ASCE STANDARD

ANSI/ASCE/EWRI

44-20

Standard Practice for the Design, Operation, and Evaluation of Supercooled Fog Dispersal Projects

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PREFACE

This standard and its previous version, ANSI/ASCE/EWRI 44-13, have been prepared in accordance with the ASCE Standards Writing Manual, August 20, 2010, revision, with recognized engineering principles, and it should not be used without the user's competent knowledge of the underlying principles for a given application.

This version of the standard was obtained by first conducting a reaffirmation ballot. Then the Ad Hoc committee, as mentioned in the acknowledgments, was established to create the first version for the ASCE/EWRI Atmospheric Water Management Standards Committee (AWM SC) balloting. Additional material was then added, including a new figure, and updated wording from the certified professionals dealing with the technology over the past 5 years or so. The AWM SC members that provided some new or revised material are listed in the acknowledgments shown below.

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Some have contributed materially to this revision by their comments and review. The primary authors of the additional material of this version of the standard were the EWRI AWM SC's Supercooled Fog Dispersal Ad Hoc Members:

Conrad G. Keyes Jr., *Chair*
Thomas P. DeFelice, *Corresponding editor*
Andrew Detwiler, Major initial commenter to this standard

At the end of 2018, additional commenters during later ballots included the following:

Bruce Boe
Bob Czys
Conrad Keyes Jr.
Darin Langerud
James Stalker

CHAPTER 1

INTRODUCTION TO SUPERCOOLED FOG DISPERSAL PROJECTS

1.1 INTRODUCTION

Fogs can pose a significant threat to public safety and quality of life in the air, on land, and at sea. For example, the luxury liner *Andrea Doria* collided with the Stockholm in fog off New York and sank on its 1956 maiden voyage. Fifty-one people died and millions of dollars in property were lost (Silverman and Weinstein 1974). An airliner (Flight VD8387) overran the runway in heavy fog after landing in Yichun, in northeastern China, killing 43 passengers on August 24, 2010. Extended periods of fog can have large economic impacts on the aviation, tourism, transportation, and mining industries (ANSI/ASCE/EWRI 2013). For example, in the early 1970s fog at one US airport caused an estimated $100,000 loss of revenue due to aircraft diversions, delays, and cancellations (Silverman and Weinstein 1974); however, one shall update costs estimates for future planning or design efforts when dealing with new projects.

The harmful effects on transportation alone have been sufficient justification for attempts to modify or disperse fogs. Silverman and Weinstein (1974) note that fog was the subject of the first scientifically designed weather modification effort of any kind. This may partially explain why supercooled fog dispersal is perhaps the only weather-modification technology that does not require long experimentation and careful measurement to detect results, because results are both visible and nearly instantaneous. The most frequently cited goal of any supercooled fog dispersal project is to increase visibility. An increase in the local temperature can be a byproduct of the clearing activities. Fog dispersal operations reduce the threat to public safety by increasing the visibility over highways and airport runways. Dispersing fog to increase visibility, especially at airports, has tremendous economic value—particularly at the local level—as transportation returns to normal levels.

Additional sunshine resulting from fog dispersal operations can often improve the quality of life for specific populations. Fog clearing in open-pit mines can allow the safe resumption of mining operations that were suspended due to decreased visibility (ASCE 2013).

Commentary: Although extended foggy periods can have negative impacts on agriculture and the mental health of the general public, there are some situations in which fog is beneficial, such as where fog water is collected for drinking water in arid regions (e.g., Schemenauer 1998) and where fog supplies some of the necessary moisture to vegetation. For example, fog supplies needed moisture to the northern California redwood trees during the summer dry season (e.g., Schemenauer 1998). Another example is the notorious winter fog in the San Joaquin Valley of California, which provides an important portion of the winter dormancy requirements of many deciduous orchard crops in the region (ASCE 2013). The San Joaquin Valley fogs are also known as "tule" fogs and are in the category of "warm fogs" that are not normally supercooled, as their temperatures are often above freezing.

Ice fogs are a special case and are slower to dissipate than supercooled fogs because they are composed mostly of tiny ice crystals and they generally form at air temperatures below about 243 °K (e.g., Huffman and Ohtake 1971). Ice fog dispersal is fundamentally different from the dispersal of supercooled fogs and may be more appropriately labeled ice fog suppression. Ice crystals predominate and form by heterogeneous nucleation and, in some instances, by homogeneous nucleation. Ice fogs are primarily caused by unnatural sources of water vapor, which may include automobile and aircraft exhaust, exhaust from utility plants, and open water, such as cooling ponds (ASCE 2013). Benson (1969) indicated that decreasing the ambient temperature of these moisture sources did improve visibility. Most attempts to disperse ice fogs have included electric fields, dehydrators of various types (e.g., gas, furnace, automobile), air movement by helicopters, polyethylene rafts, plastic films (e.g., polyethylene), injection wells, cooling towers, and chemical films (e.g., hexadeconal, ethylene glycol monobutyl ether). Presently, the standard technique used to suppress ice fog caused by exposed water sources employs a thin ethylene glycol monobutyl ether film. This film is harmless to marine life (it is biodegradable) and lasts much longer than other films, but it is less effective in suppressing ice fog than hexadeconal film (ASCE 2013). McFadden (1976) and McFadden and Collins (1978) provide details of these techniques. Ice fog suppression techniques will not be discussed in this standard.

1.2 SCOPE OF STANDARD

The focus of this standard is the dispersal of supercooled fog. Fog-clearing operations are required under US law to be reported to the National Oceanic and Atmospheric Administration (NOAA). Sponsors shall periodically publish the results of these activities, because knowing about them could improve the understanding of fogs and their impacts on society and the environment.

The remainder of this document includes capability statements for fog dispersal and an abridged version of the physics of supercooled fog formation and dispersal, as well as recommendations for planning, organizing, conducting, and evaluating a supercooled fog dispersal project. The status of supercooled fog dispersal technology is summarized in Appendix C. The International System of Units, or SI units, and any CGS units of this document can be converted using Appendix A.

1.3 HISTORICAL REVIEW OF SUPERCOOLED FOG DISPERSAL OPERATIONS

Supercooled fog is colloidally stable but is otherwise in a thermodynamically metastable state (e.g., Silverman and Weinstein 1974). Thus, supercooled fog can be dissipated by