GGF Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

5.18.7 June 2015

Contents

Introduction

This standard has been developed by the GGF **Window** Film Group, in association with all major film manufacturers, to provide a common basis for on-site peel testing of adhesive backed polymeric safety film.

1. Scope

This standard specifies a test method for on-site 180° peel adhesion of aged adhesive backed polymeric safety film ("safety film") of thicknesses ≤ 230 microns applied to flat, vertical architectural glass.

The on-site 180° peel test is to be used to determine the ongoing behaviour of the adhesive system on applied adhesively backed polymeric safety film that has been subject to natural ageing.

This test method is not applicable to films > 230 microns since the peel angle can be substantially less than 180° and peel test results (static and dynamic) can be extremely variable.

Note: Peel testing of newly applied adhesive backed polymeric film is not appropriate as there is no direct relationship between performance according to BS EN 12600 and the results of peel testing.

2. Definitions and Descriptions

2.1 See GGF Datasheet 5.18.3 "GGF Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components".

2.2 Aged adhesive backed polymeric film

Film is classed as aged only when the manufacturer's warranty has expired.

2.3 Embrittlement

Embrittlement is easy and repeated breakage of an adhesive backed polymeric film during preparation of a test strip or during peel testing; it is usually shown by aged safety film.

2.4 Adhesive Odour

An aged safety film may have significant odour due to degradation of its components by sunlight; it is particularly strong as an aged film is peeled from the glass.

2.5 Discolouration

Significant yellowing of an aged safety film compared to new film.

Note: Discolouration should not be confused with differences in film properties caused by slight lightening of a combined solar control-safety film during ageing, small batch-to-batch variations during manufacture (e.g. visible light transmission), and similar phenomena.

2.6 Adhesive Distortion

Obtrusive distortion of objects viewed through an aged safety film.

2.7 Adhesive Failure: Peeling/Bubbling

Separation of an aged safety film from the glass at its corners / edges (peeling) or elsewhere (bubbles) is evidence of adhesive degradation.

2.8 Buildings at Low Threat / High Threat

For these definitions, please refer to GGF Datasheet 5.18.6 "GGF Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass"

3. Test Conditions

3.1 Peel testing is done under the environmental conditions existing at the time of the test.

3.2 The test shall only be performed when the following conditions are satisfied:

-The glass pane is vertical

-The glass pane is ≤ 425 mm high and ≥150 mm wide

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-The drop from the bottom of the test strip to the floor is equal to or greater than the sum of the length of the test strip plus 250 mm

-The film thickness is ≤ 230 microns

-The peel test angle is ≤ 160°; ledges or other obstructions must not reduce the peel test angle to < 160°

-Water condensation is not present on the film surface (section 5.2, note)

Note: If all panes are < 150 mm wide, the method described here may be adapted by using a spring balance to estimate peel test data. The exact method should be agreed with the client in advance of peel testing.

3.2 In addition, it is preferable that panels selected for testing are sufficiently wide to allow two peel tests to be performed per panel.

3.3 One peel test shall be performed per elevation of installed safety film or per 500 m^2 of installed safety film, whichever is greater.

3.4 If failures are found, the number of peel tests is increased in order to determine whether only part or all of the installed film requires replacing. Up to one peel test per 50 m^2 of installed film may be required.

4. Test Equipment

4.1 The on-site peel test equipment shall include the following items:

-A clip of 20 ± 5 g, used to affix the test weights to the test strip

-Two steel weights of 250 ± 1 0 g

-A steel weight of 700 ± 10 g

-A steel weight of 800 ± 10 g

-Stopwatch measuring to tenths of a second or better

-Straight edged ruler

-Sharp thin bladed knife, e.g. a craft knife with snap-off blades; the blades must not scratch the glass (stainless steel blades are recommended)

-Calibrated micrometer

-Spring balance measuring 0-4000 g with an accuracy of ± 100 g, e.g. a fisherman's spring balance

4.2 The weights shall be suitably certified and of a shape and size to ensure that the peel angle is ≤ 160°, and that glazing panels of ≤ 150 mm width can be tested.

Note: The steel weights usually have hooks to hang them onto the clip; the weight of these hooks should be included as part of the steel weight. Alfred Woods & Co. of Mitcham, Surrey has a suitable test kit available. This should not be taken as an endorsement by the GGF of this product.

5. Preparation of Test Strips

5.1 Ensure the test conditions in section 3 are met. Note both glass and room temperatures and the environmental conditions; especially check that the film is fully cured, the peel angle is always ≤ 160° during the test, and the distance from the bottom of the test strip to the floor allows the weights to hang freely.

5.2 Check that the installed safety film is undamaged and is free from defects that will affect adhesion e.g. water condensation and particulates.

Note: Substantial water condensation can cause the adhesive to be constantly wet, resulting in reduction or complete loss of adhesive strength. Peel testing is therefore only valid where condensation is generally not present; condensation over occasional short periods of time of < 1 hour is acceptable provided that the film is fully cured, ventilation and temperature allow the condensation to dry quickly, and peel testing is not done on panels where condensation is currently present.

5.3 Do not pre-treat the installed film prior to testing, e.g. do not squeegee the film before testing to increase adhesion. Exceptionally, where the surface of the film is very dirty, the film may be cleaned but at least 24 hours is required for the film to dry prior to the peel test.

5.4 Ensuring all film layers are completely cut through to the glass surface, cut a 25 ± 1 mm wide vertical test strip into the safety film, preferably ≤ 200 mm away from the vertical edges of the test panel. If a 200 mm distance is not viable, cut the strip close to the vertical centre line of the glazing; allow sufficient distance from the vertical edges of the panel for the test weights to hang freely (usually ≤ 70 mm). If the test weights do not hang freely, a different test panel must be used.

Note: If the thickness of the film is already known, the thickness of the test strip may be measured at this point rather than at section 7.11 to verify that all layers in the safety film have been completely cut through.

5.5 The strip shall be at least 400 mm long and preferably 600 mm long. Cut a line at ~ 45° to the horizontal across the top of the strip.

5.6 Mark a horizontal line next to and at the bottom of the test strip (m3 in Figure 1). Place similar marks next to the test strip at 100 mm, 200 mm and 300 mm up from this initial mark (marks m0, m1 and m2 in Figure 1) giving a total length for the dynamic peel test of 300 mm in 100 mm increments.

5.7 Carefully commence manual peeling of the top part of the test strip from the glass. A sharp stainless steel blade may be required to start the peel but care should be taken to avoid damaging the glass. Peel about 100 mm of the test strip from the glass, ensuring the line of adhesive peeling is ≤ 25 mm from m0 (Figure 1); if the strip is limited in length, less than 100 mm may be used to attach the clip but the line of adhesive peeling must be ≤ 25 mm away from mark m0.

5.8 Wrap the peeled film around the clip, ensuring that it is firmly attached. Occasionally a staple may be needed for this purpose.

6. Static Peel Test

6.1 Ensuring the line of adhesive peel is above mark m0 (Figure 1), attach the weight specified in Table 1 to the clip, positioning the weight and clip such that no peel force is applied to the strip.

Table 1: Recommended weights for static peel testing of safety film

State	Recommended weights
Aged safety film – low threat	250 g
Aged safety film – high threat	500 g

6.2 Make any minor adjustments so that the line of adhesive peeling from the glass is horizontal (Figure 1).

6.3 To apply the static peel force to the test strip, position the weight so that it will have no movement at the moment of release (slight tension on the test strip is usually needed), keep it perfectly still and in position for 5 seconds, and then gently release the weight.

Note: It is advised that you are ready to catch the weight in case fast peeling of the test strip occurs – it is best to position your hands immediately beneath the weights.

6.4 Closely observe the test strip for any movement or 'creep', then remove the test weight and record the results.

7. Dynamic Peel Test

7.1 Ensuring the line of adhesive peel is above mark m0, attach the lowest weight specified in Table 2 to the clip, positioning the weight and clip such that no peel force is applied to the test strip.

7.2 Check that the weight used gives at least slow 'creep' of the film. If the specified weight does not cause peeling of the film, incrementally increase the weight using Table 2 to obtain at least a slow 'creep'

7.3 If the maximum weight from Table 2 does not cause peeling of the film, incrementally increase the weight using Table 3 to obtain at least a slow 'creep'. If no peeling occurs at the maximum weight given, use the spring balance test method (section 7.9).

Table 2: Recommended weights for dynamic peel testing

State	Recommended weights
Aged safety film – low threat	500 g 700 g
Aged safety film – high threat	700 g 950 g 1300 g

Table 3: Sequence for increasing weights for dynamic peel testing after maximum recommended weight has been reached

State	Incremental weights (use in the order shown)
Aged safety film – low threat	950 g, 1050 g, 1300 g, 1500 g, 1750 g, & 2000 g
Aged safety film – high threat	1500 g, 1750 g, & 2000 g

7.4 Make any minor adjustments so that the line of adhesive peeling from the glass is horizontal (Figure 1).

7.5 Zero the stopwatch.

Note: Optionally, the weight may be attached at this point in the procedure to test the first 100 mm increment,; however, ensure the line of peeling remains horizontal and aligned with the appropriate mark, and that no peel force is applied to the test strip before the test begins.

7.6 Keeping the line of adhesive peeling horizontal, manually peel the test strip down the glass pane until the line of adhesive peel is exactly aligned with the top mark (m0 in Figure 1). Once this operation is completed, ensure that no peel force is placed on the test strip so that the line of adhesive peeling remains aligned with the mark.

7.7 To apply the dynamic peel force to the test strip, position the weight so that it will have no movement at the moment of release, i.e. so that movement of the weight occurs only by the effect of gravity (slight tension on the test strip is usually needed). Keep the weight perfectly still and in position for 5 seconds, and then gently release the weight, starting the stopwatch at the same time.

Note 1: It is advised that you are ready to catch the weight in case fast peeling of the test strip occurs – it is best to position your hands immediately beneath the weights.

Note 2: The strip may stop peeling if it has not been cut through, if peeling stops, immediately remove the weights and stop the stopwatch. Note the time taken and re-cut the strip on both sides. Replace the weights on the clip, recommence the peel and restart the stopwatch. If there is any uncertainty about the validity of the test, especially if the time for a 100 mm increment is close to 20 seconds or if the time for 300 mm is close to 60 seconds, repeat the test with a new test strip.

Note 3: The peel test is invalid if the weight is already moving when it applies force to the test strip because peel strength varies with the speed of testing. It is essential to ensure that no impetus is imparted to the weight as it is released.

7.8 Timing

Timing of the 100 mm segments and the total 300 mm distance for the dynamic peel test can only be done where at least slow 'creep' is present; the procedure above should be used to determine which weight gives the required movement.

7.8.1 Note the time taken for the weight to peel the film over the first 100 mm increment (between marks m0 and m1 in Figure 1).

7.8.2 If the time taken for the test strip to peel 100 mm is ≤ 30 seconds for the first 100 mm increment, allow the strip to continue peeling for the other 100 mm increments between marks m1 and m2 and then between marks m2 and m3 (Figure 1), noting the time taken for each increment and the total time taken for the complete 300 mm length.

7.8.3 If the peel rate is slow (> 30 seconds for the first 100 mm increment):

7.8.3.1 Stop the dynamic peel after 30 seconds and gently lift the weight so that no peel force is applied to the test strip; note the length of the test strip that has peeled within the first 100 mm increment (between marks m0 and m1 Figure 1).

7.8.3.2 If the peel rate is > 30 seconds for the first 100 mm increment, stop the stop watch and repeat section 7.2 to 7.8.3.1 between marks m1 and m2 and then between marks m2 and m3 (Figure 1).

7.8.4 If the specified weight does not cause peeling of the film, incrementally increase the weight using Table 3 to obtain at least a slow 'creep'. If no peeling occurs at the maximum weight, use the spring balance test method (section 7.9).

Note: If the peel rate changes from one 100 mm increment to another it may be necessary to adopt a mixture of the methods above.

7.9 If no peeling occurs with the weights, remove the weights leaving the spring clip in place. Attach one end of the spring balance to the clip ensuring the scale is visible. Align the direction of pull parallel to and close to the test strip so that the peel angle is ≥ 160°. Pull the spring balance, slowly increasing the applied force, monitoring the reading on the scale. Record the force required to produce peeling of the test strip such that the time for each 100 mm increment is ≥ 20 seconds; if the reading is > 4000 g without peeling record "> 4000 g".

7.10 Remove the weights (or spring balance) and clip; record the results.

7.11 Measure and record the safety film thickness using a calibrated micrometer. Ensure that no contaminants are present to affect correct thickness measurement.

Note: As an approximation, it is possible to measure the total film thickness including adhesive and other coatings. The thickness of these coatings is not normally sufficient to make the total film thickness appear to be that of thicker safety films (e.g. a 100 micron safety film with coatings will not generally be close to the thickness of a 150 micron film)

7.12 If the total time is < 75 seconds, cut a similar test strip (as in section 5) 50 to 200 mm from one vertical edge of the panel, allowing sufficient distance for the test weights to hang freely (usually ≤ 70 mm). Test this second strip as described in 7.1 to 7.10. If no panels are available of sufficient width then two adjacent panels may be tested instead of two tests on one panel.

Note: It is possible to test safety film applied to sloping glazing and / or small pane sizes using a suitable spring balance and the principles described in this document, as long as the peel angle is ≥ 160°. The exact test procedure and pass/fail criteria should be agreed with the client prior to the test; this test procedure should include consideration of both the static peel test and dynamic peel test requirements.

8. Additional Test Observations

8.1 Note any adhesive peeling or bubbling, or film embrittlement.

8.2 View the aged safety film in natural daylight (not direct sunlight) from a distance ≥ 2m and at an angle of ≤ 30° from the perpendicular to the test pane. To better see any distortion, look at objects through the film, not at the film itself. Note any particularly obtrusive distortion.

8.3 Note any discolouration or adhesive odour.

Note: Safety film has a small amount of natural adhesive distortion; this is not a defect but is a natural consequence of the high amounts of adhesive used to make these high performance products.

9. Test Evaluation

9.1 Static Peel Test (section 6) – No significant movement is preferred but very slow 'creep' is allowed.

9.2 Dynamic Peel Test, total time (section 7): The time taken for the total 300 mm length shall be ≤ 60 seconds. If the peel rate was slow and distances moved have been recorded, the total time for 300 mm will be ≤ 90 seconds.

9.3 Dynamic Peel Test, incremental times: The time taken for each of the 100 mm lengths shall be ≥ 20 seconds; since initial peel rates can be slightly faster than normal, the time allowed for the first 100 mm increment is ≤ 17.5 seconds as long as the total time (section 9.2) is ≥ 60 seconds. If the peel rate was slow and distances moved have been recorded, the time for every 100 mm increment will be ≤ 30 seconds.

9.4 Dynamic Peel Test – the film must peel when ≤ 4000 g weight is used (sections 7.9 - 7.10).

9.5 Table 4 gives a summary of the above requirements.

9.6 There shall be no embrittlement that makes the peel impossible to perform e.g. from repeated breaking of the test strip (section 8.1).

9.7 There shall be no adhesive bubbling or peeling (section 8.1) and no obtrusive adhesive distortion (section 8.2) present in any part of the test pane.

9.8 Using the dynamic peel test data of aged film, the expected remaining lifetime can be taken from Table 5.

Table 4: *Summary of the peel test requirements (see Figure 1 for marks)*

Peel test type	Requirement
Static	No movement preferred; very slow 'creep' is allowed
Dynamic, $m_0 - m_3$	≥ 60 seconds
Dynamic, $m_0 - m_1$	≥ 17.5 seconds
Dynamic, $m_1 - m_2$ & $m_2 - m_3$	≥ 20 seconds
Dynamic	Must move with ≤ 4000 g

Table 5: *Expected lifetime of aged safety film*

Test Weight	Expected remaining lifetime for building at	
	Low Threat	High Threat
500 g	4 years	—-
700 g	6 years	2 years
950 g	—-	4 years
≥ 1300 g	—-	6 years

Note: Expected lifetime is indicative of the useful lifetime remaining in the safety film; it is subject to environmental conditions in future years and cannot be guaranteed

9.9 Discolouration and adhesive odour are allowed but these indicate film degradation and therefore a shorter expected remaining lifetime than those given in Table 5.

10. Test Report

10.1 The test report shall include the following:

-Date and time of test

-Details of the testing organisation (name, address, etc.)

-Person performing the peel tests

-Film thickness in microns

-Film type and, if available, product code, manufacturer and installer

-Environmental conditions at the time of test e.g. sunny, cloudy, approximate glass temperature, room temperature

-Deviations from the test method, if any, and an explanation of why they were done

10.2 The test report shall also include the following minimum details for each peel test performed:

-Precise location of the peel test (e.g. pane / window / elevation / floor)

-Static peel test results with the weights used (section 6)

-Dynamic peel test results with the weights used, times taken / distances moved for each 100 mm increment, and, if applicable, total time for the 300 mm length (section 7)

-The additional test observations for aged safety film (section 8)

-Pass / Fail for static and dynamic peel testing, and for aged safety film (sections 6 and 9)

-Recommendations for future peel testing

-The expected remaining lifetime for aged safety film from Table 5 (see also section 9.9)

An example of a blank peel test record is shown in the Annex.

Note 1: Adhesive odour and film discolouration are indicative of film degradation but are not pass/fail criteria by themselves. Removal of aged safety film where significant adhesive odour is present should be done in well ventilated conditions; breathing apparatus and/or out of hours working may also be necessary.

Note 2: Film thickness is not a pass / fail criterion by itself. However, aged safety film may no longer meet the minimum specified performance and / or thickness requirements with respect to the threat to the building, e.g. for explosion protection.

11. Further peel testing

11.1 Peel testing is a destructive test, so the tested panels will require replacement of the complete piece of film. Ensure that future peel tests do not test the panels previously tested.

11.2 It is recommended to peel test between one to two years before the remaining lifetime of the film indicated from the dynamic peel testing (section 7).

12. References

Current GGF Datasheets for adhesive backed polymeric film are:

5.18.1 "GGF Visual Quality for Adhesive Backed Polymeric Filmed Glass"

5.18.2 "GGF Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass"

NOTE: Figure 1: Should be after all of the 12. References 5.18.1 to 5.18.8

Figure 1:
On-site peel testing of adhesive backed polymeric safety film on glass

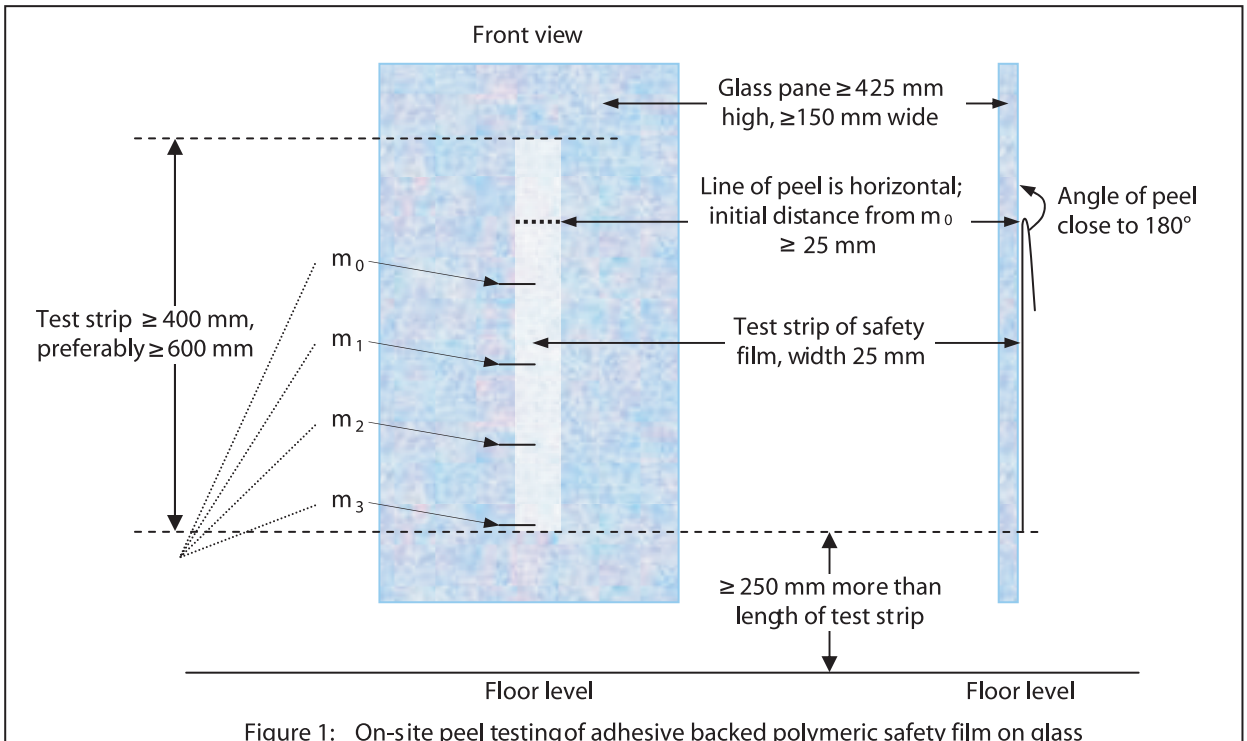

Figure 1: On-site peel testing of adhesive backed polymeric safety film on glass

5.18.3 "GGF Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components"

5.18.4 "GGF Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use"

5.18.5 "GGF Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method"

5.18.6 "GGF Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass"

5.18.7 "GGF Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass"

5.18.8 "GGF Adhesive backed Polymeric Film-Guidelines for installation on existing Glazing"

13. Acknowledgement

The Home Office Scientific Development Branch (HOSDB) has provided valuable assistance and advice in preparation of this Datasheet.