Test specification for load spectra tests

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OPTIMAT BLADES

TG1

Olaf Krause

Change record

Issue/revision	date	Pages	Summary of changes
0	27.04.2005	All	New document
1	30.05.2005	5,6	Load levels for UD material fixed

Table of contents

1 Introduction 4
2 Materials 4
3 Laminates 4
4 Test specimens 4
5 Test procedures for load spectra tests 4
5.1 General remarks 4
5.2 Strain measurement 4
5.3 Temperature measurement 4
5.4 Initial static test 5
5.5 Load spectra test 5
5.5.1 Wisper load spectra 5
5.5.2 NewWisper load spectra 6
5.6 Reporting 6
6 References 7

1 Introduction

This report describes the load spectra test procedures used within Task Group 1.

2 Materials

General information about the materials is given in [1].

3 Laminates

General information about the laminates is given in [1].

4 Test specimens

General information about the laminates is given in [1]. For the load spectra tests, the standard UD and standard MD specimens are used only in the 0°-direction.

5 Test procedures for load spectra tests

5.1 General remarks

Each specimen has to be investigated by eye for any irregularities or damage. The alignment of the tabs has to be checked with a planar tool. Width and thickness of the specimens has to be measured with an accuracy of 0.01 mm.
All tests are accomplished force-controlled at predetermined load levels and testing conditions, which are given in the subsequent chapters. The load levels are given in terms of 'Load per unit width': Therefore this value has to be multiplied with the actual width of the specimen to derive the load for testing.

5.2 Strain measurement

Strain in the loading direction is measured with two strain gauges (recommended gauge length 6 – 10 mm) placed back to back on the sides of the specimen or with extensometer. Strain measurements should be set to zero before closing of the second clamp to determine initial bending of the specimen. Load, displacement and stiffness are measured throughout the fatigue test if possible.

5.3 Temperature measurement

The measurement of the surface temperature of the specimen is recommended at least for one specimen at each load level. Temperature has to be measured continuously or periodically with a thermocouple or any other suited measuring device at a specified location and shall not exceed the temperature limit of 35°C except for the temperature rise before failure. The measuring point is located nearby the tab line (approximately 5 mm distance) of the lower tabs. It has to be assured, that the temperature measurement is not influenced by environmental effects, such as air flow of a cooling fan. Anyway this measurement is not a measure for the temperature inside the specimen, since it is influenced by the friction between debonding tabs and the specimen. Furthermore the different types of measuring devices and exact conditions of the temperature measurement yield different results. Therefore an exceedance of the temperature limit is acceptable, unless it is a major exceedance (more than 10° C). In this case, the appropriate task leader has to be informed immediately.

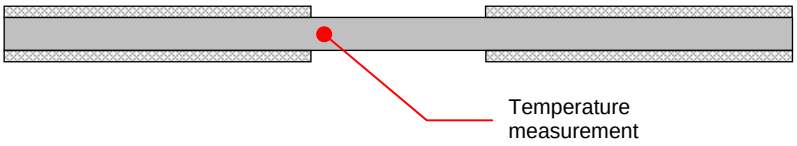

Figure 1: Temperature measurement Optimat specimen

5.4 Initial static test

Elastic properties of the undamaged material are measured within applied strain of 0.05% - 0.25% during a first initial static test. This test is a loading-unloading test from force 0 up to maximal load determined according to chapter 5.5. The load should be applied using a linear ramp with a constant loading rate corresponding to a testing frequency of 0.02 Hz.

5.5 Load spectra test

The load spectra tests are performed with the well-known Wisper and the recently established NewWisper loading [3] sequence. Both, the Wisper and NewWisper sequence are divided into 64 classes representing discrete load levels. Zero load is located at class 25 for the Wisper sequence and at class 22 for the NewWisper sequence.
The load should be applied force-controlled in sinusoidal form using frequencies corresponding to a constant loading rate *F'*. The frequency for a specific half cycle of the loading sequences connecting two transition points can be determined according

$$f = \frac{F'}{4 \cdot F_a}$$

with *f* as frequency, *F'* as loading rate and F_a as load amplitude.
A first estimate of the load levels is determined using an equivalent stress parameter [2] and given in the following tables.

5.5.1 Wisper load spectra

Load level	Estimated passes	Load per class [kN/mm]	Maximum load [kN/mm]	Loading rate [(kN/mm)/s]
1	7.54	0.04375	1.70625	11.69
2	37.68	0.03721	1.45119	13.84
3	75.35	0.03458	1.34862	14.84

Table 1: Load level definition UD

Load level	Estimated passes	Load per class [kN/mm]	Maximum load [kN/mm]	Loading rate [(kN/mm)/s]
x	7.54	0.0546	2.12875	14.38

Table 2: Load level definition MD

5.5.2 NewWisper load spectra

Load level	Estimated passes	Load per class [kN/mm]	Maximum load [kN/mm]	Loading rate [(kN/mm)/s]
1	22.60	0.04375	1.61875	11.69
2	113.0	0.03721	1.37677	13.84
3	226.0	0.03458	1.27946	14.84

Table 3: Load level definition UD

Load level	Estimated passes	Load per class [kN/mm]	Maximum load [kN/mm]	Loading rate [(kN/mm)/s]
x	22.60	0.0546	2.0202	14.38

Table 4: Load level definition MD

5.6 Reporting

The required information for reporting to OptiDat is given in Table 5.

Data field	Description / Units / Remarks
Optimat name	Unique ID of the specimen
Thickness	[mm]
Minimum width	[mm]
Date of test (start/end)	Formatted dd.mm.yy
Test type	W (Wisper) or NW (NewWisper)
F_max	Applied load, [kN]
e_max	Strain at applied load, [%]
s_max	Stress at applied load, [MPa]
No. of cycles to failure	
Failure mode	
LRF	[GPa/s]
Strain rate	[%/s]
Eit	Modulus in longitudinal direction, [GPa]
Test machine	
Control type	Load or displacement
Type of grips	
Clamping force	[kN]
Specimen temperature	[°C]
Remarks	Bending and any further important information

Table 5: Required data to report for load spectra tests

6 References

[1] Olaf Krause, Theodore P. Philippidis, *General test specification*, DLR/UP, doc. OB_TC_R014 rev. 3, 02.07.2004.

[2] P. Brøndsted, S. Andersen, H. Lilholt, *Fatigue damage accumulation and lifetime prediction of GFRP materials under block loading and stochastic loading*, 18th Risø International Symposium on Materials Science, 1997.

[3] *New Wisper sequence*, DEWI, doc. OB_TG1_O005 rev. 0, 24.04.2005.