MasterFlow® Grouts
The Critical Link Between Foundation and Turbine
The latest technical developments in the construction of wind turbines are creating giant towers capable of producing higher levels of renewable energy. The foundations of these towers need to meet ever higher quality requirements while at the same time reducing construction periods. Wind power turbines are high, slender structures that are exposed to high dynamic wind loads and other service stresses.

The interaction of the machine with the load transferring components of the installation — tower, foundation and anchors — requires special attention in the design of a wind turbine. The most important loads acting on a wind turbine structure are:

- Axial load
- Rotation
- Vibration
- Bending
- Torsion

All these loads need to be transferred / absorbed by the grout connecting the tower to the foundation structure. A careful design and selection of the grouting material is therefore of utmost importance. Safe and durable installation of wind turbines largely depend on high performance building materials which connect the tower to its base / foundation.

BASF’s specially developed ultra-high performance materials — MasterFlow grouts — meet all these requirements, have faster installation times and lead to long-term maintenance-free operation of onshore wind farms.

**Safe and durable installations:**
- Ultra-high early and ultimate strengths
- Excellent long term durability
- Volume stability for the life of the design

**Opportunity for wider weather windows:**
- MasterFlow grouts are applicable down to +35 °F
- Rapid strength development
- Placement in cold and hot environments

**MasterFlow grouts are validated by many testing institutes:**
- For grouting onshore wind turbines to the foundation

**Improved risk management:**
- BASF provides warranties
- Engineering and field staff support available

**Cost effective installations:**
- MasterFlow grouts can considerably reduce the overall installation time

**Fast and easy installation:**
- MasterFlow grouts safeguard on time project completion
- Wind turbines may even be connected to the grid earlier
- Quicker electricity production is possible
Master Builders Solutions by BASF

Building on partnerships. Our Master Builders Solutions experts find innovative and sustainable solutions to meet your specific construction needs. Our global experience and network help you to be successful – today and tomorrow.

Master Builders Solutions

The Master Builders Solutions brand brings all of BASF’s expertise together to create chemical solutions for new construction, maintenance, repair and renovation of structures. Master Builders Solutions is built on the experience gained from more than a century in the construction industry. The know-how and experience of a global community of BASF construction experts form the core of Master Builders Solutions. We combine the right elements from our portfolio to solve your specific construction challenges. We collaborate across areas of expertise and draw on the experience gained from countless construction projects worldwide. We leverage global BASF technologies, as well as our in-depth knowledge of local building needs, to develop innovations that help make you more successful and drive sustainable construction.

Admixture Systems for the best concrete mixes in foundations

Ultra-high performance MasterFlow grouts for wind turbines
MasterFlow® Cementitious Grouting Solutions for Onshore Wind
Product Selector

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>DESCRIPTION</th>
<th>AGGREGATE TYPE</th>
<th>PERFORMANCE</th>
<th>APPLICATIONS</th>
<th>DYNAMIC LOADS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>TEMP RANGE</td>
<td>FLOWABILITY</td>
<td>EXTENDED WORKING TIME</td>
</tr>
<tr>
<td>MasterFlow</td>
<td>Nonshrink precision grout</td>
<td>Mineral</td>
<td>50 – 80°F (10 – 27°C)</td>
<td>★★</td>
<td>★★★</td>
</tr>
<tr>
<td>555</td>
<td></td>
<td></td>
<td>Fluid</td>
<td>Flowable</td>
<td>Plastic</td>
</tr>
<tr>
<td>MasterFlow</td>
<td>Nonshrink precision grout with extended working time</td>
<td>Mineral</td>
<td>45 – 90°F (7 – 32°C)</td>
<td>★★★★★★★★★</td>
<td>★★★★★★★★★</td>
</tr>
<tr>
<td>928</td>
<td></td>
<td></td>
<td>Fluid</td>
<td>Flowable</td>
<td>Plastic</td>
</tr>
<tr>
<td>MasterFlow</td>
<td>Ultra high strength, hybrid performance precision grout</td>
<td>Mineral</td>
<td>35 – 100°F (2 – 38°C)</td>
<td>★★★★★★★★★</td>
<td>★★★★★★★★★</td>
</tr>
<tr>
<td>4316</td>
<td></td>
<td></td>
<td>Fluid</td>
<td>Flowable</td>
<td>Plastic</td>
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</tbody>
</table>

**TECHNICAL DATA**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>MASTERFLOW</th>
<th>555</th>
<th>928</th>
<th>4316</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strength, psi (MPa)</td>
<td>3 days</td>
<td>4,200 (29)</td>
<td>4,500 (31)</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Flowable</td>
<td>4,500 (31)</td>
<td>5,000 (34)</td>
<td>10,900 (75.2)</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>5,800 (40)</td>
<td>6,000 (41)</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>28 days</td>
<td>7,000 (48)</td>
<td>7,500 (52)</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Flowable</td>
<td>7,500 (52)</td>
<td>8,000 (55)</td>
<td>16,700 (115.1)</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>8,500 (59)</td>
<td>9,000 (62)</td>
<td>–</td>
</tr>
</tbody>
</table>

| Working time, minutes | 5 – 20 | 30 – 60 | 30 – 60 |

**PACKAGING AND YIELD**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>BAG / LBS (KG)</th>
<th>YIELD / FT³ (M³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MasterFlow 555</td>
<td>50 (22.7)</td>
<td>0.42 (0.012)</td>
</tr>
<tr>
<td>MasterFlow 928</td>
<td>55 (25)</td>
<td>0.50 (0.014)</td>
</tr>
<tr>
<td>MasterFlow 4316</td>
<td>50 (22.7)</td>
<td>0.39 (0.011)</td>
</tr>
</tbody>
</table>

**MasterFlow 555 Mineral-Aggregate Grout**
A semi-fluid, non-shrink mineral-aggregate grout. It is ideally suited for grouting machines or plates requiring optimum load bearing support. MasterFlow 528 Extended Working Time Grout is a hydraulic cement-based mineral aggregate non-shrink grout with extended working time. It is ideally suited for grouting machines or plates requiring precision load-bearing support. It can be placed from fluid to damp pack over a temperature range of 45 to 90°F (7 to 32°C).

**MasterFlow 928 Mineral-Aggregate Grout**
MasterFlow 928 grout is a hydraulic cement-based mineral aggregate non-shrink grout with extended working time. It is ideally suited for grouting machines or plates requiring precision load-bearing support. It can be placed from fluid to damp pack over a temperature range of 45 to 90°F (7 to 32°C).

**MasterFlow 4316 High-Performance Grout**
A unique grout that provides high early and ultimate compressive strengths over a wide variety of application and service temperatures. The superior performance of MasterFlow 4316 lies in its novel hydraulic cement binder with applied nanotechnology and premium mineral aggregates which, when mixed with water, produces a flowable and pumpable grout that can be installed in temperatures ranging from 35 to 100°F (2 to 38°C).
MasterFlow® Epoxy Grouting Solutions for Onshore Wind

Product Selector

MasterFlow 649 High-Flow Grout

A high-strength epoxy grouting material for support of heavy equipment. It ensures the proper transmission of static and dynamic loads to the equipment foundation. It offers high early and 7-day strengths for applications requiring fast turnaround as well as good chemical and crack resistance.

MasterFlow 647 Injection Resin

A modified epoxy resin grout, specially formulated for grouting cracks in structures and machinery foundations. Suitable for pressure injection of grouted baseplates beneath compressors, turbines, and other vibrating and rotating machinery.

TECHNICAL DATA

PROPERTY | MASTERFLOW 649
---|---
Compressive strength, psi (MPa) | |
Hours | 55° F (13° C) | 73° F (23° C) | 90° F (32° C)
8 | 700 (5) | 9,400 (65) |
16 | 7,000 (48) | 13,700 (96) |
24 | 11,500 (81) | 16,000 (112) |
48 | 16,400 (115) | 18,500 (130) |
72 | 17,100 (118) | 19,000 (134) |
96 | 18,000 (124) | 20,000 (141) |

PACKAGING AND YIELD

PROPERTY | PACKAGING | YIELD FT³ (M³)
---|---|---
MasterFlow 649 | |
57.4 lb unit | one 5.6 lb pail (2.5 kg) | 0.43 (0.012)
Hardener | one 1.87 lb bottle (0.85 kg) |
Aggregate | one 50 lb bag (22.7 kg) |
230 lb unit | one 22.3 lb pail (10.1 kg) | 1.73 (0.049)
Resin | one 7.6 lb bottle (3.4 kg) |
Hardener | four 50 lb bags (22.7 kg) |
MasterFlow 4316
For Onshore Wind Turbine Installations

Ultra High Strength Hybrid Cementitious Grout
MasterFlow 4316 is a unique grout that provides high early and ultimate compressive strengths over a wide variety of application and service temperatures. The superior performance of MasterFlow 4316 lies in its novel hydraulic cement binder with applied nanotechnology and premium mineral aggregates which, when mixed with water, produces a flowable and pumpable grout that can be installed in temperatures ranging from 35 to 100° F (2 to 38° C). It offers the strength of an epoxy with the ease of application of a cementitious grout.

FEATURES
- High early compressive strength
  - 4,300 psi at 8 hours
  - 8,000 psi at 1 day
  - 16,000 psi ultimate strength
- 95% Effective Bearing Area
- Extremely dense material with proven fatigue resistance – durable
- Outstanding shrinkage, impact and vibration resistance
- Ability to place in cold weather (35° F / 2° C)
- In service temperatures up to 1000° F (538° C)
- Homogeneous, flowable and pumpable
- Application advantage – one component, easy mixing, placement and cleanup

Concrete tower foundation

TEST DATA

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD REQUIREMENT</th>
<th>35° F (2° C)</th>
<th>72° F (22° C)</th>
<th>100° F (38° C)</th>
<th>TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strengths, psi (MPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ASTM C 109</td>
</tr>
<tr>
<td>8 hours</td>
<td>none</td>
<td>4,300 (30)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 hours</td>
<td>none</td>
<td>6,500 (44.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day</td>
<td>1,000 (7)</td>
<td>4,100 (28.3)</td>
<td>min. 8,000 (65.2)</td>
<td>min. 8,000 (65.2)</td>
<td></td>
</tr>
<tr>
<td>3 days</td>
<td>2,500 (17)</td>
<td>8,700 (60)</td>
<td>10,900 (75.2)</td>
<td>10,600 (73.1)</td>
<td></td>
</tr>
<tr>
<td>7 days</td>
<td>3,500 (24)</td>
<td>10,000 (68.9)</td>
<td>min. 12,000 (82.7)</td>
<td>min. 12,000 (82.7)</td>
<td></td>
</tr>
<tr>
<td>28 days</td>
<td>5,000 (34)</td>
<td>11,900 (82)</td>
<td>16,700 (115.1)</td>
<td>17,000 (117.2)</td>
<td></td>
</tr>
<tr>
<td>Setting Time, min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ASTM C 191</td>
</tr>
<tr>
<td>Initial</td>
<td>–</td>
<td>180</td>
<td>180</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Final</td>
<td>–</td>
<td>220</td>
<td>210</td>
<td>180</td>
<td>LA Rattler, 2,000 Cycles</td>
</tr>
<tr>
<td>Impact Resistance, %</td>
<td>–</td>
<td>–</td>
<td>43</td>
<td>–</td>
<td>DNV-OS-C502-458</td>
</tr>
<tr>
<td>Mass Loss, %</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
<td>Loaded at 7,639 psi (82.7 MPa) at 5Hz cycle rate</td>
</tr>
<tr>
<td>Fatigue</td>
<td>–</td>
<td>–</td>
<td>No deterioration after 2,000,000 cycles</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Effective Bearing Area</td>
<td>High - Greater than 95%</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>ASTM C 1339</td>
</tr>
</tbody>
</table>
MasterFlow 649
For Onshore Wind Turbine Installations

High Strength Epoxy Grout

MasterFlow 649 is an epoxy resin-based precision grout used to secure critical equipment for proper alignment and transmission of static and dynamic loads. With carefully balanced physical properties and excellent resistance to chemical attack, elevated service temperatures, vibration and torque, MasterFlow 649 is formulated for easy installation, with good flow characteristics suitable for pouring or pumping. It also offers simple soap and water cleanup.

TEST DATA

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>RESULTS</th>
<th>TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strength, psi (MPa), when cured at Cure rate, filled 6.25:1</td>
<td></td>
<td>ASTM C 579, modified</td>
</tr>
<tr>
<td>Hours</td>
<td>55° F (13° C)</td>
<td>73° F (23° C)</td>
</tr>
<tr>
<td>8</td>
<td>--</td>
<td>700 (5)</td>
</tr>
<tr>
<td>16</td>
<td>--</td>
<td>7,000 (48)</td>
</tr>
<tr>
<td>24</td>
<td>1,300 (9)</td>
<td>11,500 (81)</td>
</tr>
<tr>
<td>48</td>
<td>9,400 (65)</td>
<td>16,400 (115)</td>
</tr>
<tr>
<td>72</td>
<td>13,900 (96)</td>
<td>17,100 (118)</td>
</tr>
<tr>
<td>96</td>
<td>16,700 (115)</td>
<td>18,000 (124)</td>
</tr>
</tbody>
</table>

| Tensile strength, psi (MPa) filled 6.25 : 1 | 2,300 (16) | ASTM C307 |

| Flexural strength, psi (MPa) filled 6.25:1, cured 7 days at 73° F (23° C) | ° F (° C) | 4,600 (32) |
| | 76 (24) | 140 (60) | 170 (77) |

| Shrinkage, unrestrained linear in/in, filled 6.25:1 | 0.00065 | ASTM C331 |
| Impact strength | Better than concrete |
Master Builders Solutions from BASF

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Master Builders Solutions products from BASF for the Construction Industry:

- **MasterAir®**  Solutions for air-entrained concrete
- **MasterBrace®**  Solutions for concrete strengthening
- **MasterCast®**  Solutions for manufactured concrete product industry
- **MasterCem®**  Solutions for cement manufacture
- **MasterEmaco®**  Solutions for concrete repair
- **MasterFinish®**  Solutions for formwork treatment
- **MasterFlow®**  Solutions for precision grouting
- **MasterFiber®**  Comprehensive solutions for fiber reinforced concrete
- **MasterGlenium®**  Solutions for high-performance concrete
- **MasterInject®**  Solutions for concrete injection
- **MasterKure®**  Solutions for concrete curing
- **MasterLife®**  Solutions for enhanced durability
- **MasterMatrix®**  Advanced rheology control solutions for self-consolidating concrete
- **MasterPel®**  Solutions for water tight concrete
- **MasterPolyheed®**  Solutions for high-performance concrete
- **MasterPozzolith®**  Solutions for water-reduced concrete
- **MasterProtect®**  Solutions for concrete protection
- **MasterRheobuild®**  Solutions for super-plasticized concrete
- **MasterRoc®**  Solutions for underground construction
- **MasterSeal®**  Solutions for waterproofing and sealing
- **MasterSet®**  Solutions for workability control
- **MasterTop®**  Solutions for industrial and commercial floors
- **MasterWeld®**  Solutions for construction adhesives
- **Ucrete®**  Flooring solutions for harsh environments

BASF Corporation
Construction Systems
889 Valley Park Drive
Shakopee, MN 55379 USA

Customer Service 1(800) 433-9517
Technical Service 1(800) 243-6739
master-builders-solutions.basf.us

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