 5 and 7 is compatible with zinc and can be used as a direct support.**

Compatible timber	Incompatible timber
Pine	Larch
Spruce	Oak
Scots pine	Chestnut
Poplar	Red cedar
	Douglas fir
	White cedar
	Gum tree

Note: If your building is in a wooded area you should be aware of any influence that surrounding trees could have on zinc.

■ **Plywood and treated wood, examples of incompatible supports**

- Plywood and chipboard panels can be composed of acidic wood species (pH<5) or contain tannins, phenolic acids, which may increase the risk of corrosion on the underside of the zinc.
- Wood treatment and preservation products: products which comprise mineral elements (copper-chromium-arsenic (CCA) or chromium-bromine-boron (CCB) types) should be avoided in direct contact with the zinc. They can create a corrosive action on the zinc under damp conditions.

Zinc in relation with...

Concrete, mortar & bituminous felt support

Concrete

Installing VM ZINC® directly on a concrete or reinforced concrete support has to be avoided.

Cement mortar

In the case of localised supports (parapets, gutters, etc.) of under 40 cm in width, cement mortar can be used as long as a "neutral" separation membrane (PH 5 to 7) is placed between the zinc and the support.

Bituminous Felt

Bituminous felt is prohibited for use in direct contact with zinc because of the risk of water being retained.
This constitutes a corrosion risk since the water cannot be removed from the felt.

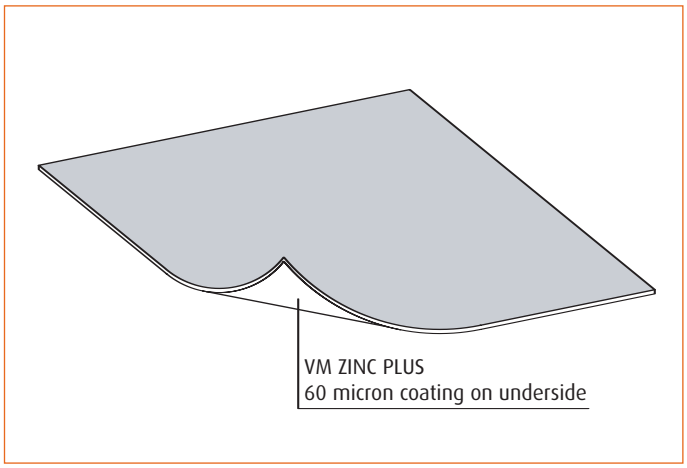
Using sealing compounds

Generally, VM ZINC® does not recommend the use of sealing compounds. However, some facade and roof joints require the use of sealing compounds to ensure continuous water-tightness over the entire building envelope. Sealing compounds that are compatible with zinc and adhere to it must be used. MS polymer based compounds (without solvents) usually have the required properties (follow the manufacturer's recommendations). However, the use of acetogenic silicones must be avoided (contain acidic solvent which attacks zinc).

Solutions for managing incompatible supports

VM ZINC PLUS: the customised solution

VM ZINC PLUS is a unique solution that offers a protective coating on its underside to protect the VM ZINC® from possible corrosion due to the lack of ventilation. This innovative product makes Umicore Building Products the only zinc manufacturer to offer a "true" solution where zinc can be applied to a non ventilated substrate.



Note: The "PLUS" added to the brand name indicates a patented protection on the underside of the titanium zinc roofing material.

VM ZINC PLUS roofing material

VM ZINC PLUS consists of rolled titanium zinc, which is protected on its underside by a 60-micron-thick polyester lacquer.

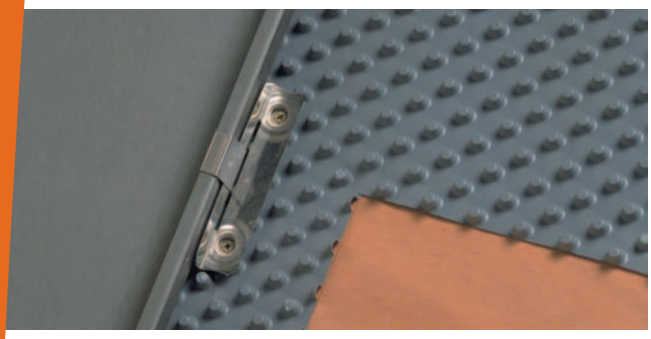
The 60-micron lacquer allows the zinc to be laid directly on an incompatible support thanks to its protective underside coating.

VM ZINC PLUS can be bent, folded or profiled without any surface change. It requires the same methods of laying as for natural VM ZINC®.
VM ZINC PLUS conforms to the European EN 988 and EN 1179 standards for high quality rolled titanium zinc.

Feng Chia University, Taichung (Taiwan)
Architect(s): H.Y.C Architects & Partners
Contractor(s): Bluescope Lysaght Taiwan

Solutions for managing incompatible support

DELTA VM ZINC membrane



The DELTA VM ZINC system consists of using VM ZINC® sheets on a neutral underlay. The DELTA membrane then acts as a separating layer over the incompatible support.

Name

DELTA VM ZINC Separation Membrane.

Material

High density Polyethylene Membrane in a distinctive grey colour.

Thickness

0.6 mm. with 8.6 mm studs.

Packing

- 40 sq. m. coils, 2 x 20m
- Pallet of 6 vertical coils. The circumference of each coil is taped using three 15-cm wide adhesive strips with VM ZINC® marking. Each pallet is protected with transparent film through which the VM ZINC® marking is visible. The film is reinforced at the bottom to avoid any damage on delivery.

Effective surface area

38 sq. m. (no studs on 140 mm at edges for overlap).

Stainless steel fixing and sliding clips

designed for the DELTA VM ZINC membrane. Clips are only for the standing or batten seam systems.

Characteristics of DELTA VM ZINC

- Allows direct laying of VM ZINC® roofing on incompatible roof support.
- Provides a breathing space for the underside of the zinc in order to allow the self-protecting process of zinc to occur.
- Provides a drainage surface for possible moisture infiltration under the roofing.
- Provides a temporary weather-tight membrane for the roofing complex during the installation of the roofing material.

Properties

- Chemically and electrically neutral.
- Resistant to mould and chemical agents.
- Stabilised for thermal cycles and dimensionally stable between -30 °C and 80 °C.

Note: **DELTA is not advised for high hygrometry climates**

Management of condensation

Generalities

Good management of condensation is necessary when choosing components for a roofing or cladding complex. The choice of the roof system is essential for dealing with this natural phenomenon.

Condensation occurs in the following situations

- Differential between the temperature of metals (residual radiation) and the daytime/night-time air temperature cycle (natural dew).
- Migration of water vapour through the layers of the building envelope materials from warmest to coolest environment.

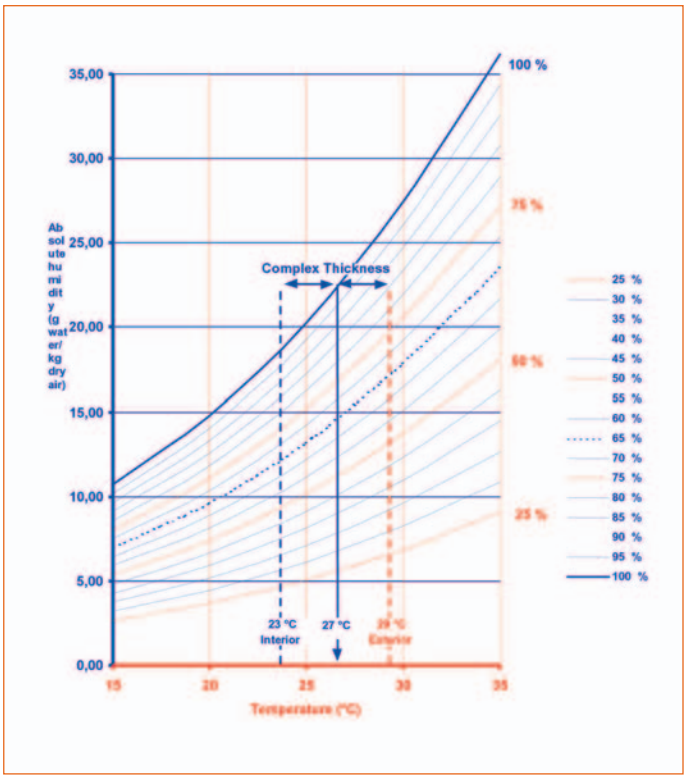
Night-time condensation

During some periods, particularly on clear nights, metals continue losing calories through residual radiation. In these conditions, the temperature of zinc can be lower than that of the air, condensation then forms on the underside and top side of the material. The condensation on the underside of the VM ZINC® can run down onto the underlying components of the complex threatening their durability. It is therefore essential to take this phenomenon into account when choosing the components of a roofing or cladding complex.

Migration of water vapour - Building envelope thermal exchange

Condensation appears at the point where the air is saturated with humidity (dew point). The direction of thermal exchange is always from the hottest environment towards the coldest environment. In hot countries, because of air conditioning, these exchanges are from the outside of the building towards the inside. (Nevertheless, beware of unexpected breakdowns or changes to the building's air conditioning schedule which can reverse these exchanges).

Mollier's graph



Finally, it is essential to take into account the migration of water vapour and the thermal exchanges of a building envelope complex at the design stage in order to prevent the formation of condensation inside the building.

Mollier's graph associates the thermal conductivity and resistance to water vapour of the different layers of materials. It is possible to identify the location of the dew point. Locating the dew point is essential in the design of the roofing and cladding complex.

Simplified example: For an outside temperature of 29°C with 85% relative humidity and an air-conditioned office block with a temperature of 23°C, the graph shows that condensation appears at 27° C.

Management of condensation

Ventilated systems rules

Swimming pool, St Quentin en Yvelines (France)
Architect(s): Carduner

Ventilation ensures that the dew point does not occur on the underside of the zinc. The air gap located beneath the support allows the evacuation of humidity caused by internal condensation.
The following rules apply with low to moderate hygrometry levels.

Roof ventilation rules

The air gap located beneath the support allows the evacuation of humidity caused by internal condensation. In addition, if water infiltration occurs, moisture can be absorbed by the wood support and evacuated through the air gap. This air gap should have a minimum thickness of 40 mm. If the slope exceeds 12 metres, this minimum should be 60 mm.

To ensure the proper airflow in the ventilation space, an air inlet should be set at the eaves and an outlet at the ridge. It is possible, in the case of an empty roof space, for vents to be set in the gable to replace linear openings, provided that the gables are no more than 12 metres apart.

At a very minimum, a ventilation opening equal to 1/3000th of the projected roof surface should be provided, divided equally between inlet and outlet. When the slope length is greater than 12 meters, the openings should be distributed along lines at a maximum distance of 12 meters from one another.

Cladding ventilation rules

A facade is a vertical element - i.e. 90 degrees to the horizon. All other sloping planes, which can be directly influenced by precipitation, should be thought of and designed as roofs.

In general, building facades can be divided into two main categories: curtain walls and rain screen systems. In the case of a sealed curtain wall, the building is completely isolated from the exterior facade by a sealed airtight cavity.

A masonry cavity wall incorporating a water barrier, flashing and frequent, narrow width openings (weep holes) is a recognisable and frequently used example of this type of rainscreen wall. The theory is that the cladding will allow the ingress of some water. The cavity behind the cladding is drained and the ventilation at the back promotes rapid evaporation or removal of any water ingress. Compartmentalisation is rare. For cladding, the air gap must be 20 mm minimum.

Management of condensation

Non ventilated systems

Unventilated systems provide a solution for:

- Buildings with a high hygrometry level (swimming pool, paper mills, shower room, etc.)
- Special shapes which don't allow good ventilation (domes, spheres, etc.)
- Tropical and humid climates.

When installing an unventilated solution, VM ZINC PLUS must be used (see page 4).

Do not hesitate to consult us for further information.

China Technical College, Hsinzue (Taiwan)
Architect(s): Tien-Hao Huang Architecture & Associates
Contractor(s): Bluescope Lysaght Taiwan

Multi purpose hall, Dornbirn (Austria)
Architect(s): Kaufmann 96 GmbH
Contractor(s): Fa. ERO, Fa. Helmut Rümmele

Management of wind & rain constraints

Rain and wind load should be taken into account together in determining the building envelope's degree of impermeability and the wind uplift resistance of the sheets.

Lighthouse, Estados Islands (Arg.)
Architect(s): H. Bouin

Rain constraints

For roofing applications, attention must be paid in particular to:

- joining methods, overlapping of roofing elements.
- junctions at uneven points, chimneys, elevator shaft extrusions, skylights and dormer windows, upstand flashing against walls.
- valley strips.

For cladding applications, the rain factor is less important for rainscreen panels. Some ingress of water is generally tolerated. Water flows down inside the panels and is evacuated.

Wind load for building applications

It is the responsibility of the design team/architect to determine loads for the building resulting from wind action in accordance with the applicable national standards. This type of standard defines:

- Reference speeds or pressures to be taken into consideration according to the geographical distribution of winds in the region.
- Calculation methods required for the engineer to calculate the effects of wind on the building according to its geometry (special attention is required for edges and corners), as well as the influence of the surrounding topography on the variation of wind speeds. In the case of a building situated at the top of a steep slope, special wind load calculations must be made (dynamic pressure).

Photo: José Hevia

Private house, Santander (Spain)
Architect(s): Pablo Oriol Salgado

Zinc thermal expansion

Almost all metals expand and contract with changes in temperature. Zinc has a thermal expansion of 2.2 mm/m for a temperature variation of 100° C.

To accommodate for the change in length, sliding clips are used to hold the panels in place. Umicore Building Products offers specially designed clips for use with zinc.

Thermal expansion coefficients of different metals

100° C temperature variation /m	
Stainless steel	1.02 to 1.65 mm
Steel	1.2 to 1.4 mm
Copper	1.7 mm
Zinc	**2.2 mm**
Aluminium	2.4 mm
Lead	2.9 mm

VM ZINC PLUS and thermal expansion
Because of thermal expansion, you may wish to use a slip sheet between the support and the VM ZINC PLUS product. This will allow the zinc to move freely as it changes length. This can be particularly important when installing on abrasive materials or those that may become "sticky" at higher temperatures.

All the roofing and facade systems described in this architectural guide allow optimum management of the expansion of zinc.

Private house, Aspen (USA)
Architect(s): Bill Poss & Associates

Basic principles of acoustics

Definition of noise

Noise is an airborne vibration, which has an effect on our eardrum.
We can picture this vibration as a wave rippling over the surface of the water when we throw a stone into it.
Noise has two characteristics: its level and its frequency.

Sound level

Sound level is defined in terms of intensity (loud or faint noise). It is measured in decibels (dB). The human ear is more sensitive to bass sounds than to treble sounds, therefore noise level measurements must be balanced using a filter (A) to reflect perceived noise. The result of this correction is expressed in dB (A).

Examples of noise levels:

Activity in db(A)	Min	Max
Hearing threshold	0	10
Quiet bedroom	25	30
Quiet street	40	60
Dishwasher	45	70
Normal conversation	50	60
Television	65	75
Dog barking	90	102
Pneumatic drill	100	120
Pain threshold	120	-

Perceived noise volume doubles every 10 dB (A). The doubling of acoustic energy is equivalent to an increase of 3 dB in noise level:
100 dB (A) + 100 dB (A) = 103 dB (A).

Frequency

Frequency of a noise indicates its pitch. Low pitched or bass sounds have a low frequency and high pitched or treble sounds a high frequency. Frequency is expressed in Hertz (Hz). The human ear responds to sounds in a frequency range between 20 and 16,000 Hz. A normal conversation ranges from 100 to 8,000 Hz. The ear does not respond in a linear fashion across the frequency range; it is more sensitive to bass sounds than treble sounds.

Sound propagation

In a building, we can distinguish 2 types of noise:

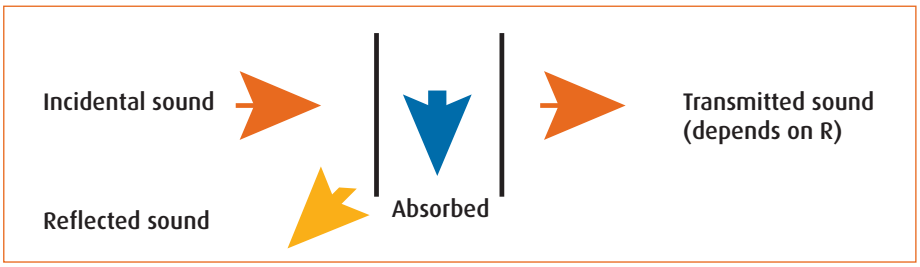
- Airborne sounds which are propagated in the air. These noises come from outside the building (traffic, planes, etc.) or from inside (hi-fi system, conversations, etc.).
- A concussion (impact) sound, which is propagated in the walls of the building and is the result of impacts (footsteps, drills, etc.).

Most noises encountered in buildings consist of both airborne and impact sounds.

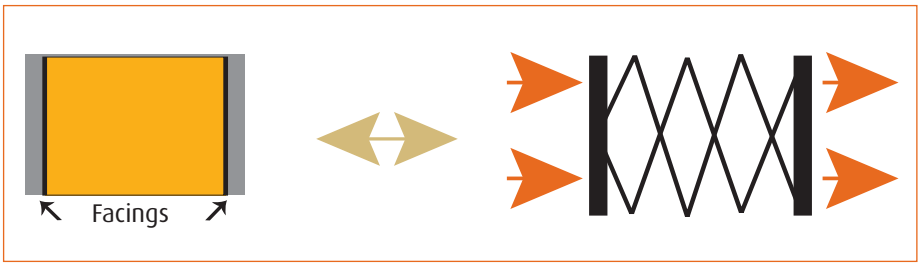
Basic principles of acoustics

Sound insulation

Block diagram of the propagation of a sound though a wall



Flow diagram of a "mass-spring-mass" system



Airborne sounds

The aim of sound insulation is to minimise sound transmission. The way a product or a wall reduces sound transmission is expressed by its sound reduction index rating (R). This characteristic value is measured using a standardised test EN ISO 140-3.

Complexes efficiently manage airborne sound insulation with a structure known as “mass-spring-mass”. This system works in the same way as a shock absorber. To optimise sound insulation, the facing weight can be increased and the nature and thickness of the insulation layer can be changed.

Note: Different sound reduction indexes are used to accurately describe sound insulation:

- RW: the weighted sound reduction index is obtained by comparison with a standard reference spectrum (EN ISO 717-1).
- RW + C: insulation for a noise whose level remains the same across the frequency range (conversation, music, TV...). The RW + C unit is dB (A).
- RW + Ctr: insulation for a noise whose level is higher in low frequencies (traffic noise, etc.). The RW + Ctr unit is dB (A).

Acoustic performances of a material or a system are presented as follows:

Rw(C;Ctr) = X (-Y;-Z) i.e. Rw = X; Rw +C = X-Y; Rw + Ctr = X-Z

The required airborne sound insulation depends upon national legislation and the location of the building (near a noisy road, an airport, etc.).

Impact sounds

The impact of rain or hailstones on a roof generates a more or less significant noise, which can disturb the building occupants. An international test standard for roof complexes is currently being prepared.
The impact sound pressure level (Lp) expresses the interior sound level of the building when the roof is subjected to rain. The lower the Lp, the better the insulation is. The Lp level required varies according to the type and purpose of the building.

Insulation for impact sound is influenced by:

- The nature of the external facing: zinc performs better than more rigid alloys (aluminium, steel, etc.)
- The density (spacing) of fixing elements and their separation from the interior support
- The nature and thickness of the insulation used in the building.

Basic principles of acoustics

VM ZINC® acoustic properties

VM ZINC®'s acoustic performance for airborn noise is good.
The acoustic behaviour of materials is influenced by several parameters: their mass, reactivity, and vibration absorption. The acoustic properties of VM ZINC® can be explained through an analysis of these parameters.

Noiseproof wall in VM ZINC®
Blanquefort (France)
Architect(s): Déesse 23

Mass

If we consider a metallic plate, the weight of the panel is a crucial parameter for acoustic insulation. Hence, the higher the weight, the better the acoustic insulation.
The VM ZINC® used in the building envelope has a high weight (4.67 kg/m^2 for 0.65 mm thickness; 5.74 kg/m^2 for 0.8 mm) which is a considerable advantage for airborne sound insulation.

Mass law

The sound reduction index increases by 6 dB when the mass or the frequency is doubled.
Example: a panel of thickness t has a sound reduction of X (dB). Then a panel of thickness 2t has a sound reduction of X+6 (dB). Doubling the thickness doubles the weight of the panel. In the same way, if at a frequency f the sound reduction index is X (dB) then at a frequency 2 f the sound reduction index is X+6 (dB).

Reactivity

When an airborne vibration hits the surface of a material or when the surface is submitted to impacts, the energy is transferred to the material in the form of a vibration. Reactivity expresses the ability of a metal to transmit these vibrations more or less rapidly. This property is characterised by the mechanical impedance Z.
The higher the Z, the slower the velocity of vibration propagation.
VM ZINC® has a high mechanical impedance (24 W, thickness = 0.65 mm; 45 W, thickness = 0.8 mm).
Therefore VM ZINC® has a low reactivity towards vibrations that reach its surface.

Vibration absorption

The vibration transmitted to the metal is absorbed (by energy loss) more or less efficiently depending on the kind of material. The loss factor h expresses this property: the higher the h, the faster the vibration is absorbed.
VM ZINC® has a rather high loss factor (3.10-4) compared to other metallic materials. This is a significant advantage especially regarding impact sound reduction.

Protection

Against fire risk

Private house, Seattle (USA)

Fire protection should be taken into account from the design stage including the design of the building envelope.
The design team is responsible for deciding the building's risk class which depends on the occupation rate and the type of activities to be carried out in the building.
According to the building classification particular requirements must be respected in the design of roof and facade elements. These are clearly defined in the regulations published by the appropriate national authority.

The classifications for flame spread across surfaces or elements, as well as specific construction requirements such as those stated in the official codes, allow the element's reaction to fire to be calculated and should be respected.

Against fingerprints & dirt

Fingerprints

Fingerprints can be noticeable on wall applications. Because of the "self-healing" nature of zinc, fingerprints will be obscured by the formation of the patina over time. To remove them, use mineral oil available from Umicore Building Products. Some mineral oils may react adversely with the zinc so be sure to use only VM ZINC® specified mineral oil. To prevent fingerprints from forming initially, installers should wear cotton gloves.

Grease and dirt

If grease or dirt accumulates on the zinc during the installation process, it should be gently removed with a clean/dry cloth. Do not allow the installer to attempt to use cleaning products or rub hard to remove any dirt or grease. Remember that the patina has a self-healing nature. The dirt will be removed over time with natural rain water.

Scratches

If a scratch appears during the installation process, you should reassure the installer that the self-healing patina will minimise the effects of the scratch over time. If the scratch is especially deep or wide then the panel may need to be replaced. In general, minor scratches are expected and are self-correcting.

Protective film

Most VM ZINC® products are shipped with a protective film. The product should be installed with the protective film in place to help prevent scratches. The film should be removed promptly after installation since the film is not UV resistant and residues of the adhesives may remain on the metal. Umicore Building Products recommends that the protective film be removed no later than six weeks from the date of installation.

The sole purpose of this document is to describe the main technical characteristics of VM ZINC® products manufactured by Umicore.

The specification and installation of these products are the sole responsibility of the architects and building professionals who must ensure these products are used in a way suited to the end purpose of the construction and that they are compatible with other products and techniques used.

The specification and installation of the products implies respecting the standards in force and the manufacturer's recommendations. In this regard, Umicore publishes and regularly updates specification and installation manuals for specific geographic areas and provides training courses. All the information on the latter can be obtained from the local VM ZINC® team.

Umicore can not be held responsible for any specification or use of its products that has not respected all these standards, recommendations and practices.

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