REPORT No. 077030-003-a (M1)

CUSTOMER	SYNTHESIA TECHNOLOGY EUROPE S.L.U.
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PURPOSE	AIR PERMEABILITY TESTING OF BUILDING COMPONENTS AND BUILDING ELEMENTS, ACCORDING TO UNE-EN 12114:2000
TESTED SAMPLE	POLYURETHANE PANEL REF.: “POLIURETAN SPRAY S-303HFO”
DATE OF RECEIPT	25/09/2018
TEST DATE	10/10/2018
DATE OF ISSUE	30/10/2018
DATE OF TRADUCTION	11/12/2018
DATE OF MODIFICATION	01/04/2019

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Signed: Ion Oteiza

Technical Project Manager

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* Uncertainty related to the tests is available to the customer, if required.
* This report modifies and supersedes report No. 077030-003-a

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CHARACTERISTICS OF THE SAMPLE

On 25 September 2018 TECNALIA received from the company SYNTHESIA TECHNOLOGY EUROPE S.L.U. a polyurethane panel referenced as "**POLIURETAN SPRAY S-303HFO**", whose main characteristics are as follows:

SAMPLE TYPE:	Polyurethane panel
TESTED SAMPLE DIMENSIONS (mm)	1,300 x 1,300
TOTAL SURFACE (m^2)	1.69
SAMPLE THICKNESS (mm)	100

REASON FOR CHANGE

There was a typo on graph 1 and graph 2.

Annex I of this report displays the photographs taken during testing.
Annex II of this report includes the technical specifications provided by the customer.

TEST BENCH

KS MSD DIGITAL test bench by K. SCHULTEN FENSTERTECHNIK, with pneumatic cylinders for sample fastening.

TEST REQUESTED

- **Air permeability testing of building components and building elements**, according to UNE-EN 12114:2000

TEST CONDUCTED

The test conducted was:

AIR PERMEABILITY TEST

Air permeability is the ability of a building element to allow air to pass when subject to differential pressure.

In order to carry out the test, the sample is subjected to a series of stages of positive and/or negative pressure differences and the air flow crossing the sample is measured at each stage. The measurement results are corrected for the reference conditions.

The test standard in Annex B indicates how to calculate the "*c*" and "*n*" flow equation coefficients.

$$V = c\,\Delta p^{n}$$

$$ln(V) = ln(c) + n\,ln(\Delta p)$$

This equation corresponds to a linear relationship of the type:

$y = ln(V)$; $a = ln(c)$ and $x = ln(\Delta p)$

The *a* and *n* coefficients will be calculated using the linear regression technique described below. The *c* flow coefficient is expressed as:

C = exp (a)

The coefficients are calculated using the following relationships:

*average estimates

$$\bar{x} = \frac{1}{N}\sum_{t=1}^{N} xt \quad \text{and} \quad \bar{y} = \frac{1}{N}\sum_{t=1}^{N} yt$$

*variable estimates

$$s_x^2 = \frac{1}{N-1}\sum_{t=1}^{N}(xt - \bar{x})^2$$

$$s_y^2 = \frac{1}{N-1}\sum_{t=1}^{N}(yt - \bar{y})^2$$

$$s_{xy}^2 = \frac{1}{N-1}\sum_{t=1}^{N}(xt - \bar{x})(yt - \bar{y})$$

The best estimations of the coefficients *a* and *n* are:

$$n = \frac{S_{xy}}{S_x^2}$$

$$a = \bar{y} - n\bar{x}$$

RESULTS

1.- AIR PERMEABILITY TEST

Positive pressures

Environmental conditions:

Temperature: **20 ºC** Relative humidity **51%** Atmospheric pressure: **99.7 kPa**

Upon completion of the air permeability test as per UNE-EN 12114:2000, the results obtained are shown in the following table:

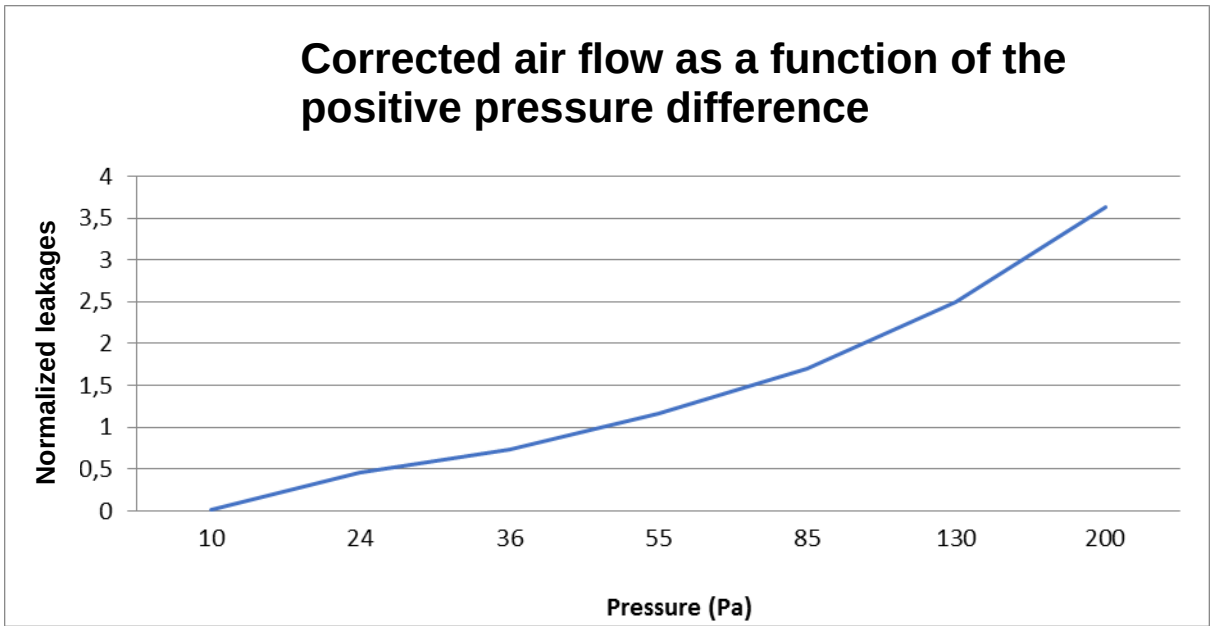
Pressure (Pa)	V_{X+} (m^3/h)	V_{0+} (m^3/h)	Permeability as a function of the area V_{A+} ($l/sec.m^2$)	($m^3/h.m^2$)
10	0.02	0.02	0.00	0.01
24	0.77	0.77	0.13	0.46
36	1.24	1.23	0.20	0.73
55	1.98	1.97	0.32	1.17
85	2.89	2.87	0.47	1.70
130	4.25	4.22	0.69	2.50
200	6.18	6.14	1.01	3.63

where: V_{X+} = Measured air leakage
V_{0+} = Air leak corrected based on the reference conditions in Section 8.2 of standard UNE EN 12114:2000
V_{A+}= Permeability as a function of the area.

Flow equation coefficients:

***n* = 1.5**
c = 0.0

The following graph represents the volume of air that passes through the joints of the sample (in m^3/h) in accordance with the positive pressure applied, according to standard UNE-EN 12114:2000



Graph 1

Negative pressures

Environmental conditions:

Temperature: **20 ºC** Relative humidity **50%** Atmospheric pressure: **99.7 kPa**

Upon completion of the air permeability test as per UNE-EN 12114:2000, the results obtained are shown in the following table:

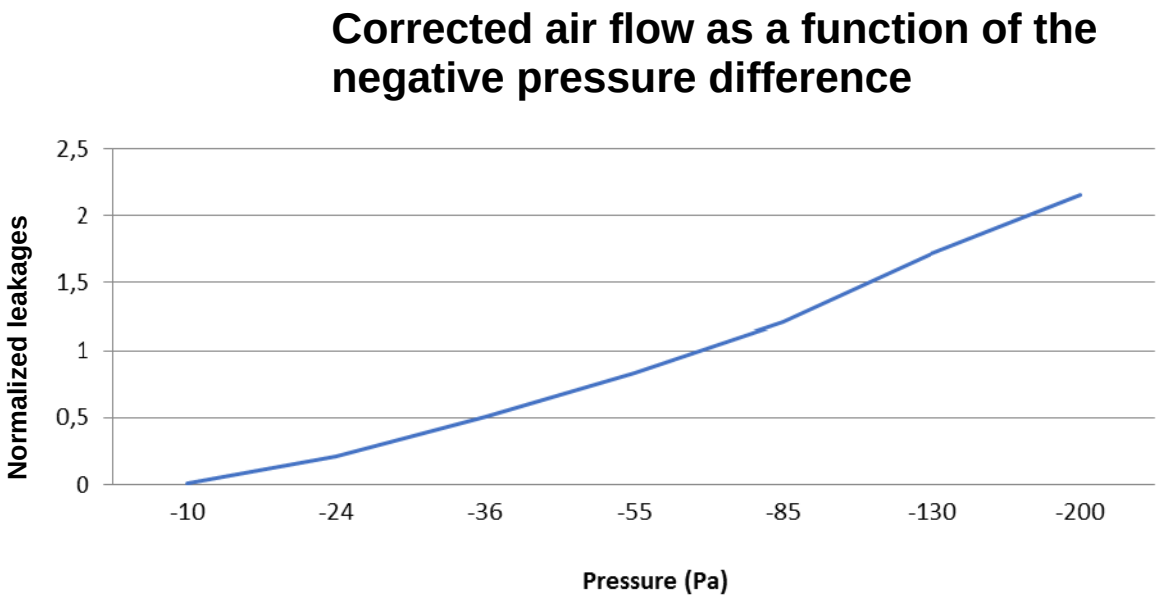
Pressure (Pa)	V_{X+} (m^3/h)	V_{0+} (m^3/h)	Permeability as a function of the area V_{A+} ($l/sec.m^2$)	($m^3/h.m^2$)
-10	0.02	0.02	0.00	0.01
-24	0.35	0.35	0.06	0.21
-36	0.87	0.86	0.14	0.51
-55	1.42	1.41	0.23	0.83
-85	2.06	2.05	0.34	1.21
-130	2.91	2.89	0.48	1.71
-200	3.66	3.64	0.60	2.15

where: V_{X+} = Measured air leakage
V_{0+} = Air leak corrected based on the reference conditions in Section 8.2 of standard UNE EN 12114:2000
V_{A+}= Permeability as a function of the area.

Flow equation coefficients:

***n* = 1.4**
c = 0.0

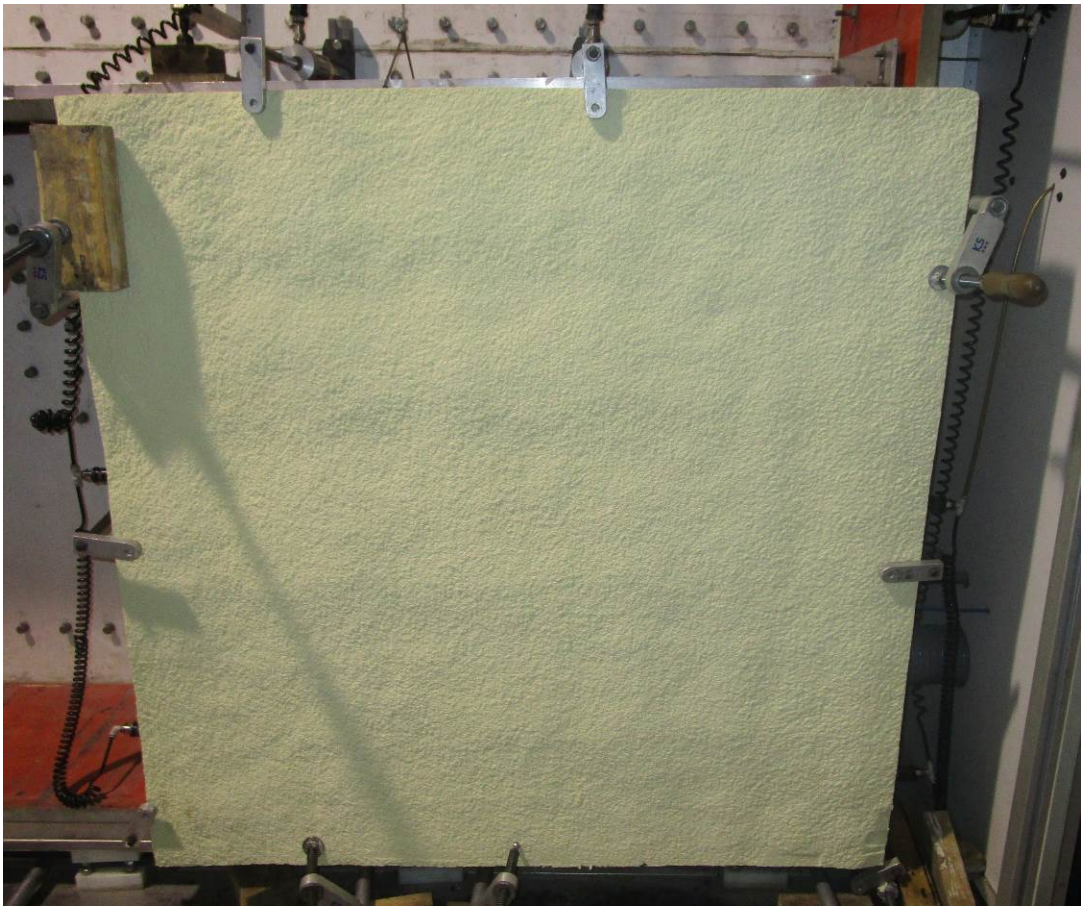
The following graph represents the volume of air that passes through the joints of the sample (in m^3/h) in accordance with the negative pressure applied, according to standard UNE-EN 12114:2000



Graph 2

ANNEX I

PHOTOGRAPHS OF THE TESTED SAMPLE



Photograph 1

Photograph 2

ANNEX II

TECHNICAL DOCUMENTATION

Synthesia Technology

TECHNICAL DATA SHEET
Date of Issue: September 2018

Poliuretan® Spray S-303 HFO

Isocianato H

DESCRIPTION

Two-component polyurethane system (polyol and isocyanate) formulated to obtain closed-cell rigid foams to be sprayed-in-place for thermal insulation.

Poliuretan® Spray S-303 HFO was developed using the 4th generation of blowing agents which leads to a very low Global Warming Potential.

CE

COMPONENTS

COMPONENT A: **Poliuretan Spray S-303 HFO**
Mixture of polyols containing catalysts, flame-retardants and foaming agents. (containing HFO)

COMPONENT B: **ISOCIANATO H**
MDI polymeric (Methane diphenyl diisocyanate)

USES

Poliuretan® Spray system is applied by spraying with a high pressure equipment fitted with heating, with a mixing ration of 1:1 in volume. Their main applications are the thermal insulation of building closings, houses (partitioning), industrial buildings, farms, etc with a moulded density of 35 to 45 g/l.

Advantages in Application:

- Total suppression of thermal bridges. The insulation presents neither joints nor cracks, since it is a continuous insulation.
- Good adherence to the substrate. No glues or adhesives are needed for the installation.
- Possibility of insulation and waterproofing in a single process. This characteristic is due to its closed-cell and watertight structure, as well as its continuous application, which means that no joints are formed.
- Mobility. It is possible to get to any site quickly without having to transport or store bulky products such as other insulating material.
- Cavity-sealing for sound insulation – absorption.
- Increase of the living area compared with other insulating material.

CONDITIONS OF USES

For the preparation and application of Poliuretan® Spray system, the ATEPA Rules on the Application of Insulating Material should be taken into consideration. (www.aisla.org).

Cavitations of the pumps may cause a decompensation of the polyol mixture/isocyanate ratio producing a foam with poor quality. In order to avoid such a problem, equipment suppliers recommend the use of separate pumps.

The surfaces must be clean, dry and free of dust and grease to ensure good adherence of the foam to the substrate; if the substrate is metallic it must also be free of oxide and rust. A suitable primer is recommended to guarantee good adherence on metal substrates as well as a minimum applied density of 37 Kg/m³.

The foam performance is influenced by a great number of factors which are listed below:

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TECHNICAL DATA SHEET
Date of Issue: September 2018

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Isocianato H

- Weather conditions: temperature and humidity of the atmosphere and the substrate surface, as well as other environmental factors (wind, etc.)
- Adjustment of the machinery, a proper ratio.
- Application type: vertical, horizontal, roofs.
- Application process: coat thickness, varnish application.

GENERAL INSTRUCTIONS

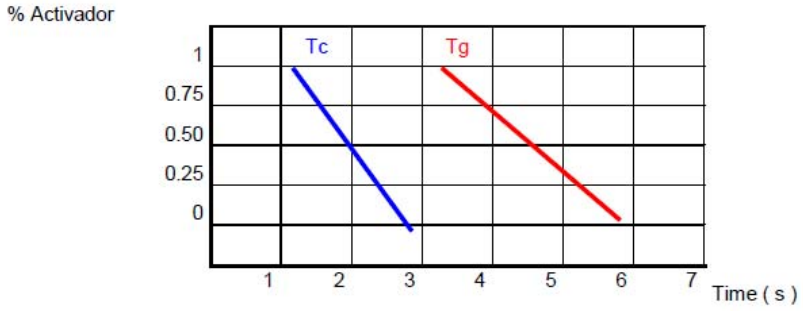
Coat thickness is perfectly controllable and can be modified by varying the speed of application and/or the gun mixing chamber; thickness should be between 10 and 20mm.
It must be taken into account that the foam performance is greater the lower the number of coats applied for the same thickness. Nevertheless, it is not convenient to apply thicknesses above 20 mm, in order to avoid blistering and problems that may take place due a high exothermic reaction.

On cold surfaces, the first coat takes longer to react and growth is not usually 100%. Whereby, in these cases, the first coat should be a varnish for a heat development, which should heat the substrate providing a proper foaming of the second coat.

The recommended temperature in hoses is 30 to 50ºC, depending on the weather conditions and a working setpoint pressure of 800-1200 psi. The minimum recommended substrate temperature during spraying is 5ºC and the components temperature is 20-30ºC.

In certain unfavourable atmospheric conditions (cold substrates, low temperature, high humidity, etc.) it is advisable and approved the addition of about 1% to 2% of **Activator 7014** in the polyol, in this case the drum must be mechanically agitated to provide an appropriate homogenisation.
*(varying the cream time **-tc-** and gel time **-tg-** according to the % of activator added, see attached graphic)

The addition of any type of catalyst other than the catalyst approved by Synthesia Internacional, S.L.U. is neither recommended nor authorised since it may affect the characteristics of the foam and produce unevenness in the process.



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Isocianato H

PROTECTION OF THE FOAM

Rigid PUR foams applied outdoors are darkened and brittle by the action of UV radiation. Thus, all foams that are to be used in these conditions must be protected with a suitable coating (acrylics, butyl rubber, vinyl, asphalt, mono and bi-component polyurethanes, etc.) Synthesia Internacional, S.L.U., supplies an acrylic coating (AQ 3300), and urethane bi-components POLIURETAN® URESPRAY (System F-75 and F-100). The ideal coating is one which meets the following requirements:

a.- Physical properties:
- Resistance to atmospheric and chemical agents.
- Good tensile strength.
- Good foam adherence.
- Resistance to UV radiation.

b.- Regarding the application:
- Fast drying.
- Possibility of spray gun application.

COMPONENTS CHARACTERISTICS

Characteristics	Units	H	S-303 HFO
Specific weight 20ºC	g/cm³	1,23	1,14
Viscosity	cPs	150 - 250 (25ºC)	300 - 500 (22ºC)
NCO content	%	30 - 32	-

SYSTEM SPECIFICATIONS

Measured in a test beaker at 22ºC, in the indicated mixing ratio. The test is carried out according to our standard (MANS-01) which is in concordance with the Annex E of the product at EN 14315-1

Mixing Ratio A / B: 100/100 in volume
100/100 ± 4 in weight

Characteristics	Units	S-303 HFO-W	S-303 HFO-S
Cream time	s	3 ± 1	3 ± 1
Gel time	s	6 ± 2	7 ± 2
Tack free time	s	8 ± 3	8 ± 3
Free density	g / l	33 ± 3	33 ± 3

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FOAM SPECIFICATIONS

Characteristics		Units	S-303 HFO
Apparent Core Density	EN 1602	kg/m³	35 - 45
Closed Cell Content	ISO-4590	%	≥ 90
Thermal resistance and thermal conductivity	EN 12667 EN 12939		See performance chart
Compressive strength	EN 826	KPa	≥ 150
Reaction to fire	EN 13501-1	Euroclass	E(1)
Water absorption (W_p)	EN 1609	Kg/m²	≤ 0,2
Water vapour resistance factor (μ)	EN 12086	-	≥ 70
Dimensional Stability -20ºC (24h)	EN 1604	% Vol.	DS(TH)2

(1) Result of valid test for any applied thickness (60 mm of thickness)
(2) Not declared level

Performance chart
Sprayed insulation foam product CCC4 system. Diffusion open faces.

e_p	25	30	35	40	45	50	55	60	65
λ_D	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028
R_D	0,90	1,10	1,25	1,45	1,65	1,80	2,00	2,20	2,35
e_p	70	75	80	85	90	95	100	105	110
λ_D	0,028	0,028	0,026	0,026	0,026	0,026	0,026	0,026	0,026
R_D	2,55	2,75	3,05	3,25	3,45	3,65	3,85	4,00	4,20
e_p	115	120	125	130	135	140	145	150	155
λ_D	0,026	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025
R_D	4,40	4,80	5,00	5,20	5,40	5,60	5,80	6,00	6,20
e_p	160	165	170	175	180	185	190	195	200
λ_D	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025
R_D	6,40	6,60	6,80	7,00	7,20	7,40	7,60	7,80	8,00

e_p Thickness; mm
λ_D Declared aged thermal conductivity; (W/mK)
R_D Thermal resistance level; (m²K/W)

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Isocianato H

SAFETY RECOMMENDATIONS

Poliuretan® Spray system do not represent significant risks if handled properly. Avoid contact with eyes and skin. The instruction given in the Safety Data Sheet must be followed during the manufacturing and handling of the system.

SUPPLY

Normally, the product is supplied in non-returnable steel drums of 220 litres (blue for Component A and black for Component B).

STORAGE RECOMMENDATIONS

VERY IMPORTANT: Poliuretan® Spray system **S-303 HFO** is sensitive to humidity and must be stored in hermetically sealed drums or containers. **The storage temperature must be kept between +5 and +35ºC.** Lower temperatures considerably increase the polyol viscosity, rendering it difficult to apply, and may build up crystallizations in the isocyanate. Higher temperatures may cause alterations in the polyol, loss of blowing agent, greater consumption and swelling of the drum, as well as uncontrolled foaming when the pump nozzle is placed into the drum. In order to avoid the latter, it is recommended to have the drums set-down for a certain period in a ventilated and fresh place before using them.

In case the drums are supplied with white plastic caps, special care should be taken during the handling of these caps as they are more fragile than the metallic ones and could be deformed.

To maintain the aforementioned characteristics of the systems, the drums should be hermetically sealed when not in use.

Properly stored, the shelf-life is 4 months for S-303 HFO; and 9 months for Component B (isocyanate).

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Isocianato H

ANNEX: APPLICATION TROUBLESHOOTING

Our Technical and Commercial service will provide you with guidance in any queries you may have on the preparation of this product. Nevertheless, some problems that may appear during the process are outlined below.

Problem	Possible cause	Solution
Uneven atomisation.	Gun needle wrongly adjusted or dirt in the mixing chamber.	Adjust the position. Clean the chamber.
Atomisation with colour streaks.	Bad mixing due to obstruction of components or differences in viscosity.	Check pressures, fix obstruction. Adjust and increase temperatures.
Poor and closed atomisation.	High component viscosities. Cold atmosphere.	Increase temperatures and pressures.
Atomisation too open and forming mist.	Too much air in gun tip. Excessive mixing pressure.	Reduce air passage. Reduce the pressure a little.
The material takes too long to react, it falls off.	Cold surface.	Increase hose heating.
Material too fast, uneven finishing with mist.	Pressure excess.	Reduce air pressure in the gun and mixture.
The material is granulated as it gets on the surface and it is obstructing the gun.	Temperature excess.	Reduce hose heating.
Blistering.	Coatings thickness higher than 20mm.	Apply thinner coatings.

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