



Concrete Plant International
North America Edition

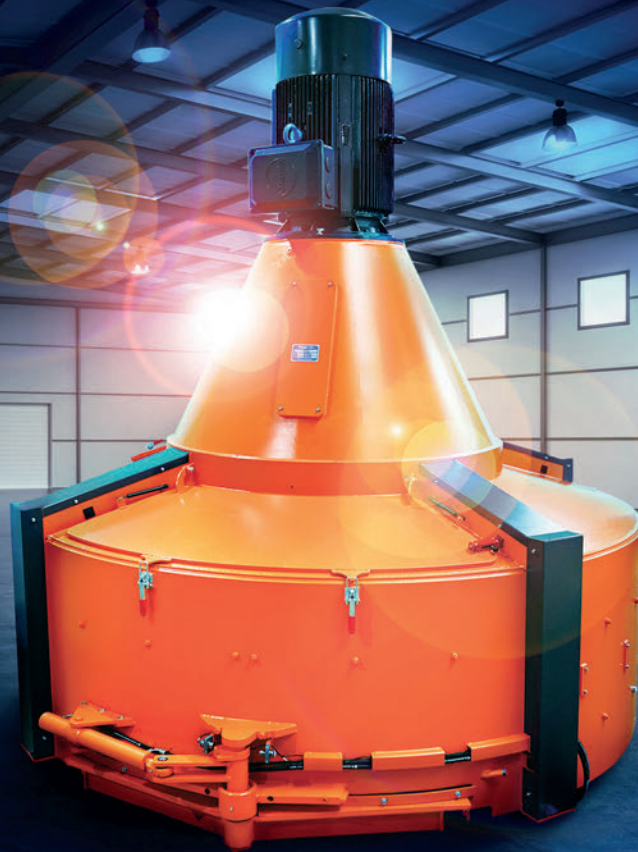


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Useful tool

Meeting Temperature Requirements in Concrete Construction with Infrared Thermometers

■ Luke M Snell, Xenia, USA

There are many specifications and recommended practices that require taking temperatures at the batch plant or on the job site. The one we are most familiar with is determining the temperature of the fresh concrete. This is one of the required fresh concrete tests and the detail of doing this test is spelled out in ASTM C1064. It requires a calibrated thermometer to be inserted into the fresh concrete 3 inches (75 mm) and the temperatures to be measured to the nearest 1 F (0.5 °C). This obviously requires a special thermometer that is capable of meeting these requirements.

This is just one of many times temperatures are required to be measured in concrete construction. In all other cases, the details on the thermometers to be used are not specified and it is up to the user to select a thermometer that can do the job. The infrared (IR) thermometer is the logical thermometer to use.

What is an IR thermometer

The IR thermometer is a “point and shoot” thermometer that determines the surface temperature of an object in a fraction of a second. It measures the infrared radiation that an object is giving off. All objects above absolute zero temperature give off IR radiation. The higher the temperature the more IR radiation is given off. This radiation is not visible nor is it harmful. It does, however, take special equipment i.e., an IR thermometer, to measure the amount of IR radiation. Since the amount of IR radiation is related to the temperature of the object, the IR thermometer can accurately determine its temperature. This is similar to using a thermometer with encapsulated mercury in it. When the temperature rises, the mercury expands. By having an accurate scale on the thermometer, the expansion of the mercury is used to determine the temperature. The major difference is the IR thermometer measures the IR radiation whereas the mercury thermometer measures the expansion of the mercury. Both thermometers indirectly help us determine what the temperature is.

Where can we use IR thermometers in concrete construction
The American Concrete Institute’s specifications and recommended practices have several references to where temperatures should be measured and where the IR thermometer is



IR thermometers: Top row is the pistol type, bottom row is the pocket type.

the only logical way to get the needed temperature and show compliance with these requirements.

Listed below are some of the references where the IR thermometer is appropriate to use to establish if the temperatures requirement are being met:

1. Do not place concrete on a surface that is less than 35 F (2 °C) **ACI 301,5.3.2.1b**
2. Cool reinforcements, embedments and forms if their temperatures are higher than 120 F (50 °C) **ACI 301, 5.3.2.1c**
3. When using curing blankets (cold weather), record the temperatures of the concrete at least twice a day and at several concrete locations that are under the curing blanket. **ACI 306R, 4.4**



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4. When heating aggregates (cold weather), make sure that there are no hot spots where the aggregate temperatures exceed 212 F (100 °C). Also make sure that the average temperature of the aggregates is below 150 F (65 °C) when added to the concrete batch. **ACI 306R, 5.6**
5. Embedments larger than 1 square inch (650 square mm) must be above 10 F (-12 °C). **ACI 306R, 6.2**
6. Do not place concrete on a frozen sub base. **ACI 306R, 6.3**
7. When moist curing, water should be no more than 20 F (11 °C) cooler than the concrete. **ACI 305R, 6.2.6**
8. Concrete temperatures should be no more than 30 F (17 °C) different than the temperature of the base at the time of placement. **ACI 302, 4.6**
9. Temperatures inside a building should be maintained at 50 F (10 °C) during the placing, finishing, and curing of a concrete slab. **ACI 302, 4.6**
10. When installing adhesive anchors, the concrete temperature must be within the manufactures temperature limits. **ACI-CRSI Certification, Adhesive Anchor Installer, Chapter 4**

How do you select an appropriate IR thermometer?

There are several IR thermometers available that vary in cost and the temperature range they are capable of measuring. It is important to have a way of evaluating which IR thermometer will meet your needs. Below are the specifications I have used to select an IR thermometer for concrete construction.

1. Able to measure temperatures within a range of -20 to 300 F (-30 to 150 °C).
Most IR thermometers will have a wider operating range than the one introduced above and will be acceptable to use. The expensive IR thermometers will have a much higher operating range that you do not need and are not worth the extra cost.
2. Have a fixed emissivity of 0.95.
Being able to vary the emissivity is not necessary for concrete construction. All of the materials you will be measuring the temperatures will have an emissivity close to 0.95 value. An IR thermometer with a fixed emissivity of 0.95 is adequate.
3. Accuracy of the reading to be at least 3 %, ±4 F (2 °C).
Although most IR thermometers will provide temperature readings to 0.1 degrees, its accuracy is only as given above. Most IR thermometers are much more accurate than given in their product specifications and will provide adequate temperature measurements for concrete construction.



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Performing the ice cube test: The IR thermometer is providing accurate readings if the indicated temperature is 32 F (0 °C) ±4 F (2 °C).



Estimating the temperature of fresh concrete as it enters the chute. This temperature is approximately the same as the required ASTM temperature test.

4. Adjustable to either Celsius or Fahrenheit readings. All IR thermometers I have used allows the user to easily change temperature readings from Celsius to Fahrenheit. Most users will set the IR thermometer to read one of the temperature scales and never change that setting. Once the appropriate temperature scale has been selected, all of the temperatures will be on that scale and the user will not need to reset the scale setting. Note the display will show an F if it is on the Fahrenheit scale and a °C if it is on the Celsius scale. There will be no confusion about what scale you are reading.
5. It uses batteries that are available and easy to replace. Most IR thermometers will use a 9 V, AAA, or flat batteries. I find the ones with flat batteries are slightly more difficult to replace.
6. Has a laser pointer
Laser pointers are not necessary and it does not influence the temperature readings. It does help the user to identify the object you are taking its temperature. Usually, an IR thermometer with a laser pointer will cost slightly more than those that do not have a laser pointer. The laser pointer assures the user of which object they are measuring its temperature. Thus, the laser pointer is worth the slightly extra cost.
7. The Dot to Spot Ratio (D:S) should be at least 4:1. The Dot to Spot Ratio (D:S) tells the user how close you need to be to an object to determine its temperature. For example, if the D:S is 4:1, to determine an accurate temperature of a 1 inch (25 mm) water pipe, you would

- need to keep the IR thermometer within 4 inches (100 mm) of the water pipe. The D:S Ratio of 4:1 will allow you to be a safe distance from the object you are taking its temperature. This can keep you out of harm's way. In concrete construction, you can get relatively close to the objects that you need to take its temperature. A high D:S ratio is not needed.
8. Select the IR thermometer that has favorable customers' reviews. These reviews are available on the internet. Some of the available IR thermometers are poorly made and are basically toys. When you go on the internet, you will be able to read the customer's reviews that explain their successes or failures with this brand of IR thermometer. For those that need or want to buy American made products, you can also find out where the IR thermometer was made.
9. Select the style of IR thermometer that you can easily store and use (Pistol shaped or Pocket). Most IR thermometers are either shaped like a pistol or are small and compact so that it can fit into your pocket (called a pocket IR thermometer). Pocket IR thermometers are easy to store and in cold weather one can keep them in a pocket, so the body heat keeps it warm and within the recommended operating temperature range. You can do the same thing with a pistol IR thermometer however it is bulkier in your pocket and not as comfortable to carry. Both IR thermometers are acceptable - the choice is entirely up to the user.

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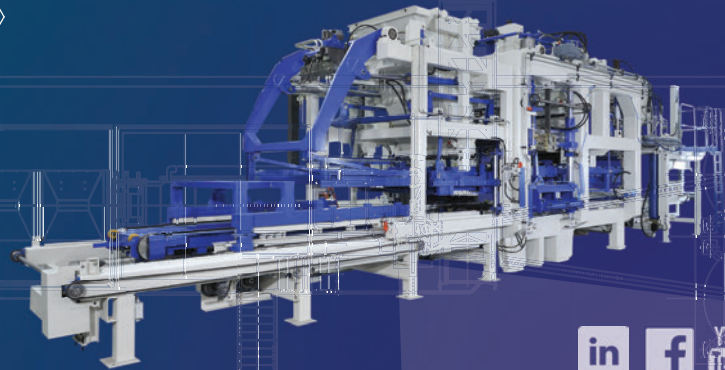
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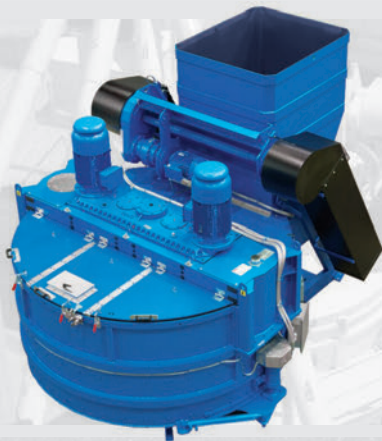


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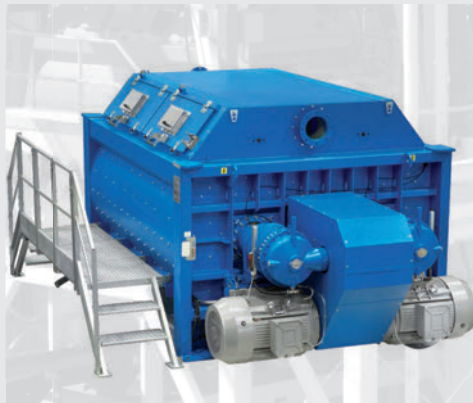
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10. Do not select the IR thermometers that are used to measure a person's temperatures for concrete construction. These IR thermometers are designed for a specific use and a selected temperature range. These IR thermometers are easily identified in their project description and on their packaging.

Best procedures for accurate temperatures with the IR thermometer

The IR thermometer is easy to use. You simply point at an object and push the button or trigger and the temperature of the object is displayed. There are some simple procedures you should follow to make sure you get an accurate temperature.

1. Hold the IR thermometer as close to the object as possible while keeping yourself at a safe distance when taking a temperature. Remember the D:S ratio. You must be relatively close to the object to get an accurate temperature but you must also keep yourself out of harm's way.
2. Use the laser pointer to make sure the IR thermometer points at the object you want its temperature. The laser helps you pinpoint the exact location where the temperature is being measured.
3. Do not point the laser at a person's eyes. It is a class II laser and can damage a person's eyesight. It is not a toy and the user should not play with the laser pointer.
4. Do not take the temperature directly of a shiny object. The laser will reflect off the shiny object and can reflect into your or other people's eyes. If it is necessary to take the temperature of a shiny object, the recommended procedure is to attach black tape to the object and wait two minutes for the temperature on the tape to stabilize. Then take the temperature by carefully focusing the laser beam only on the black tape.
5. Do not take a reading through a window. The temperature will be a combination of the temperatures of the window and what is outside the window and the temperature will be inaccurate. You must take the temperature directly on the desired object.
6. Clean the lens and IR thermometer often with a soft cloth or tissue. Remember that construction sites can be dusty. To keep the IR thermometer working correctly, it should be kept as clean as possible.
7. Do not take a reading when it is dusty or smoky. Dust and smoke in the air will influence the amount of Infrared radiation that the IR thermometer will receive. The temperature readings under these conditions will be inaccurate.
8. Remember the IR thermometer is an electronic piece of equipment.

It must be stored and handled carefully. The IR thermometer should not be thrown into the tool box along with your other tools. Keep it in a protected and in safe place when it is not in use.

9. Calibrate the IR thermometer when you buy it to make sure it is working properly and you are using it correctly. The simplest way to check your IR thermometer is to perform the ice cube test:
 - a. Fill a glass with ice
 - b. Pour water into the glass until the glass is full of water and ice
 - c. Wait at least two minutes for the temperature of the water to stabilize
 - d. Take 5 readings of the water (not the ice)
 - e. Your IR thermometer is providing accurate readings if all the measured temperatures are at 32 F (0 °C) +/- the accuracy the manufacturer stated on their data-sheet. If the reading are outside this range, replace the IR thermometer.
10. If you think your IR thermometer may have been damaged or you suspect the readings might be in error, do the ice cube test as shown above. This test is also useful for the first time user to gain confidence in using the equipment.
11. Remember the IR thermometer is not a toy. The user needs to be reminded that the laser can damage a person's eye and they need to be careful when using the IR thermometer. Also remember that the IR thermometer is not a toy for children to play with.

Concluding thoughts

Once you become familiar with using your IR thermometer, you will likely find many other uses. Mechanics, equipment operators and car enthusiasts can use the IR thermometer to locate hot spots in a motor. Building inspectors and homeowners will evaluate the efficiency of heat/cooling systems or heat loss around windows. You may just want to show off your IR thermometer to your fellow workers by making sure your coffee is at your desired temperature. Once you become familiar with the IR thermometer it will become a valuable tool and you will find many more uses. ■

References

For those that want more information about using IR thermometers in concrete construction, the following articles are recommended:

- [1] Snell, L.M, and Cheek, M.A., "Estimating Fresh Concrete Temperatures," Concrete International, June 2006, pp. 49 - 51.
- [2] Snell, L., and Cheek, M., "Using Infrared Thermometers in Concrete Construction," Concrete Plant International, Feb. 2007, pp 40 - 42.
- [3] Snell, Luke M "Monitoring Temperatures in Concrete Construction Using IR Thermometers" Concrete International, January 2015, pp 59-63.