MasterFlow® 9200

Ultra high strength, cement based grout with applied nanotechnology for grouting onshore VESTAS wind turbine installations

Installation GUIDE
for
MASTERFLOW® 9200

Grouted connections for Vestas onshore wind turbine foundations
Grouting of anchor cage AC1.0 and AC1.5 guideline

2 Mw Platforms V90-V100-V110-V116-V120

4 Mw Platforms V105-V112-V117-V126-V136-V150

EnVentus Platforms V138-V150-V162

IMPORTANT: READ THIS FIRST

BASF Construction Chemicals does not warrant the performance of this product unless the instructions of this document and other related BASF Construction Chemicals documents are adhered to in all respects.

This application guide describes the basic installation procedure for grouting grouted connections used in some offshore wind turbine foundations. The manual only describes the quality assurance of the Masterflow 9200 prior to and after the installation. This manual has a table of content that mentions all important area that must be filled out once the project and equipment have been chosen.

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To be filled out once project has been chosen

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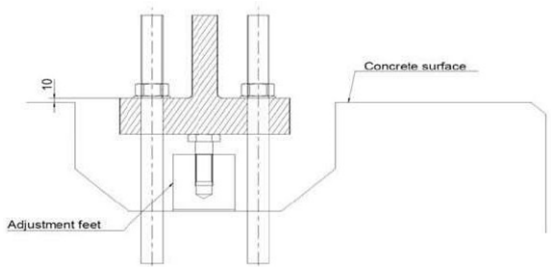
Enclosure 1: General installation information

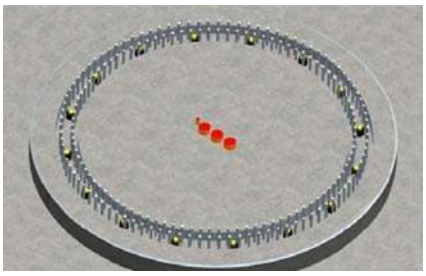
1. Foundation preparation

The foundation surfaces must be clean and free of all oil, grease, and other materials that can impair the adhesion of the grout. Eliminate sources of vibration (which can cause settlement and bleeding) until grout hardens.
Before installing the tower base section, the trench shall be cleaned and loose particles removed by blasting, high-pressure water, vacuum cleaner, etc. If blasting, the threaded anchor ends must be protected against damages from blasting.

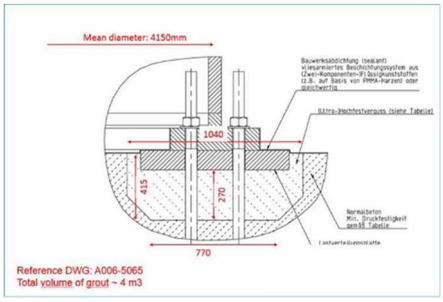
Thereafter the tower base is correctly positioned by the contractor appointed for the erection of the tower. For more information we refer to the Vestas Grouting of anchor cage 1.0 and 1.5 - General Guideline"



Situation showing tower base installed on adjustment feet.


Situation after installation of adjustment feet.

The concrete must be dampened prior the installation of the grout but should be free of standing water when the grout is being placed.



EnVentus design

2. Mixing the grout

2.1. BASIC PRINCIPLES

A. Make sure to always have the correct mixing and pumping equipment available

and position them as close as possible to the base tower. Enough grouting hoses should be available, representing an accumulated length which is twice the anticipated grouting length (as part of the contingency plan).

B. Use forced action mixers only (e.g. paddle mixers), with a capacity to mix at least 100 kg Masterflow 9200 at once.

C. Wet out the mixing equipment with water and remove the free water.

D. Pour the mixing water in the mixer first and add the dry grout to the water in a steady stream.

E. The best retarder for non-catalyzed grouts is a lower “as mixed” grout temperature. This is usually accomplished using cold or iced mixing water or cool storage of the dry grout material.

F. BASF grouts are supplied in a ready to use form requiring only the addition of water.

G. Do not use grout from damaged bags.

H. Mix with potable water only.
Water demand (per 25 kg bag): 1.75 – 2.00 liters at 20°C.
The correct water demand should preferably be determined in accordance with ASTM C230, by measuring the spread of flow of the product after mixing.

I. Mix for at least 5 to 7 minutes depending on the temperature. Longer mixing times might be required at cold temperatures

2.2. LARGE VOLUME BATCHES (> 100 kg)

Because large volumes of grout tend to warm up rapidly and thicken, it is essential that the following procedure be rigorously observed.

A. Take whatever means necessary to produce a grout temperature under 25 °C after mixing. This includes the following:

i. Use cold mixing water as required (cold water on ice if necessary).

ii. Make arrangements for batching the dry grout into the mixer in less than 2 minutes.

iii. Mixing for a longer period reduces handling time – the longer a large volume of grout is held as a mass in the mixer, the faster it warms up and thickens.

iv. In case the already mixed grout will remain for a longer period in the mixing equipment, we advise not to continuously mix the material but interrupt the mixing, only remixing every 5 to 10 minutes for a brief period (max. 1 minute).

B. Prearrange for rapid, continuous and efficient transporting/pumping of the grout.

3. Placing the grout

Grout should be placed as quickly as possible after it has been properly mixed and discharged. The method of placement will depend on the type and size of the object to be grouted and environmental temperatures.

Pump equipment and hoses must be selected allowing rapid placement of the Masterflow 9200 grout. Larger hose diameters and/or shorter hose lengths may be chosen in order to ease the installation of the material.
Properly lubricate the hoses before pumping the grout through the machine and hoses.

Recommended grout thickness for Masterflow 9200 in 2 Mw / 4 Mw platforms is 25 – 300 mm.
For **EnVentus** platforms, recommended grout thickness is 25-500 mm.

4. Hot weather grouting (above 25 degrees Celsius)

High ambient temperatures accelerate stiffening and require grout mixing and placing procedures that can only be accomplished in the period of time the grout remains workable.

The alternative is to extend the length of time the grout is workable and applicable through the use of cold materials (e.g. store materials in cool conditions, use iced water) and cool foundations. This approach does not affect the characteristics of the grout.
This is the only method of extending the working time that may be used with BASF grouts.

Another alternative is to reduce grouting lengths and/or increase hose diameters whenever possible. This will allow for faster grout installation.

4.1. RECOMMENDATIONS:

A. Store the bags of grout in as cool a place as practicable, but at least in the

shade.

B. Cool the Mixing Water: To lower the “as mixed” temperature of the grout, use

cold water. If necessary, float ice in drums of water, employing enough drums so that when water is drawn off for mixing, the replacement water has time to cool. Insulating the drums or wrapping them with wet rags will help keep the water cold. Do not add ice directly to the grout mix, and do not use ‘dry ice’ as a cooling agent.

Where large batches of grout are to be mixed or where the bags of grout product are over 30 °C, consider substituting shaved ice for some of the mixing water on a weight-for-weight basis. Generally, shaved ice can be used in place of 50 to 70 % of the mixing water by weight of the mixing water. Do not use more ice than will be completely melted within the proper mixing time of the grout. Un-melted ice poured with the grout will float to the top of the grout and will melt after or during installation, producing water pockets in the grouted connection with resulting loss of bearing capacity.
Always pour the mixed grout through a screen to remove un-melted ice, lumps and foreign material.

It is good practice to take the temperature of the initial batch to determine if more or less cooling is required. An “as mixed” temperature of less that 2 °C can be damaging to the grout. Therefore, the ice must be carefully controlled in batching and mixing.

C. If the mixer is warm, cool it by charging the mixer with cold or iced water. This will help reduce heating of the grout.

D. If the grout is being pumped, a warm pump line can heat the grout and cause plugging. Covering the line with e.g. white paint will help cool the pump line. Also, consider using reflective insulation around the line and erecting sunshades to shield the line form the hot sun. The pump line can be cooled by filling it with chilled water or chilled cement slurry before batching the grout. However, the chilled priming mix must be completely discharged and discarded before pumping the grout.

E. Grout early in the morning or at night when temperatures are cooler

F. Specially for EnVentus platforms where the thickness is higher, store powder and mixing water in cool / cold conditions prior to grouting. Cool the flange of the

tower with ice (do not place ice directly on the fresh grout but do indirect cooling by cooling down the steel flange. This way you will drag the heat out of the grout)

4.2. WHEN COOLING CANNOT BE ACCOMPLISHED:

The following approach should be considered in order to cope with rapid setting in hot weather:

i. Provide increased mixing capacity so the grout can be poured faster and continuously.

ii. Cover the hoses with e.g. a white paint, to prevent heat take up by the lines. Controlling the temperature of the environment and grout as mixed and placed, minimizes the mixing water demand, provides more working time and results in higher compressive strengths.

5. Cold weather grouting (below 10 degrees Celsius)

Cool and cold temperatures affect the properties of grout in the same manner as concrete and mortars.

Cold temperatures retard setting times and leads to retarded strength development. Cold foundations quickly draw heat from the smaller volume of grout between them and these masses control the temperature of grout.

Storing the dry grout in a warm area and/or using warm water will raise the as-mixed temperature and should be considered. However, the actual temperature of the foundation, equipment and machinery should be the guiding factor as to whether grouting should take place or not with the specific grout involved.

	Workability time (h)			
	2 °C	20°C	25°C	30°C
Typical	> 5	> 5	> 4	> 4
Minimum	> 5	> 4	> 3	> 2.5

For Masterflow 9200, +2 °C is the minimum grout temperature after mixing. Environmental temperature should also be above +2°C

There are three important factors, which must be considered for successful cold weather grouting.

A. Mixed grout temperature and consistency: the temperature of the bags, the

temperature of the mixing water, the size of the batch being mixed and the temperature in the mixing and working area effect the temperature of the mixed grout.

i. Optimum storage temperatures for grouting in cold weather are over 10 °C.

ii. Warm the mixing water as necessary to provide mixed grout at the desired temperature, but do not mix grout warmer than necessary. Warmer mixed grout will require more mixing water for a given consistency and reduce the handling time in proportion to its temperature. Do not use mixing water over 25 °C.

iii. Less mixing water = higher strength. Early age strengths at cool temperatures are relatively low, but cold placed and cured grouts will be approximately as strong as normally placed grouts at 28 days and stronger at ultimate strength.

iv. Cool and cold grouts stay fluid and flowable longer than normal temperature grouts. Hence, the working time of less fluid, cool grout will be approximately the same as more fluid, warm grout.

B. Foundation and Equipment Temperature:

i. Accurately measure the temperature of the foundation and base tower.

ii. If the temperature of the foundation and/or base tower is below the minimum placing temperature, bring them up to the minimum temperature or postpone the grouting process until the foundation and base tower have again reached a minimum temperature of +2°C.
Apply heat uniformly. Cooler in place temperatures (above the minimum) are better, unless early strength is necessary. (Heating methods should comply with equipment manufacturers and erectors instructions.)

C. Ambient (Curing) Temperature:

i. Newly placed grout must be protected from freezing. After placement, the grout must be maintained at or above minimum placing temperature until the grout has attained final set. Thereafter, the temperature must preferably be kept above freezing until the compressive strength exceeds 25 MPa.

ii. Cold and cool temperatures retard early strength gain. Early strengths may be accelerated by using heated water and maintaining placed grout temperature around 20 °C for 24 hours. However, this must be carefully and uniformly applied to avoid thermal shock damage.

	Workability time (h)			
	2 °C	20°C	25°C	30°C
Typical	> 5	> 5	> 4	> 4
Minimum	> 5	> 4	> 3	> 2.5

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6. Pumping MASTERFLOW® 9200 grout

BASF grouts can be pumped with the same equipment that will pump cement-sand or pea gravel mixes. Pumps should have a hopper capable of mild agitation and be fitted with a return line to allow grout to re-circulate during temporary hold ups. A 50 mm internal diameter pump hose is preferred, although smaller diameter hose can be used for short distances.

Typical pumping and mixing equipment

Rigid thin wall metal tube to pump underneath flange

Whenever a large volume of grout is to be pumped, or for pumping distances over 25 meters, a 50 mm or more inner diameter grout line should be used. Minimum diameter grout lines are shown below. Consider the use of a rigid thin wall metal (e.g. copper) tube flattened to oval shape attached to the grout line, in order to pump the grout properly under the T-flange of the base tower.

Keep the line from the pump to the discharge outlet as short as possible. Protect the grout line from heating by the sun by covering with wet burlap or cloth, or by coating the line with a white paint. Pack the grout line in ice and use iced mixing water when temperatures are extreme to retard stiffening from heat build-up and minimize line plug-ups. All reducers of line diameter from the pump outlet should be long tapers rather than abrupt reducers. The latter creates a restriction that can cause the grout to bridge the smaller opening and plug the line. All valves should be of the quick opening gate, plug
or similar types to allow unrestricted passage of the grout. Do not use line connections with reduced diameter and/or globe valves that severely restrict flow of the grout even when fully open.

Always lubricate the hoses, using pure cement slurry, prior to pumping the Masterflow 9200 through the lines.
Minimum grout line sizes for power driven pumps – inside diameter:
It is always desirable to use a 50 mm hose when pumping over distances of 25 meters or more. The minimum hose sizes are: (larger diameter hoses for the same length are allowed and be of advantage in some cases)

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Length	10 meters (ca. 30 ft)	10 - 25 meters (ca. 30 – 80 ft)	Over 25 meters (> 80 ft)
Inside diameter	25 mm (1”)	35 mm (1.5”)	50 mm (2”)

The need for adequate mixing equipment to keep the mixer and grout lines filled throughout the complete placement cannot be overemphasized. A slug of air entering the pump and lines usually ends up as a void in the placed grout. Mix grouts and mortars in paddle-type or forced action pan mixers rather than drum-type mixers. Keep mixed grout as cool as possible within product limitations using cold water and shaved ice if required until discharged, and by agitating and re-circulating mixed material in the pump hopper when not actually pumping through to the work. Hand agitation should be used to prevent material from stiffening against the pump hopper walls. Keep the grout pump line “alive” at all times.

Place sieve/screen over the pump hopper to remove lumps of grout, ice, or other debris that may jam the pump or plug the grout line. Keep the pump hopper, at least half full of grout, always so as not to draw air into the line. (If this should be done by accident, the line must be bled). If it is not possible to draw the discharge outlet of the line back to be re-circulated through the pump hopper until the air is bled, it may be necessary to bleed the line to waste, to prevent the inclusion of an air void in the work.

Take care to ensure air is not entrapped.
Have the following, immediately available, always: Hose connected to a water line with good pressure and the other end connected to a pipe smaller in diameter than the grout line diameter and more than half the length of the grout pipe. The purpose is to quickly insert the water line into the grout pipes to quickly clean them out in the event of a breakdown or blockage.

Start the pumping process against a temporary form (e.g.PU-foam) installed underneath the T-flange and radial in the trench for preventing the grout to flow in two directions. Pump the grout into the trench at the bottom, continue until the grout exits the opposite side of the T-flange and the top level is in level with the concrete (maintain a pressure head). Slowly move the inlet place of grouting as grout continues to come up on the opposite side and keep focus on maintaining the pressure head of the grout already pumped in place to ensure that air is being displaced rather than trapped.
Grout should not be placed indiscriminately at separate locations along one side as this prevents tracing the actual movement and progress of the grout and can result in large pockets or voids being trapped between such placing points.
Only at the very end of the grouting process remove the temporary form from underneath the T-flange to prevent air entrapment where grout materials join. Steel packing straps can be used below the flange of the base tower and worked slowly

back and forth to encourage the flow of the grout at the point where the last grout joins the first pumped material. Do not use chains, as these might entrap air.

PU-foam used as temporary form

7. Curing

All BASF cementitious products require thorough curing in order to achieve their full potential in strength and durability. Premature drying harms grouts, not only the strength and durability suffer loss, but more importantly, the chemical action that reduces or eliminates drying shrinkage after hardening. Properly cured, Masterflow 9200 provides however continued bearing even at later age.

Curing is generally accomplished in two steps and these should commence immediately after the grout placement.

1. Preventing Early Moisture Loss, Plastic State:
Cover exposed, freshly placed grout with damp clean cloths as soon as possible after placing or protect from wind and direct sunshine with plastic sheets. Maintain this curing until final set and/or exposed grout is to be finished.
Then follow No. 2 below. Final set can be determined as that time at which one cannot penetrate the grout with a pointed trowel.

2. For Long-Term Curing in the Hardened State:
As soon as final set occurs, remove damp cloths or plastic sheets and trim shoulder or finish as desired.
NEVER remove forms or cut back grout below underside of unit grouted BEFORE grout has hardened. Immediately thereafter, liberally apply Masterkure curing agents on all exposed grouts. Applying curing compound by brush is preferred to spray, to avoid waste and not spray the agent over the T-flange of the base tower.
Curing compounds are difficult to remove from intricate metal parts.

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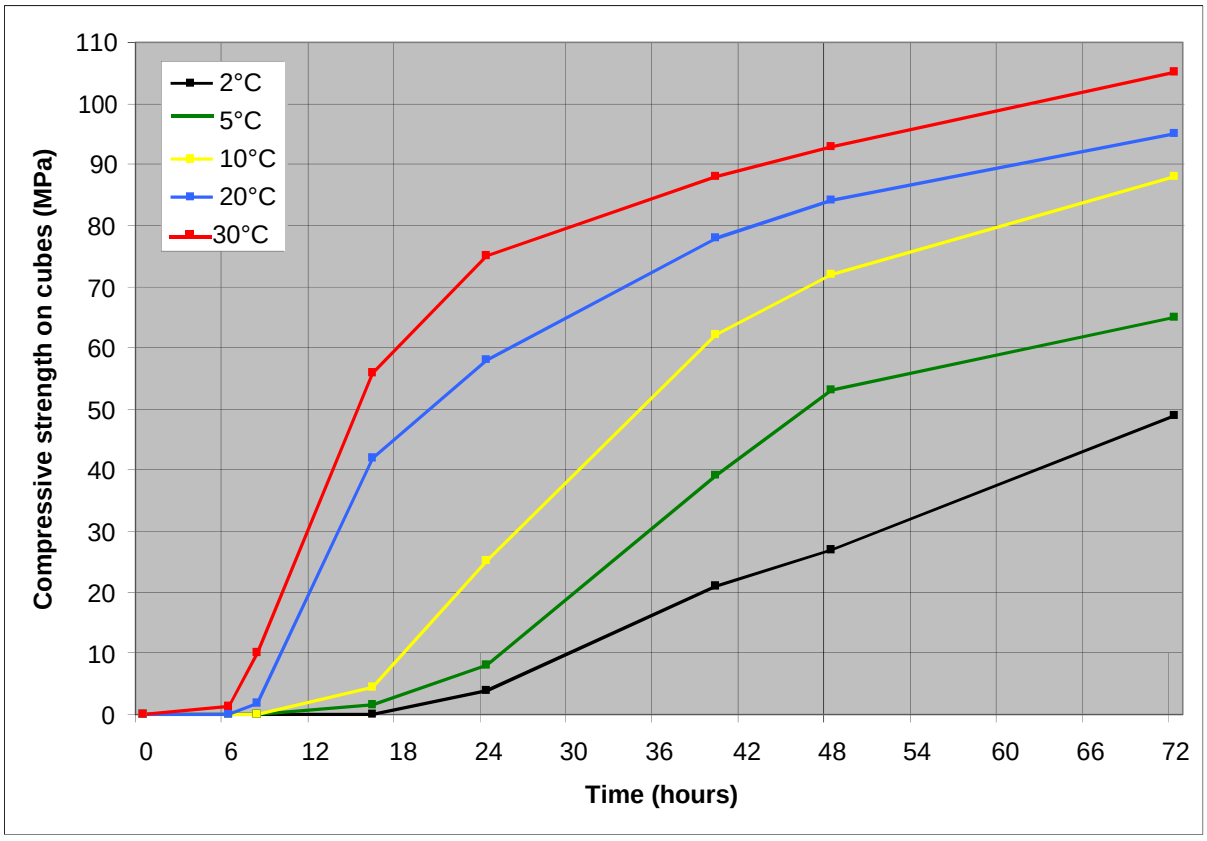
8. Hardening rate at different temperatures

Typical hardening rates at different temperatures (curing conditions, powder, water, molds all at given temperature) are shown in the following graph.
These values are indicative only and can vary depending on mixing water demand, environmental conditions, installation conditions etc…
Compressive strength development results have been measured on 75 mm cubes.



Typical early age hardening rates for Masterflow 9200

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Enclosure 2: Detailed equipment description

A. Mixing equipment

To be filled out once project has been chosen

B. Pumping equipment and hoses

To be filled out once project has been chosen

Enclosure 3: Checklist before start

A. Grouting pump

To be filled out once project has been chosen

B. Mixers

To be filled out once project has been chosen

Enclosure 4: Quality assurance sheets

A. Quality document No. 1:

Certificate of conformity / analysis for Masterflow 9200 delivered to the project

BASF Construction Chemicals will provide certificate of conformity / analysis for the material delivered to the project on request.

Enclosure 4: Quality assurance sheets (continued)

B. Quality document No. 2:

Sampling of material and preparation of cube specimens on the offshore jobsite:

Cubes or prisms representing the grout under each wind turbine base are to be made. All samples are marked uniquely. The samples are de-molded after 24 hours (or later dependent on the installation temperature) and stored under water at 20 degrees until the compressive strength is to be measured, typically after 28 days.

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Sampling

During the grouting of each tower base, samples of Masterflow 9200 grout are taken. The samples of Masterflow 9200 grout are taken from the mixer/pump hopper immediately after completion of mixing. The samples should be taken evenly during the whole operation.

Measuring the consistency

Consistency of the freshly mixed material is typically measured using the ASTM C230 method (without additional shocks). This gives a good indication of the quality of the mixed material. The spread of flow measured with this method should be ≥ 25 cm at 20°C.

Casting of specimens

During casting, the samples are not subjected to vibration. After the mold has been half filled with Masterflow 9200 grout, it is dropped onto the table min. 5 times from a height of ca. 1 cm. This is repeated when the mold has been completely filled. The top of the mold is levelled by the use of a steel tool.

Curing conditions:

The free surfaces of the cast specimen are protected against evaporation by fitting a cover (plastic or similar) over the surface immediately after casting. 24 hours after casting (dependent on the temperature) the specimens are de-molded.

The samples are stored under water at 20°C until compressive strength is measured.

Additional samples can be made for storage under jobsite conditions, in order to verify
the strength development and to determine the time for pre-stressing the tension bolts.

Marking

Upon de-molding of the samples, they are marked with the tower ID and an individual number.

Testing:

The samples are stored and tested at a laboratory, which has equipment and expertise for testing Masterflow 9200. The samples are tested at 28 days maturity.

The expected compressive strength at 20°C is > 120 MPa.

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Enclosure 4: Quality assurance sheets (continued)

C. Quality document No. 3:

On-site quality monitoring

This sheet covers the quality activities to be performed for each transition piece to be grouted on the installation.

Tower ID No	

Date	**Time** Start Stop

Air temp.	**°C**	**Grout temp.**	**°C**

For each annuli “x” test-specimen are made.

Time	**Marking**	**Comments**	**Time**	**Marking**	**Comments**
1			6		
2			7		
3			8		
4			9		
5			10		

In the event that the water dosage, mixing time etc. is changed and deviates from the grouting procedure, comments should be given below (including information about batch number, deviation, reason and result).

	Deviation	**Reason**	**Result**

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Enclosure 4: Quality assurance sheets (continued)

D. Quality document No. 4:

Documentation of complete grouting of cavity

To document that each of the cavity is filled with Masterflow 9200 grout according to scope of work, the following should be checked and verified for each annulus.

Tower ID no.:_____

Date:_____

Description	Verified	Comments
Compare theoretical required volume with the actually pumped volume.		
Visual verification that Masterflow 9200 grout material has reached the correct level.		

Verified on site by:

_____ _____

On behalf of Company *On behalf of Masterflow 9200 grouting contractor*

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Enclosure 5: Personal protection equipment

Additional information to be filled out once project has been chosen

Enclosure 6: MSDS of Masterflow 9200

To be added once project has been chosen. Most actual MSDS available from BASF Construction Chemicals or on the website www.basf-cc.dk

Enclosure 7: Handling and storing of Masterflow 9200 after delivery to the project

To be filled out once project has been chosen

Enclosure 8: Daily report sheets

To be filled out once project has been chosen

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