Section 9.4
Volume II

MASS CONCRETE CONTROL PLAN

9.4.1 PURPOSE

This document provides guidance for the preparation and implementation of the Mass Concrete Control Plan (MCCP) when required by the Florida Department of Transportation (FDOT), herein after called the Department. The guide also describes the responsibilities of the Contractor's Specialty Engineer in the preparation, submittal, and follow-up of the MCCP.

9.4.2 AUTHORITY

Sections 20.23(3)(a), 334.044(2), 334.044(10)(a), and 334.048(3) Florida Statutes.

9.4.3 SCOPE

The principal users of this document are Contractors and Contractors' Specialty Engineers.

9.4.4 REFERENCES

American Society for Testing and Materials (ASTM) Standard Test Methods and Specifications.

American Association of State Highway and Transportation Officials (AASHTO), Part II Tests.

American Concrete Institute (ACI), Reports of the Technical Committees.

Code of Federal Regulations (CFR), Federal-Aid Policy Guide (FAPG), Subchapter G – Engineering and Traffic Operations, Part 637 – Construction Inspection and Approval, Subpart B – Quality Assurance Procedures for Construction.

Florida Department of Transportation Approved Products List (APL).

Florida Department of Transportation Construction Project Administration Manual (CPAM).

Florida Department of Transportation Standard Specifications for Road and Bridge Construction (Specifications).

Florida Department of Transportation Sampling and Testing Methods (FSTM).

ACI PRC 207.1 Mass Concrete – Guide.

ACI 207.2R Report on Thermal and Volume Change Effects on Cracking of Mass Concrete.

ACI 207.4R Report on Cooling and Insulating Systems for Mass Concrete.

ACI 224R Control of Cracking in Concrete Structures

ASTM C157/C157M Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete. ASTM International, West Conshohocken, PA.

FM 5-621 Florida Method of Test for Optimizing Aggregate Gradation for Portland Cement Concrete. Florida Sampling and Testing Methods, Florida Department of Transportation, Gainesville, FL.

Gajda, John and Feld, Jon (2015), When Should Mass Concrete Requirements Apply, Aspire Vol. 9, No. 3, Summer 2015, pp. 44-45.

Zayed, Abla et al. (2021), Correlation of Slag Cement Composition with Durability of Portland Cement-Slag Concrete, BDV25-977-63, Florida Department of Transportation, 335 pages.

9.4.5 GENERAL INFORMATION

The ***Contract Documents*** identify all structural elements considered to be mass concrete. The Contractor's Specialty Engineer must develop an MCCP in accordance with the ***Specifications Section 346*** and this Section of the Materials Manual and submit it for the Department's review and approval.

The MCCP shall include calculations for each mass concrete element, ensuring that the maximum allowable concrete core and differential temperatures are in accordance with ***Specifications Section 346***.

The Contractor shall record core and differential temperatures for all structures identified in the Contract Documents and monitor only the elements indicated in ***Specifications Section 346***.

9.4.6 MASS CONCRETE CONTROL PLAN PREPARATION, REVIEW, AND APPROVAL PROCESS

Prepare the MCCP in accordance with ***Appendix A***. Submit for review the MCCP along with the following two forms to be completed by the Contractor: 1) the Project Personnel Contact Information Form, and 2) the Mass Concrete Field Report Form to the Project Administrator (PA). Example forms are shown in ***Appendices B.1*** and ***B.2*** and copies can be requested from the State Materials Office (SMO).

The PA will review the submitted MCCP and forward it to the District Materials and Research Office (DMRO). After reviewing the MCCP, the DMRO will submit it to the SMO. The SMO will approve the MCCP or return it for revision.

Address all comments and suggestions for a returned MCCP and submit the revised MCCP to the SMO, PA and DMRO. The revised MCCP will be approved when all the comments and suggestions have been satisfactorily resolved.

Construction of the structural elements covered by the MCCP can proceed once the MCCP is approved.

9.4.7 MASS CONCRETE MIX DESIGN

Consider the following recommendations when selecting a concrete mix design:

(1) Maximum total cementitious material content of 752 lb/yd^3.

(2) Maximum water content of 275 lb/yd^3.

(3) Use an optimized aggregate gradation (OAG) in accordance with ***FM-5-621***.

(4) When possible, select concrete mix designs approved for 56 days in accordance with ***Specifications Section 346***.

9.4.8 TEMPERATURE CONTROL MEASURES

Calculate concrete core temperatures and core-surface temperature differentials using ambient air temperatures of 45°F, 55°F, 65°F, 75°F, 85°F, and 95°F. Determine the maximum estimated core temperatures and temperature differentials for each ambient temperature as a function of concrete placement temperature. An example of the Department's adiabatic temperature rise data for portland cement types I/II and IL is included in ***Appendix C***.

Specify the maximum allowable concrete placement temperature provided that the maximum and differential temperatures are not exceeded.

Provide a post-cooling pipe system design when the calculated maximum and differential temperatures exceed the allowable limits for the anticipated concrete delivery temperature.

Calculate the water flow rates required based on the temperature of the water source to be used.

Include the following items in the MCCP based on the assumptions used for the temperature calculations:

(1) The minimum insulation to control the differential temperatures.

(2) The process to be followed during curing if the differential temperature is rising and reaches 31°F.

(3) The pre-cooling measures to be taken, if any.

(4) The post-cooling procedures to be used, if any.

(5) Measures to prevent thermal shock of the concrete.

9.4.9 INSTALLATION OF TEMPERATURE MEASURING AND RECORDING DEVICES

(1) Provide information on the temperature measuring and recording devices to be used, as well as any remote monitoring devices and software.

(2) Indicate the locations of the temperature sensors clearly on the approved shop drawings. Use a backup sensor in each location.

(3) Position the surface temperature sensors 2.00 ± 0.25 inches inside the concrete and secure them to a fixed element such as reinforcing steel.

(4) Position the core temperature sensors at the expected location of the maximum temperature. When cooling pipes are to be used, position the core sensor equidistant between the nearest cooling pipes.

(5) Position the ambient temperature sensor in a location near the element and protect it from direct exposure to rain, sun, and sources of radiated heat, such as concrete or asphalt pavement surfaces.

(6) Ensure that the sensors record temperatures at least once an hour, starting at the end of concrete placement, and continue until the core-ambient temperature differential has remained less than 50°F for 24 hours.

(7) Take immediate actions when the core to surface temperature differential is rising and reaches 31°F or when there is an adverse weather event.

9.4.10 PRE CONCRETE PRODUCTION MEETING

The Specialty Engineer or designee should participate in the pre concrete production meeting to ensure that the following items are discussed:

(1) The availability of a concrete production facility to supply concrete at a rate sufficient for the total volume to be placed in the allotted time without interruptions and at the required placement temperatures.

(2) Thermal control materials and processes to reduce differential temperatures.

(3) Methods to protect the structures from detrimental environmental conditions such as excessive surface evaporation, rain, flooding, etc.

(4) Precautions to be taken for any sequential concrete section placement.

(5) Alternative plans of action to follow if there are interruptions in concrete delivery, placement, and curing, or if other unexpected jobsite conditions arise, including equipment failure and lack of resources needed.

(6) Protection of concrete surface immediately after concrete placement. Include protective structures, actions if there is exposure to ground water, salt water, or brackish water, and availability of replacement materials.

9.4.11 MCCP COMPLIANCE REQUIREMENTS

Any modifications to the MCCP must be submitted as addenda to the original MCCP for SMO review and approval. The addendum must include the justification for the proposed changes.

Prior to the first concrete placement of each concrete element, ensure that the installation and operation of the temperature measurement and recording devices is acceptable.

The underlaid seal concrete should be free from untreated structural cracks (crack width greater than 0.004 inch or crack depth greater than 0.5 inch).

9.4.12 RESPONSE TO HIGH CORE-SURFACE TEMPERATURE DIFFERENTIAL

If the core-surface temperature differential is rising and reaches 31°F, provide instructions on corrective actions to be taken, such as adding another layer of insulating blankets or supplying additional heat evenly to the surfaces to reduce the differential.

Temporarily have the element monitored more frequently until the temperature differential is stable or decreasing, then resume original monitoring frequency.

9.4.13 EXCEEDANCE OF MAXIMUM ALLOWABLE TEMPERATURE OR TEMPERATURE DIFFERENTIAL

The approval of the MCCP shall be revoked for any exceedance of the maximum allowable temperature values. Instruct immediate corrective actions when either the core temperature or the temperature differential of any mass concrete element exceeds, or based on the observed temperature profile, is expected to exceed its maximum allowable value. The Contractor shall submit an Engineering Analysis Scope in accordance with ***Specification Section 346***.

The Department may waive revocation of the MCCP when an exceedance of the maximum temperatures is not related to an inadequacy of the MCCP.

Revise and resubmit the MCCP based on the conclusions of the Engineering Analysis Report. Ensure that no concrete is placed until the revised MCCP has been approved in writing by the SMO.

9.4.14 SUBMISSION OF MASS CONCRETE FIELD REPORT

Submit to the SMO, within three workings days after completion of temperature recording for each mass concrete element, a Mass Concrete Field Report as an editable electronic spreadsheet that includes:

(1) Project information.

(2) Element identification.

(3) Date and time of any changes to the temperature control measures.

(4) All original electronic temperature readings.

(5) Any relevant curing notes.

The Mass Concrete Field Report shall include the Project Contact Information Table, Field Report Summary, and Temperature Data Log, examples of which are shown in ***Appendices B.2.1***, ***B.2.2***, and ***B.2.3***. Also submit data logger summaries and graphs and results of the visual inspection of each element.

9.4.15 CRACK INSPECTION OF CONCRETE SURFACES AFTER FORM REMOVAL

The Engineer Analysis will address the disposition of cracked concrete in accordance with ***Specifications Section 400***.

APPENDIX A

REQUIRED CONTENTS OF MCCP

A-1 Title Page (Order Is at Discretion of Specialty Engineer)

(1) Report Title
(2) Name of Contractor
(3) Project Name
(4) Financial Project Identification Number (FPID)
(5) County and FDOT District
(6) Location
(7) Date
(8) Specialty Engineer's Name and Company
(9) Specialty Engineer's Signature and Seal
(10) Lines for FDOT Approval and Date
(11) Page Numbers

A-2 Table of Contents

(1) List Relevant Entries and Page Numbers

A-3 Brief Description of the Project

(1) Location
(2) Names and Numbers of Bridges
(3) Types of Mass Concrete Elements to be Cast
(4) Project Environmental Classifications
(5) Mix Design Numbers of Mass Concrete to be Placed

A-4 Project Contact Information (Table to be Filled Out by the Contractor)

An example table is shown in ***Appendix B.1*** and electronic copies can be requested from the State Materials Office.

A-4.1 Project Information

(1) Project Name
(2) FPID
(3) District
(4) County
(5) Location

A-4.2 Phone Numbers, Email Addresses, and Company Names for the Following:

(1) Contractor's Specialty Engineer
(2) Contractor's Project Manager
(3) Contractor's Superintendent
(4) Contractor's Designees (Responsible for the installation of the temperature measurement and recording equipment, monitoring temperatures, and implement additional temperature control measures, if needed.)
(5) FDOT District Structural Materials Engineer
(6) FDOT District Materials Research Engineer
(7) FDOT District Concrete Manager
(8) FDOT Construction Project Manager
(9) CEI Senior Project Engineer
(10) CEI Project Administrator
(11) SMO Mass Concrete Specialist

A-5 Information Table for Mass Concrete Elements

(1) Environmental exposure for each element
(2) Element location and bridge number
(3) The number of each type of mass concrete element
(4) Dimensions of each element
(5) Concrete mix design used for each element
(6) Contractor-supplied unique sequential identification code for each element indicating the bridge number, location of element, type of element, least dimension size, and environmental exposure. List the abbreviations used by the Contractor for the identification codes.
(7) Provide a summary table listing the maximum concrete placement temperatures, maximum peak and differential temperatures, and estimated formwork removal ages for each concrete element at the listed ambient temperatures at time of concrete placement (see **Table A-1**).
(8) Indicate which elements will be actively monitored

Table A-1

Maximum Concrete Placement Temperatures, Maximum Peak and Differential Temperatures, and Estimated Formwork Removal Ages

Concrete Mix Design Number(s):							
Element Location, Type, and Dimensions	Ambient Air Temperature at Time of Placement	Maximum Concrete Placement Temperature	Post-Cooling Water Temperature (if used)	Calculated Temperature Rise	Peak Core Temperature	Maximum Differential Temperature	Estimated Age for Formwork Removal
	45°F						
	55°F						
	65°F						
	75°F						
	85°F						
	95°F						

APPENDIX B

Forms

Appendix B.1 Project Contact Information Table (To be Completed by the Contractor)

Copies of the Form Can be Requested from the State Materials Office

Base Information Table

Project Name:	ABC
FPID	XXXXXX-X-52-01
District:	Number
County:	Name
Location:	See contract documents

Include contacts to personnel directly involved in the project execution and can be reached during and after the project completion. **Information should be filled by the Contractor and CEI**. See ply "Contacts" for FDOT personnel information.

Position	Company	First and last name	Land Phone	Mobile Phone	Email Address
Contractor's Specialty Engineer					
Contractor's Project Manager					
Contractor's Superintendent					
Contractor's Designee					
Contractor's Designee					
Contractor's Designee					
Contractor's Designee					
District Structural Materials Engineer	FDOT				
District Materials Research Engineer	FDOT				
District Concrete Manager	FDOT				
FDOT Project Manager	FDOT				
CEI Senior Project Engineer					
CEI Project Administrator					
SMO Mass Concrete Specialist	FDOT				SM-MassConcrete@dot.state.fl.us

Notes:
1) Neither add rows nor columns.
2) Leave blank if not available.
3) Provide the resume of designee(s).

Acronym Key:
FPID: Financial number of the project
FDOT: Florida Department of Transportation
CEI: Construction Engineering and Inspection
SMO: State Materials Office

Appendix B.2 Example Mass Concrete Field Report (To be Completed by the Contractor)

This Excel Spreadsheet consists of a **Field Report Summary** tab, an **Hourly Temperature Data** tab, and a **Temperature Profiles** tab. A copy of this example spreadsheet can be requested from the State Materials Office Mass Concrete Specialist.

B.2.1 Example Field Report Summary

Mass Concrete Field Report	
1. Temperature Information	
1.1 Financial Project Identification Number (FPID)	XXXXXX-X-52-01
1.2 Project name or description	
1.3 District	Number
1.4 County	Name
1.5 Beginning of the concrete placement (date and time)	
1.6 End of the concrete placement (date and time)	
1.7 Mix design number	
1.8 Average ambient temperature at time of placement (°F)	
1.9 Average concrete temperature at time of placement (°F)	
Has Maximum Core Temperature Been Reached? (dropdown menu)	
1.10 Peak core temperature (°F)	Not Established Yet
1.11 Time of peak core temperature (Days)	
Has Maximum Differential Temperature Been Reached? (dropdown menu)	
1.12 Peak core-top or core-side differential temperature (°F)	Not Established Yet
1.13 Time of peak core-top or core-side differential temperature (Days)	
1.14 Peak core-bottom differential temperature (°F)	
1.15 Time of peak core-bottom differential temperature (Days)	
1.16 Time when core is within 50°F of ambient temperature (Days)	
1.17 Element type (footing, column, cap, abutment)	
1.18 Element dimensions L x W x H (ft)	
1.19 Element ID	
1.20 Bottom insulation material and thickness (footing)	
1.21 Side and top insulation	

2. Element Visual Inspection	
2.1 Date and time of visual inspection	
2.2 Did the element develop structural cracks?	
3. Cooling Pipes	
3.1 Average pressure in the system (psi)	
3.2 Average inlet flow rate (gpm)	
3.3 Average outlet flow rate (gpm)	
3.4 Average inlet water temperature (°F)	
3.5 Average outlet water temperature (°F)	
3.6 Running time (Days)	
3.7 Material (PVC, CPVC, PE, etc.) and schedule of pipe	
3.8 Nominal diameter of the pipe (in.)	
3.9 Actual volume of grout (ft^3)	

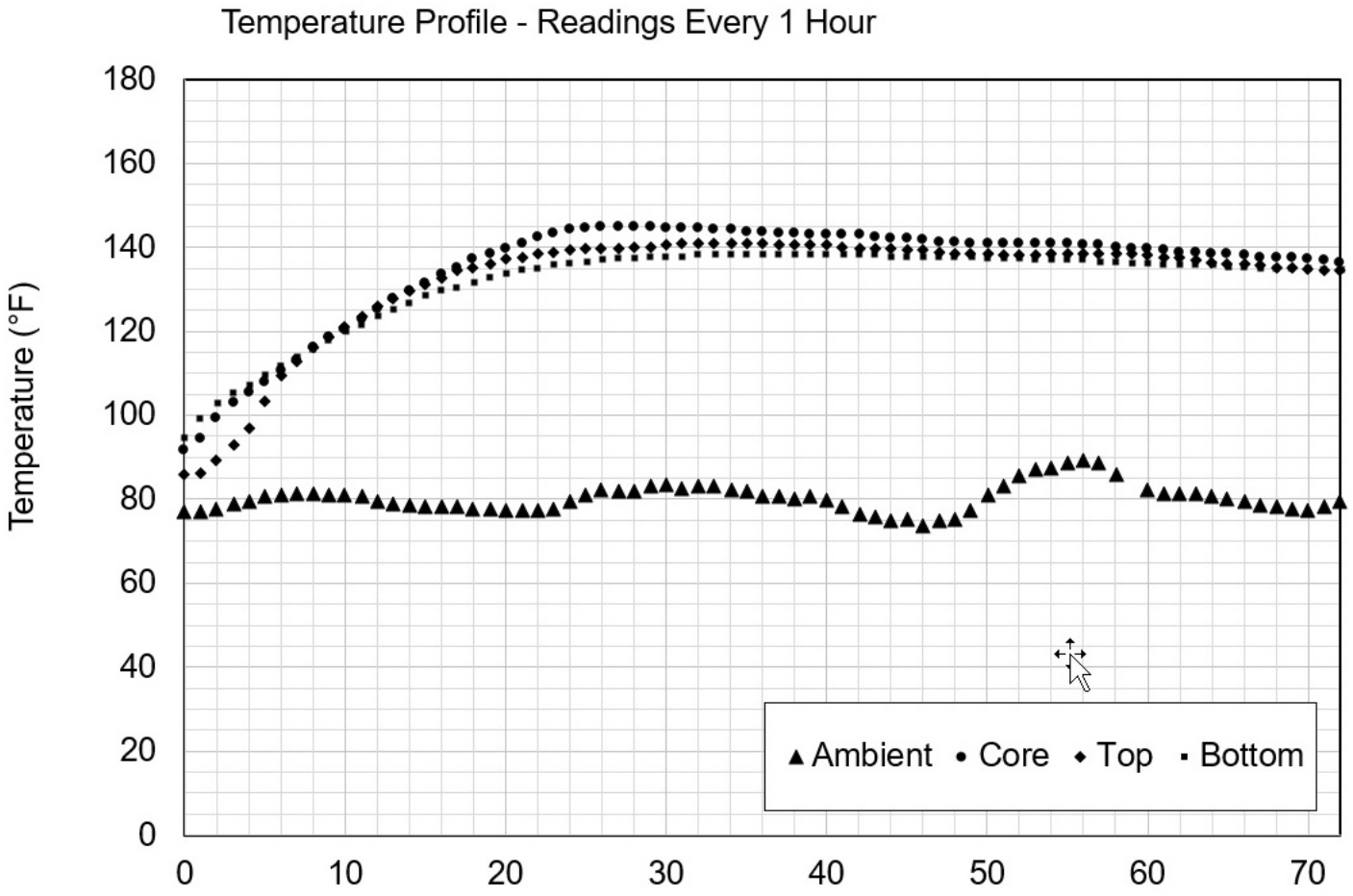
B.2.2 Example Hourly Temperature Data (To be Completed by the Contractor)

Field Temperature Data						
FIN:	XXXXXX-X-52-01	Project Name:		Peak Core Temperature:		**In Notes Section, record all changes to temperature control measures:** • When add or remove blankets • When apply or remove heat • When turn water on/off • When increase or decrease water flow rate or temperature • When have adverse weather event
Element:		District:	Number	Peak Differential Temperature:		
Element ID:		County:	Name	Days for Core to Cool to < 50°F of Ambient:		
Start Date & Time:		Element Dimensions:		Average Concrete Temperature at Placement:		
Finish Date & Time:		Concrete Mix Design:		Average Ambient Temperature at Placement:		

Do Not Enter Data in This Section					Enter Data in This Section				Do Not Enter Data in This Section			
Date / Time	Date	Time	Cumulative Hours	Cumulative Days	Ambient (°F)	Core (°F)	Top (°F)	Bottom (°F)	Core-Top (°F)	Core-Bottom (°F)	Core-Ambient (°F)	Notes
			0	0.00					0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	
									0.0	0.0	0.0	

B.2.3 Example Temperature Profiles (To be Completed by the Contractor)

(Include temperature differential profiles on a separate plot)



APPENDIX C

C.1 Adiabatic Temperature Data for Type I/II Portland Cement – Mix containing 665 lb/yd^3

Type I/II	Adiabatic Temperature Rise (deg F)						
	Starting Temp (deg F)						
Time (days)	40°F	50°F	60°F	70°F	80°F	90°F	100°F
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.25	0.0	0.1	0.8	3.1	8.8	18.7	32.9
0.50	3.1	9.9	22.8	41.4	60.2	73.6	81.4
0.75	18.8	38.4	60.2	75.5	83.6	87.6	89.7
1.00	44.3	66.8	80.3	86.7	89.7	91.2	91.9
1.25	67.0	81.3	87.7	90.5	91.9	92.5	92.8
1.50	79.9	87.6	90.8	92.2	92.9	93.2	93.3
1.75	86.3	90.5	92.3	93.1	93.5	93.6	93.5
2.00	89.6	92.1	93.2	93.7	93.8	93.8	93.7
2.25	91.5	93.1	93.8	94.0	94.1	94.0	93.8
2.50	92.6	93.7	94.1	94.3	94.2	94.1	93.9
2.75	93.4	94.1	94.4	94.4	94.4	94.2	94.0
3.00	93.9	94.4	94.6	94.6	94.4	94.3	94.0
3.25	94.3	94.7	94.7	94.7	94.5	94.3	94.1
3.50	94.6	94.8	94.8	94.7	94.6	94.4	94.1
3.75	94.8	95.0	94.9	94.8	94.6	94.4	94.1
4.00	95.0	95.1	95.0	94.9	94.7	94.4	94.2
5.00	95.4	95.4	95.2	95.0	94.8	94.5	94.2
6.00	95.7	95.5	95.3	95.1	94.8	94.5	94.2
7.00	95.8	95.6	95.4	95.1	94.9	94.6	94.3
8.00	95.9	95.7	95.4	95.2	94.9	94.6	94.3
9.00	95.9	95.7	95.5	95.2	94.9	94.6	94.3
10.00	96.0	95.7	95.5	95.2	94.9	94.6	94.3
11.00	96.0	95.8	95.5	95.2	94.9	94.6	94.3
12.00	96.0	95.8	95.5	95.2	94.9	94.6	94.3
13.00	96.1	95.8	95.5	95.2	94.9	94.6	94.3
14.00	96.1	95.8	95.5	95.2	94.9	94.6	94.3

C.2 Adiabatic Temperature Data for Type IL Portland Cement – Mix containing 665 lb/yd^3

Type IL	Adiabatic Temperature Rise (deg F)						
	Starting Temp (deg F)						
Time (days)	40°F	50°F	60°F	70°F	80°F	90°F	100°F
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.25	0.5	1.7	4.2	8.5	15.0	23.7	33.7
0.50	7.9	15.4	25.8	38.1	50.5	61.1	69.1
0.75	22.2	35.5	49.5	61.7	70.7	76.9	81.0
1.00	38.6	53.6	65.8	74.3	79.9	83.5	85.9
1.25	53.1	66.3	75.2	80.9	84.5	86.8	88.3
1.50	64.1	74.4	80.8	84.7	87.2	88.8	89.8
1.75	71.8	79.6	84.2	87.1	88.9	90.0	90.8
2.00	77.2	83.0	86.5	88.7	90.0	90.9	91.4
2.25	80.9	85.4	88.1	89.8	90.9	91.5	91.9
2.50	83.6	87.2	89.3	90.7	91.5	92.0	92.3
2.75	85.6	88.5	90.2	91.3	92.0	92.4	92.6
3.00	87.1	89.5	90.9	91.8	92.4	92.7	92.9
3.25	88.3	90.3	91.5	92.2	92.7	93.0	93.1
3.50	89.2	90.9	92.0	92.6	93.0	93.2	93.2
3.75	90.0	91.5	92.3	92.9	93.2	93.3	93.4
4.00	90.6	91.9	92.7	93.1	93.4	93.5	93.5
4.25	91.2	92.3	92.9	93.3	93.5	93.6	93.6
4.50	91.6	92.6	93.2	93.5	93.7	93.7	93.7
4.75	92.0	92.9	93.4	93.7	93.8	93.8	93.8
5.00	92.4	93.1	93.6	93.8	93.9	93.9	93.9
6.00	93.4	93.9	94.1	94.2	94.3	94.2	94.1
7.00	94.0	94.3	94.5	94.5	94.5	94.4	94.3
8.00	94.5	94.7	94.8	94.7	94.7	94.5	94.4
9.00	94.8	94.9	95.0	94.9	94.8	94.6	94.5
10.00	95.0	95.1	95.1	95.0	94.9	94.7	94.5
11.00	95.2	95.3	95.2	95.1	95.0	94.8	94.6
12.00	95.4	95.4	95.3	95.2	95.0	94.9	94.6
13.00	95.5	95.5	95.4	95.3	95.1	94.9	94.7
14.00	95.6	95.6	95.5	95.3	95.2	94.9	94.7