# A Total Hygienic Solution - Floor, Drain And Curb Research

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HACCP INTERNATIONAL
FOOD SAFETY
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CERTIFICATION

## Sanitary Design in the Food & Beverage Industry

As Food & Beverage companies in the United States are pushing to improve plant hygiene, sanitary design standards have begun to take shape. While there are many building products on the market that satisfy a specific need, there has yet to be a study investigating the performance and compatibility of multiple products being used together in the same space, with the same exposures.

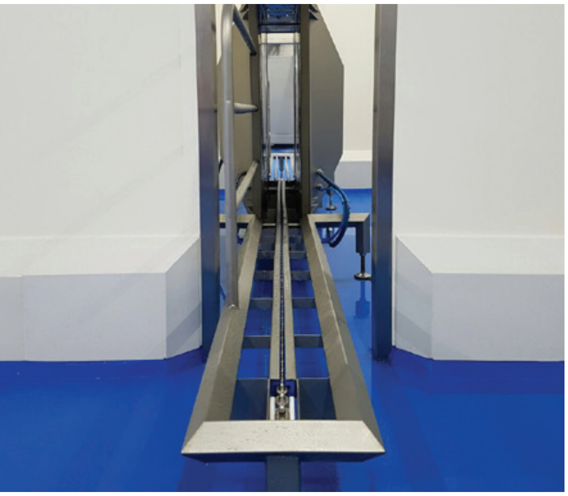
The purpose of this document is to provide guidelines for facility design as it relates to the interworking of resinous floors, drains, and polymer curbs as one complete system: a **Total Hygienic Solution**. The Hygienic Design Committee was formed to examine, compile, and share its findings, using research and test results from three world-leading manufacturers in their respective fields of expertise: Stonhard, manufacturer and installer of resinous floors; Blücher, manufacturer of HygienicPro drains; and PolySto, manufacturer of hygienic curbs. This research methodically evaluates the effectiveness of each product as well as seeks to validate their connections to and compatibility with one another in contributing to the overall improvement in plant hygiene.

## Resinous Flooring in the Food & Beverage Industry

Resinous flooring solves a number of food safety problems. By nature, resinous floors are impervious to water and are poured or trowel-applied seamlessly over concrete substrates. Contaminants remain on the surface of the floor and are washed away during scheduled sanitation times. The most common floor found in the food and beverage market is Polyurethane Cement. This composite material cures to a hard, impact-resistant surface designed to withstand thermal shock and exposure to organic acids, caustics and aggressive cleaning agents.

**Resinous floor and wall systems provide the seamless, slip-resistant, cleanable, durable and chemical-resistant surface necessary for long-term performance in food, beverage, and pharmaceutical facilities.**

It is common for food and beverage facility managers to have questions about USDA, FDA, and HACCP certifications and regulations. Currently, the FDA and USDA do not certify flooring, but they do provide guidelines that can be met or exceeded. HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement, and handling, to the manufacturing, distribution and consumption of the finished product. The FDA offers guidelines, but does not, as mentioned above, certify flooring systems for HACCP. HACCP International, a specialized project management company, identifies and manages hazards to assist food manufacturers in reducing the risks of food contamination events by implementing hazard analysis critical control points specific to the manufacturer's facility. Suppliers to the food industry, including resinous flooring manufacturers, can submit their products to



HACCP International to acquire certification as "food safe" under HACCP International guidelines.

HACCP International will review the material composition of floor coatings to determine if they are food safe. Non-toxic materials are preferred, as well as materials that prohibit the proliferation of harmful pathogens and food contaminants.

The FDA's Food Establishment Plan Review Guide, covers design, installation, and construction recommendations for food facilities in Section III. Part 10 of Section 3 covers specific guidelines for floor finishes.

Poured-in-place or troweled resinous systems are approved finishes for food and drug preparation and storage rooms, and the waste disposal and washing areas within manufacturing facilities. These finishes are also approved for walk-in refrigeration and freezer areas, as are stainless steel and poured synthetic materials. The use of any other materials must be submitted to the FDA for evaluation and approval. These finishes are deemed acceptable because they make for smooth, non-absorbent and easy-to-clean flooring systems. Additionally, food safe floor coatings of epoxy-, silicone- or polyurethane-based materials are required to maintain flooring performance and provide long-lasting durability.

## Prefabricated Curbing in Food Processing Environments

Curbs used in food processing environments, where hygiene is a priority, should be constructed with materials that are chemical, impact and water resistant. **Polymer composite curbs provide a solution to the hygiene challenges posed by concrete curbs.** Prefabricated polymer composite curb systems are made by mixing polyester resins and quartz granulates and finished with a bacteriostatic and shock-resistant polyester gel coat. In the production of these curbs, a monolithic system is created by molding the polyester quartz mass with the polyester gel coat. Both materials have the same chemical composition (polyester), which creates a durable curbing solution. This type of curbing is repairable, easy to clean and chemical resistant.

## The Importance of Proper Hygienic Drain Installation

The drainage system is an integral part of a factory, and subsequent changes to the layout of the drainage system can be costly, i.e., often the entire floor will have to be replaced. Common mistakes when planning a drainage system include: 1) insufficient flow capacity to remove all water to avoid water pooling on the floor; 2) insufficient capacity to collect waste from processing procedures; and 3) inadequate access for cleaning inside the drainage system. Materials used in drainage must not be vulnerable to hot water and chemicals used in cleaning processes. Proper procedures must ensure that cracks will not form around drains since any opening can promote and potentially harbor bacterial growth. **Choosing an efficiently designed drainage system that takes all of these factors into consideration will provide long-term benefits and savings.** Cleaning requirements should be taken into consideration when specifying system components and capacity and when designing the layout.

The capacity of the system should be based on the maximum flow rate expected plus allowances for change of use in the future.

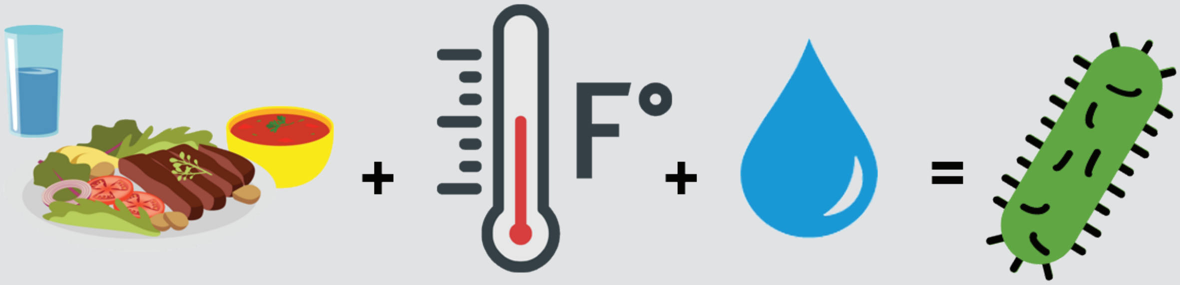
## How Can Building Design Improve Outcomes for Food and Beverage Facilities?

Food and Beverage manufacturing environments are extremely tough on the building envelope. These facilities take abuse from thermal stress, impacts, cleaning processes and chemical attack while running around-the-clock operations. Such stresses are most evident in spaces where the resinous floor makes direct contact with the curbs and drains. Without proper care and attention to engineering details, premature failures may occur at the transitions of these materials. In order to ensure these materials become a sustainable, integral part of the building, we must examine the connection points between the products and identify the best practices for long-term success.

> *Failures in the building design could lead to hidden places for harmful bacteria, such as listeria, to grow and cause product contamination.*

Failure issues are extremely critical to the food and beverage industry due to the impact on both internal and external environments. Internally, the goal of all food and beverage manufacturers is to make safe products for consumers. Failures in the building design could lead to hidden places for harmful bacteria, such as listeria, to grow and cause product contamination. The external effect could be disastrous, leading to costly product recalls, revenue loss, brand damage, and in some of the worst cases, human illness. For these reasons, major food and beverage companies are taking a hard look at their equipment and building designs to be on the leading edge of technology and design in order to eliminate these potential issues.

**Proper building design is critical to protect food and beverage facilities from harmful bacteria.**



## Investigation: Can Total Hygienic Design Be Achieved in a Food & Beverage Facility?

The following research was conducted to investigate a TOTAL HYGIENIC DESIGN for the food and beverage industry that creates a complete and seamless surface starting at the drain connection to the floor, all the way to the floor connection at the curbs. This is best described as a “bathtub effect” as the goal is to essentially create a single functioning unit in which water and waste are properly disposed from the facility and leave no place for harmful contaminants to hide.

## TEST 1 Resinous Flooring

*EHEDG (European Hygiene Engineering & Design Group) is a non-profit consortium of equipment manufacturers, food producers, suppliers to the food industry, research institutes and universities, public health authorities and governmental organizations. EHEDG’s Guidelines: Section 8.6 (below) describes the hygienic design needed for flooring. We included our own findings with this report.*

### EHEDG 8.6 Floors

Floors provide the foundation for safe, hygienic food production in factories. The hygienic design and installation of floors to ensure a correct level of ongoing hygiene is thus critical and must be undertaken as part of an integrated plan. Such an integrated plan must take consideration of:

- the requirement for protection of the floor from any traffic and spillages within the building
- pitch to drain to ensure that all fluids generated by the process and cleaning are effectively removed from the process area
- the prior installation of drainage elements
- the requirements for the installation and supporting of process equipment
- the requirements for effective curbing and supports for walls
- the requirements for installation of doorways and thresholds
- the requirements for the installation of effective barrier protection systems
- the requirements for the health and safety of food operatives, particularly with respect to slips and trips
- the relationship between the choice of floor surface and the characteristics of the food products and process.

Floors are critical areas, for example, they are places where Listeria monocytogenes are likely to be found and where the bacteria could persist despite cleaning and disinfection [1-3]. Slipping accidents correspond to around 20% of work place injuries. For these reasons, slip resistance and hygiene are mandatory. According to the EC regulation 852/2004: “floor surfaces are to be maintained in a sound condition and be easy to clean and, where necessary, to disinfect. This will require the use of impervious, non-absorbent, washable and non-toxic materials unless food business operators can satisfy the competent authority that other materials used are appropriate. Where appropriate, floors are to allow adequate surface drainage.” According to the European Directive 89/391/EEC, employers are responsible for implementing a process of prevention of accidents. As collective protective measures must be taken before individual protective measures, floors in greasy and/or wet food processing areas should be rough enough to avoid slipping accidents.

The food and beverage industry contains a wide range of environments which can be very challenging to floor coverings. In particular, the floor may have to meet requirements for chemical resistance - against acids, alkalis, oils, fats, cleaning products and disinfectants - and process - for abrasion resistance, especially against the small hard wheels widely encountered in the food industry - and for temperature and thermal shock resistance.

If the floor is not resistant to the in-service conditions, it will become damaged, degraded, or fail and will not be able to meet the other requirements of the floor, such that it is easy to clean and provides a safe and attractive working environment.
Repairing a failing floor often involves high costs, including management and production time. Good floor design and selection of materials to meet the technical performance and durability requirements can minimize maintenance and remove the need for future repair works.

All joints and edges on floors, and connecting equipment/fixtures to floors must be sealed. In wet areas floors should drain easily. Floor drains must be connected to a drainage system. The design of drainage systems is covered in section 8.7.
Poor hygiene of floors can be expressed at three levels:

- Failure of floor installation. For example drainage across the floor may be inadequate leading to ponding of water with associated microbiological and health and safety issues.
- Failure of floor interfaces. For example, if drains are not installed correctly, gaps may appear between the channels and the floor finish leading to the ingress of moisture and microbiological issues.
- Failure of the flooring material. This may be related to potential excessive absorption of moisture by the flooring materials per se or the development of surface features which can retain soil and microorganisms, e.g. the formation of gas bubbles which burst during the laying of the material, or the exposure of voids within the materials due to wear or the opening of joints in a tiled floor.

Hygiene control of floors is complex and reflective of the initial installation of the floor, interfaces of the floor (with e.g. drains, equipment, barriers, curbs), the correct selection of flooring materials, and the effect of wear.

It is clear from the above that the quality of workmanship during the installation of the chosen floor finish is critical to the performance of a floor. Care should be taken in selecting flooring contractors and guidance from the flooring manufacturer should be sought in this regard.

This chapter shall give guidance on good floor design and finding the right floor material to meet all the requirements for different hygienic areas in food or beverage production facilities.

### Pitch and Tolerance

In wet areas, undrainable, standing water (ponding) upon the floor should be prevented as floors will become unsightly, unhygienic and potentially slippery. Liquids evaporating to dryness on the floor become chemically more aggressive and so reduce the life of the floor. In addition, scale deposits can build up on the floor which are difficult to remove and which might harbor bacteria.

The required pitch depends upon the activity in the area under consideration, whether a floor is permanently wet, whether it is dry, the frequency and nature of any spillages, and the frequency and methods of cleaning. Generally more textured floors will require steeper pitch to be free draining.

Good surface tolerance is required to avoid standing water. Floors should be specified such that over a 3 m length, a tolerance of 3 mm under a 3 meter straight edge, or better, is acceptable. A simplified method to check the efficient runoff of water from sloped areas is using a sufficient amount of water. The area shall be completely free of standing water after about one hour. No ponds shall remain.

Floors in dry production areas should normally be flat <1%, (< 10 mm/m) for ease of construction; slopes in wet areas should be up to 2% (< 20 mm/m); extreme pitching should be avoided. Generally a pitch of 1.5% (15 mm/m) provides a largely free draining floor. It should be noted that especially in greasy environments, a steeper pitch will require a more slip-resistant surface to ensure worker safety.

**Joints**

All joints are weak points in a floor and will become maintenance items. Joints should be positioned away from areas subject to regular discharge of liquids from vessels and in locations where they are accessible for inspection and maintenance. Some floor materials require joints at certain intervals, while many resins and vibrated tile floor materials can be laid in very large areas without joints, provided that the substrate concrete is jointless.

Joints will be required to accommodate thermal and vibrational movements in the floor to prevent random cracking of the substrate.

Typical situations where joints are required include:

- boundaries between different substrates
- boundaries between different floor materials
- to isolate load supporting columns set in the floor
- around ovens and other process equipment
- adjacent to channels
- around areas subject to thermal shock

Care should be taken to avoid perimeter joints adjacent to walls where a coved skirting is required.

Joints must be designed to accommodate the anticipated movements. The width (and depth) of the joint will depend upon the amount of movement expected and the flexibility of the joint sealant. Joints must be properly detailed with a closed cell packing rod (backing material) to achieve the required sealant depth and to allow the sealant to move freely.

All joints must be regularly inspected, and in the event of the joint sealant splitting, delaminating or degrading, the sealant should be removed and the joint refilled with fresh sealant.

It is important that the nature of the cleaning and disinfection chemicals, ingredients and product spillages are known when choosing a floor covering. Frequency and size of any spillage, together with the concentrations and temperatures, help determine the suitability of floor finishes.

**Thermal Shock Resistance**

Sudden temperature changes, resulting from accidental spillage or deliberate discharges of hot water and oils from plant and equipment or from steam and high-temperature cleaning, can be very damaging to floors. If not designed to accommodate the thermal stresses and movements created, the subfloor can crack, leading to failure of the floor material.

Thermal shock can cause complete delamination of floor materials or micro-cracking in the surface of resin floors, can erode cementitious floors, and cause the failure of joints in tiled floors.

The temperature, frequency and magnitude of any spillages should be taken into account when choosing a floor material, taking special attention to its thickness which has to be high to reach high thermal resistance.

There are no flooring materials that can withstand any significant spillage of cryogenic materials - e.g. liquid nitrogen. Normally cryogenic liquids are safely contained within the process plant and should a significant leakage occur, damage to the floor is likely to occur and will necessitate a localized repair. If regular dripping/spilling onto the floor occurs in one location, the floor should be protected with a stainless steel drip tray or plate.

### Mechanical Resistance Traffic and Load

Traffic ranges from light foot traffic to heavy fork lift and pallet truck movements. Tray racks and bins on small hard wheels are very aggressive, especially when concentrated at doorways, for example. Loads from heavy machinery and tanks (steel feet, vibrating machines) must also be taken into account when designing the subfloor.

A floor's abrasion resistance and mechanical durability is influenced by a number of factors. In general terms, thicker floors last longer, especially where there is heavy, or frequent hard wheeled traffic. The weight of traffic in terms of both frequency and load, especially hard wheeled traffic, should be taken into account when choosing a flooring material.

### Hygiene

Floors should be capable of being easily cleaned with industry standard cleaning equipment chemicals and techniques. This will require dense and impervious systems such that soil remains at the surface where it can be readily removed by cleaning. Cracks (whether caused by structural or thermal movements, impact damage or poor adhesion) are likely to provide harborage for bacteria. When delamination also occurs, water can penetrate underneath both tile and resin floors, leading to fouling and rapid floor failure.

Very thin resin floors are often porous or rely on a thin seal coat for their hygienic properties, which can be relatively short lived in service. Porosity can also be caused by chemical attack or extreme thermal shock in some flooring systems.

Other floor damage caused by impact, scratching or gouging actions on the floor surface may also have a negative impact on floor hygiene. Surface defects are also caused by the crushing of weak aggregates and aggregate pluck out. Bubbles sometimes appear at the surface of resin floors as a result of the mixing and curing process which may also affect the hygienic properties and cleanability.

### Slip Resistance and Tread Safety

Tread safety has to be provided to the staff to help prevent accidents. It should be noted that to prevent slips, trips and falls, an adequate level of cleaning, good working practices and appropriate footwear are also required.

Because of the amount of oil/fat and other food products that get onto the floor of food factories, slip-resistant floors are required to help provide a safe working environment. The degree of texture/slip resistance necessary will vary widely throughout a food processing facility and will depend upon the level and frequency of spillage, the frequency of cleaning, the type of traffic and the work activities that take place in that location. Floors with high difference in slip-resistance should not be positioned adjacent to each other. When walking from a smooth floor to a rough one, people may be destabilized which increases the chance to fall.

In resin floors, anti-slip properties are usually obtained by inclusion of large aggregates (with size in the millimeter range) which increase floor roughness. These can be sprinkled on the mortar before curing (multi- coat systems) or be incorporated in the mortar prior to application (one coat systems). Thin anti-slip coatings that are applied after the base mortar has cured should be avoided as they are short lived in trafficked environments.

With multi-coat systems, the size, nature and amount of aggregate incorporated into the surface have a significant impact on the durability of the slip-resistant profile. Fine aggregates <0.75 mm provide relatively short lived profiles where there is hard wheeled traffic. Quartz/silica aggregates are relatively weak and are eroded by hard plastic and steel wheeled traffic. The use of granite, basalt, silicon carbide, bauxite and other hard aggregates will help retain the slip resistant profile over a long service life.

Multi-coat systems normally require a finishing/encapsulation coat to round out the valleys of the texture in order to provide a cleanable surface.

### Aesthetics

The aesthetics of the floor is also a consideration. A good looking floor creates the right environment that encourages operatives to maintain that environment to the required standard.

The use of colors can also be used to assist in the demarcation of different hygiene zones and to control the movement of personnel and traffic, helping to improve safety and reducing the risk of contamination.

### Durability/Longevity

A failing floor is not hygienic, safe, nor attractive, and may lead to contamination of foodstuffs or accidents. If a floor lacks the required durability, the surface will erode and become unhygienic.

In order for a floor to be long-lasting, it must have the necessary chemical, temperature and mechanical resistance. Without these properties, a floor will require a high level of maintenance in order to prevent failures.

Flooring repair needs to be managed carefully to prevent contamination of products. Temperature and moisture will be a factor as well as whether products or raw materials are present (including plant equipment). The needs of production may severely limit the amount of time for flooring repairs. In many cases, it will be necessary to close production and remove products and plant equipment in order to rehabilitate the floor.

The Hygienic Design Committee recommends thick, mortar-based flooring as the safest and most cost-effective option.

# TEST 2 Rounded Drains for Resinous Flooring

## Background

The EHEDG guideline 44 for Hygienic Design of Buildings considers connections between the drainage and floors to be a very critical spot. Crevices allow for the entry of contaminated water that cannot later be removed. It is impossible to secure against the infiltration and growth of bacteria in such openings.

Often starting with a crack in the corner,
crevices expand along the side of the drainage.

Guideline 44 offers recommendations on how to reduce this risk. Figure 8.7.10 of the guideline illustrates the recommendation for round shapes on resin floors. Blücher followed this recommendation, constructing a drainage range called HygienicPro®. Years of use in the Food & Beverage market show round drains work better than square drains. To confirm this, the following testing was completed using a HygienicPro +20 round drain.

## Testing Method

The EU Approval ETAG 022 Annex G was chosen to test the difference between using a round-shaped drain and a square-shaped drain. The test examines water tightness around penetrations and other details in a room with wet walls and floors comprised of rigid substrates.

This test was considered as the best to simulate the food industry environment and is made in cooperation between the Blücher offices in Norway with a resinous flooring provider.

## Materials Tested

The resinous flooring material in combination with the Blücher HygienicPro +20 drainage with both round and square shape. The test was made by the approved Norwegian Sintef Test institute. The test covered both temperature and load as shown below.

### Temperature Test

100 cycles

Test A: 90° C water in 60 seconds covering the floor

Test B: After this 60 seconds of 10° C water covering the floor.

1500 cycles

Test A: 60°C water in 60 seconds

Test B: After this 10° C water in 60 seconds.

### Load Test

Test A: 200.000 times load test with 1300 kg cylinder pressure.

Test B: Cylinder load was increased to 5, 10 and 20 tons.

### Blücher Hygiene +20 round versus square drains

The EU ETAG Test is the best method to test the influence from current heat and weight load on the joint between drain and floor, as it provides valid documentation for securing a proper solution for this critical area in hygienic environments.

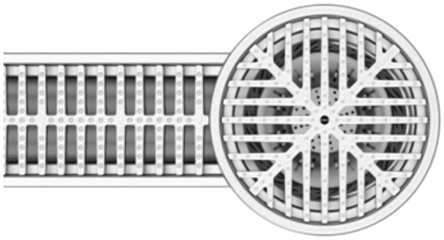
### Test Results

The installation of the round drain was waterproof after the test and no cracks were observed in the flooring material at the drain.

The installation of the square drain was waterproof, but cracking in the surface layer had started.

### Conclusion

The HygienicPro +20 round drain fastens well to the floor and is a proven, hygienic solution. Sharp corners create vulnerable spots and should be avoided. The round drain recommendations of EHEDG are test-verified. Testing proves that the HygienicPro +20 is a hygienic solution for the edge of channels. Testing confirms that the construction of a round drain is the best connection between a resinous floor and the drainage system.



**Blücher Hygienic Pro Round and Resin for Channels**

The Blücher HygienicPro channel has been developed based on the conclusions of the drainage section of the EHEDG guideline 44 for buildings. The ETAG 22 test on drains for resinous flooring shows that the recommendations in the Guideline 44 is correct, and that a safe construction of channels is also based on having as many round shapes as possible in a construction.

## TEST 3 Pre-Cast Polymer Curbing

### Background

Testing of the pre-cast curbing material was completed on 4-25-2008 by Gent University at the Magnel Laboratory for Concrete Research. The following test results illustrate the average compressive strength, tensile splitting strength, and modulus of elasticity of polyester concrete. These results are compared with the nominal value of the average compressive strength, tensile splitting strength, and secant modulus of elasticity mentioned in Table 3.1 of the European Standard EN1992-1-1:2004; Eurocode 2: Design of concrete structures; Part 1-1: General rules and rules for buildings.

### Testing Method

On 02-29-2008, 6 cylindrical test specimens with a nominal diameter of 150 mm and a nominal height of 300 mm are delivered to the Magnel Laboratory for Concrete Research in order to determine:

- the compressive strength of 3 cylindrical test specimens
- the splitting tensile strength of 4 cylindrical test specimens
- the modulus of elasticity of 1 cylindrical test specimen

For the determination of the compressive strength and the modulus of elasticity, cylindrical test specimens with a nominal length to diameter ratio of 2 are used. This is consistent with the delivered test specimens. The surfaces are leveled by means of a diamond grinding disc.

For the determination of the tensile splitting strength, cylindrical test specimens with a nominal length to diameter ratio of 1 are used. The delivered test specimens are sawn in two by a wet diamond saw in order to obtain a nominal height of 150 mm.

The test specimens are stored at laboratory ambient conditions. All tests are performed on 03-17-2008.

### Compressive Tests

The compression tests are performed following NBN EN 12390-3 on 3 cylindrical test specimens with a nominal height of 300 mm and a nominal diameter of 150 mm. The results are given in Table 1.

**Test No. 20081105**

### TABLE 1

| Specimen Designation | Dimensions (mm) 0 x h | Mass Air-Dry (kg) | Density Air-Dry (kg/m³) | Maximum Load (kN) | Compressive Strength (N/mm²) |
|---|---|---|---|---|---|
| 1 | 149,4 x 294,8 | 10,781 | 2086 | 1332 | 76,0 |
| 2 | 150,1 x 296,2 | 10,883 | 2076 | 1358 | 76,7 |
| 3 | 149,3 x 295,9 | 10,695 | 20651 | 1331 | 76,0 |

### Tensile Splitting Tests

The tensile splitting tests are performed following NBN B15-218 on 4 cylindrical test specimens with a nominal height of 150 mm and a nominal diameter of 150 mm. The results are given in Table 2. All test specimens fail according to the splitting plane imposed by the test.

### TABLE 2

| Specimen Designation | Dimensions (mm) 0 x h | Mass Air-Dry (kg) | Density Air-Dry (kg/m³) | Maximum Load (kN) | Tensile Splitting Strength (N/mm²) |
|---|---|---|---|---|---|
| A | 148,5 x 147,8 | 5,406 | 2112 | 315 | 9,1 |
| B | 148,7 x 148,6 | 5,368 | 2080 | 360 | 10,4 |
| C | 149,0 x 148,5 | 5,459 | 2108 | 340 | 9,8 |
| D | 148,7 x 147,8 | 5,389 | 2098 | 355 | 10,3 |

**The Modulus of Elasticity Test**

The Modulus of Elasticity Test is performed according to NBN B15-203 on 1 cylindrical test specimen with a nominal height of 300 mm and a nominal diameter of 150 mm.

A displacement controlled compression test is performed on the air-dry specimen during which the load-strain diagram is recorded. The strain of the test specimen is measured directly, using 3 strain gauges. After a preparation cycle, 3 load cylces are performed, after which the load is increased until failure of the specimen.

Based on the last 2 load cycles, the calculated secant modulus of elasticity (following NBN B15-203) is 22537 N/mm2. The maximum load is 1190 kN or 67,7 N/mm2. The measurements were terminated at a strain of 9000 x 1e. The load-strain curve of the electronic measurements is given in Figure 1.

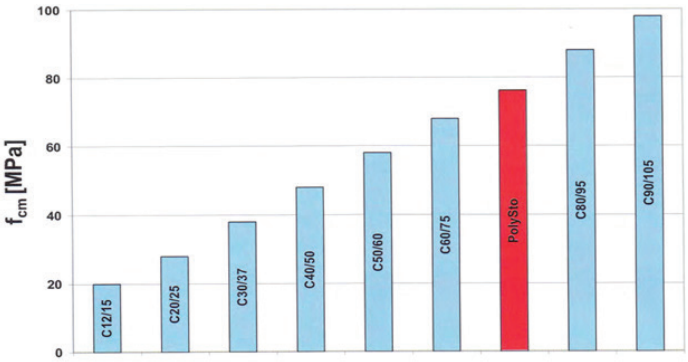


Figure 1: Comparison of the average compressive strength
(concrete classes conform EN1992-1-1)

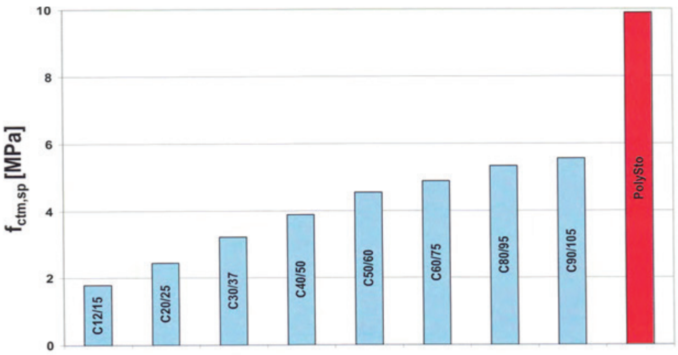


Figure 2: Comparison of the average tensile splitting strength
(concrete classes conform EN1992-1-1)

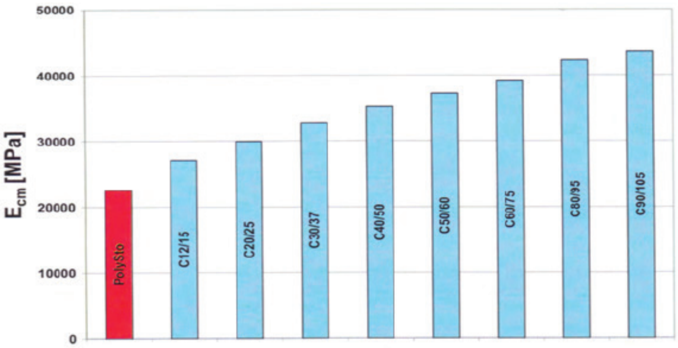


Figure 3: Comparison of the average secant modulus of elasticity
(concrete classes conform EN1992-1-1)

**Conclusion:**

The precast curbing material show superior compressive and tensile splitting strength compared to standard concrete curbing design. This material should be considered superior for use in a complete hygienic design situation.

### Test conditions and results by LAB CALIM

| Conditions contact on the sample | Liquid Simulator | Observation of the specimens | Observations fluid simulator | Values (*) individual overall migration in mg / dm ^2 (rounded to .01) | Average Value (*) mg / dm^2 (rounded to nearly 0.1 for aqueous food simulants and to olive oil) |
|---|---|---|---|---|---|
| 10 Days<br>40 Degrees C | Distilled Water | No Apparent Change | Limpid | 0,7 - 1,1 - 1,0 | 0,9 |
| 0 Days<br>40 Degrees C | Acetic Acid 3% | No Apparent Change | Limpid | 1,6 - 1,6 - 1,5 | 1,6 |
| 10 Days<br>40 Degrees C | Ethanol 15% (v /v) | No Apparent Change | Limpid | 1,1 - 1,1 - 1,2 | 1,1 |
| 10 Days<br>40 Degrees C | Olive Oil | No Apparent Change | Limpid | < 0,1 - < 0,1 - < 0,1 | <1 |

## TEST 4

## Resinous Flooring Compatibility Testing

### Background

The connection point between the resin-based flooring material to the drains and curbs is traditionally the most vulnerable location and is subject to premature failures that could lead to disbondment and cracking of the material. If this occurs, bacteria may begin to harbor in these areas. The purpose of the testing is to evaluate adhesion between the unlike materials and determine compatibility for use in order to protect against these problems.

### Testing Method

ASTM D7234-12 Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers; Date: 07-01-2012. This test was completed in a laboratory setting by Stonhard Hygienic Engineer, Robert Copeland, on 06-18-2018. The test results are as follows.

### Results:

1. **Testing Information**

**Product and Environment**

| | |
|---|---|
| Product Tested: | Stonclad UT over various products: PolySto Natural Curb (prepped vs unprepped), PolySto Sanicoat Curb (prepped vs unprepped), Blücher Stainless Steel (unprepped, wiped clean) |
| Tester: | Robert Copeland |
| Test Location: | Stonhard Technical Service Lab |
| Reason for Test: | To test adhesion of Stonclad UT over PolySto/Blücher products |
| Substrate: | Polymer Composite/Steel Plate |
| Adhesive: | JB Weld |
| Temperature: | 70 °F |
| Relative Humidity: | 50% |

### Test Device

| | |
|---|---|
| Device: | Elcometer 106 Pull Off Adhesion Tester |
| Manufacturer: | Elcometer |
| Model No.: | Elcometer 106 |
| Serial No.: | 3527093 |
| Last Calibration Date: | 05-15-2018 |
| Calibration Due Date: | Not Applicable |
| Date of Bond Test: | 06-05-2018 |

Example of concrete curb with resinous mortar. Signs of impact and damage. Concrete exposed to water will absorb and repel the covering resinous top layer and create a perfect harbor for bacterial growth.

## 2. Testing Summary

### Description of Samples

- Three or four dollies will be applied to each of the surfaces listed in Table 1 using JB Weld.
- For clarification regarding the Testing Summary, please reference the definitions and guidelines outlined in the Appendix.

**Table 1: This table details the various test samples for this report. Each surface will have three or four tabs adhered and pulled with the portable adhesion tester, which correspond directly to the Test Numbers in the second column.**

| Test Numbers | Surface (D) | Stonhard Mortar (E) |
|---|---|---|
| 1, 2, 3 | Blücher Stainless Steel | Stonclad UT |
| 4, 5, 6 | Blücher Stainless Steel | Stonclad UR |
| 7, 8, 9, 10 | Blücher Stainless Steel | Stonclad UT |
| 11, 12, 13 | PolySto Natural Unprepped | Stonclad UT |
| 14, 15, 16 | PolySto Sanicoat Unprepped | Stonclad UT |
| 17, 18, 19 | PolySto Natural Prepped (40 grit sand) | Stonclad UT |
| 20 | PolySto Natural Prepped (diamond grind) | Stonclad UT |
| 21, 22, 23 | PolySto Sanicoat Prepped (40 grit sand) | Stonclad UT |
| 24 | PolySto Sanicoat Prepped (diamond grind) | Stonclad UT |

## 2.2. Testing Procedure

- The goal of each bond test will be to test the adhesion between Stonclad UT and the surface of two types of PolySto curbing, and the adhesion between Stonclad UT and Blücher's Stainless Steel drain covers.
- The surface of a PolySto Natural curb and a PolySto Sanicoat curb were the only areas that were mechanically prepared. A part of each of these two curbs was sanded with 40 grit sand paper, and part was prepared with a diamond grinder. All surfaces, prepped and unprepped, were wiped clean before applying Stonclad UT.
- After the Stonclad had time to cure, the surface was prepared with a blast machine. Bond tabs were applied to the Stonclad using a healthy amount of JB Weld.
- Once the JB Weld was completely cured, the bond tabs were pulled using the Elcometer 106 Adhesion Tester.
- Results were recorded.

## 3. Results

The background data related to the bond test have been recorded in the table below. The bond test results have been recorded in the column labeled "Tensile Bond Strength" and the predominate failure mode for each test has been recorded in the column labeled "Predominate Failure Mode".

**Table 2: This table contains a summary the data and results pertaining to the bond test performed.**

| Test No | Core Depth (in.) | Over-layment Thickness (appx.) | Scored (Yes / No) | Depth of Failure Plane (in) | Apparatus Load Rating (lb) | Core Diameter (in) | Core Area (in2 | Tensile Bond Strength (psi) | Predominate Failure Mod |
|---|---|---|---|---|---|---|---|---|---|
| 1 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 2 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 3 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 4 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 150 | F4 (100%) |
| 5 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 400 | F4 (100%) |
| 6 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 7 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 8 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 400 | F4 (100%) |
| 9 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 450 | F4 (100%) |
| 10 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 350 | F4 (100%) |
| 11 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 100 | F2 (100%) |
| 12 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 400 | F4 (100%) |
| 13 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F2 (100%) |
| 14 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 250 | F4 (100%) |
| 15 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 16 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 200 | F4 (100%) |
| 17 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 18 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 200 | F4 (100%) |
| 19 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 20 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 21 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 300 | F4 (100%) |
| 22 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 200 | F4 (100%) |
| 23 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 250 | F4 (100%) |
| 24 | N/A | ¼ in | Yes | N/A | 1,000 psi | 0.98 | 0.75 | 200 | F4 (100%) |

3.2. All images correlating to the Bond Tests detailed above are contained in Figures 1-7.

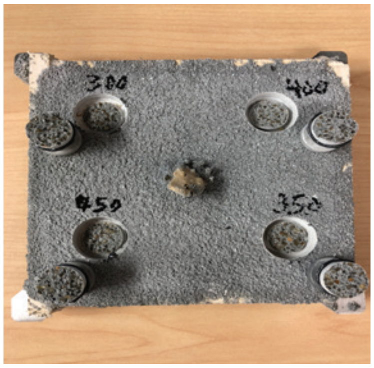


Figure 1: Pull test results for Stonclad UT (top) and Stonclad UR (bottom) over Blücher Stainless Steel

Figure 2: Pull test results for Stonclad UT over Blücher Stainless Steel

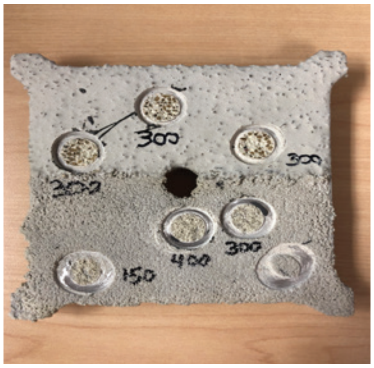


Figure 3: Stonclad UT on Natural and Sanicoat PolySto curbs

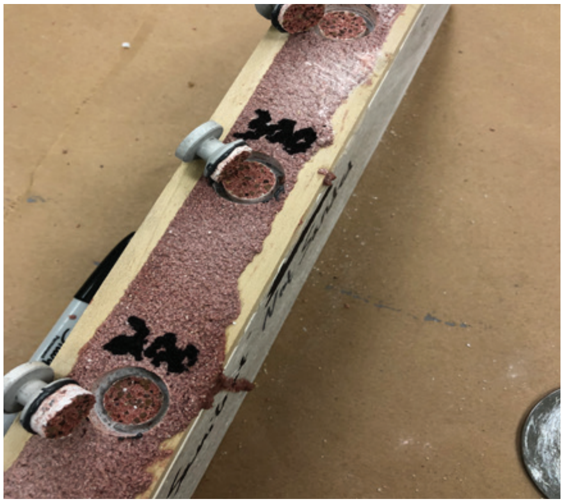


Figure 4: Pull test results for Stonclad UT over PolySto Natural unprepped

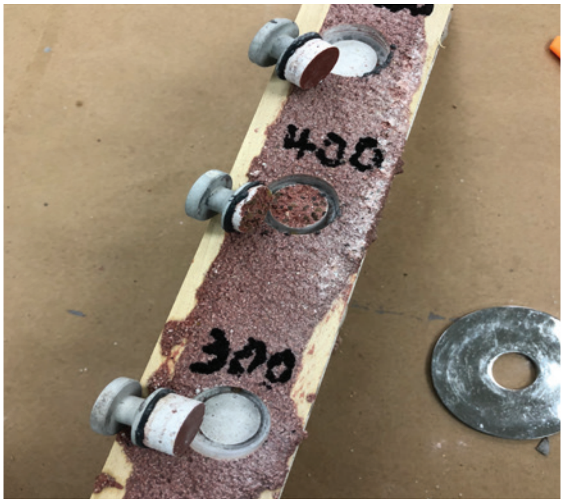


Figure 5: Pull test results for Stonclad UT over PolySto Sanicoat unprepped

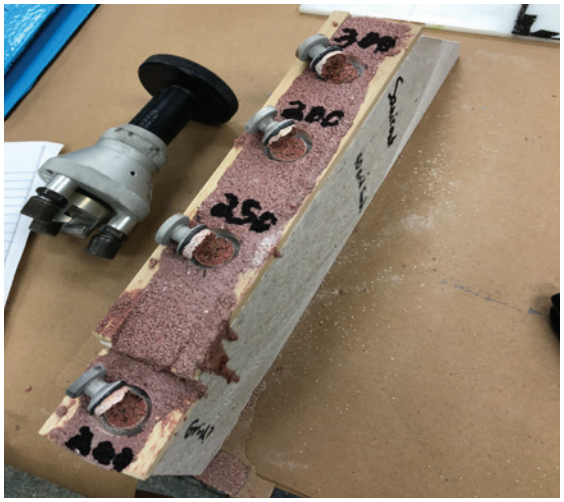


Figure 6: Pull test results for Stonclad UT over prepped PolySto Natural

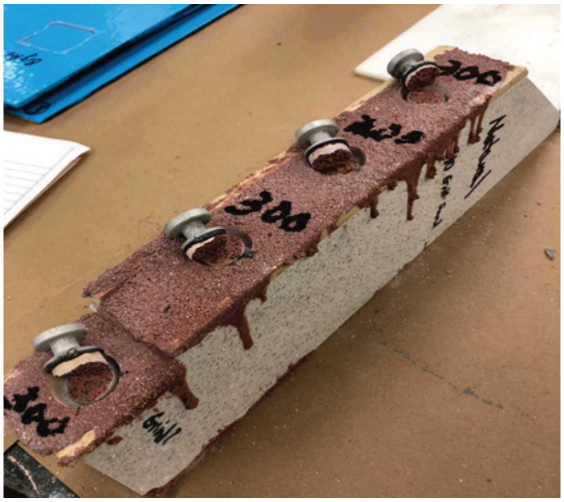


Figure 7: Pull test results for Stonclad UT over prepped PolySto Sanicoat

## 4. Conclusion

- Based on the results recorded in the sections above, all showed very promising bond strengths. The results of Stonclad UT over the Blücher Stainless Steel show high bond strength in all tests. This test also shows that the bond strength of Stonclad UT to all PolySto curbs (natural or sanicoat, prepped or unprepped) is strong.

## 5. References

- ASTM D7234-12 Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers; Date: 07-01-2012

## 6. Appendix

### Definition of System

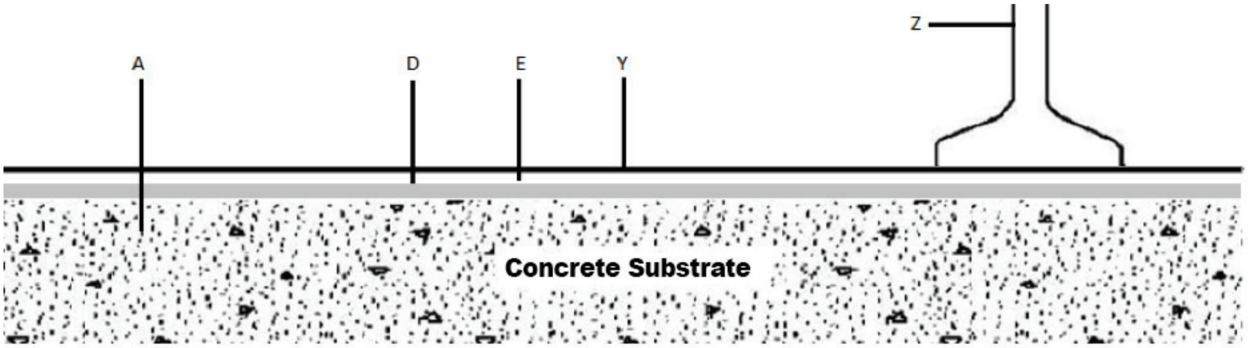
- For the purposes of defining bond test Failure Modes, the naming conventions for the bond test system will be consistent with Sections 9.3.1-9.3.4 in the ASTM D7234-12. See the table below for the definitions.

**Table 3: This table defines the bond test system and clearly identifies and designates all the components.**

| Designation | System Component | Additional Notes |
|---|---|---|
| A | Concrete Substrate | None |
| X | Steel Substrate | Not Shown in Figure |
| D | Coating | First Coating |
| E | Coating | Second Coating |
| F | Coating | Third Coating; Additional Coatings (G, H, etc.) |
| Y | Adhesive | None |
| Z | Bond Tab / Loading Fixture | None |

- The definitions defined in the table are illustrated in the figure below.

**Figure 8: This diagram illustrates the designations defined in the table above.**



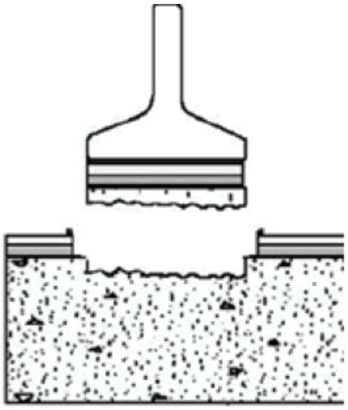
- Cohesive failures will be described by the layers within which they occur as A, D, E, F, etc., and the percentage of each.
- Adhesive failures will be described by the interfaces at which they occur as A/D, D/E, A/Y etc., and the percentage of each.

**Failure Modes**

- The following failure modes have been taken directly from the ASTM D7234-12 to help define the data and failure modes recorded in the above report. All interpretations of the failure modes are taken directly from the ASTM D7234-12 document (Sections 7.2.1.1.1., 7.2.2.1., 7.2.3.1., 7.2.4.1, and 7.2.5.1. in this document).
- Cohesive Failure in the Substrate – "F1"
- This is the preferred mode of failure for coatings on concrete. The value obtained in this failure mode is primarily dependent on the tensile strength of the concrete at or close to the surface. Low values in this failure mode point to a deficiency in the concrete.

Figure 9: This diagram illustrates the cohesive failures within the substrate.

**Adhesive Failure between Coating System and Substrate – "F2"**



Substrate Failure A

This is not the preferred mode of failure for coatings on concrete, especially when low pull-off adhesion values are obtained. This mode of failure is usually due to insufficient surface preparation of the concrete, contamination on the concrete surface, or incompatibility between the coating and the concrete. One exception is elastomeric coatings, which occasionally fail in this mode.

**Adhesive Failure between Layers in the Coating System – "F3"**

This is not the preferred mode of failure for coatings on concrete, especially when low pull-off adhesion values are obtained.

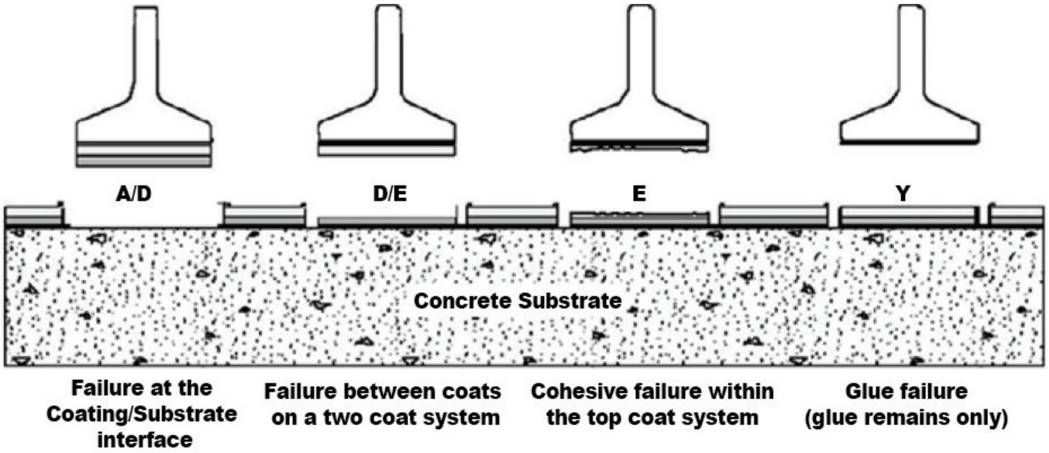
**Cohesive Failure in the Coating System – "F4"**

This is not the expected mode of failure for most coatings on concrete. If the tensile strength of the coating exceeds the tensile strength of the concrete, this failure mode should not be encountered unless there is a deficiency in the coating.

**Adhesive Failure of the Loading Fixture Adhesive – "F5"**

When this failure mode accounts for 20% or more of the failures, the results are disregarded, as failure in this mode indicates that the result is not a measure of the adhesion of the system to the substrate.

Figure 10: This diagram illustrates the four remaining failure modes (from left to right): Adhesive failure between coating system and substrate, Adhesive failure between layers in the coating system, Cohesive failure in the coating system, and Adhesive failure of the loading fixture adhesive

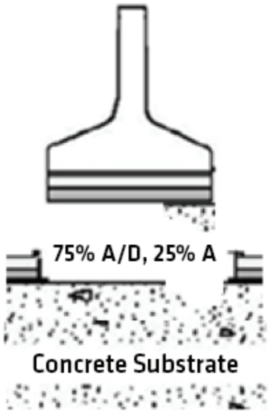


### Combination Failures

Cohesive and Adhesive failures occasionally occur at the same time. In this case, the tester will specify the extent of each type of failure by assigning an approximate percentage to each. In the figure below, for example, there is an approximate 75% Adhesive failure between coating system and substrate (A/D, F2) and an approximate 25% Cohesive failure in the substrate (A, F1).

These types of combination failures can apply to any of the five failure modes detailed above.

Figure 11: This diagram illustrates a combination failure: an approximate 25% Cohesive failure in the substrate (F1) and an approximate 75% Adhesive failure between coating system and substrate (F2).

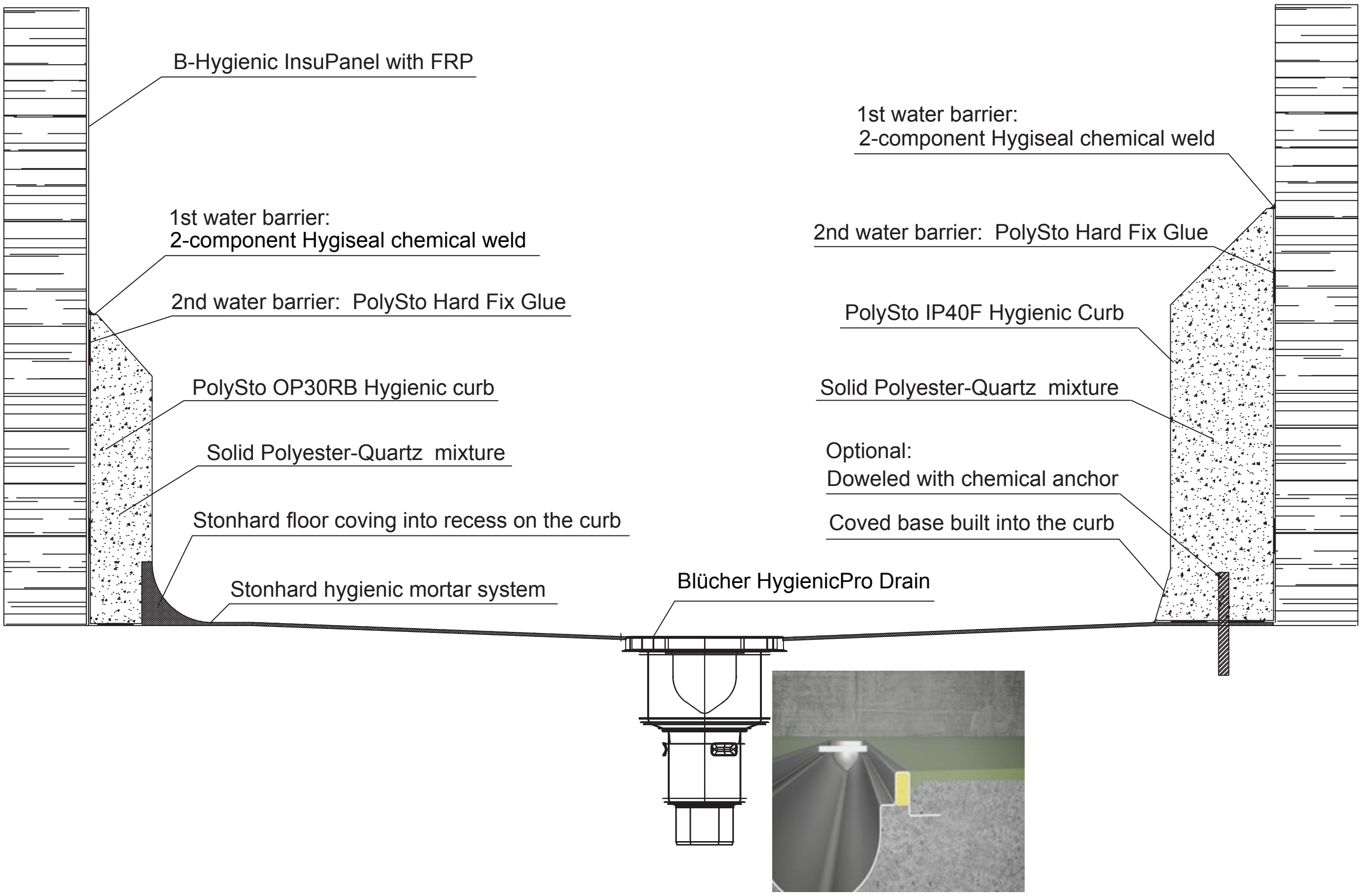


## Overall Results & Recommendations

Based on the industry-accepted test methods performed, along with the associated results on all the three products, it is the Hygienic Design Committee's conclusion that the combination of a polymer curb, resinous floor and rounded drain system is a completely compatible and reliable hygienic solution to be used in food and beverage facilities. The results from our testing have led us to create the recommendation below. This Total Hygienic Solution utilizing Stonhard's Stonclad HACCP-certified, seamless, urethane flooring, Blücher HygienicPro Drains, and PolySto Hygienic curbs, along with their complementary products, can be used to ensure you have a seamless system beginning at the room exterior all the way to the drains. In addition, The Hygiene Design Committee's recommendation for minimizing biofilm formation, a harborage point for bacteria, is to connect the drain to a Blücher stainless steel piping system beyond the exit of the facility's hygienic area exit point. The overall goal is to reduce water and eliminate any potential points of failure such as gaps or cracking over time.  From the vast array of products that each manufacturer produces, we have narrowed down to the best solutions to combat pathogens and bacterial growth.  Reducing overall risk from these types of organisms improves the hygienic success of any food and beverage facility and protect from the risk of costly recalls.

# A Total Hygienic Solution

**Polysto hygienic curbing, Stonhard floor and Blücher drain detail.**



## Learn More

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BLÜCHER was founded in 1965 by Johannes Blücher Skibild, a skilled and visionary plumber with both feet on the ground. Today, BLÜCHER is one of Europe's leading producers of stainless steel drainage systems with subsidiaries and sales offices across Europe, in Russia, the Middle East, USA and China. BLÜCHER's head office with production, product development, storage, and administration facilities is based in Vildbjerg, in the western part of Denmark. **www.Blücher.com**

PolySto is the leading and preferred European producer of hygienic wall protection for the food and pharmaceutical industry. **www.polysto.com**

### Reference and Citations

EHEDG 44

ETAG 022 Annex G

European Standard EN 1992-1-1:2004

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