

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Structural Cementitious Grout

with type designation(s)
G2000

Issued to

Y-MatTec A/S
Holstebro, Midtjylland, Denmark

is found to comply with
DNV standard DNV-ST-C502 – Offshore concrete structures

Application :

Load carrying, vertically and diagonally oriented cylindrical-shaped grouted connections, filled with displacement grouting.

Further details, including properties, operational limitations and approved production facility, are given overleaf. Please refer to last page of this TAC for important information related to the validity of the TAC.

Issued at **Høvik** on **2022-02-28**

This Certificate is valid until **2023-02-28**.

for **DNV**

DNV local station: **Oslo Marine Structures Verification**

Approval Engineer: **Marie Elise McGeorge**

Paola Mayorca
Group Leader - Concrete Structures

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid. The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.



Introduction

This Type Approval Certificate (TAC) has been issued in accordance with the DNV Type Approval scheme described in DNV-SE-0295, December 2018 (amended September 2021). Reference is made to the technical requirements specified in DNV-ST-C502, February, 2018 (amended October 2021).

This Type Approval Certificate should be read in conjunction with *DNV Summary Report – 2022-0217– Rev. 0* providing references and background data for all presented information. This Type Approval Certificate does not act as an approval for design of any particular grouted connection.

The TAC is issued with a validity period of 1 year, due to the pending 1-year creep results and the repeated low temperature setting-time tests.

Product description

Table 1 outlines general product information and validity range of the Certificate for Y-MatTec G2000.

Table 1 - Validity for Type Approval Certificate for Y-MatTec G2000

Details of Manufacturer / Owner of Certificate	Y-MatTec A/S
Maximum aggregate size	≤ 4 mm
Water Demand (fresh water)	Depending on grouting temperature the initial water demand is set to: 75-85 litres of water per 1000 kg of dry powder, 0 – 30 °C
Approved Production Facility	Y-MatTec A/S: Nybovej 34, 7500 Holstebro, Denmark

Responsibility

The owner, stated as that to which the Certificate has been "issued to" on page 1, takes responsibility that both the design and production are in compliance with the standards listed on page 1 of this Certificate.

Marking of product

The delivered product shall be clearly marked with the manufacturer's name and production facility. Furthermore, the Production Batch Id., production date, shelf life, storage/handling instructions, weight and water demand shall be clearly identified by the label. The current TAC is applicable for production of Y-MatTec G2000 for big bag storage/transportation. Reference to the TAC shall be included on the product label.

Application

The application limitations for the Y-MatTec G2000 material have been determined by laboratory and mock-up tests independently witnessed by DNV. The subsequent application limitations in Table 2 have been established during the Certification Scheme.

Table 2 - Main Operational Limitations for Application of Y-MatTec G2000

Description	Unit	Limitations
Nominal Bore (NB) for grout hoses/lines ¹⁾	inch	NB ≥ 3
Grout annulus thickness ²⁾³⁾	mm	40 ≤ t ≤ 600
Pumping length through 3" NB flexible hoses ⁴⁾	m	L ≤ 200
Pumping elevation head using 3" NB flexible hoses	m	H ≤ 20
Minimum application temperature (t _{app,min}) ⁵⁾⁶⁾⁷⁾⁹⁾	°C	0
Maximum application temperature (t _{app,max}) ⁸⁾⁹⁾	°C	30
Verified free-fall height through water ¹⁰⁾	mm	350

- 1) Limitation for nominal bore is also valid for valves/couplings between each segment of grouting lines/hoses. I.e. the valves/couplings shall not have a reduced nominal bore compared to the grouting lines/hoses.
- 2) Limitations for grout thickness are valid for annulus in tubular/conical grouted connections.
- 3) Temperature gradients over the grouted section should be considered for the application in question
- 4) The pumping lengths given for 3" NB grout hoses are considered to be conservative compared to larger diameter hoses. However, temperature effects shall be considered for evaluating the pumping lengths.
- 5) The minimum application temperature is defined based on a test temperature of -1°C, per DNV-ST-C502, App. H
- 6) The minimum application temperature reflects the temperature limit where the material is Certified to develop strength during low temperature grouting.
- 7) The minimum application temperature shall be taken as the temperature limit of the structure, immediately adjacent to the grouted part, for not less than 72 hours after grouting, or after the grout has attained sufficient strength to resist early frost damage. In lieu of specified requirements related to resistance of early frost damage in DNV-ST-C502, this value may be taken conservatively as 35 MPa. In addition the minimum application temperature shall be taken as the minimum temperature the material will be exposed to during mixing, pumping, placement.
- 8) Maximum application temperature shall be taken as the maximum temperature the material will be exposed to during mixing, pumping, placement and during the first 24 hours after placement. This includes the temperature of ambient air, surfaces the grout will be in contact with, the structure immediately adjacent to the grouted part, and / or water temperature.
- 9) Due consideration shall be given to special measures, pre-conditioning of materials and equipment, as well as mixing of the grout, when performing grouting close to the extremes of the qualified temperature range. Reference is made to the Generic Method Statement (Table 10). Temperature effects/gradients for the application in question need to be considered specifically for each project.
- 10) The maximum stated free fall height is based on successful mock-up testing representative of a typical MP-TP connection. For large volume/wide annuli connections project specific testing may be required to confirm good quality grout is present throughout the entire effective length of the connection.

Fresh Properties

The tests of fresh properties of Y-MatTec G2000 grout witnessed by DNV as part of the Certification Scheme are listed in Table 3 and Table 4. Properties are based on tests undertaken after mixing with laboratory equipment.

Table 3 - Summary of fresh properties for Y-MatTec G2000 for testing at 20°C

Test Id.	Type of Test	Test Method	Test Temperature	Test Values
				Mean
FG1	Flow test (2 min)	ASTM C230/C1437	20°C	302 mm
	Flow test (30 min)			278 mm
	Flow test (60 min)			260 mm
	Flow test (90 min)			245 mm
	Flow test (120 min)			228 mm
FG2	Fresh density	EN 1015-6		2440 kg/m ³
FG3	Bleeding	ASTM C940		No observed bleeding
FG4	Air content	EN 1015-7		0.7 %
FG5	Initial setting time	EN 196-3 ¹⁾		07:31 hh:mm
	Final setting time	EN 196-3 ¹⁾		09:30 hh:mm

1) Weight of moving parts 1000 grams instead of 300 grams as specified in EN 196-3

Table 4 - Summary of fresh properties for Y-MatTec G2000 for testing at $t_{\text{test, min}}$ (-1°C)

Test Id.	Type of Test	Test Method	Test Temperature	Test Values
				Mean
FG1	Flow test (2 min)	ASTM C230/C1437	-1°C	293 mm
	Flow test (30 min)			250 mm
	Flow test (60 min)			200 mm
	Flow test (90 min)			163 mm
	Flow test (120 min)			145 mm
FG2	Fresh density	EN 1015-6		2433 kg/m ³
FG3	Bleeding	ASTM C940		No observed bleeding
FG4	Air content	EN 1015-7		1.8 %
FG5	Initial setting time	EN 196-3 ¹⁾		06:53 hh:mm
	Final setting time	EN 196-3 ¹⁾		-2)

1) Weight of moving parts 1000 grams instead of 300 grams as specified in EN 196-3

2) Data not obtained. TAC Rev0 is to be updated within 3 months from issue date.

Hardened Properties

Characteristic 28-days strengths of relevant hardened material properties for Y-MatTec G2000 are given in Table 5. The 5 % characteristic values are determined in accordance with Appendix D of EN 1990 on the basis of each individual test results from all production batches being tested as part of the laboratory test programs. Properties are based on tests undertaken after mixing with laboratory equipment.

Table 5 - Characteristic 28-days strengths for Y-MatTec G2000 acc. to EN 1990

Material Property	Test Specimen	Curing/Testing Temperature [°C]	Notation	Characteristic Value [MPa]
Compressive Strength	150 x 300 mm cylinders	-1	f_{ck}	100.7 ²⁾
		20		117.8 ¹⁾
	75 mm cubes	20	f_{ck}	128.0 ¹⁾
	40 x 40 x 160 mm prisms	-1	$f_{ck,prisms}$	88.7 ²⁾
		20		118.5 ¹⁾
	40 x 40 x 160 mm prisms	-1	$f_{ctk,fl}$	12.8 ²⁾
Flexural Strength		20		16.4 ²⁾

- 1) Several cubes were cast for quality control purposes during the mock-up trials and initial production. These cubes showed a lower strength than the calculated 28 day characteristic strength based on the test results from the laboratory test program. Due to this, a characteristic cube strength was calculated based on the test results obtained during initial production. Reference is made to DNV Summary Report 2022-0217 Rev. 0 for details. The values of f_{ck} and $f_{ck,prisms}$ is calculated based on the conversion factors presented in Table 9.
- 2) Values achieved during laboratory testing, using laboratory mixing equipment.

Mean values of hardened material properties of Y-MatTec G2000 documented during the laboratory test programs are presented in Table 6 and Table 7. Additional hardened properties are presented in Table 8.

Table 6 - Summary of hardened properties for Y-MatTec G2000 for testing at 20°C

Test Id.	Type of Test	Test Method	Testing / Curing Temperature	Test Values	Unit
				Mean	
HG1	Hardened density	EN 12390-7	20°C	2435	kg/m ³
HG2	1 day compressive strength (150 x 300 mm cyl)	EN 12390-3	20°C	70.6	
	3 days compressive strength (150 x 300 mm cyl)			102.5	MPa
	7 days compressive strength (150 x 300 mm cyl)			111.6	MPa
	28 days compressive strength (150 x 300 mm cyl)			130.5	MPa
	90 days compressive strength (150 x 300 mm cyl)			141.2	MPa
HG3	28 days compressive strength (75 mm cubes)	EN 12390-3	20°C	142.3	MPa
HG4	28 days flexural strength (40 x 40 x 160 mm prisms)	EN 196-1	20°C	17.4	MPa
HG5	Creep coefficient after 1 day loading	ASTM C512	20°C	0.115	-
	Creep coefficient after 28 days loading			0.340	-
	Creep coefficient after 91 days loading			0.447	-
	Creep coefficient after 365 days loading			-	-
HG6A ¹⁾	Autogenous shrinkage strain after 1 day curing	ASTM C1698	20°C	-0.215	mm/m
	Autogenous shrinkage strain after 56 days curing			-0.238	mm/m
HG6B	Restrained shrinkage strain after 7 days curing	ASTM C1581	20°C	-0.003	mm/m
	Restrained shrinkage strain after 28 days curing			-0.025	mm/m
HG7	Static Young's modulus	ASTM C469	20°C	47.1	GPa
	Poisson's ratio	ASTM C469	20°C	0.19	-

Table 7 - Summary of hardened properties for Y-MatTec G2000 for testing at $t_{\text{test, min}}$ (-1°C)

Test Id.	Type of Test	Test Method	Testing / Curing Temperature	Test Values	Unit
				Mean	
HG1	Hardened density	EN 12390-7	-1°C	2439	kg/m ³
HG2	3 days compressive strength (150 x 300 mm cyl)	EN 12390-3	-1°C	63.0	MPa
	7 days compressive strength (150 x 300 mm cyl)		-1°C	89.8	MPa
	28 days compressive strength (150 x 300 mm cyl)		-1°C	105.3	MPa
	90 days compressive strength (150 x 300 mm cyl)		-1°C	111.9	MPa
HG4	28 days flexural strength (40 x 40 x 160 mm prisms)	EN 196-1	-1°C	14.6	MPa

Table 8 - Summary of additional hardened properties for Y-MatTec G2000 for testing at 20°C and $t_{\text{test, min}}$ (-1°C)

Type of Test	Test Method	Testing / Curing Temperature	Test Values	Unit
			Mean	
28 days compressive strength (40 x 40 x 160 mm prisms)	EN 196-1	20°C	131.3	MPa
		-1°C	97.5	MPa
28 days splitting tensile strength (150 x 300 mm cyl)	EN 12390-6:2009	20°C	8.18	MPa

Relevant conversion factors between strength properties obtained on different test specimens are given in Table 9. The conversion factors are based on mean values presented in Table 6.

Table 9 - Conversion factors for 28-days strengths for Y-MatTec G2000 at 20°C

Conversion factor	Value
$f_{\text{ccm}} / f_{\text{cm}}$	0.92
$f_{\text{ccm}} / f_{\text{cm,prisms}}$	0.99
$f_{\text{cm}} / f_{\text{cm,prisms}}$	1.08

Approved Procedures

The approved Y-MatTec procedural documentation for application of Y-MatTec G2000 is shown in Table 10. This Type Approval Certificate is only valid when Y-MatTec's approved contractors is performing the grouting operation in accordance with the referenced generic method statement and offshore QC procedures.

Table 10 - Approved Procedural Y-MatTec Documentation for application of Y-MatTec G2000

Description	Title of Document
Generic Method Statement	Generic Grouting Procedure, Product: Y-MatTec G2000, Method Statement, Rev 1.2, dated 25.02.2022
Qualification Scheme for 3 rd Party Grouting Contractor	Generic Grouting Procedure, Product: Y-MatTec G2000, Method Statement, Rev 1.2, dated 25.02.2022
Offshore QC Procedure	Generic Grouting Procedure, Product: Y-MatTec G2000, Method Statement, Rev 1.2, dated 25.02.2022

Traceability

In order to operate under a valid Type Approval Certificate for Y-MatTec G2000, a comprehensive traceability system of all delivery shall be maintained on a project specific basis. This system shall allow the location of all production blends at any point along the delivery line.

Manufacturing Site Approval

The initial audit of Y-MatTec's primary production facility at Y-MatTec A/S, Holstebro, Denmark was successfully carried out 17th of November 2021, according to App. I of DNV-ST-C502 (February 2018, amended October 2021).

DNV shall at any time, upon request, be given access to all areas and facilities for production and quality control at the manufacturing facility. The frequency and timing of periodical surveys shall be confirmed in advance with the manufacturer, see Sec 5.4 of DNV-SE-0295.

2 and 3.5 year periodical inspections are required within a 5 year valid period to maintain the certificate valid. The start of the 5 year period is normally the same as the issue date. Per DNV-SE-0295: "The exact timing of the inspections shall be arranged in advance with DNV by the manufacturer."

The main elements of the Periodical Assessment are to:

- Review design, materials, production process, and performance with respect to possible changes, in order to ensure compliance with Type Approval documentation and/or referenced material specifications.
- Ensure traceability between manufacturer's product marking and the DNV Type Approval Certificate.

Renewal Assessment

The scope of the Renewal Assessment is to verify that the conditions stipulated for the Type Approval are complied with and that no alterations are made to the product design or selection of materials. The renewal assessment shall be performed after five (5) years of issuance of this Certificate (Certificate Renewal).

Validity of Type Approval

The following information is provided for all structural grout TACs issued by DNV in accordance with the requirements of DNV-ST-C502, and in accordance with the Type Approval scheme set out in DNV-SE-0295.

The TAC is valid for the grouting of structural connection types for which generic grouting procedures / method statements have been approved as part of the Type Approval process. In this case vertically and diagonally oriented cylindrical-shaped grouted connections, filled with displacement grouting. Operational limitations are specified within the approved procedures. If applicable, additional precautions may be specified within the approved procedures without details explicitly stated on this TAC. The approved procedures are listed in DNV report No. 2022-0217 Summary Report, rev. 0, Section 3.2.

The TAC is valid when the material is applied by the owner of the TAC, or by an approved 3rd Party contractor, when the qualification scheme has been approved as part of the Type Approval process. The approved 3rd Party contractor qualification scheme is given in DNV report No. 2022-0217 Summary Report, rev. 0, Section 3.3.

The TAC is valid when the material is tested, and field records are kept, in accordance with approved QC procedure. The approved QC procedures are listed in DNV report No. 2022-0217 Summary Report, rev. 0, Section 3.4.

The TAC is valid when the material is transported and stored, and traceability records are kept, in accordance with approved QC procedures. The approved QC procedures are listed in DNV report No. 2022-0217 Summary Report, rev. 0, Section 3.4.

The TAC is valid when grout is transported, mixed, pumped and installed in line with procedures documented through the Validation testing conducted as part of the Type Approval process. For primary / contingency applications significantly outside of that tested during the Type Approval process in scale, grout line arrangement, duration, or complexity, additional testing may be required on a project specific basis. This should be assessed by the designer, or specifier. If the extent, or limitations of the testing conducted during the Type Approval process is questioned, the manufacturer shall be contacted. The approved Validation test reports are listed in DNV report No. 2022-0217 Summary Report, rev. 0, Section 3.5.

Validation tests are based on idealised conditions and sometimes on reduced scale equivalents. While every effort has been made to capture conservatism, some combinations of application parameters may unintentionally result in conditions which are outside of that documented through the Validation testing. The designer, or specifier, should account for project specific demands of the particular design and / or installation operation, and shall assess if additional testing is required on a project specific basis.

END OF CERTIFICATE