

STANDARDS FOR MIXING WATER IN CONCRETE

Disclaimer: This information summarizes requirements for mixing water for use in ready mixed concrete and is intended for educational purposes of persons qualified to understand the intent and purpose. NRMCA is not responsible for misinterpretation and misuse of the content of this summary.

In October 2004 ASTM approved two new standards that address mixing water for use in concrete. While the requirements for water were addressed in ASTM C 94, increased pressures on concrete producers to use process water from concrete production operations and other recycled sources created a need for a more comprehensive coverage on standards for water. This resulted in two new standards developed through the ASTM consensus process – one a specification for water and the other a test method that specifically covers measurement of density and solids content in process water:

ASTM C 1602/C 1602M-04 - *Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete*

ASTM C 1603/C 1603M-04 - *Standard Test Method for Measurement of Solids in Water*

ASTM C 1602

This is a performance based specification that allows a concrete producer to qualify a source of water for use in concrete. The standard defines the following sources:

Potable water – that which is fit for human consumption

Non-potable water – other sources that are not potable, that might have objectionable taste or smell but not related to water generated at concrete plants. This can represent water from wells, streams or lakes.

Water from concrete production operations – process (wash) water or storm water collected at concrete plants.

Combined water – a combination of one or more of the above defined sources recognizing that water sources might be blended when producing concrete. All requirements in the standard apply to the combined water as batched into concrete and not to individual sources when water sources are combined.

Mixing water in concrete includes batch water added when ingredients are batched into a mixer, ice, water added by the driver, free moisture on aggregates and water introduced in any significant quantity when admixtures are used.

Requirements for use

Potable water can be used without testing or qualification.

When other sources are used in whole or when two or more sources are blended, the water has to be qualified by tests. The primary requirements for this qualification are strength and set time to the limits in Table 1.

TABLE 1 - Concrete Performance Requirements for Mixing Water (Mandatory)

	Limits	Test Methods
Compressive strength, min % control at 7 days ^A	90	C 31/C 31M, C 39/C 39M
Time of set, deviation from control, h: min ^A	From 1:00 early to 1:30 later	C 403/C 403M

^A Comparisons shall be based on fixed proportions for a concrete mix design representative of questionable water supply and a control mix using 100 % potable water or distilled water.

These requirements are the same as were in previous versions of ASTM C 94. The change is that while previously strength and set time was tested on mortars and pastes, the current standard requires them to be tested on concrete using standard cylinders (ASTM C 39) and the measurement of set time by penetration resistance of mortar extracted from concrete samples, ASTM C 403.

The intent is to test and qualify water on one type of concrete mix typically produced at that concrete plant. Requirements for the control mix with tap water and the test mix with the proposed water are provided in the Annex. Basically the batches should contain the same materials. The water content of the test batch should not be less than that of the control batch, the air content should be within 1.5% and dosage of other admixtures such as water reducers should be the same. The temperature of the batches should be similar and no set controlling admixtures should be used in the test batch. The use of hydration stabilizing admixtures, if they will be used to treat process water, is permitted.

The standard allows for testing to be conducted on samples from production batches or on laboratory batches made in accordance with ASTM C 192.

The most critical water combination proposed for use should be tested and qualified. Water combinations at levels less than that qualified can be used. For instance if a producer tests non-potable water from a pond at 100% of the mixing water, all other combinations where that water is blended with city water are permitted. If a producer tests wash water at 100,000 ppm (10%) solids content and it complies with the requirements of Table 1 water at that and lower solids content are permitted.

Optional requirements

The other requirement is for the producer to test and maintain documentation on the chemistry and solids content of the mixing water. This is considered an “optional” requirement that the producer needs to comply with only if the purchaser specifically invokes one or more of these requirements when the order is placed.

TABLE 2 Optional Chemical Limits for Combined Mixing Water

Max concentration in combined water	Limits, ppm	Test Methods
Chloride as Cl ⁻ prestressed other reinforced concrete	500 1000	C 114
Sulfate as SO ₄	3000	C 114
Alkalies as (Na ₂ O + 0.658 K ₂ O)	600	C 114
Total solids by mass	50,000	C 1603

The requirements in Table 2 also remain unchanged from the previous version of C 94 except for the reference test methods.

These provisions apply to the combined mixing water. So for example if the producer tests a source of water but only proposes to use it at 50% of the mixing water with the rest being city water, the dilution factor will be applied to the tested concentrations when reporting this information.

Testing Frequencies

One of the sticky points in getting this specification agreed upon in ASTM was on how often should a producer test the water sources. The following table summarizes the testing frequency requirements.

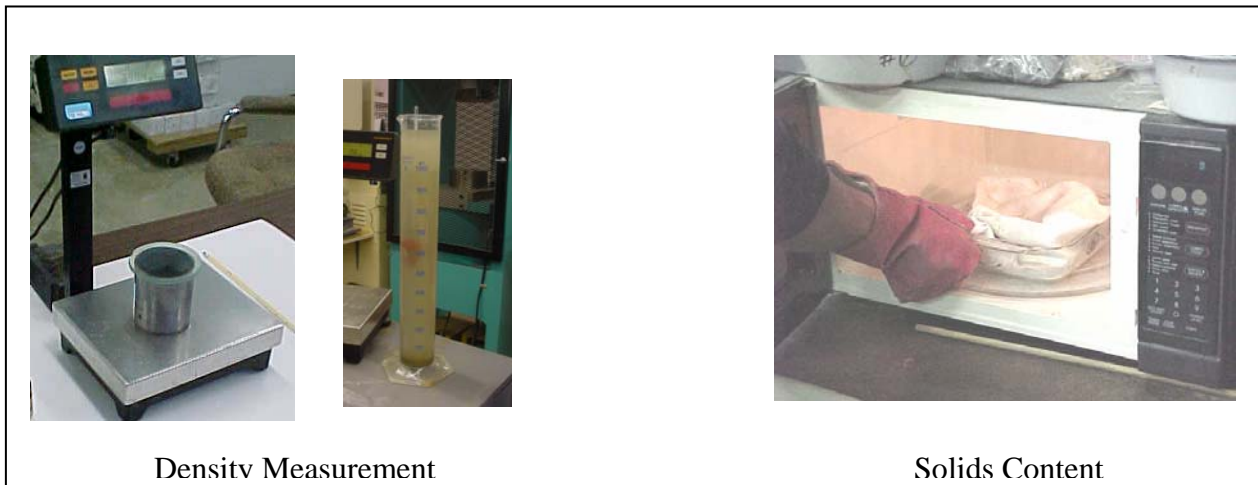
Water source	Density	Table 1	Table 2
Potable		No testing	
Non Potable	N/A	3 months /(4)/ annual	6 months
Wash Water (based on density)			
< 1.01	Daily	6 months /(2)/ annual	6 months
1.01 – 1.03		Monthly /(4)/ 3 months	
>1.03		Weekly /(8)/ monthly	

Non-potable sources of water and that from concrete production should be tested before first used and thereafter at frequencies listed for tests in Table 1 and 2. Testing frequencies of strength and setting time can be reduced when the number of consecutive tests in () comply with the requirements of Table 1. The testing frequencies for wash water depend on the density of the combined water (not wash water) proposed for use. Density less than 1.01 represents the situation of using clarified wash water from a sedimentation pit. The density of 1.03 represents a solids content of 50,000 ppm. Testing frequency to qualify water sources increases when the producer plans to use water at higher solids content. If the intent is to use water at higher than 1.03 (50,000 ppm), water should be tested weekly and after 8 tests are collected and meet the requirements, the frequency can be reduced to 1 per month.

When wash water is used, density should be tested daily. Chemistry of non-potable and wash water sources for compliance with Table 2 should be tested once every 6 months.

ASTM C 1602

This method provides procedures to measure the density of wash water or storm water that contains suspended solids. The sample of water should be taken carefully so that it contains the representative solids content and transferred to a measure of known volume of at least 200 mL. The volume of the measure should be calibrated by weighing it full with tap water in accordance with procedures in ASTM C 29. The procedure is the same as used for calibrating unit weight buckets or air meter bases. The top of the measure should be covered with a glass or Plexiglas plate and weighed. The water sample is then put into a Pyrex dish and placed in a microwave oven and dried. The weight of solids in the water sample is then determined. This provides the density and solids content of the water. A hydrometer is permitted but due to rapid settlement of solids the weighing method is preferred.



The solids content in parts per million (ppm) is calculated by:

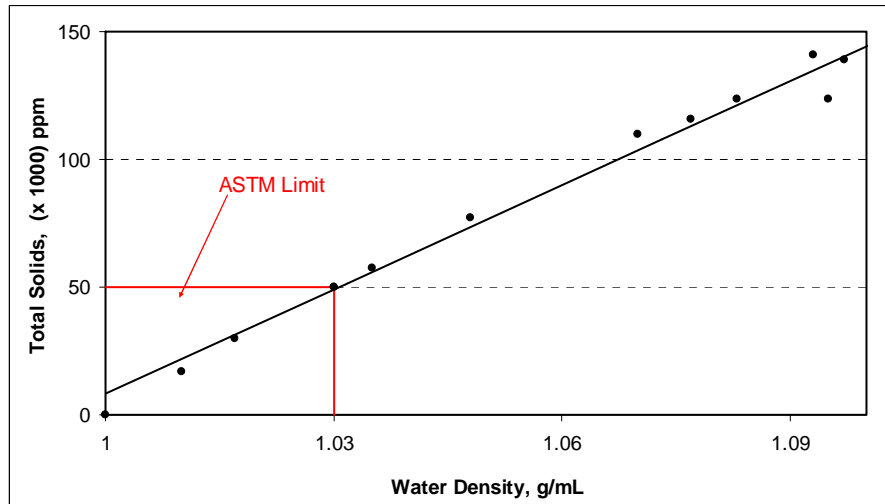
$$S_{\text{ppm}} = \frac{M_s}{M_w} \times 1,000,000$$

Where:

- S_{ppm} is the solids content in ppm
- M_s is the mass (weight) of the solids after drying
- M_w is the mass (weight) of the water sample

Relationship between Density and Solids Content

By measuring the density and solids content at several levels, a relationship can be established. A plot such as one below can be developed along with a regression equation that describes the relationship using any spreadsheet software.



From this chart the density measured during regular production can be used to quantify the solids content in the wash water.

If the relationship above is not developed, the standard allows the user to use the following equation to calculate the solids content from the measured density:

$$S_{\text{ppm}} = \left(\frac{D_w - 1}{D_s - 1} \right) \times \frac{D_s}{D_w} \times 1,000,000$$

Where: D_w is the density of the water
 D_s is the density of the solids in the water.

A simplified form of this equation can be obtained by using a value of 2.6 for the density of the solids, D_s :

$$S_{\text{ppm}} = 1,625,000 \times \left(1 - \frac{1}{D_w} \right)$$

Batching blends of wash water and tap water

The appendix of C 1602 provides some guidance on blending two sources of water to comply with a target solids content.

When the solids content is known the percentage of each water source can be determined by:

$$P_1 = \frac{S_T - S_2}{S_1 - S_2} \times 100$$

When the density of water is known the following equations apply:

Water batched by weight use:

$$P_1 = \frac{D_T - D_2}{D_1 - D_2} \times \frac{D_1}{D_T} \times 100 \text{ or}$$

Water batched by volume use:

$$P_1 = \frac{D_T - D_2}{D_1 - D_2} \times 100$$

Where: P_1 is the percentage of water source 1
 D_T and S_T is the target solids content of the mixing water (spec limit)
 D_1 and S_1 is the density of water source 1, respectively
 D_2 and S_2 is the density of water source 2

Example:

If the solids content of water in an agitated slurry (source 1) from a reclaimer system is 10,000 ppm and it needs to be blended with city water (assume solids content is 0 ppm), and the specification allows the mixing water content to not exceed 50,000 ppm, the percentage of slurry in the blended water can be calculated as:

$$P_1 = \frac{S_T - S_2}{S_1 - S_2} \times 100 = P_1 = \frac{50,000 - 0}{120,000 - 0} \times 100 = 42\% \text{ slurry}$$

If the total batch water is 32 gallons per cubic yard, the producer would use 13 gallons of slurry and 19 gallons of city water. This will keep the solids in the wash water to below the target limit of 50,000 ppm.

ASTM Standards can be obtained from ASTM International at www.astm.org



National Ready Mixed Concrete Association
900 Spring Street
Silver Spring, Maryland 20910
(301) 587-1400
www.nrmca.org