(translation)

REPORT

Testing of Lacomet® FL

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1. ASSIGNMENT

1.1 *Introduction*

The assignment was instigated by Mr. D. van der Net of Coil Laminates B.V. on the 7th December 2006 in order to assess and to analyze the product quality of Lacomet® FL. Coil Coating Laminates B.V. have asked BDA Geveladvies B.V. to assess the material for use as a lead replacement in construction industry.
This assignment is dated the 11th December, 2006 and has been confirmed in writing by BDA Geveladvies B.V.

1.2 *Aim of the assignment*

The aim of the trials and the assignment is to assess the capability of Lacomet® FL as a lead replacement in construction industry and to ensure that the current (Dutch) building regulations are adhered to. The material will be tested on water tightness of the joints, the manner of application and on thermo shock resistance. In addition to this, the material will be tested for fatigue, wind gust resistance and the resistance against corrosion.

The research will also answer the question as to what extent Lacomet® FL can withstand the heat of the hot air gun which is used when applying roofing material.

1.3. *Procedure*

The results of this report will be presented by Mr. A.R. Hameete of BDA Keuringsinstuut B.V. under the auspices of Messrs. R.H. Hartman and ir. G. Koers of BDA Geveladvies B.V.

The reporting will be carried out by ir. G. Koers. Once the material has been described the test methods will be explained, after which the results will be presented.

2. CONCLUSIONS

2.1 *Thermo shock and processing*

In practice, the materials in façades are exposed to fluctuations in temperature varying between –20°C and +80°C. The worst scenario of temperature stress is a sudden cooling-off (of 80°C to approx. 15°C). This is called thermo shock.

- Lacomet® FL is insensitive to thermo shock;
- Lacomet® FL is easy to handle;
- Lacomet® FL does not give way under its own weight;
- Lacomet® FL is resistant against the heat which emanates from the hot air gun or torch during the "normal" application of roof covering;
- Joints are easily made with mastic sealant, tape or welts.

2.2 *Chemical effects and corrosion susceptibility*

- Lacomet® FL is insensitive to chemical effects of aggressive substances emanating from masonry (brickwork);
- Lacomet® FL complies to the highest demands for filiform corrosion according to EN 1396;
- Lacomet® FL falls under the Corrosion Index 3 (the best score) of EN 1396.

2.3 *Fatigue*

- Lacomet® FL is, during normal bending, not particularly sensitive to fatigue (see Graph 4.3);

2.4 *Traction (Tensile Strength)*

The tensile strength of Lacomet® FL is more than sufficient for the usual applications in cavity constructions.

2.5 *Wind gust resistance*

- No danger exists from wind gusts with normal projecting strips of Lacomet® FL (maximum 100 mm);
- It is standard that chimney lockers are sealed against the underlying construction.

3. PRODUCT INFORMATION

3.1 *General*

Coil Coating Laminates B.V. is a company that specializes in the manufacturing of laminated aluminum. The company produces fiber metal laminates, comparable to, for instance, Glare®. The technology of aluminum laminating is actually used for many applications. The specially developed aluminum product is amongst others applied as a lead replacement in construction industry and exists of two layers of colour lacquered aluminum with an interlayer of fiber strengthened composite material. The product is specially designed as a replacement of all possible sheet lead applications and will be put on the market under the name of Lacomet® FL.

3.2 *Specifications*

The following product specifications have been supplied by the manufacturer:

–	Length	:	per role 20 m^1 up to 100 m^1
–	Width	:	100 mm to 1000 mm
–	Thickness	:	0,6 mm
–	Weight	:	1,05 $kg.m^{-2}$
–	Aluminum quality	:	non alloy
–	Stability	:	-50^oC to +150^oC
–	Heat Generating Coefficient	:	approx. 1,00 $W.m^{-1}.K^{-1}$
–	Color	:	RAL 7037 (gray)

3.3 *Intended applications*

The Lacomet® FL product can be applied as:

- Lead flashing
- Cavity tray flashings
- Abutment flashings
- Stepped flashings
- Coping flashings
- Flat roof on façade joins
- Stepped flashings and Abutment flashings on flat profiled tiles and slates only
- Valley through flashings & Secret gutter flashings

4. TRIALS

4.1 *Thermo shock pressure and processing*

In the laboratory of the BDA Keuringsinstituut B.V. a brick test wall has been constructed with a breadth of approx. 4 m and a height of approx. 1.5 m. In this test wall Lacomet® FL has been mounted on two levels. In this set up, different joints, corner solutions and baluster bushings are shown with the aim of testing the application ability of Lacomet® FL. The test set-up is a simulation practice, wherein Lacomet® FL is exposed to thermo shock pressure and wherein the sensitivity of the application of roof covering is tested. This test set-up also makes it possible to test the water resistance of the Lacomet® FL joints. The set-up has been constructed out of an interior cavity sheet of cellular concrete blocks wherein inspection holes have been placed in strategical positions in front of which an exterior brick wall.

At a height of approximately 5 m the first layer of Lacomet® FL with joints was built in. (2 joints with silver tape, 2 mastic sealant joins and a baluster bushing). At approx. 1 m height a second layer of Lacomet® FL was applied, also with welding joins (2 × SMP mastic sealant, BATU gray tape, single Butyl tape, double Butyl tape, Uniflex MS, Superfix and double Butyl tape on the corner and a baluster bushing).

For the benefit of the performance of Lacomet® FL under thermo shock conditions, the whole test set-up was placed in a water tank for pumping round the water so as to cool the test wall (simulation rain test). A series of radiation lights were placed in front of the test wall so that the test wall could be warmed-up until the temperature in the bricked up heat sensor reached 80^{o}C (black panel temperature). After the thermo shock test had been completed the test wall was given approximately 14 days to dry, after which the test set-up was ready to be tested for water tightness of the joints. After completing the determination of the water tightness of the welding joins the wall had yet again another 14 days to dry. For determining the sensitivity of Lacomet® FL against the heat which is emanated during the application of roofing material with the hot air gun or the torch, a wooden roof has been added.

After all the tests had been carried out, the test set-up was carefully dismantled, so that the Lacomet® FL could be checked for possible flaws that were created as a result of the test.

Processing material

The application of Lacomet® FL has been carried out by reputable lead processing contractors. The first layer was applied by Weijers Service in Portugaal, and the second layer by Daklyn in Zwijndrecht. After an initial skepticism, it turned out that the application of Lacomet® FL was no more difficult than the processing of lead. Each "lead" solution can well be realized by folding, sealing and cutting. The processing (the bending, folding, making of overlaps and of joints) of Lacomet® FL is identical to that of sheet lead (with the exception of the hammering). The material can be cut to size. The material cannot be hammered out. That is because the material is not plastic. This has the advantage in that it will not bulge out under its own weight, which does happen in the case of lead. The mounting on the interior wall can be carried out with bottleneck strips, but this is not strictly necessary. Securing with sufficient screws and synthetic rings is also possible. The possibility of tearing under the influence of its own weight does not exist. With a thickness of 0.6 mm, Lacomet® FL is relatively thin. In practice, one can cut oneself on it. It is therefore recommended that all accessible (remaining visible) edges within children's reach should be equipped with flanges if that would be necessary for safety reasons.

Thermo shock

In practice, materials found in façades are exposed to temperature swings varying from between –20°C to +80°C. The worst occurrence of temperature pressure is a sudden cooling down (of 80°C to approx. 15°C). This is called thermo shock. In the test wall, Lacomet® FL has been warmed up alternately to 80°C and cooled to a maximum temperature of 15°C. The warming up period lasted 5 hours and the cooling down period lasted 3 hours.

Per working day, the test wall has firstly been exposed for five hours of warming up with the aid of the lamps, after which the thermo shock has been applied by spraying cold water on to the wall up to a maximum of 15°C. In total, the wall underwent 20 cyclic movements.

The test began on the 20th of February, 2007 and was completed on the 19th March, 2007.

Impermeability to water

After a period of about 2 weeks the test set-up was sufficiently dry for the testing of water tightness of the joints. Firstly, the bottom layer of Lacomet® FL was tested. For the benefit of the control of the water tightness of the joints, a considerable amount of water was poured on to the Lacomet® FL via the cavity. The water flowed outwards via the upper side of the Lacomet® FL, via the joints in the brick work (bed joints and cross joints). The underside of the Lacomet® FL remained completely dry. None of the joints leaked.

Directly thereafter, the upper layer of Lacomet® FL was tested with the result that none of the joints showed any signs of leakage.

Application of roof covering

Approximately two weeks after the water tightness trial of the joints, the test set-up was sufficiently dried so that the influence of dampness would not affect the sensitivity of Lacomet® FL against the heat which was released during the application of the roof covering with the hot air gun or torch. With the intention of determining the sensitivity of Lacomet® FL before applying roof covering with the hot air gun, a flat roof construction

has been created against the test wall. The flat roof was placed approximately 120 mm under the Lacomet® FL. The roof covering was fixed onto the flat roof with the hot air gun. Lacomet® FL was not damaged in any way.

Although it is according to NVN 6050 no longer permissible, roof covering is often fixed to the undersurface with open fire (torch). It concerns a preliminary norm that most probably will get norm power from 2009. Until then, working with open fire is not yet forbidden. It is for this reason that a trial has also been carried out with a torch. It can be observed that Lacomet® FL experienced no noticeable damage with the normal use of the torch. Lime deposits which originated from the thermo shock trial peeled (flaked) off during the upward bending of the Lacomet® FL. This indicates that the lime deposits do not become attached to the Lacomet® FL and that it is not etched.

Disassembly of the trial set-up

After all the intended trials had been concluded, the trial set-up was carefully disassembled. The idea behind this was to visually inspect all the sides (lower and upper sides) of the Lacomet® FL and the joints.

The following has been observed:

- Lacomet® FL was not damaged,
- The Lacomet® FL surface survived the trial completely unscathed.
- The joints were perfectly intact.

4.2 *Corrosion test*

Lacomet® FL is a laminated product of aluminium with an interlayer of fiber strengthened composite. The synthetic core material is, in principal, sensitive to ageing. Ageing of synthetics is initiated by the ultra violet component of light. The synthetic core is fully protected against ultra violet light by the aluminium finishing layers. It is therefore not necessary to test for ageing in the BDA trial set-up. Ageing of the synthetic core will not arise as long as the aluminium finishing layers remain intact. Because of

this, the corrosion resistance of Lacomet® FL has been determined, according to EN 1396.

In 1995-1996 the ECCA (European Coil Coating Association), the umbrella organization of the European coil coating industry developed the EN 1396 for the defining of corrosion and weather firmness for coated aluminum in the construction. In this Standard the quality description of coated aluminium for corrosion and weatherability has been recorded in indices.

Corrosion resistance Index 1 needs little resistance against corrosion (i.e. dry interior applications in offices); materials with Index 2 need to be better resistant to, for instance, applications falling under land climate conditions. The heaviest category is Index 3. Index 3 guarantees that after 3 years of exposure to the elements, (exposed sheltered from rain, vertically exposed in a northerly direction at the mouth of the river Waterweg near Hoek van Holland), that no undercreep of more than an average of 2 mm shall appear neither from a defined scratch on the sample panel nor from also well-defined bends of the panel.

Lacomet® FL complies to the highest requirements for filiform corrosion according to EN 1396. Lacomet® FL falls under Corrosion – Index 3.

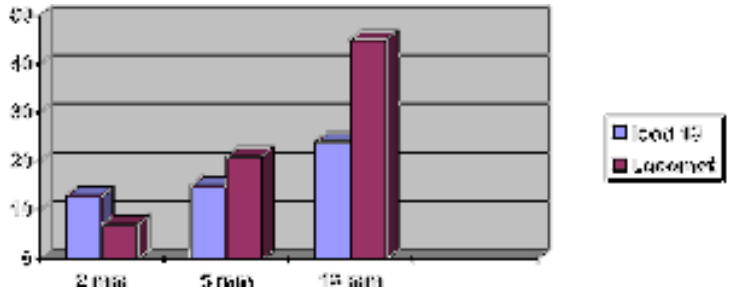
4.3 *Fatigue*

In some sheet lead applications, the lead is continuously being bent up and down. There is a comparing fatigue test which has been carried out between Lacomet® FL and sheet lead (code 18). Fatigue resistance is determined by bending the material 90^{o}C upwards and 90^{o}C downwards. The test piece has a width of 200 mm and a length of 150 mm and is wedged over the whole width, on two sides, between two plates of which the far end has been sloped at an angle of 45^{o}. The distance over which the test piece can bend between the clamps was kept at 2, 5 and 15 mm. The tests were repeated three times per clamp distance.

The average result is that damage to Lacomet® FL arose after, respectively, 7, 21 and 45 bends. With Lead (code 18) damage developing after 13, 15 and 24 bends.

The test was carried out at a speed of 1000 mm.min^{-1}.

The results have been shown in graph form below:



Significance of axes:

– vertical coordinates = number of bends

– horizontal coordinates = clamp distance

With a distance of 2 mm between the plates, so a sharp fold, the sensitivity for continuous bending is larger than that of sheet lead (code 18). With a distance of 5 mm the sensitivity is already smaller than that of sheet lead. The aim of the test is to form an objective comparison between the two materials. In practice, sheet lead is bent manually upwards and downwards, with the result that the folding line shifts continually. The distance of 2 mm between the flanges is, compared to the situation in practice, very small. Nevertheless, a fair (reasonable) amount of resistance against fatigue has been determined that quickly improves with the increasing distance of the flanges.

4.4 *Tensile Strength*

The determination of tensile strength has been carried out according to the principal of NEN-EN 12311-2, Method B: Flexible Tracks for water seals – Determination of Tensile Strength – Part 2: Synthetic and Rubber Tracks for water seals for roofs (2000-10).

The average tensile strength of sheet lead (code 18) is 425 N (50 mm)$^{-1}$ and for Lacomet® FL 890 N (50 mm)$^{-1}$. Lacomet® FL is a factor 2 stronger per unit of length.

4.5 *Wind Gust Resistance*

The resistance against wind gusts is determined by measuring the force which is needed to bend a test strip that is clamped in on one side. The test piece has a width of 50 mm and a length of 250 mm and is on one side clamped to a board with a steel strip. The test piece is then pulled from the board at an angle of 90^{o}. The test piece is held at a distance of 150mm from the board. The test was carried out at a speed of 25 $mm.min^{-1}$.

To lift up Lacomet® FL a force of 2 N is needed. The maximum bending moment that can be absorbed was recorded to be 2 *150/50 = 6 $Nmm.mm^{-1}$. A strip of material with a projection of X=100 mm can be blown away if the wind suction is larger than p = 1.2 $kN.m^{-2}$, as calculated below.

(The maximum bending moment which has occurred amounted to:
$M_{\text{max absorbed}} = p_w * X^2/2 = 1.2 * (100)^2/(2*1000) = 6$ $Nmm.mm^{-1}$)

Because Lacomet® FL is compressed against the rear construction in the envisaged application, an occasional gust of wind will not form any danger. A factor C_{pe} = 1.0 for the wind suction can be adhered to.
A thrust of 1.2/1,0 = 1.2 $kN.m^{-2}$ is the result.

This thrust occurs according to Table A1 of Dutch Standard NEN 6702, a building with a height of 25 m in a built-up environment area I (immediately along the coast), a building with a height of 35 m in a built-up environment area II (some kilometers land inwards), and a building with a height 55 m in a built up environment area III (inland).

If the building heights in areas I, II and III are not exceeded then a strip of Lacomet® FL, with a projected width of a maximum 100 m, will not be subjected to the occurrence of wind gusts under normal working conditions.

Chimney lockers always have to be sealed to the undersurface so as a preventative against wind gusts.

5. RECOMMENDATIONS

It is recommended that all accessible (remaining visible) edges within children's reach should be equipped with welts if that is required for safety reasons. Chimney lockers will always have to be sealed to the undersurface as a preventative against wind gusts (for instance, with MS Polymer sealant).

Gorinchem, 29th January 2008

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ANNEX 1

(Photo coverage)

ANNEX 2

(Laboratory Report)

ANNEX 3

(Detailed drawings)