WORKSHOP

Mode II interlaminar fracture toughness and the factors affecting it

CERTBOND Project: Mode-II quasi static characterization of co-cured composite adhesive joints

Serafín Sánchez-Carmona, Alberto Barroso

GERM
GROUP OF ELASTICITY AND STRENGTH OF MATERIALS

UNIVERSIDAD DE SEVILLA

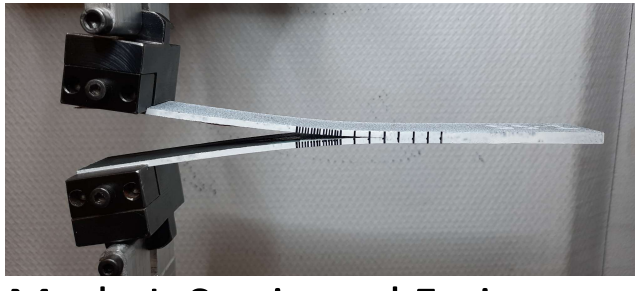
May 13th, 2025

CERTBOND Project:
Mode-II quasi static characterization of co-cured composite adhesive joints

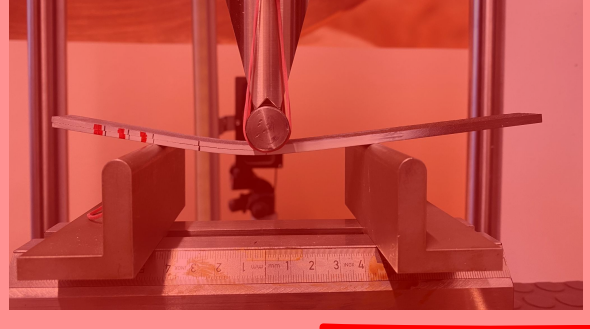
CertBond
COST Action CA18120

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the European Union

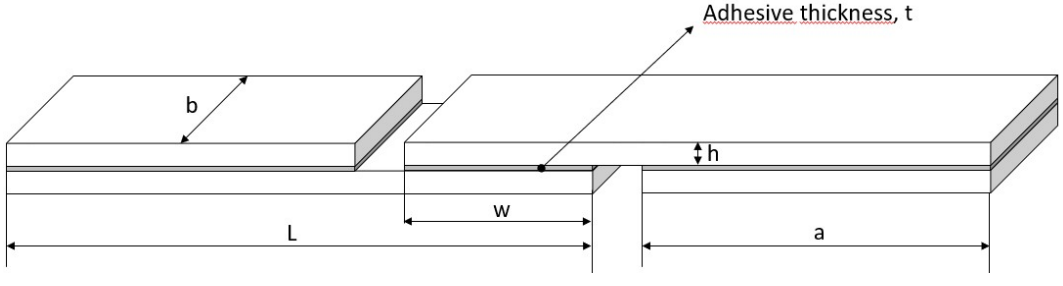


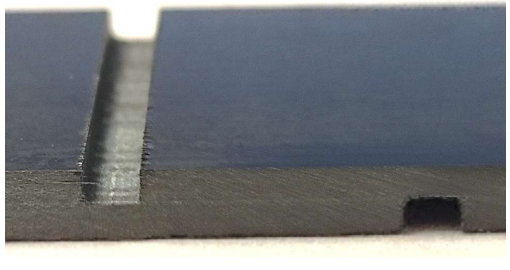
Mode I: Static and Fatigue



Mode II: Static and Fatigue

Failure prediction (static & fatigue)
of co-cured single-lap joints.





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Round Robin Exercise

- Participants

	Mode I QS	Mode I Fat	Mode II QS	Mode II Fat	SLJ QS	SLJ Fat
EPFL	X	X				
Univ. Minho	X		X			
Univ. Seville	X		X		X	
TU Delft	X	X				
Univ. Girona	X	X		X		
Univ. Patras		X		X		X
Univ. Aveiro			X			
Univ. East Sarajevo			X			
Univ. Bayreuth			X			
Univ. Nantes				X		
Polit. Milano				X		

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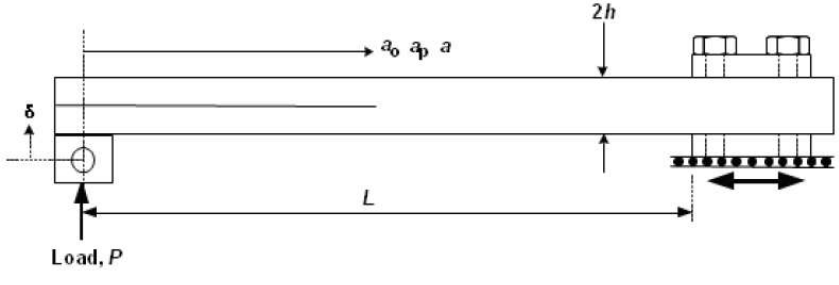
INTERNATIONAL STANDARD **ISO 15114**

First edition
2014-05-15

Fibre-reinforced plastic composites — Determination of the mode II fracture resistance for unidirectionally reinforced materials using the calibrated end-loaded split (C-ELS) test and an effective crack length approach

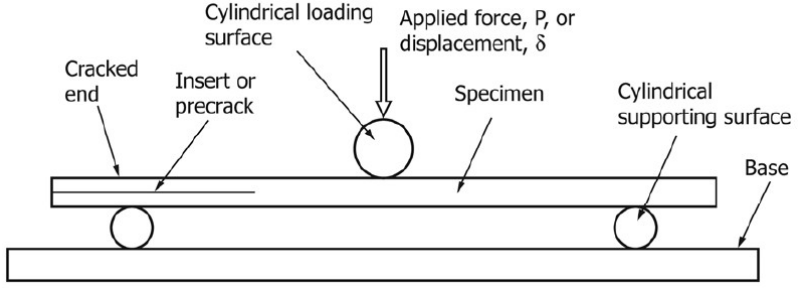


Designation: D7905/D7905M – 19$^{\varepsilon 1}$

Standard Test Method for Determination of the Mode II Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites[1]

This standard is issued under the fixed designation D7905/D7905M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial changes were made to Table 1 in November 2019.



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ASTM INTERNATIONAL

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Introduction

Previous attempts to determine mode II delamination resistance curves (R-curves) for composites have been hampered by the experimental difficulty of determining crack length in the absence of any applied beam opening displacement and when a complex damage zone develops ahead of the crack front. The effects of friction in the different mode II test specimens have also been widely debated and have typically been determined to introduce errors of between 1 % and 3 % in G_{IIC} determination for ELS specimens (n.b. friction effects would appear to be more significant in 3 point loaded end notch flexure (3ENF) (to be standardized by ASTM) and, particularly, in the 4 point loaded (4ENF) test specimen. Stabilized ENF was not popular in round-robin trials).

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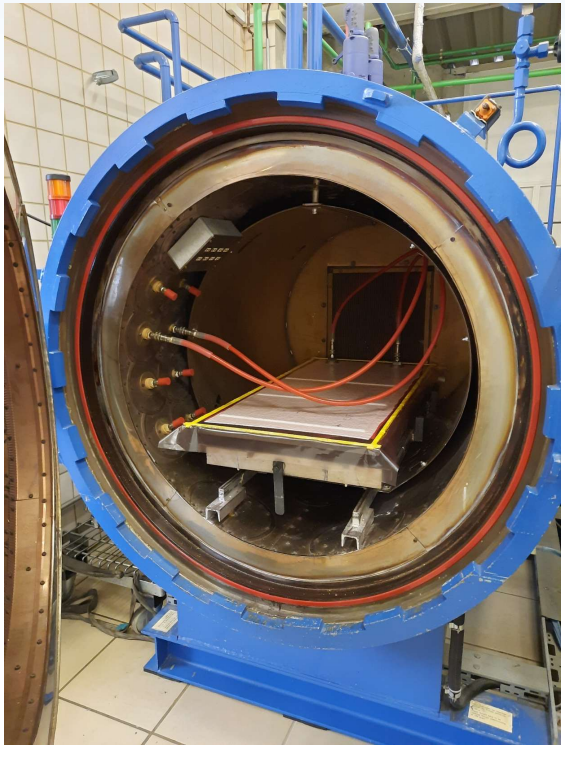
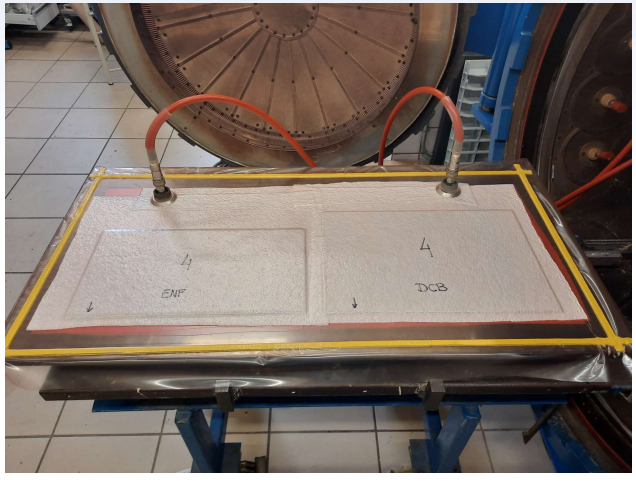
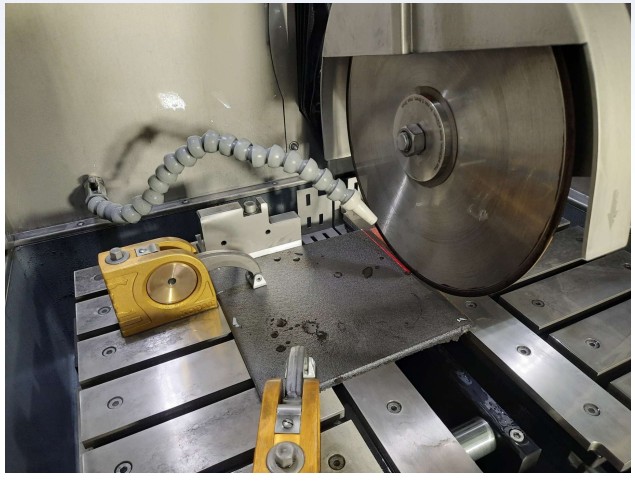
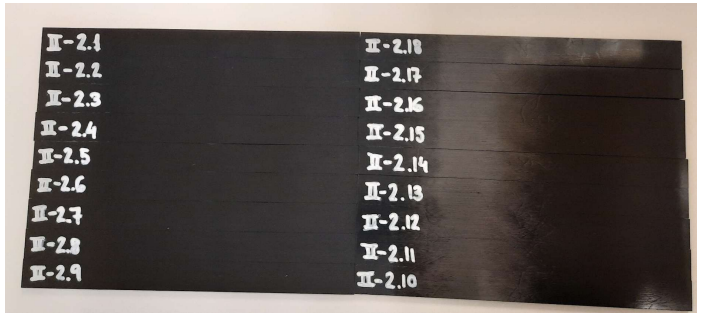
Manufacturing of samples

UNIVERSIDAD D SEVILLA 1505









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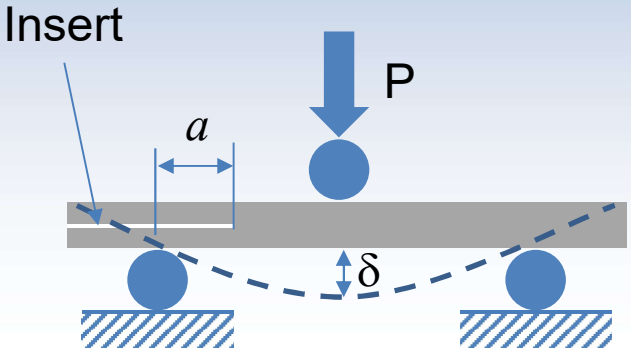
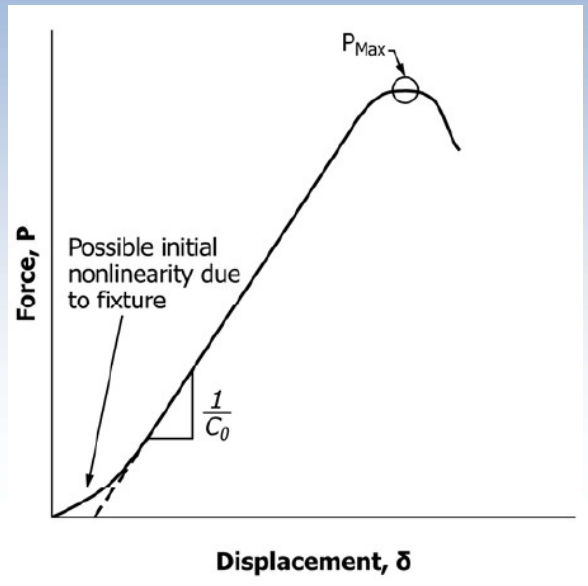
Test procedure and calculations





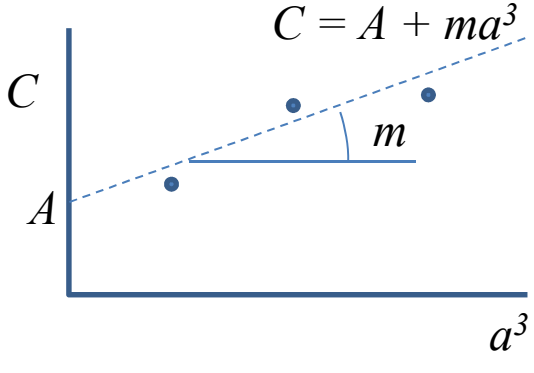
Insert (NPC specimen) a = 20, 30 and 40 mm

Crack (PC specimen) a = 20, 30 and 40 mm

Loading (50% of P_{max}) & Unloading (0.5 mm/min)

Loading (P_{max} ⇒ crack advance NPC ⇒ PC) & Unloading (0.5 mm/min) (C obtained up to 50% P_{max})

Doubts regarding the unloading stage



$$G_Q = \frac{3mP_{max}^2 a_0^2}{2B}$$ validation ⇒ $G_{IIC} = G_Q$

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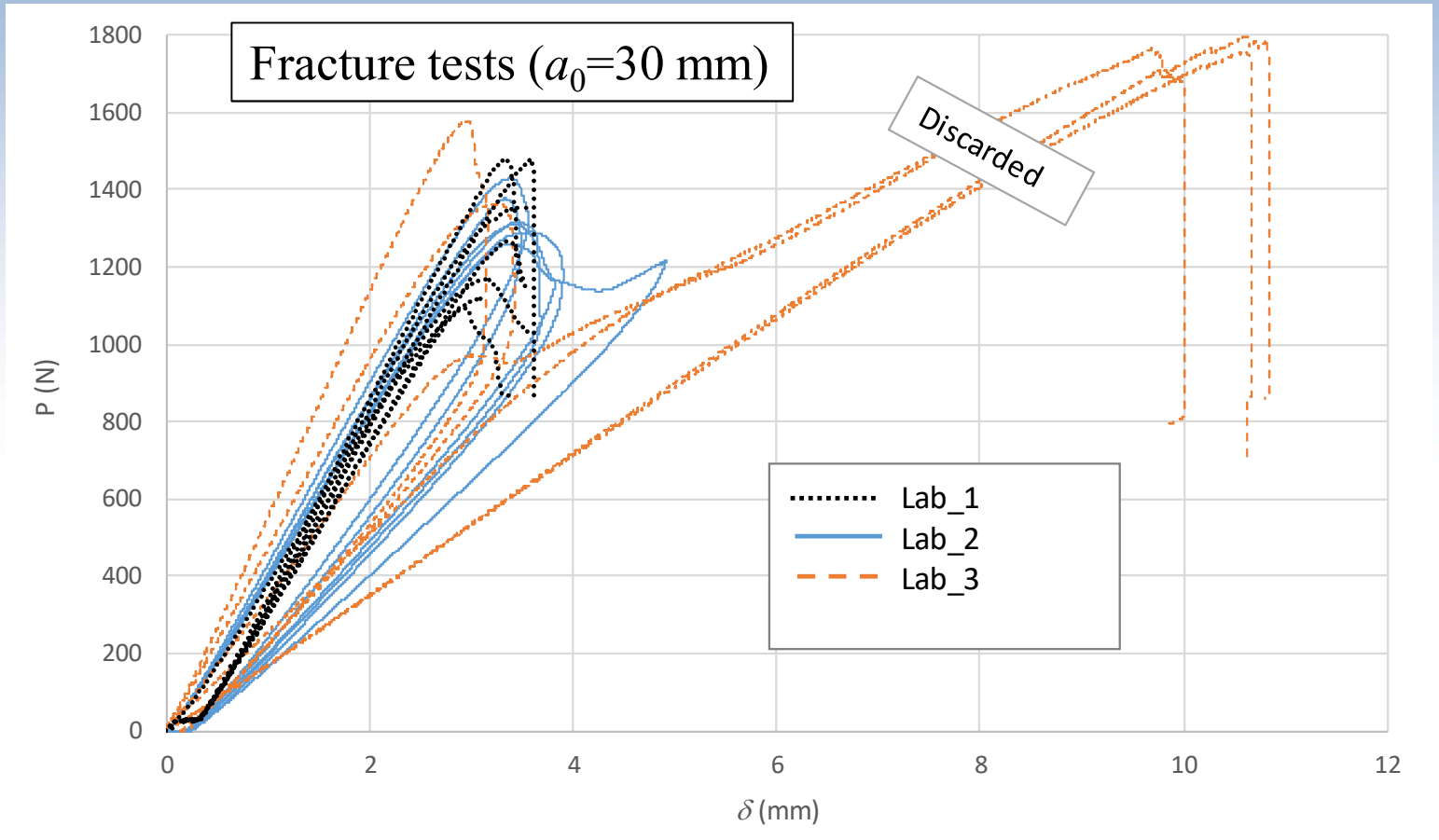

1. Lab_3. Four specimens with an unexpected much higher failure load $\Rightarrow$ discarded

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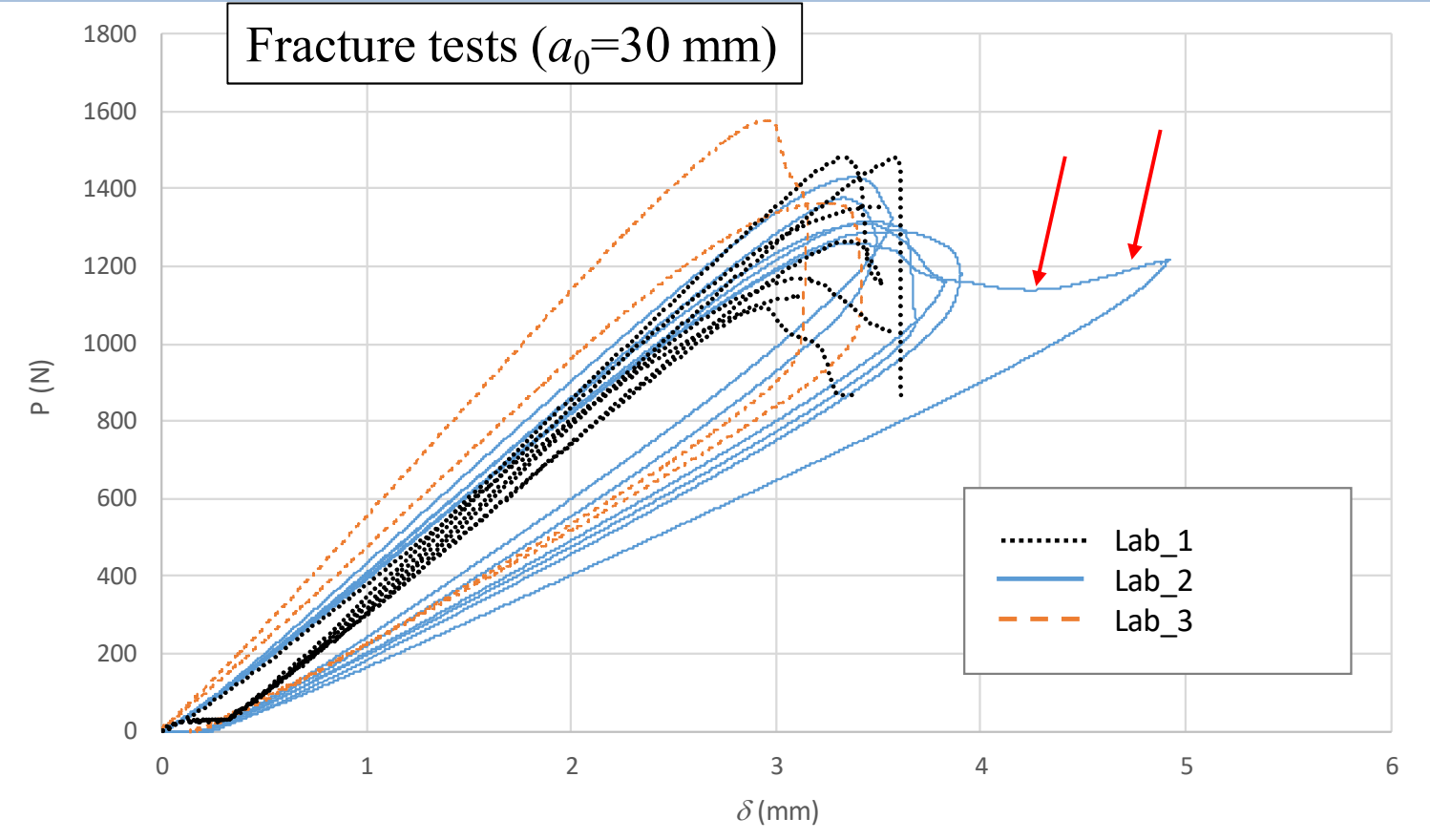

1. Lab_3. Four specimens with an unexpected much higher failure load ⇒ discarded
2. Criterion for unloading (crack advance vs load drop) (see one specimen in Lab_2)
3. Test duration. One simple loading&unloading ≈ 6 minutes.
   Each sample 6 L&U ⇒ 36 min. A set of 6 samples may take 4 or 5 hours !!!

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	Lab_1		Lab_2	
	NPC	PC	NPC	PC
G_{IIC} (kJ/m2)	**3.15**	**2.66**	**2.69**	**2.21**
desvest (kJ/m2)	0.57	0.22	0.26	0.39
CoV (%)	18.0	8.2	9.5	17.8

1. Fracture Toughness is lower for the PC specimen.

2. No clear trend for scatter in results
   For Lab_1 much higher in the NPC tests.
   For Lab_2 much higher in the PC tests.

3. Doubts regarding the requirement of recording the unloading stage.

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