

TYPE APPROVAL CERTIFICATE

This is to certify:**That the Structural Cementitious Grout**with type designation(s)
Ducorit S8

Issued to

ITW Performance Polymers ApS
Aalborg, Denmarkis found to comply with
DNV GL standard DNVGL-ST-C502 – Offshore concrete structures**Application :****For use in load carrying grouted connections.****Further details, including properties, operational limitations and approved production facilities, are given overleaf.**Issued at **Høvik** on **2018-09-12**This Certificate is valid until **2023-09-11**.for **DNV GL**DNV GL local station: **Oslo Marine Structures**
VerificationApproval Engineer: **Andrew McVey**

Paola Mayorca
Group Leader

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.



This Type Approval Certificate should be read in conjunction with *DNV GL Summary Report - 2018-0897 – Rev0* 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.

Reference is made to DNV GL-ST-C502 (February, 2018) for details relating to the Certification Scheme.

Product description

Table 1 outlines general product information and validity range of the Certificate for Ducorit S8.

Table 1 Validity for Type Approval Certificate for Ducorit S8

Details of Manufacturer / Owner of Certificate	ITW PP ApS
Maximum aggregate size	$\leq 1 \text{ mm}$
Fresh Density of Mixed Grout¹⁾	$2.22 \text{ kg/l} \leq \rho \leq 2.31 \text{ kg/l}$
Mixing Water Demand (fresh water)	Approx. 145 litres of water per 1000 kg of dry powder ($140 \text{ l} / 1000 \text{ kg of dry powder} \leq w \leq 150 \text{ l} / 1000 \text{ kg of dry powder}$)
Approved Production Facility	ITW Performance Polymers ApS, Rørdalsvej 44, 9220 Aalborg Ø, Denmark

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, water demand and density range shall be clearly identified by the delivery note. The current TAC is applicable for production of Ducorit S8 for big bag and silo storage/transportation. Reference to the TAC shall be included on the delivery note / declaration by ITW PP ApS.

Application/Limitation

The application limitations for the Ducorit S8 material have been determined by laboratory and mock-up tests independently witnessed by DNV GL. The subsequent application limitations in Table 2 have been established during the Certification Scheme.

Table 2 Main Operational Limitations for Application of Ducorit S8

Description	Unit	Limitations
Minimum size for flexible hydraulic hoses	inch	≥ 2
Grout annulus thickness ¹⁾	mm	$30 \leq t \leq 700$
Pumping length through 2" flexible hydraulic hoses ²⁾³⁾	m	$L \leq 300$
Pumping length through 3" flexible hydraulic hoses ²⁾	m	$L \leq 400$
Pumping elevation head using 2" flexible hydraulic hoses ²⁾	m	$H \leq 20$
Minimum application temperature ($t_{app,min}$) ⁴⁾	°C	1
Maximum application temperature ($t_{app,max}$) ⁵⁾	°C	30
Verified free-fall height through water ⁶⁾	mm	450

1) Limitations for grout thickness are valid for annulus in tubular/conical grouted connections.

2) The above limitations for pumping lengths/elevations are not absolute as they are representing performed test setups where no problems were encountered. For applications requiring different lengths/elevations pumpability tests are recommended on a project basis.

3) The pumping lengths given for 2" flexible hydraulic hoses are considered to be conservative compared to larger diameter hoses. However, temperature effects shall be considered for evaluating the pumping lengths.

4) The minimum application temperature is defined based on a test temperature of 0°C.

5) Due consideration shall be given to pre-conditioning of materials/equipment at elevated temperatures.

6) When the inlets are located at a distance exceeding 450 mm above the seal or bottom of the form, additional measures shall be implemented to limit the risk of segregation due to free-fall through water.

Minimum application temperature specified in Table 2 reflects the temperature limit where the material will develop strength during low temperature curing. Temperature effects/gradients for the application in question need to be considered specifically for each specific project.

Fresh Properties

Fresh properties of Ducorit S8 grout documented during the laboratory test programs are presented in Table 3 and Table 4. Properties are based on tests undertaken after mixing with laboratory equipment.

Table 3 Summary of fresh properties for Ducorit S8 for testing at 20°C

Test Id.	Type of Test	Test Method	Test Temperature	Test Values		
				Min	Max	Mean
FG1	Flow test (2 min)	ASTM C230/C1437	20°C	290 mm	300 mm	295 mm
	Flow test (30 min)			295 mm	310 mm	302 mm
	Flow test (60 min)			260 mm	300 mm	278 mm
	Flow test (90 min)			250 mm	285 mm	263 mm
	Flow test (120 min)			250 mm	280 mm	260 mm
	Flow test (180 min)			160 mm	190 mm	175 mm
	Flow test (240 min)			140 mm	160 mm	150 mm
FG2	Fresh density	EN 12350-6		2270 kg/m ³	2270 kg/m ³	2270 kg/m ³
FG3	Bleeding	ASTM C940		No observed bleeding		
FG4	Air content	EN 12350-7		2.1 %	2.2 %	2.1 %
FG5	Initial setting time ¹⁾	EN 196-3		09:15 hh:mm	09:20 hh:mm	09:17 hh:mm
	Final setting time ¹⁾	EN 196-3		10:25 hh:mm	11:05 hh:mm	10:45 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 Ducorit S8 for testing at t_{test, min} (0°C)

Test Id.	Type of Test	Test Method	Test Temperature	Test Values		
				Min	Max	Mean
FG1	Flow test (2 min)	ASTM C230/C1437	0°C	255 mm	280 mm	265 mm
	Flow test (30 min)			295 mm	300 mm	298 mm
	Flow test (60 min)			270 mm	300 mm	285 mm
	Flow test (90 min)			245 mm	260 mm	252 mm
	Flow test (120 min)			245 mm	250 mm	247 mm
	Flow test (180 min)			235 mm	240 mm	238 mm
	Flow test (240 min)			230 mm	240 mm	235 mm
FG2	Fresh density	EN 12350-6		2220 kg/m ³	2230 kg/m ³	2220 kg/m ³
FG3	Bleeding	ASTM C940		No observed bleeding		
FG4	Air content	EN 12350-7		4.0 %	4.9 %	4.3 %
FG5	Initial setting time ¹⁾	EN 196-3		19:40 hh:mm	23:10 hh:mm	21:32 hh:mm
	Final setting time ¹⁾	EN 196-3		22:55 hh:mm	25:30 hh:mm	24:25 hh:mm

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

Hardened Properties

Characteristic 28-days strengths of relevant hardened material properties for Ducorit S8 are given in Table 5 and Table 6. The 5 % characteristic values are determined in accordance with Appendix D of EN 1990 on the basis of each individual test result from all production batches being tested as part of the laboratory test program. Properties are based on tests undertaken after mixing with laboratory equipment.

Table 5 Characteristic 28-days strengths at 20°C for Ducorit S8 acc. to EN 1990

Material Property	Test Specimen	Curing/Testing Temperature [°C]	Notation	Characteristic Value [MPa]
Compressive Strength	150 x 300 mm cylinders	20	f_{cck}	91.5
	75 mm cubes		f_{ck}	104.0
	40 x 40 x 160 mm prisms		$f_{ck,prisms}$	94.4
Flexural Strength	40 x 40 x 160 mm prisms		$f_{ctk,fl}$	12.0

Table 6 Characteristic 28-days strengths at $t_{test, min}$ (0°C) for Ducorit S8 acc. to EN 1990

Material Property	Test Specimen	Curing/Testing Temperature [°C]	Notation	Characteristic Value [MPa]
Compressive Strength	150 x 300 mm cylinders	0	f_{cck}	79.9
	40 x 40 x 160 mm prisms		$f_{ck,prisms}$	83.1
Flexural Strength	40 x 40 x 160 mm prisms		$f_{ctk,fl}$	10.7

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Min, max and mean values of hardened material properties of Ducorit S8 documented during the laboratory test programs are presented in Table 7 and Table 8.

Table 7 Summary of hardened properties for Ducorit S8 for testing at 20°C

Test Id.	Type of Test	Test Method	Testing / Curing Temperature	Test Values			Unit
				Min	Max	Mean	
HG1	Hardened density	EN 12390-7	20°C	2260	2290	2280	kg/m ³
HG2	3 days compressive strength (150 x 300 mm cyl)	EN 12390-3	20°C	69.4	75.5	72.8	MPa
	7 days compressive strength (150 x 300 mm cyl)		20°C	77.3	85.2	82.1	MPa
	28 days compressive strength (150 x 300 mm cyl)		20°C	90.7	100.1	95.7	MPa
	91 days compressive strength (150 x 300 mm cyl)		20°C	106.8	116.6	110.5	MPa
HG3	28 days compressive strength (75 mm cubes)	EN 12390-3	20°C	103.9	117.0	110.0	MPa
HG4	28 days flexural strength (40 x 40 x 160 mm prisms)	EN 196-1	20°C	12.1	14.4	13.3	MPa
HG5	Creep coefficient after 1 day loading	ASTM C512	20°C	-	-	0.406	-
	Creep coefficient after 7 days loading			-	-	0.728	-
	Creep coefficient after 28 days loading			-	-	1.255	-
	Creep coefficient after 56 days loading			-	-	1.472	-
	Creep coefficient after 91 days loading			-	-	1.619	-
	Creep coefficient after 180 days loading			-	-	-	-
	Creep coefficient after 365 days loading			-	-	-	-
HG6	Autogenous shrinkage strain after 7 days curing	ASTM C1698	20°C	-	-	0.283	mm/m
	Autogenous shrinkage strain after 14 days curing			-	-	0.294	mm/m
	Autogenous shrinkage strain after 28 days curing			-	-	0.291	mm/m
	Autogenous shrinkage strain after 56 days curing			-	-	-	mm/m
HG7	Static Young's modulus	ASTM C469	20°C	33.5	35.8	34.9	GPa
	Poisson's ratio	ASTM C469	20°C	0.16	0.21	0.20	-
HG8 ¹⁾	28 days compressive strength (40 x 40 x 160 mm prisms)	EN 196-1	20°C	89.8	104.6	100.1	MPa
HG9A ¹⁾	Fatigue factor C5 – submerged (60 x 120 mm cyl)	DNV GL-ST-C502	General	-	-	0.95	
HG9B ¹⁾	Fatigue factor C5 – in air (60 x 120 mm cyl)	DNV GL-ST-C502	General	-	-	1.0	

1) HG 8 and HG 9 represents additional testing documented for Ducorit S8

Table 8 Summary of hardened properties for Ducorit S8 for testing at $t_{\text{test, min}}$ (0°C)

Test Id.	Type of Test	Test Method	Testing / Curing Temperature	Test Values			Unit
				Min	Max	Mean	
HG1	Hardened density	EN 12390-7	0°C	2220	2260	2245	kg/m ³
HG2	3 days compressive strength (150 x 300 mm cyl)	EN 12390-3	0°C	57.5	64.3	60.4	MPa
	7 days compressive strength (150 x 300 mm cyl)		0°C	68.4	86.2	79.0	MPa
	28 days compressive strength (150 x 300 mm cyl)		0°C	79.0	91.0	86.6	MPa
	91 days compressive strength (150 x 300 mm cyl)		0°C	92.0	99.7	96.0	MPa
HG4	28 days flexural strength (40 x 40 x 160 mm prisms)	EN 196-1	0°C	10.1	13.1	12.1	MPa
HG8 ¹⁾	28 days compressive strength (40 x 40 x 160 mm prisms)	EN 196-1	0°C	81.6	96.1	90.0	MPa

1) HG 8 represents additional testing documented for Ducorit S8

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 10 and Table 11. Where test results are available at different temperatures for both properties the conversion factors are presented for both temperatures tested.

Table 9 Conversion factors for 28-days strengths for Ducorit S8

Conversion factor	
$f_{\text{ccm}} / f_{\text{cm}}$	0.87
$f_{\text{ccm}} / f_{\text{cm,prisms}}$	0.96
$f_{\text{cm}} / f_{\text{cm,prisms}}$	1.10

Table 10 Mean 28-days strengths for Ducorit S8 for testing at 20°C

Material Property	Test Specimen	Curing/Testing Temperature [°C]	Notation	Mean Value [MPa]
Compressive Strength	150 x 300 mm cylinders	20	f_{ccm}	95.7
	75 mm cubes		f_{cm}	110.0
	40 x 40 x 160 mm prisms		$f_{\text{cm,prisms}}$	100.1
Flexural Strength	40 x 40 x 160 mm prisms		$f_{\text{ctm,fl}}$	13.3

Table 11 Mean 28-days strengths for Ducorit S8 for testing at $t_{\text{test, min}}$ (0°C)

Material Property	Test Specimen	Curing/Testing Temperature [°C]	Notation	Mean Value [MPa]
Compressive Strength	150 x 300 mm cylinders	0	f_{ccm}	86.6
	40 x 40 x 160 mm prisms		$f_{\text{cm,prisms}}$	90.0
Flexural Strength	40 x 40 x 160 mm prisms		$f_{\text{ctm,fl}}$	12.1

Approved Procedures

The approved ITW PP ApS procedural documentation for application of Ducorit S8 is shown in Table 12. This Type Approval Certificate is only valid when ITW PP ApS's approved Contractors are performing the grouting operation in accordance with the referenced generic method statement and offshore QC procedure.

Table 12 Approved Procedural ITW PP ApS Documentation for application of Ducorit S8

Description	Title of Document
Generic Method Statement	DOC-321 – Generic Offshore Grouting Method Statement Scope Procedure Ducorit S8, Temp. Ver. 3, Rev.5, Dated 2018.09.03
Qualification Scheme for 3 rd Party Grouting Contractor	DOC-322 - Ducorit S8 Licensed Applicator Approval Program, Rev.5, Dated 2018.09.03
Offshore QC Procedure	RENEW-QC-2018-008 - Calculation of characteristic value of compressive strength, Dated 2018.08.27

Traceability

In order to operate under a valid Type Approval Certificate for ITW PP ApS Ducorit S8, 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.

Transferring a 24 tons production batch to larger units, where a number of production batches are mixed, entails the risk of having to recall material from several batches even if only one non compliance, e.g. deficient results from Factory Production Control Testing or non conforming raw materials, is found.

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Manufacturing Site Approval

The initial audit of ITW Performance Polymers ApS, Gasvaerksvej 46, 9000 Aalborg, Denmark, according to App.I of DNVGL-ST-C502, was successfully carried out during the 24th and 25th of April 2018.

DNV GL shall at any time, upon request, be given access to all areas and facilities for production and quality control at the manufacturing facility (Certificate Retention). The frequency and timing of periodical surveys shall be confirmed in advance with 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 GL 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).

END OF CERTIFICATE