

DEPARTMENT FOR BUILDING PHYSICS
Laboratory for Building Physics

TEST REPORT 1103/23-520-2-EN

on testing hail resistance on
External Thermal Insulation Composite System

DALMAÇYALI ORGANIC
THERMAL INSULATION SYSTEM

according to
according to FM Approval 4473

Orderer: **BETEK BOYA VE KİMYA SANAYİ A.Ş. ,**
Zümrütevler Mahallesi, Ural Sokak No:38 34852 Maltepe / İstanbul / Turkey

Order form: **Confirmation of the offer 1075/2023 with an e-mail from 13. 11. 2023**

Responsible
investigator: **mag. Barbara Treppo Mekiš, univ.dipl. inž. grad.**

Head of Laboratory: **doc. dr. Katja Malovrh Rebec**

Director: **doc. dr. Aleš Žnidarič, univ.dipl. inž. grad.**

Date: **13. 5. 2024**

The report has been internally reviewed and approved by all listed persons, which is confirmed by the final electronic signature.
Document authenticity check : www.zag.si/pristnost

The results of the tests refer only to the tested specimens. This report may only be reproduced as a whole. Complaints will be considered only if received within 15 days from the date of issue of the report. Total number of pages: 12; Total number of annexes : 0.

Table of Contents

1. Introduction	3
2. Methodology.....	3
2.1 Samples	3
2.2 Test method	4
3. Test results.....	5
4. Photodocumentation	7

1. Introduction

The orderer, BETEK BOYA VE KİMYA SANAYİ A.Ş., Zümrütevler Mahallesi, Ural Sokak No:38 34852 Maltepe, İstanbul, Turkey, ordered ZAG testing of the hail resistance of the External Thermal Insulation Composite System (ETICS) »DALMAÇYALI DOUBLE CARBON THERMAL INSULATION SYSTEM«.

The test method is based on the method »FM Approval št. 4473 – Specification Test Standard for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls«, which is intended to test roofing products to resistance to hail. For this purpose, the orderer produced, prepared and sent the samples to ZAG. For the samples in question, the contracting orderer declared Category 3 according to FM Approval No. 4473.

2. Methodology

2.1 Samples

Applicant	BETEK BOYA VE KİMYA SANAYİ A.Ş. Zümrütevler Mahallesi, Ural Sokak No:38 34852 Maltepe, İstanbul Turkey	
Facade system (ETICS)	DALMAÇYALI ORGANIC THERMAL INSULATION SYSTEM	
Dimensions of the sample	90 × 90 cm; 6 specimens	
Thermal insulation material	Expanded polystyrene - EPS with trade name Dalmaçyalı Ideal Carbon Thermal Insulation Board EPS-EN 13163-T(1)-L2-W2-S2-P5-DS(N)2-CS(10)50-TR100-(WL(T)5-E; -λ=0,034 (thickness 100 mm)	
Base coat	Dalmaçyalı Organic Thermal Insulation System Plaster	
Glass-fibre mesh	Dalmaçyalı Reinforcement Mesh S110	
Finishing coat	Dalmaçyalı Organic Thermal Insulation System Coating 1,5 mm	
Internal sample designation	ZAG T 8-2/24/2	
Date of sample receipt	2. 2. 2024	
Date of measurements and tests	16. 4. 2024	

Sample conditioning: More than 24h at laboratory conditions: $T = 22 \pm 5 \text{ }^{\circ}\text{C}$,
 $rH = 60 \pm 5 \%$.

Position during testing: Sample placed vertically, freestanding, perpendicular to the direction of testing, loosely fastened to the frame.

2.2 Test method

The test method is based on the controlled bombardment of the sample with the ice balls of different sizes, known mass and known incident speed. Test results shall be presented in accordance with the category of the standard, observing the damage to the sample. The sample corresponds to a particular category if there are no evidence of visible cracking or breakage according to the parameters of this category on the sample. The parameters of the categories that express realistic hail load are listed in Table 1.

Table 1: The parameters of the categories according to FM Approvals No. 4473.

Category	Nominal ice ball diameter (mm)	Nominal ice ball mass (g)		Kinetic energy, E (J)	
		Target	+10%	Target	+10%
1	31,8	15,3	16,8	5,0	5,5
2	38,1	26,5	29,2	10,4	11,6
3	44,5	42,1	46,3	19,0	20,9
4	50,8	62,9	69,2	32,2	35,5

Testing on the sample under consideration was carried out with an aerial cannon. The test equipment consisted of an aerial cannon with adjustable speed of a projectile, a metering system for measuring the velocity of the projectile at the exit from the cannon tube and ancillary equipment.

The aerial cannon for bombardment was calibrated to the required kinetic ball impact energy prior to testing. The device was installed in a corresponding position that the incident missiles during the test were perpendicular to the sample ($90^\circ \pm 5^\circ$). The distance of the outlet opening of the cannon to launch the ice balls was less than 1.5 m from the sample.

Ice balls were prepared by freezing distilled water in freezing molds at -22°C . During the test, the corresponding number of nominally equal ice balls was fired onto the sample. The target location of the ice balls, missiles, were different places on the sample. Before the launch, each ice ball was weighed to determine its mass, and measured to determine the diameter.

3. Test results

Test results are shown in Table 2.

Table 2: Test results on the sample under consideration according to FM Approvals No. 4473.

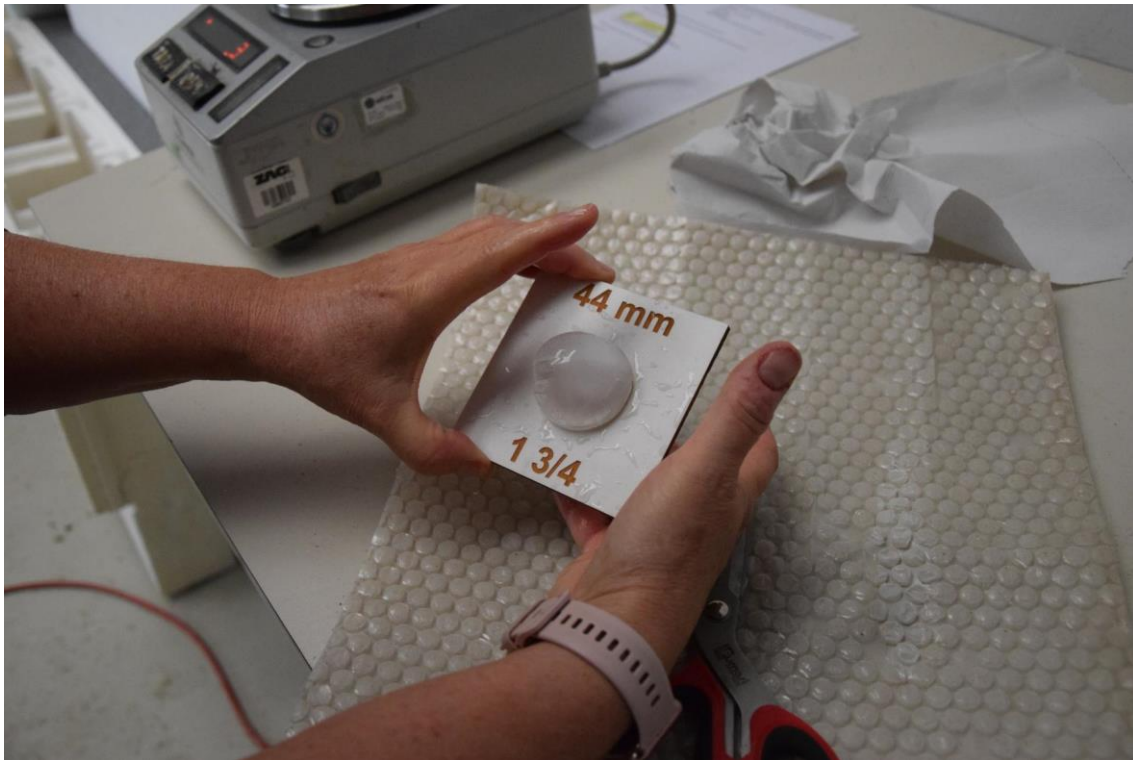
Category	The serial number of the missile	Nominal diameter of the ice ball (mm)	Nominal mass of ice ball (g)	Impact kinetic energy of the ice ball (J)	Description of damage
3	1	44,5	42,1	19,4	Very small depression on the outer surface of the ETICS
3	2	44,5	42,7	20,0	Very small depression on the outer surface of the ETICS
3	3	44,5	43,1	20,8	Very small depression on the outer surface of the ETICS
3	4	44,5	43,0	20,6	Very small depression on the outer surface of the ETICS
3	5	44,5	42,4	20,5	Very small depression on the outer surface of the ETICS
3	6	44,5	42,8	20,7	Very small depression on the outer surface of the ETICS
3	7	44,5	42,3	20,1	Very small depression on the outer surface of the ETICS
3	8	44,5	43,1	20,2	Very small depression on the outer surface of the ETICS
3	9	44,5	42,8	20,4	Very small depression on the outer surface of the ETICS
3	10	44,5	44,0	20,1	Very small depression on the outer surface of the ETICS
3	11	44,5	43,3	19,4	Very small depression on the outer surface of the ETICS
3	12	44,5	43,5	20,2	Very small depression on the outer surface of the ETICS
3	13	44,5	42,4	19,7	Very small depression on the outer surface of the ETICS
3	14	44,5	42,9	19,2	Very small depression on the outer surface of the ETICS
3	15	44,5	42,1	20,6	Very small depression on the outer surface of the ETICS
3	16	44,5	44,4	20,6	Very small depression on the outer surface of the ETICS
3	17	44,5	42,2	20,7	Very small depression on the outer surface of the ETICS

Category	The serial number of the missile	Nominal diameter of the ice ball (mm)	Nominal mass of ice ball (g)	Impact kinetic energy of the ice ball (J)	Description of damage
3	18	44,5	43,3	20,8	Very small depression on the outer surface of the ETICS
3	19	44,5	42,7	19,8	Very small depression on the outer surface of the ETICS
3	20	44,5	44,2	20,3	Very small depression on the outer surface of the ETICS
3	21	44,5	42,6	19,1	Very small depression on the outer surface of the ETICS
3	22	44,5	42,5	20,4	Very small depression on the outer surface of the ETICS
3	23	44,5	42,3	19,9	Very small depression on the outer surface of the ETICS
3	24	44,5	43,7	19,2	Very small depression on the outer surface of the ETICS
3	25	44,5	42,1	19,0	Very small depression on the outer surface of the ETICS
3	26	44,5	43,1	20,6	Very small depression on the outer surface of the ETICS
3	27	44,5	42,6	19,2	Very small depression on the outer surface of the ETICS
3	28	44,5	43,7	20,6	Very small depression on the outer surface of the ETICS
3	29	44,5	42,1	19,4	Very small depression on the outer surface of the ETICS
3	30	44,5	44,1	20,9	Very small depression on the outer surface of the ETICS
3	31	44,5	44,5	20,8	Very small depression on the outer surface of the ETICS
3	32	44,5	42,6	19,3	Very small depression on the outer surface of the ETICS

During the test, i.e. controlled bombardment with the ice balls with a nominal size of 44.5 mm and a nominal impact energy of 19.0 J (category 3), very small depressions have occurred on the outer surface of the ETICS, therefore the Category 3 is achieved. There was no difference in damage between individual specimens of the sample.

4. Photodocumentation

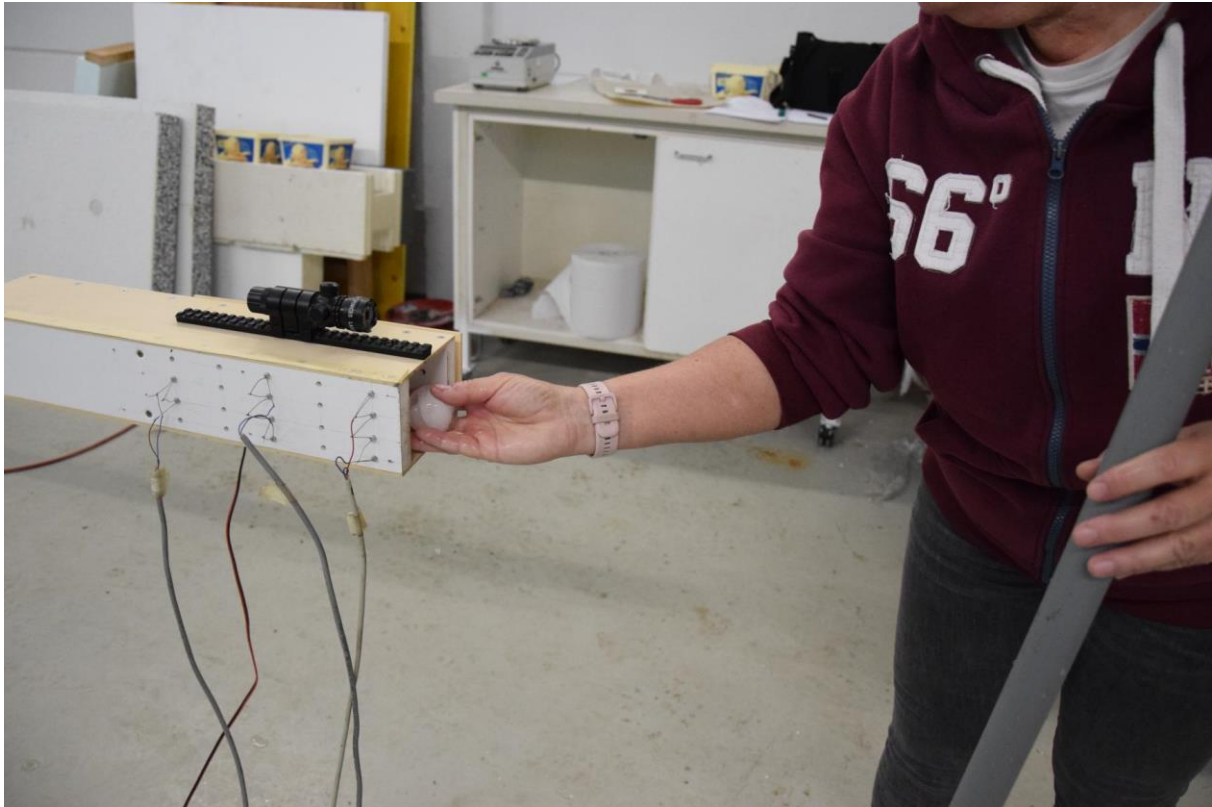
Photodocumentation of the testing is stored at ZAG's archive under the designation 048137d.



Picture 1: Checking the size of the ice balls



Picture 2: Weighing of the ice balls



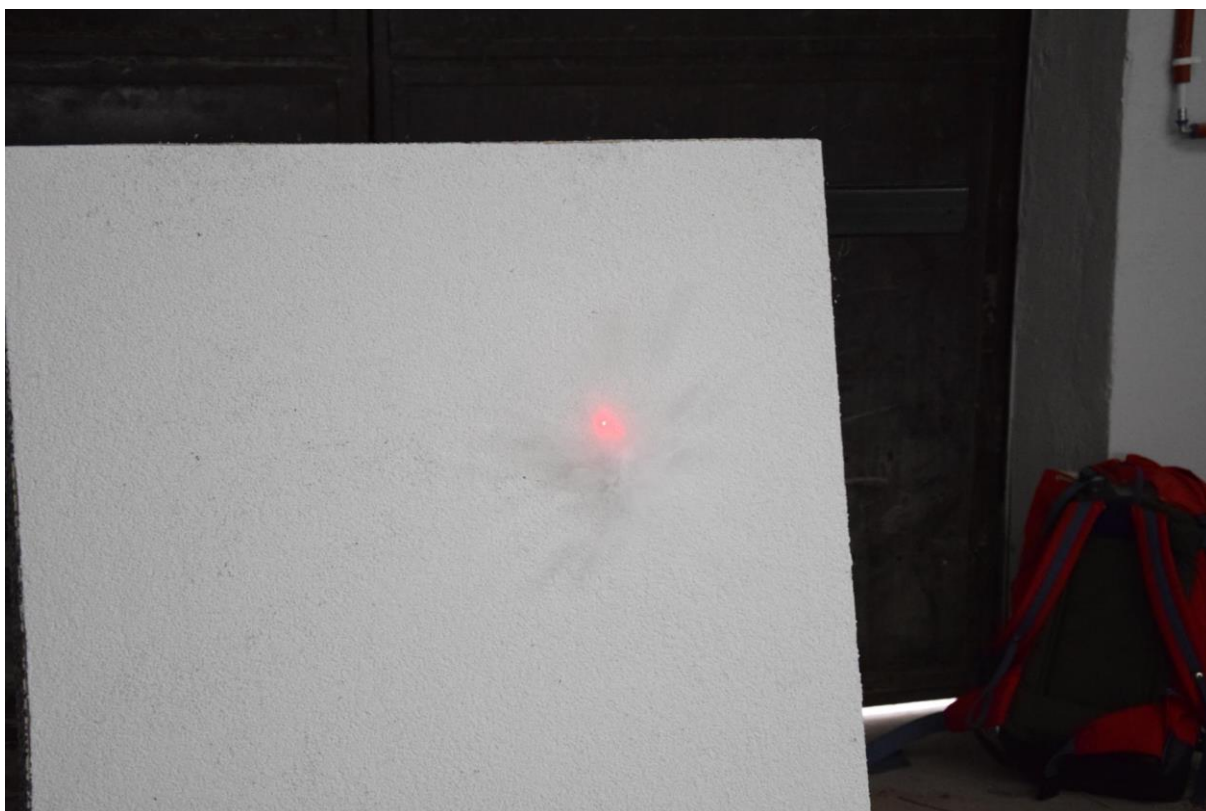
Picture 3: Inserting the ice ball into the bombarding equipment



Picture 4: The velocity measurement cell on the end of the bombarding pipe.



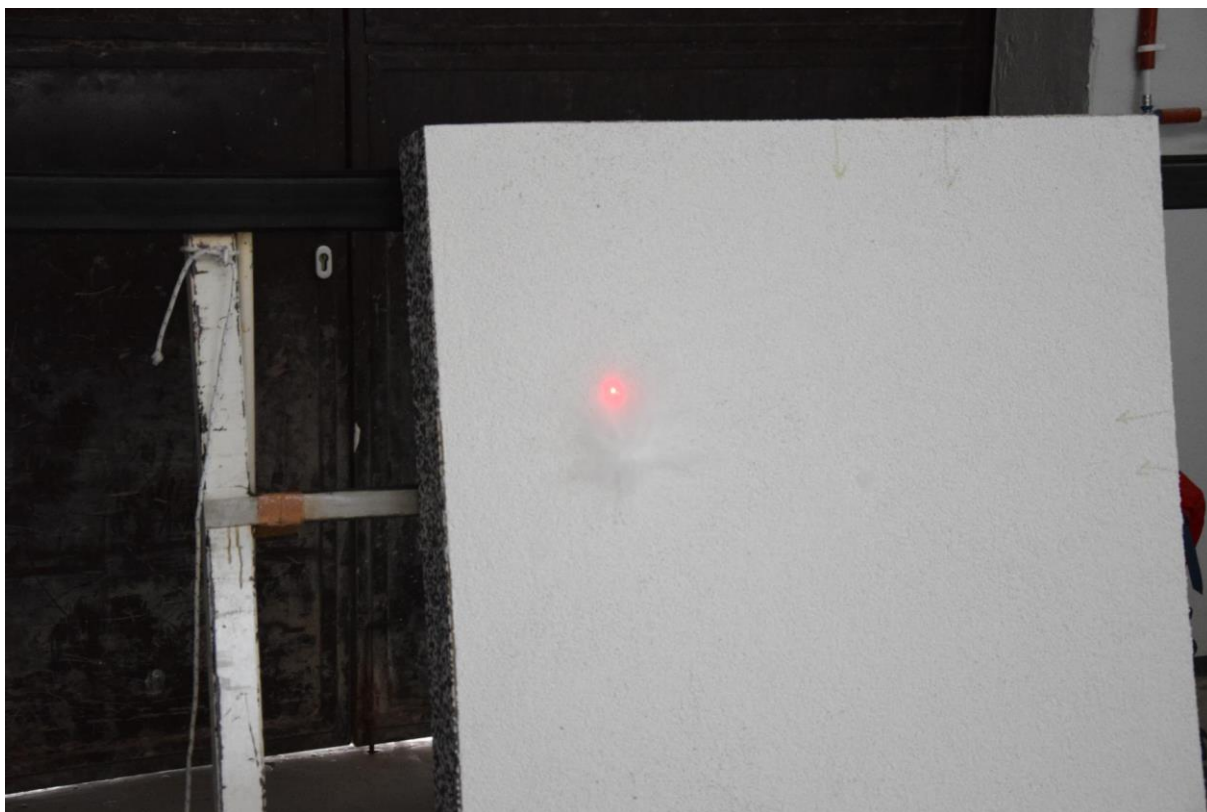
Picture 5: Moment of the impact of the ice ball



Picture 6: Moment of the impact of the ice balls - closer look



Picture 7: Inspection of the damage caused by the impact - only a slight depression is visible on the surface of the ETICS, without any cracks



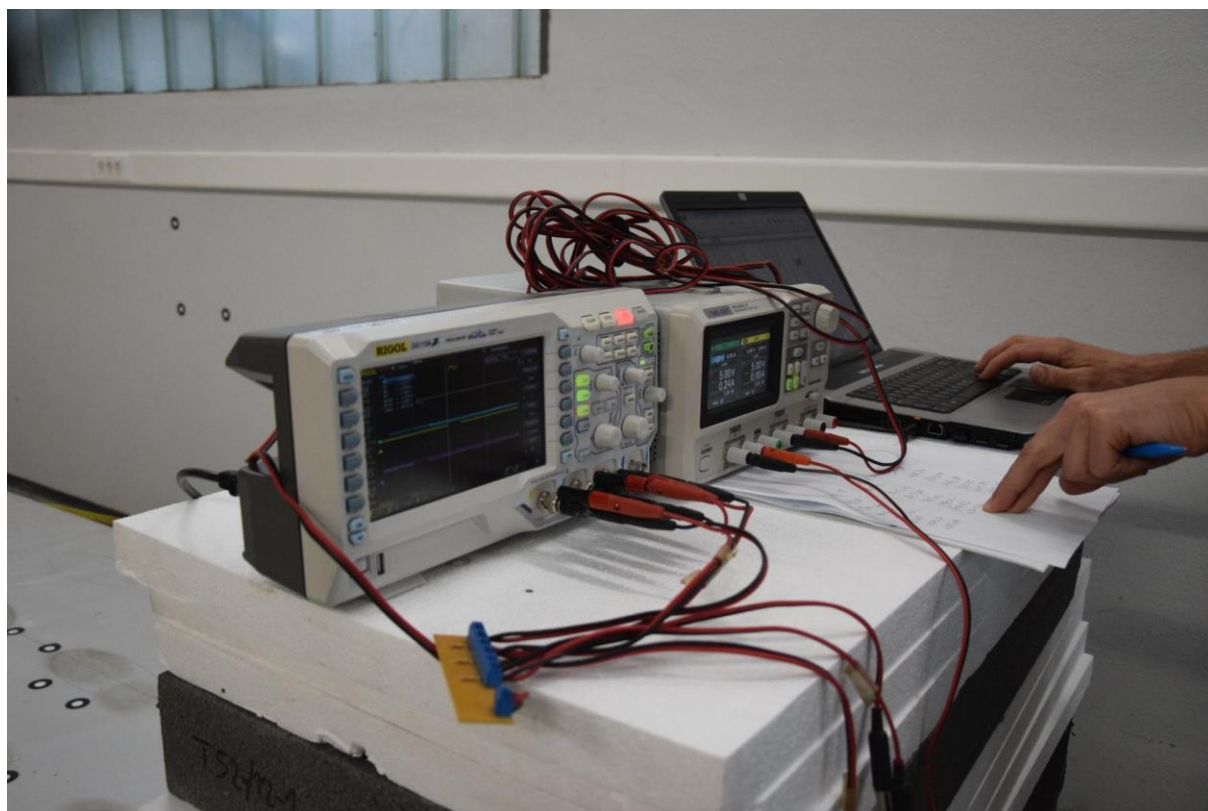
Picture 8: Another moment of the impact



Picture 9: After the impact some ice is visible on the surface of the ETICS



Picture 10: Inspection of the damage after the impact - almost no visible damage on the surface of the ETICS



Picture 11: The measurements equipment

Test report prepared by:
Barbara Treppo Mekiš, M.Sc.