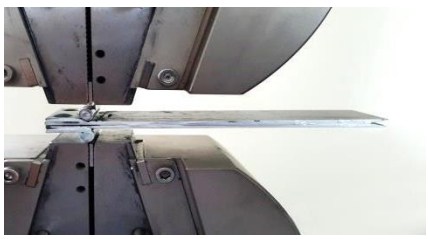
Measuring crack length of DCB specimens (ASTM D5528, D3433 and ISO 25217)

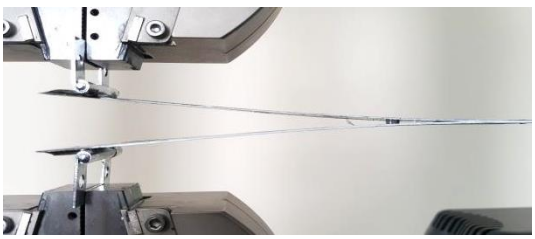
This guide provides information on preparing a test specimen for measurement with the Crack Length Gauge tool and includes hardware and software set up recommendations.

Published October 2022

Summary of test

Standard /specimen geometry	ASTM D5528	D3433 and ISO 25217
Material	Unidirectional Fibre-Reinforced Polymer Matrix Composites	Adhesive between material
Length (mm)	At least 125	241 – 356
Width (mm)	20 - 25	25.4
Laminate thickness (mm)	3 - 5	15 – 64
Test speed (mm/min)	1 - 5	Typically less than 5
Required accuracy of measurements (mm)	±0.5	The standard indicates that every effort should be made to measure this accurately but does not specify a required accuracy





This test is performed on laminated specimens. A load is applied to cause the laminations to pull apart. The length of the delamination (crack length) is measured and recorded as the specimen is pulled.

Hardware set up

Camera

IM-CAM-036 at 23fps, 2464 x 2056 is recommended as standard for this application. However, if the test duration is particularly short (e.g. less than 20 seconds) then IM-CAM-037 at 51fps, 1936 x 1216 is a good alternative as it has a faster measurement rate.

The camera should be positioned square-on to the specimen, ensuring that the entire specimen will remain within the Field of View (FoV) even when the crack is fully opened.

Lens

The length of the specimen, and the distance between the loading points when the crack is fully open (Figure 1), define the required FoV. General Purpose lenses are usually quite suitable for this application and there are multiple combinations of focal length and working distance that can achieve the required FoV. A selection of common configurations is shown in Table 1.

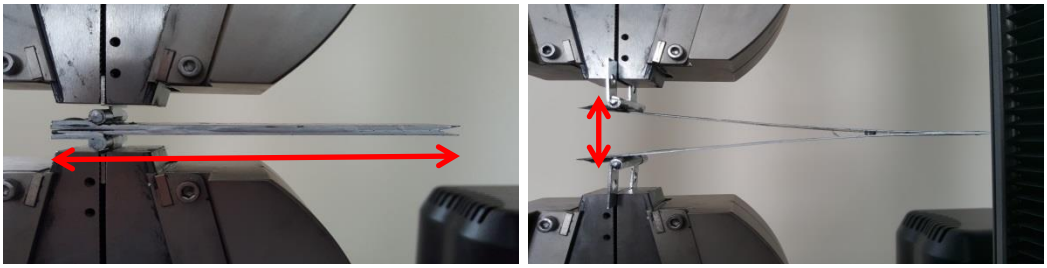


Figure 1: Length of specimen (left image) and distance between loading points when crack is fully open (right image)

Specimen size		IM-CAM-036 (23 fps, 2464x2056)		IM-CAM-037 (51 fps, 1936x1216)
Length (mm)	Maximum distance between loading points	IM-LENS-GP004 16mm focal length lens	IM-LENS-GP005 25mm focal length lens	IM-LENS-GP006 50mm focal length lens
130	80		390	700
150	90	300	450	790
200	120	360	600	1000
250	150	510	800	
360	220	720	1120	

Table 1: Suggested working distances (mm) for a range of specimen sizes and camera/lens combinations. Configurations shown in this table have the potential for ±5% error.

For more details about camera and lens combinations view our range of data sheets: UVX Flexi camera product range and UVX Flexi lens product range.

Light

The light should be placed to the side of the camera. It should be at the same height as the camera and close to it such that the light direction is within 30 degrees of being square-on to the face of the specimen.

Some users apply white paint along the anticipated crack path to aid in visually seeing the crack. If this white paint is very overexposed in the image, then moving the light slightly further away from the camera can help but do try to keep the light within 30 degrees of being square-on. Note that even if the white paint is overexposed in the image, it will not affect the performance of the Crack Length Gauge.

Specimen preparation

The front edge of the specimen needs to be marked with a speckle pattern.

If the specimen thickness is greater than 25mm then the edge of the specimen can be marked directly. However, the specimens are often only 3-5mm thick which is not sufficient space to apply the speckle marking. The solution is to apply a strip of 10mm thick foam to each surface of the specimen which increases the effective thickness to about 25mm, without affecting the specimen stiffness. Neoprene foam with a self-adhesive backing, about 10mm thick and small cell-size is ideal for this purpose and readily available, including pre-cut lengths direct from Imetrum.

A suitable 'speckle' pattern can easily be applied, either to the surface of the foam or the edge of the specimen, using the Imetrum Stamp Kit. Use Table 2 to select the correct speckle size. Figure 2 shows a specimen that has been prepared with foam and a 'speckle' pattern.

Camera	Specimen length (mm)		
	<200	200-300	>300
23 fps, 2464 x 2056	0.5	0.5	0.8
51 fps, 1936 x 1216	0.5	0.8	1.1

Table 2: Ideal speckle size

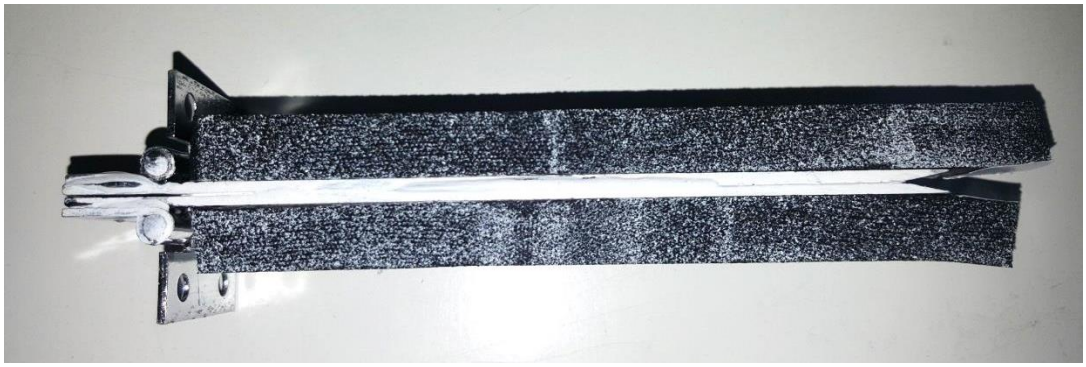


Figure 2: Foam strip with 'speckle' pattern applied to top & bottom of specimen

The method is as follows:

1.1	Apply white paint to the specimen edge (to aid in manual identification of the crack tip), if desired.
1.2	If foam is required to increase the effective thickness of the specimen, then cut the foam strip to length (make it slightly longer than the specimen). Avoid using any pieces of foam that are damaged or squashed (the surfaces should be nice and flat).
1.3	Apply the speckle pattern either to the foam or to the specimen edge as appropriate. Re-ink the stamp on the stamp pad prior to each application. Ensure the full length of specimen/foam is covered with 'speckles' and re-

	stamp any blank or faint areas. Take care that the paper backing on the sticky side of the foam does not interfere with the stamping process.
1.4	If using foam, stick it to the specimen. The foam should be applied flush with the front edge. It should be as close as possible to the loading point and then slightly overhang the end of the specimen (this facilitates removal of the foam after the test). Each foam strip can often be re-used on multiple specimens. If the foam begins to lose stickiness, then replace as it may affect the measurement.

Video Gauge™ set up

Set the tracking option 'match threshold' to 0.3. Remember to use a calibrated plane for the crack measurement so that the crack length is reported in your chosen units.

Add the Crack Length Gauge measurement tool and align it with the specimen as shown in Figure 3. Notice that the gauge consists of three main rectangular regions. The top and bottom regions each have three red sides and one blue side, the middle region has four blue sides. When positioning the gauge, take note of the following:

- The dotted centre-line of the gauge is aligned along the centre-line of the specimen.
- The tip of the small arrowhead should be aligned with the tip of the pre-crack.
- The dotted vertical line represents the datum point for the crack length measurement. It should be aligned with the point that you want to correspond with a crack length of zero.
- The top and bottom regions need to be entirely filled with speckle pattern. They should not overhang or touch the edges of the patterned area.
- The anticipated crack path should be entirely contained within the middle region.

Ensure that the 'mode' of the Crack Length Gauge tool is set to 'DCB specimen'.

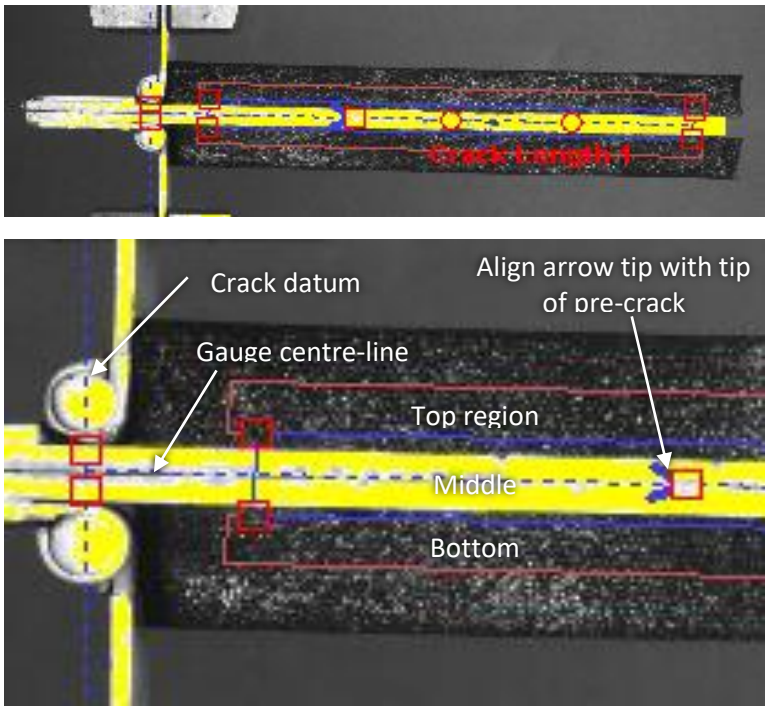


Figure 3: How to position the crack gauge over the specimen (overview at top and zoomed in view at the bottom)

the

Test procedure

2.1	Mount the sample in the test frame ensuring that the foam is not compressed by the grips
2.2	Ensure the specimen is horizontal (using an appropriate support or applying a small pre-load can help)
2.3	Check that the camera is positioned such that the fixed side of the specimen is close to the edge of the image – this helps to ensure that the specimen will remain within the field of view as the crack opens
2.4	Start the test running in Video Gauge™ and wait for a few seconds prior to starting the UTM

Things to watch out for

If you find that the measured crack length is not accurate, then the Crack Length Gauge 'threshold' setting should be adjusted to compensate. If the reported crack length is too long then increase the threshold, if it is too short then reduce the threshold. Once you have established the correct threshold for a particular specimen type then it can be used on all subsequent specimens of that type. (For a recommended procedure on how to adjust the threshold value, please refer to the separate Technical Guide TG1037).

The digital meter may report 'Invalid gauge' if it has not been able to calculate the crack length. Sometimes there might be a kink in the outline of the crack gauge (see Figure 4). Both of these have a few possible causes:

1. Some parts of the foam do not have a good pattern on them. If a kink is visible in the gauge outline, then this indicates where the area of poor pattern is on the specimen. If the poor pattern is near to one end of the specimen, then you may still be able to get some good data by re-positioning the crack gauge to avoid the area of poor pattern and re-processing the test in post-process mode. Otherwise, you will need to prepare new foam strips according to the guidelines and repeat the test.

2. The specimen has moved suddenly and jumped in the image. In this case you may still be able to get a good measurement by enabling the tracking option 'Try local first, if target is not found do a wide area search' and re-processing the test in post-process mode. This problem is most likely to occur at the beginning of the test when the initial load causes the specimen to rotate in the image. This can usually be avoided by applying a small pre-load to the specimen prior to starting the test.

3. The specimen has bent significantly during the test (e.g. if the distance between loading points extended by more than half the sample length). In this case you may still be able to make a good measurement by enabling the tracking options for 'stretch', 'rotate' and 'deform' and re-processing the test in post-process mode. (Those options should only be enabled in post-process mode).

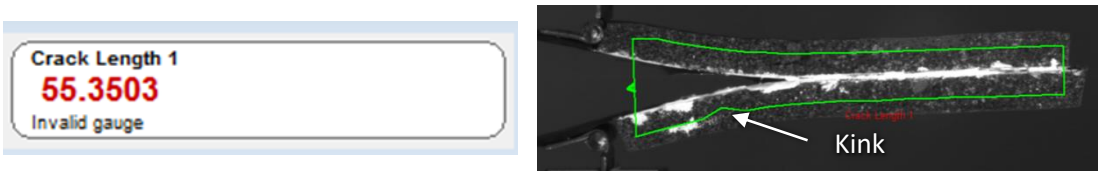


Figure 4: Digital meter showing 'Invalid gauge' (left) and kink in gauge outline (right)

If the digital meter reports ‘Out of bounds’ it means that the calculated position of the crack tip is outside the boundary of the Crack Length Gauge. There are several possible causes for this:

1. If the actual crack tip is within the gauge’s boundary, then you may need to adjust the ‘threshold’ value to ensure that the calculated crack length is accurate.

2. If the actual crack tip is outside of the gauge’s boundary, then you will need to re-position the crack gauge to ensure that the actual crack tip remains within its boundary throughout the test.

3. The foam strips may have started to detach from the specimen (Figure 5). This can be compensated for by repositioning the Crack Length Gauge to avoid this area and reprocessing in post-process mode.

Figure 5: Example of foam strip detaching from the end of the specimen

Example test results