PROTOCOL FOR EQUIPMENT VERIFICATION TESTING OF DISINFECTION BY-PRODUCT PRECURSOR REMOVAL BY PACKAGED AND/OR MODULAR DRINKING WATER TREATMENT SYSTEMS FOR SMALL PUBLIC OR PRIVATE WATER SUPPLIES

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PROTOCOL FOR EQUIPMENT VERIFICATION TESTING OF DISINFECTION BY-PRODUCT PRECURSOR REMOVAL BY PACKAGED AND/OR MODULAR DRINKING WATER TREATMENT SYSTEMS

1.0 INTRODUCTION

This document is the study protocol to be used for verification testing of equipment designed to achieve removal of precursors to disinfection by-products (DBPs). In order to participate in the equipment verification process, the equipment Manufacturer must adhere to the requirements of this study protocol in developing a Manufacturer Field Operations Document (FOD). The final submission of the Manufacturer FOD shall:

- include the information requested in this protocol;
- conform to the format identified herein; and
- conform to the specific NSF International (NSF) Equipment Verification Testing Plan or Plans related to the statement or statements of capabilities that are to be verified.

The Manufacturer FOD may include more than one Testing Plan. Equipment testing might be undertaken to verify performance of a packaged plant systems employing processes that may include but are not limited to coagulation/clarification, oxidation or mixed oxidation processes, adsorption, biological filtration or membrane filtration for removal of DBP precursors.

This protocol document is presented in two fonts. The non-italicized font provides background information that the Manufacturer may find useful in preparation of the Manufacturer FOD. *The italicized text indicates specific study protocol deliverables that are required of the Manufacturer and that must be incorporated in the Manufacturer FOD.*

The following glossary terms are presented here for subsequent reference in this protocol:

- Certification - the attestation that a piece of equipment and/or a device has met all applicable requirements, e.g., standard performance criteria and policies, and continues to meet all applicable requirements.
- Distribution System - a system of conduits by which a primary water supply is conveyed to consumers, typically by a network of pipelines.
- Manufacturer - a business that assembles and/or sells package plant equipment and/or modular systems. The role of the Manufacturer is to provide the package plant and/or modular system and technical support during the Verification Testing Program. The Manufacturer is also responsible for providing assistance to the third party testing

organization during operation and monitoring of the package plant or modular system in the Verification Testing Program.

- Manufacturer Field Operations Document (FOD) - a document of field testing operations and procedures. The document will be prepared by Manufacturer or by third party on behalf of Manufacturer and will include the specific details of the experimental approach in the section titled Field Operations Procedures.
- Modular System - A functional assembly of components for use in a drinking water treatment system or packaged plant, each part of which provides a limited form of treatment of the feed water(s). Treated waters may be discharged to another packaged plant module or to the distribution system if the modular system includes the final step of treatment.
- NSF Equipment Verification Testing Plan - a specific testing plan for each packaged plant technology application, such as systems employing coagulation/clarification, oxidation or mixed oxidation processes, adsorption, biological filtration or membrane filtration, and other processes for removal of DBP precursors. This plan will be developed by NSF for the Manufacturer to assist in development of the Manufacturer FOD for the Verification Testing Program.
- Plant Operator - the person working for a small water system who is responsible for operating packaged water treatment equipment to produce treated drinking water. This person may also collect samples, record data and attend to the daily operations of equipment throughout the testing periods.
- Packaged plant - a complete water treatment system including all components from connection to the feed water(s) through discharge to the distribution system.
- Study Protocol for Equipment Verification Testing - this document. Protocol will be used for reference during Manufacturer participation in Verification Testing Program.
- Testing Organization - an organization qualified to perform studies and testing of package or modular systems. The role of the testing organization is to ensure that there is skilled operation of a package plant during the intense periods of testing and that all of the tasks required by the Study Protocol for Equipment Verification Testing are performed properly. The Testing Organization is responsible for:
  - ⇒ managing, evaluating, interpreting and reporting on the data produced by the verification testing and study;
  - ⇒ providing logistical support, scheduling and coordinating the activities of all participants in the verification testing and study, i.e., establishing a communications network;
  - ⇒ advising the Manufacturer on feed water quality and test site selection, such that the locations selected for the verification testing and study have feed water quality consistent with the objectives of the Study Protocol for Equipment Verification Testing.

- Verification - to establish the evidence on the range of performance of equipment and/or device under specific conditions following a predetermined study protocol.
- Water System - the water system that operates using packaged water treatment equipment to provide treated water to its customers.

1.1 Background

U.S. Environmental Protection Agency (EPA) has partnered with NSF, a nonprofit testing and certification organization, to verify performance of small packaged drinking water systems that serve small communities. It is expected that both the domestic and international markets for such systems are substantial. EPA and NSF have formed an oversight stakeholders group composed of buyers, sellers, and state permitters, to assist in formulating consensus testing protocols. A goal of verification testing is to enhance and facilitate the acceptance of small packaged drinking water treatment equipment by state drinking water regulatory engineers and consulting engineers while reducing the need for testing of equipment at each location where the equipment use is contemplated.

NSF will meet this goal by working with equipment Manufacturers and other agencies in planning and conducting Equipment Verification Testing Programs, evaluating data generated by such testing and managing and disseminating information. The Manufacturer is expected to secure the appropriate resources to support their part of the equipment verification process, including provision of equipment and technical support.

The verification process established by EPA and NSF is intended to serve as a template for conducting water treatment verification tests that will generate high quality data for verification of equipment performance. The verification process is a model process that can help in moving small packaged and/or modular drinking water treatment equipment into routine use more quickly. The verification of an equipment's performance involves five sequential steps :

1. Development of a verification/Manufacturer FOD;
2. Execution of verification testing;
3. Data reduction, analysis, and reporting;
4. Performance and cost (labor, chemicals, energy) verification;
5. Report preparation and information transfer.

1.2 Objectives

The specific objectives of the Equipment Verification Testing Program may be different for each Manufacturer, depending upon the statement of capabilities of the specific equipment to be tested. The objectives developed by each Manufacturer will be defined and described in detail in the Manufacturer FOD developed for each piece of equipment. The objectives of the Equipment

Verification Testing Program may include:

- Generation of field data appropriate for verifying the performance of the equipment;
- Generation of field data in support of meeting current or anticipated water quality regulations;
- Evaluation of new advances in equipment and equipment design.

An important aspect in the development of verification testing is to describe the procedures that will be used to verify the statement of performance capabilities made for water treatment equipment. A verification testing plan document shall incorporate the QA/QC elements needed to provide data of appropriate quality sufficient to reach a defensible position regarding the equipment performance. Verification testing conducted at a single site may not represent every environmental situation which may be acceptable for the equipment tested, but it will provide data of sufficient quality to make a judgment about the application of the equipment under conditions similar to those encountered in the verification testing.

It is important to note that verification of the equipment does not mean that the equipment is "certified" by NSF or EPA. Rather, it recognizes that the performance of the equipment has been determined and verified by these organizations.

1.3 Scope

This protocol outlines the verification process for equipment designed to achieve removal of precursors to DBPs. The scope of this protocol includes testing plans for packaged and/or modular drinking water treatment systems designed to achieve removal of DBP precursors. This protocol is not an NSF or third-party consensus standard and it does not endorse the packaged plants or technologies described herein.

An overview of the equipment verification process and the elements of the Manufacturer FOD to be developed by the Manufacturer are described in this protocol document. Specifically, the Manufacturer FOD shall define the following elements of the verification testing:

- Roles and responsibilities of verification testing participants;
- Procedures governing verification testing activities such as equipment operation and process monitoring; sample collection, preservation, and analysis; and data collection and interpretation;
- Experimental design of the Field Operations Procedures;
- Quality assurance (QA) and quality control (QC) procedures for conducting the

verification testing and for assessing the quality of the data generated from the verification testing; and,

- Health and safety measures relating to biohazard, electrical, mechanical and other safety codes.

Content of Manufacturer Field Operations Document:

The structure of the Manufacturer FOD must conform to the outline below: The required components of the Document will be described in greater detail in the sections below.

- *TITLE PAGE*
- *FOREWORD*
- *TABLE OF CONTENTS - The Table of Contents for the Manufacturer FOD should include the headings provided in this document although they may be modified as appropriate for a particular type of equipment to be tested.*
- *EXECUTIVE SUMMARY - The Executive Summary describes the contents of the Manufacturer FOD (not to exceed two pages). A general description of the equipment and the statement of performance capabilities which will be verified during testing shall be included, as well as the testing locations, a schedule, and a list of participants.*
- *ABBREVIATIONS AND ACRONYMS - A list of the abbreviations and acronyms used in the Manufacturer Field Operations Document should be provided.*
- *EQUIPMENT VERIFICATION TESTING RESPONSIBILITIES (described in the sections below)*
- *EQUIPMENT CAPABILITIES AND DESCRIPTION (described in the sections below)*
- *EXPERIMENTAL DESIGN (described in the sections below)*
- *FIELD OPERATIONS PROCEDURES (described in the section below)*
- *QUALITY ASSURANCE TESTING PLAN (described in the section below)*
- *DATA MANAGEMENT AND ANALYSIS (described in the section below)*
- *SAFETY PLAN (described in the section below)*

Manufacturer Responsibilities:

Preparation of a Manufacturer Field Operations Document that includes the information requested and conforms to the requirements stipulated in this protocol document, and the applicable NSF Equipment Verification Testing Plan or Plans.

2.0 EQUIPMENT VERIFICATION TESTING RESPONSIBILITIES

2.1 Verification Testing Organization and Participants

This Verification Testing Program is being conducted by NSF International with participation of manufacturers, under the sponsorship of the EPA Office of Research and Development, National Risk Management Research Laboratory, Water Supply and Water Resources Division (WSWRD) - Cincinnati, Ohio. The WSWRD and NSF jointly are administering the Equipment Verification Testing Program. The NSF's role is to provide technical and administrative leadership and support in conducting the testing.

The specific responsibilities of each participant are discussed in Section 2.4. The required content of the Manufacturer FOD and the Manufacturer Responsibilities are listed at the end of each section. In the development of a Manufacturer FOD, Manufacturers shall provide a table including the name, affiliation, and mailing address of each participant, a point of contact, description of participant's role, telephone and fax numbers, and e-mail address.

2.2 Verification Testing Agreement

After equipment has been accepted by NSF into the Environmental Technology Verification Program, a letter agreement will be signed between the Manufacturer and the NSF. The purpose of the agreement is to specify a framework of responsibilities for conducting the Equipment Verification Testing Program.

It is important to note that the entire Manufacturer FOD, including a Quality Assurance Project Plan (QAPP), must be approved by the Manufacturer and the NSF before the verification testing can proceed.

2.3 Organization

The organizational structure for the verification testing showing lines of communication shall be provided by the Manufacturer.

2.4 Verification Testing Site Name and Location

This section discusses background information on the verification testing site(s), with emphasis on the quality of the feed water, which in some cases may be the source water at the site. The Manufacturer FOD must provide the site names and locations at which the equipment will be tested. In most cases, the equipment will be demonstrated at more than one site. In all cases the equipment should be tested under different conditions of feed water quality (or source water quality) and a range of seasonal climate and weather conditions.

2.5 Site Characteristics

The Manufacturer FOD must include a description of the test site. This shall include a description of where the equipment will be located. If the feed water to the packaged plant equipment is the source water for an existing water treatment plant, describe the raw water intake, the opportunity to obtain raw water without the addition of any chemicals, and the operational pattern of raw water pumping at the full-scale facility (is it continuous or intermittent?). The source water characteristics shall be described and documented. The Manufacturer FOD shall also describe facilities to be used for handling the treated water and wastes (i.e., residuals) produced during the Verification Testing Program. Can the required water flows and waste flows produced be dealt with in an acceptable way? Are water pollution discharge permits needed?

2.6 Responsibilities

This section identifies the organizations involved in the testing and describes the primary responsibilities of each organization. The responsibilities of the Manufacturer will vary depending on the type of verification testing. Multiple Manufacturer testing for removal of DBP precursors may be conducted concurrently, and be fully in compliance with the NSF Equipment Verification Testing Program.

NSF and the equipment testing organization shall be responsible for:

- Providing needed logistical support, establishing a communication network, and scheduling and coordinating the activities of all verification testing participants;
- Advising the Manufacturer on feed water quality and test site selection, such that the locations selected as test sites have feed water quality consistent with the objectives of the verification testing (Manufacturer may recommend a verification testing site(s));
- Managing, evaluating, interpreting, and reporting on data generated by the verification testing;
- Evaluating and reporting on the performance of the DBP precursor removal technologies.

The Manufacturer shall be responsible for provision of the equipment to be evaluated. See additional Manufacturer responsibilities listed below.

Content of Manufacturer Field Operations Document Regarding Equipment Verification Testing Responsibilities:

The Manufacturer, in consultation with NSF as the technical leadshall be responsible for including

the following elements in the Manufacturer Field Operations Document:

- *Definition of the roles and responsibilities of appropriate verification testing participants*
- *A table which includes the name, affiliation, and mailing address of each participant, a point of contact, description of participant's role, telephone and fax numbers, and e-mail address.*
- *Organization of operational and analytical support*
- *List of the site name(s) and location(s).*
- *Description of the test site(s), the site characteristics and identification of where the equipment will be located.*

Manufacturer Responsibilities:

- *Provision of complete, field-ready equipment for verification testing;*
- *Provision of logistical, and technical support, as required.*
- *Provision of technical assistance to the qualified testing organization during operation and monitoring of the equipment undergoing verification testing.*

3.0 EQUIPMENT CAPABILITIES AND DESCRIPTION

3.1 Equipment Capabilities

The Manufacturer shall identify the water quality objectives to be achieved in the statement of performance capabilities of the equipment to be evaluated in the verification testing. Statements should also be made regarding the applications of the equipment, the known limitations of the equipment and what advantages it provides over existing equipment. The statement of performance capabilities must be specific and verifiable by a statistical analysis of the data. Two examples of satisfactory statements of performance capabilities are provided below:

1. "This packaged plant is capable of achieving 40% removal of dissolved organic carbon (DOC) in feed waters with total organic carbon concentrations between 2.0 and 4.0 mg/L and with feed water alkalinities less than 60 mg/L as $CaCO_3$."
2. "This packaged plant is capable of achieving 40% removal of precursors to trichloroacetic acid (TCA) in feed waters. Removal of TCA precursors will be quantified by comparison of SDS

testing results generated for feed and finished water samples. The following equation shall be used to determine percent removal of all DBP precursors:"

$$\text{\% Removal Precursor Material} = 100 \left(\frac{\text{Feedwater DBP Concentration} - \text{Finished water DBP Concentration}}{\text{Feedwater DBP Concentration}} \right)$$

A statement of performance capabilities such as: "This packaged plant will achieve removal of DOC in accordance with the Enhanced Coagulation requirement of the Disinfectants/Disinfection By-Product Rule (D/DBP Rule) on a consistent and dependable basis," would not be acceptable.

The Manufacturer shall be responsible for identification of which DBP precursors shall be monitored for removal under the statement of performance capabilities. The statement of performance capabilities prepared by the Manufacturer shall also indicate the range of water quality under which the equipment can be challenged while successfully treating the feed water. Statements of performance capabilities that are too easily met may not be of interest to the potential user, while performance capabilities that are overstated may not be achievable. The statement of performance capabilities forms the basis of the entire Equipment Verification Testing Program and must be chosen appropriately. Therefore, the design of the Manufacturer FOD should include a sufficient range of feed water quality to permit verification of the statement of performance capabilities.

It should be noted that many of the packaged and/or modular drinking water treatment systems participating in the DBP Precursor Removal Verification Testing Program will be capable of achieving multiple water treatment objectives. Although this DBP Precursor Protocol and the associated Verification Testing Plans are oriented towards removal of DBP precursors, the Manufacturer may want to look at the treatment system's removal capabilities for additional water quality parameters.

3.2 Equipment Description

Description of the equipment for the Verification Testing Program shall be provided by the Manufacturer. Data plates shall be permanent and securely attached to each production unit. The data plate shall be easy to read in English or the language of the intended user, located on the equipment where it is readily accessible, and contain at least the following information:

a. Equipment Name

b. Model #

c. Manufacturer's name and address

d. Electrical requirements - volts, amps, and Hertz

e. Serial Number

f. Warning and Caution statements in legible and easily discernible print size

g. Capacity or output rate (if applicable)

Content of Manufacturer Field Operations Document Regarding Equipment Capabilities and Description:

The Manufacturer shall be responsible for including the following elements in the Manufacturer Field Operations Document:

- *Description of the equipment to be demonstrated;*
- *Brief introduction and discussion of the engineering and scientific concepts on which the DBP precursor removal capabilities of the water treatment equipment are based;*
- *Description of the packaged treatment plant and each process included as a component in the modular system;*
- *Brief description of the physical construction/components of the equipment. Include general environmental requirements and limitations, required consumables; weight, transportability, ruggedness, power and other needed, etc.*
- *Statement of typical rates of consumption of chemicals, a description of the physical and chemical nature of wastes, and rates of waste (concentrates, residues, etc.);*
- *Definition of the performance range of the equipment;*
- *Identification of any special licensing requirements associated with the operation of the equipment;*
- *Description of the applications of the equipment and the removal capabilities of the treatment system relative to existing equipment. Comparisons shall be provided in such areas as: treatment capabilities, requirements for chemicals and materials, power, labor requirements, suitability for process monitoring and operation from remote locations, ability to be managed by part-time operators;*
- *Discussion of the known limitations of the equipment. The following operational details shall be included: the range of feed water quality suitable for treatment with the equipment, the upper limits for concentrations of regulated contaminants that can be removed to concentrations below the MCL, level of operator skill required to successfully*

use the equipment.

4.0 EXPERIMENTAL DESIGN

This section discusses the objectives of the verification testing, factors that must be considered to meet the performance objectives, and the statistical analysis and other means that the NSF will use to evaluate the results of the verification testing.

4.1 Objectives

The objectives of this verification testing are to evaluate equipment in the following areas: 1) performance relative to the Manufacturer's stated range of equipment capabilities; 2) performance relative to the DBP precursor removal requirements of enhanced coagulation as part of the proposed D/DBP Rule and any other specific or anticipated water quality regulation (i.e., Enhanced Surface Water Treatment Rule); 3) the impacts of variations in feed water quality (such as TOC, DOC, temperature, turbidity, particle concentration, microbial concentration, pH, alkalinity, etc.) on equipment performance; 4) the logistical, human, and economic resources necessary to operate the equipment; and 5) the reliability, ruggedness, cost, range of usefulness, and ease of operation.

The Manufacturer shall be responsible for selection of those treatment challenges listed in NSF test plans that are most appropriate for their equipment. For example, if equipment is only intended for removal of DBP precursors, there would be no need to conduct testing to evaluate the removal of hardness ions or metal ion species. However, it should be noted that many of the packaged and/or modular drinking water treatment systems participating in the DBP Precursor Removal Verification Testing Program will be capable of achieving multiple water treatment objectives. Although this protocol for DBP precursor removal and the associated Verification Testing Plans are oriented towards removal of DBP precursors, the Manufacturer may want to look at the treatment system's removal capabilities for additional water quality parameters.

4.2 Equipment Characteristics

This section discusses factors that will be considered in the design and implementation of the Equipment Verification Testing Program. These factors include ease of operation, degree of operator attention required, response of equipment and treatment process to changes in feed water quality, electrical requirements, system reliability features including redundancy of components, feed flow requirements, discharge requirements, spatial requirements of the equipment (footprint), unit processes included in treatment train and chemicals needed.

Verification testing procedures shall simulate routine conditions as much as possible and in most cases testing may be done in the field. Under such circumstances, simulation of field conditions would not

be necessary.

4.2.1 Qualitative Factors

Some factors, while important, are difficult or impossible to quantify. These are considered qualitative factors. Important factors that cannot easily be quantified are the modular nature of the equipment, the safety of the equipment, the portability of equipment, and the logistical requirements necessary for using it.

Typical qualitative factors to be discussed are listed below, and others may be added. The Manufacturer FOD shall discuss those factors that are appropriate to the test equipment.

- Reliability or susceptibility to environmental conditions
- Equipment safety
- Effect of operator experience on results.

4.2.2 Quantitative Factors

Many factors of the equipment characteristics can be quantified by various means in this Verification Testing Program. Some can be measured while others cannot be controlled. Typical quantitative factors to be discussed are listed below, and others may be added. The Manufacturer FOD shall discuss those factors that are appropriate to the test equipment.

- Power and consumable supply (such as chemical and materials) requirements
- Cost of operation, expendables, and waste disposal
- Hydrodynamics of packaged plant system
- Length of operating cycle.

These quantitative factors will be used as an initial benchmark to assess equipment performance.

4.3 Water Quality Considerations

The primary treatment goal of the equipment employed in this Verification Testing Program is to achieve removal of DBP precursors found in feed waters (or raw waters) such that product waters are of acceptable water quality (with limited presence of allogenic contaminants). The driving force for the goal of precursor removal is to achieve compliance with the proposed Disinfectant/Disinfection By-Product (D/DBP) Rule and the proposed Groundwater Disinfection Rule under the Safe Drinking Water Act. The experimental design in the Manufacturer FODs shall be

developed so the relevant questions about water treatment equipment capabilities can be answered.

Manufacturers should carefully consider the capabilities and limitations of their equipment and prepare Manufacturer FODs that sufficiently challenge their equipment. The Manufacturer should adopt an experimental approach to verification testing that would provide a broad market for their products, while recognizing the limitations of the equipment, and not conducting precursor removal testing that would be beyond the capabilities of the equipment. A wide range of contaminants or water quality problems that can be addressed by water treatment equipment varies, and some packaged treatment equipment can address a broader range of problems than other types. Manufacturers shall use NSF Equipment Verification Testing Plans as the basis for the specific Manufacturer FODs.

4.3.1 Feed Water Quality

One of the key aspects related to demonstration of equipment performance in the Verification Testing Program is the range of feed water quality that can be treated successfully. The Manufacturer should consider the influence of feed water quality on the quality of treated waters produced by the packaged plant, such that product waters meet the stated water quality goals (in terms of disinfection by-product concentrations) or regulatory requirements for precursor removals. As the range of feed water quality that can be treated by the equipment becomes broader, the potential applications for treatment equipment with verified performance capabilities may also increase. Characteristics of feed water quality that can be important for treatment equipment intended to remove DBP precursors are:

- dissolved organic carbon (DOC), total organic carbon (TOC), or UV-254 absorbance
- biological dissolved organic carbon (BDOC) or assimilable organic carbon (AOC)
- turbidity, particle concentration
- pH and alkalinity
- temperature, with temperatures near freezing having potential for the most difficult treatment conditions
- total dissolved solids (TDS), and other individual inorganic parameters
- presence of background microbial populations including algae, bacteria, viruses and protozoa and other organisms
- Total Kjeldahl Nitrogen (TKN), ammonia nitrogen

One of the questions often asked by regulatory engineers in approval of packaged water treatment equipment is: "Has it been shown to work on the water where you propose to put it?" By covering a large range of water qualities the verification testing is more likely to provide an affirmative answer to that question.

4.3.2 Treated Water Quality

Production of treated water of a high quality, with low concentrations of precursors to DBPs shall be the primary goal of the packaged and/or modular water treatment systems included in this Equipment Verification Testing Program. If a Manufacturer states that water treatment equipment can be used to treat water to meet specified regulatory requirements for removal of DBP precursors, the verification testing must provide data that support such a statement of capabilities, as appropriate. The statement of capabilities provided by the Manufacturer shall be related to the enhanced coagulation requirements of the proposed D/DBP Rule or the proposed Stage 1 DBP maximum contaminant levels. The Manufacturer shall be responsible for identification of the specific DBPs that shall be monitored during the Equipment Verification Testing Program. Water quality analysis for the specific DBPs identified by the Manufacturer shall be performed by an NSF-qualified laboratory. This issue shall be discussed further in Section 5.2

In addition, the Manufacturer may wish to make a statement about performance capabilities of the equipment for removal of other regulated contaminants under the SDWA that are not directly related to DBP precursor removal. For example, some water treatment equipment can be used to meet aesthetic goals that are not included as regulatory requirements of the SDWA. Removal goals for some of these parameters may also be presented in the Manufacturer's statement of capabilities. A number of water quality parameters that may be useful for assessing equipment performance of packaged and/or modular treatment systems are listed below.

- particle count or concentration
- biological dissolved organic carbon (BDOC) or assimilable organic carbon (AOC)
- heterotrophic plate count bacteria (HPC)
- color, taste and odor
- total dissolved solids
- hardness ions
- iron and manganese

4.4 Disinfection By-Product Formation Testing

For evaluation of the DBP precursor concentrations, the standardized ICR approach of the Uniform Formation Conditions (UFC) shall be employed in this Verification Testing Program. Selected samples shall be prepared for THM and HAA analysis using the following procedure which will provide the standardized set of representative chlorination conditions:

- Incubation time: 24 +/- 1 hours

- Incubation temperature: 20.0 +/- 1.0 °C
- Buffered pH: 8.0 +/- 0.2
- 24-hour Chlorine Residual: 1.0 +/- 0.4 mg Cl_2/L

For these conditions, the chlorine dose required to achieve the target chlorine residual can be determined by first conducting a demand study with the water sample. Since the TOC and DOC concentrations of a water can vary over the course of a test run, the chlorine demand of a given water may also vary. The chlorine dose must therefore be varied according to the chlorine demand of the water. Frequency of sampling and SDSDBP analysis shall be specified by the individual test plans used for the Equipment Verification Testing Program and shall also be stipulated in the Manufacturer FOD.

4.5 Recording data

For all DBP precursor experiments, data should be maintained on the pH, temperature and other water quality parameters listed in Sections 4.3.1 and 4.3.2 above. The following items of information shall also be maintained for each experiment:

- Type of chemical addition, dose and chemical combination, where applicable (e.g., alum, cationic polymer, anionic polymer, ozone, monochloramine, scale inhibitor, etc.);
- Water type (raw water, pretreated feed water, product water, waste water);
- Experimental run (e.g. 1st run, 2nd run, 3rd run, etc.);

4.6 Recording Statistical Uncertainty

For the analytical data obtained during verification testing, 95% confidence intervals shall be calculated by the field testing organization for selected water quality parameters. The specific testing plans shall specify which water quality parameters shall be subjected to the requirements of confidence interval calculation. As the name implies, a confidence interval describes a population range in which any individual population measurement may exist with a specified percent confidence. The following formula shall be employed for confidence interval calculation:

$$\text{Confidence Interval} = \overline{X} \pm t_{n-1,1-\frac{a}{2}}\left(\frac{S}{\sqrt{n}}\right)$$

where: X is the sample mean;
S is the sample standard deviation;
n is the number of independent measurements included in the data set; and
t is the Student's t distribution value with n-1 degrees of freedom;
α is the significance level, defined for 95% confidence as: 1 - 0.95 = 0.05.

According to the 95% confidence interval approach, the α term is defined to have the value of 0.05, thus simplifying the equation for the 95% confidence interval in the following manner:

$$95\%\ \text{confidence interval} \quad X \quad t_{n\ 1,0.975} \frac{S}{\sqrt{n}}$$

With input of the analytical results for pertinent water quality parameters into the 95% confidence interval equation, the output will appear as the sample mean value plus or minus the second term. The results of this statistical calculation may also be presented as a range of values falling within the 95% confidence interval. For example, the results of the confidence interval calculation may provide the following information: 520 +/- 38.4 mg/L, with a 95% confidence interval range described as (481.6, 558.4).

Calculation of confidence intervals shall not be required for equipment performance results (e.g., filter run length, cleaning efficiency, in-line turbidity or in-line particle counts, etc.) obtained during the equipment testing verification program. However, as specified by the Manufacturer, calculation of confidence intervals may be required for such analytical parameters as TOC, DOC, grab samples of turbidity, THMs, HAAs. In order to provide sufficient analytical data for statistical analysis, the Field Testing Organization shall collect three discrete water samples at one set of operational conditions for each of the specified water quality parameters during a designated testing period. The procedures and sampling requirements shall be provided in detail in the Verification Testing Plan.

4.7 Verification Testing Schedule

Verification testing activities include equipment set-up, initial operation, verification operation, and sampling and analysis. Initial operations are intended to be conducted so that Manufacturers can test their equipment and be sure it is functioning as intended. If feed water (or source water) quality influences operation and performance of equipment being tested, the initial operations period serves as the shake-down period for determining appropriate operating parameters.

For water treatment equipment involving removal of DBP precursors, an initial period of bench-scale testing of feed water followed by treatment equipment operation may be needed to determine the appropriate operational parameters for testing equipment. A number of operational may require adjustment to achieve successful functioning of the process train; these parameters may include but are not limited to: process rates, feed water pH, chemical dosages, chemical types where appropriate and equipment operations procedures that will result in successful functioning of the process train.

The timing for verification testing shall be designated on the basis of four annual testing episodes in order to cover a range of water quality conditions experienced in an annual period. For example, climatic changes between rainy and dry seasons may produce substantial variability in feed water turbidity. Cold weather operations will be an important component of seasonal water quality testing because of the impact of cold temperatures (1 °C to 5 °C) on water viscosity, diffusional processes and characteristics of raw water DBP precursor materials.

Content of Manufacturer Field Operations Document Regarding Experimental Design:

The Manufacturer shall be responsible for including the following elements in the Manufacture Field Operations Document:

- *Identification of the qualitative and quantitative factors of equipment operation to be addressed in the Verification Testing Program.*
- *Identification and discussion of the particular water treatment issues and dissolved organic carbon concentrations that the equipment is designed to address, how the equipment will solve the problem, and who would be the potential users of the equipment.*
- *Identification of the range of key water quality parameters, given in applicable NSF Testing Plans, which the equipment is intended to address and for which the equipment is applicable.*
- *Identification of the key parameters of treated water quality and analytical methods that will be used for evaluation of equipment performance during the removal of DBP precursors. Parameters of significance for treated water quality were listed above in Sections 4.3.2 and 4.3.2. and in applicable NSF Testing Plans.*
- *Description of data recording protocol for equipment operation, feed water quality parameters, and treated water quality parameters.*
- *Description of the confidence interval calculation procedure for selected water quality parameters.*
- *Detailed outline of the verification testing schedule, with regard to annual testing periods that will cover an appropriate range of annual climatic conditions, (i.e., different temperature conditions, seasonal differences between rainy and dry conditions).*

5.0 FIELD OPERATIONS PROCEDURES

5.1 Equipment Operations and Design

The NSF Verification Testing Plan specifies procedures that shall be used to ensure the accurate documentation of both equipment performance and treated water quality. Careful adherence to these procedures will result in definition of verifiable performance of equipment. (Note that this protocol may be associated with a number of different NSF Equipment Verification Testing Plans for different types of process equipment capable of achieving removal of DBP precursors).

Design aspects of water treatment process equipment often provide a basis for approval by state regulatory engineers and can be used to ascertain if process equipment intended for larger or smaller flows than that evaluated in the Verification Testing Program actually involves the same operating parameters that were relevant to the verification testing. Specific design aspects to be included in the Manufacturer FOD are provided in detail, in the Manufacturer Responsibilities section below.

Initial operations of the precursor removal equipment will allow equipment Manufacturers to refine their operating procedures and to make operational adjustments as needed to successfully treat the feed water. Information generated through this period of operation may be used to revise the Manufacturer FOD, if necessary. A failure at this point in the verification testing could indicate a lack of capability of the process equipment and the verification testing might be canceled.

5.2 Selection of Analytical Laboratory and Field Testing Organization

To assess the performance of the equipment, the quality of the treated water produced using the equipment shall be determined by analysis at an NSF-qualified analytical laboratory with proven experience in detection and measurement of total organic carbon, dissolved organic carbon, trihalomethanes, haloacetic acids, bromate, chlorate and other regulated DBPs. In all cases, current APHA Standard Methods procedures shall be used in analysis of specified water quality parameters. The NSF may provide a list of qualified laboratories from which Manufacturers can select for submission of samples for water quality analysis. Because of the variability of acceptance of laboratories from state to state, use of analytical laboratories certified in a large number of states is recommended. Furthermore, the selected analytical laboratory must be certified by the State in which the verification testing is being performed. Laboratories approved

for sample analysis for the EPA's Information Collection Rule would have nationally recognized capabilities. Analytical results from the laboratory are to be provided directly to the NSF to maintain data integrity.

For field testing operations, the Manufacturer shall employ an NSF-qualified Field Testing Organization; the list of qualified organizations may include engineering consulting firms, universities, or other qualified scientific organizations with experience operating pilot plant equipment.

5.3 Communications, Documentation, Logistics, and Equipment

NSF shall communicate regularly with the verification testing participants to coordinate all field activities associated with this verification testing and to resolve any logistical, technical, or QA issues that may arise as the verification testing progresses. The successful implementation of the verification testing will require detailed coordination and constant communication between all verification testing participants.

All Manufacturer/NSF field activities shall be thoroughly documented. Field documentation will include field logbooks, photographs, field data sheets, and chain-of-custody forms. The qualified testing organization shall be responsible for maintaining all field documentation. Field notes shall be kept in a bound logbook. Each page shall be sequentially numbered and labeled with the project name and number. Field logbooks shall be used to record all water treatment equipment operating data. Completed pages shall be signed and dated by the individual responsible for the entries. Errors shall have one line drawn through them and this line shall be initialed and dated.

All photographs shall be logged in the field logbook. These entries shall include the time, date, direction, subject of the photograph, and the identity of the photographer. Any deviations from the approved final Manufacturer FOD shall be thoroughly documented in the field logbook and provided to the NSF.

Original field sheets and chain-of-custody forms shall accompany all samples shipped to the analytical laboratory. Copies of field sheets and chain-of-custody forms for all samples shall be provided to the NSF.

5.4 Equipment Operation and Water Quality Sampling for Verification Testing

The qualified testing organization will supervise equipment operation and water quality sampling and analysis during the verification phase of testing, using the procedures described below and in the specific Verification Testing Plans. The NSF will oversee or audit these activities. All field activities shall conform with requirements provided in the Manufacturer FOD that was developed and NSF-approved for the verification testing being conducted.

If unanticipated or unusual situations are encountered that may alter the plans for equipment operation, water quality sampling, or data quality, the situation must be discussed with the NSF technical lead. Any deviations from the approved final Manufacturer FOD shall be thoroughly documented.

During routine operation of water treatment equipment, the total number of hours during which the equipment is operated each day shall be documented. In addition, the number of hours each day during which the operator was working at the treatment plant performing tasks related to water treatment and the operation of the treatment equipment shall be documented. Furthermore, the tasks performed during equipment operation shall be described by the qualified Testing Organization, the Water System or the Plant Operator.

Content of Manufacturer Field Operations Document Regarding Field Operations Procedures:

The Manufacturer shall be responsible for including the following elements in the Manufacturer Field Operations Document:

- *A table summary of the proposed time schedule for operating and testing,*
- *Field operating procedures for the equipment and performance testing, based upon the NSF Equipment Verification Testing Plan with listing of operating parameters, ranges for feed water quality, and the sampling and analysis strategy.*

Manufacturer Responsibilities:

- *Provision of all equipment needed for field work associated with this verification testing;*
- *Provision of a complete list of all equipment to be used in the verification testing. A table format is suggested;*

- *Provision of field operating procedures.*

6.0 QUALITY ASSURANCE PROJECT PLAN (QAPP)

The QAPP for this verification testing specifies procedures that shall be used to ensure data quality and integrity. Careful adherence to these procedures will ensure that data generated from the verification testing will provide sound analytical results that can serve as the basis for performance verification.

6.1 Purpose and Scope

The primary purpose of this section is to outline steps that shall be taken by operators of the equipment and by the analytical laboratory to ensure that data resulting from this verification testing is of known quality and that a sufficient number of critical measurements are taken.

6.2 Quality Assurance Responsibilities

The Manufacturer project manager is responsible for coordinating the preparation of the QAPP for this verification testing and for its approval by the NSF. The qualified testing organization project manager, with oversight from NSF, shall ensure that the QAPP is implemented during all verification testing activities.

The entire Manufacturer FOD including the QAPP must be approved by the Manufacturer and the NSF before the verification testing can proceed. The NSF must review and either approve the QAPP or provide reasons for rejection of the QAPP along with suggestions on how to modify the QAPP to make it acceptable, provided that the Manufacturer has made a good faith effort to develop an acceptable QAPP (i.e. the QAPP is 75 to 80% acceptable with only minor changes needed to produce an acceptable plan. NSF will not write QAPPs for Manufacturers.)

A number of individuals may be responsible for monitoring equipment operating parameters and for sampling and analysis QA/QC throughout the verification testing. Primary responsibility for ensuring that both equipment operation and sampling and analysis activities comply with the QA/QC requirements of the Manufacturer FOD (Section 6) shall rest with the qualified testing organization, with oversight by the NSF. QA/QC activities for the equipment shall include those activities recommended by Manufacturer and those required by the NSF to assure the verification testing will provide data of the necessary quality.

QA/QC activities for the NSF-certified analytical laboratory that analyzes samples sent off-site shall be the responsibility of that analytical laboratory's supervisor. If problems arise or any data appear unusual, they shall be thoroughly documented and corrective actions shall be implemented as specified

in this section. The QA/QC measurements made by the off-site analytical laboratory are dependent on the analytical methods being used.

6.3 Data Quality Indicators

The data obtained during the verification testing must be of sound quality for conclusions to be drawn on the equipment. For all measurement and monitoring activities conducted for equipment verification, the NSF and EPA require that data quality parameters be established based on the proposed end uses of the data. Data quality parameters include four indicators of data quality: representativeness, completeness, accuracy, and precision.

Treatment results generated by the equipment and by the laboratory analyses must be verifiable for the purposes of this program to be fulfilled. High quality, well documented analytical laboratory results are essential for meeting the purpose and objectives of this verification testing. Therefore, the following indicators of data quality shall be closely evaluated to determine the performance of the equipment when measured against data generated by the analytical laboratory.

6.3.1 Representativeness

Representativeness refers to the degree to which the data accurately and precisely represent the conditions or characteristics of the parameter represented by the data. In this verification testing, representativeness will be ensured by maintaining consistent sample collection procedures, including sample locations, timing of sample collection, sampling procedures, sample preservation, sample packaging, sample shipping, and sample equipment decontamination (Section 5), and by executing random DBP spiking procedures. Representativeness also will be ensured by using each method at its optimum capability to provide results that represent the most accurate and precise measurement it is capable of achieving. For equipment operating data, representativeness entails collecting a sufficient quantity of data during operation to be able to detect a change in operations.

6.3.2 Completeness

Completeness refers to the amount of data collected from a measurement process compared to the amount that was expected to be obtained. For this verification testing, completeness refers to the proportion of valid, acceptable data generated using each method. The completeness objective for data generated during this verification testing is 85 percent.

6.3.3 Accuracy

For water quality analyses, accuracy refers to the difference between a sample result and the reference or true value for the sample. Loss of accuracy can be caused by such processes as errors in standards preparation, equipment calibrations, loss of target analyte in the extraction process, interferences, and

systematic or carryover contamination from one sample to the next.

For equipment operating parameters, accuracy refers to the difference between the reported operating condition and the actual operating condition. For water flow, accuracy may be the difference between the reported flow indicated by a flow meter and the flow as actually measured on the basis of known volumes of water and carefully defined times (bucket and stopwatch technique) as practiced in hydraulics laboratories or water meter calibration shops. For mixing equipment, accuracy is the difference between an electronic readout for equipment RPMs and the actual measurement based on counted revolutions and measured time. Accuracy of head loss measurement can be determined by using measuring tapes to check the calibration of piezometers for gravity filters or by checking the calibration of pressure gauges for pressure filters. Meters and gauges must be checked periodically for accuracy, and when proven to be dependable over time, the time interval between accuracy checks can be increased.

6.3.4 Precision

Precision refers to the degree of mutual agreement among individual measurements and provides an estimate of random error.

6.3.5 Statistical Uncertainty

Statistical uncertainty of the water quality parameters analyzed shall be evaluated through calculation of the 95% confidence interval around the sample mean. Description of the confidence interval calculation is provided in Section 4.6 - Recording Statistical Uncertainty.

6.4 Water Quality and Operational Control Checks

This section describes the QC requirements that apply to both the treatment equipment and the on-site measurement of water quality parameters. It also contains a discussion of the corrective action to be taken if the QC parameters fall outside of the evaluation criteria.

The quality control checks provide a means of measuring the quality of data produced. The Manufacturer may not need to use all the ones identified in this section. The selection of the appropriate quality control checks depends on the equipment, the experimental design and the performance goals. The selection of quality control checks will be based on discussions among the Manufacturer and the NSF. Some types of quality control checks applicable to operating water treatment equipment were described in Section 6.3.4.

6.4.1 Quality Control for Equipment Operation

This section will explain the methods to be used to check on the accuracy of equipment operating

parameters and the frequency with which these quality control checks will be made. A key aspect of the Equipment Verification Testing Program is to provide operating results that will be widely accepted by state regulatory engineers. If the quality of the equipment operating data can not be verified, then the water quality analytical results may be of no value. Because water can not be treated if equipment is not operating, obtaining valid equipment operating data is a prime concern for verification testing.

An example of the need for QC for equipment operations is an incident of state rejection of test data because the treatment equipment had no flow meter to use for determining engineering and operating parameters related to flow.

6.4.2 Water Quality Data

After treatment equipment is being operated and water is being treated, the results of the treatment are interpreted in terms of water quality. Therefore the quality of water sample analytical results is just as important as the quality of the equipment operating data. Most QA plans emphasize analytical QA. The important aspects of sampling and analytical QA are given below:

6.4.2.1 Triplicate Analysis of Selected Water Quality Parameters

Triplicate samples shall be analyzed for selected water quality parameters at specified intervals in order to determine the precision of analysis. The procedure for determining samples to be analyzed in triplicate shall be provided in each Verification Testing Plan with the required frequency of analysis and the approximate number. The triplicate analysis shall be performed according to the requirements for calculation of 95% confidence intervals, as presented in Section 4.6.

6.4.2.2 Method Blanks

Method blanks are used for selected water quality parameters to evaluate analytical method-induced contamination, which may cause false positive results.

6.4.2.3 Spiked Samples

The use of spiked samples will depend on the testing program, and the contaminants to be removed. If spiked samples are to be used specify the procedure, frequency, acceptance criteria, and actions if criteria are not met.

6.4.2.4 Travel Blanks

Travel blanks for selected water quality parameters shall be provided to the analytical laboratory to evaluate travel-related contamination.

6.4.2.5 Performance Evaluation Samples for On-Site Water Quality Testing

Performance evaluation (PE) samples are samples whose composition is unknown to the analyst that are used to evaluate analytical performance. Analysis of PE samples shall be conducted for selected water quality parameters before pilot testing is initiated by submission of samples to the analytical laboratory and to the equipment testing organizations, if appropriate. The control limits for the PE samples will be used to evaluate the equipment testing organization's and analytical laboratory's method performance. One kind of PE sample that would be used for on-site QA in most studies done under this protocol would be a turbidity PE sample.

PE samples come with statistics about each sample which have been derived from the analysis of the sample by a number of laboratories using EPA-approved methods. These statistics include a true value of the PE sample, a mean of the laboratory results obtained from the analysis of the PE sample, and an acceptance range for sample values. The analytical laboratory is expected to provide results from the analysis of the PE samples that meet the performance objectives of the verification testing.

6.6 Data Reduction, Validation, and Reporting

To maintain good data quality, specific procedures shall be followed during data reduction, validation, and reporting. These procedures are detailed below.

6.6.1 Data Reduction

Data reduction refers to the process of converting the raw results from the equipment into concentration or other data in a form to be used in the comparison. The procedures to be used will be equipment dependent. The purpose of this step is to provide data which will be used to verify the statement of performance capabilities. These data shall be obtained from logbooks, instrument outputs, and computer outputs as appropriate.

6.6.2 Data Validation

The operator shall verify the completeness of the appropriate data forms and the completeness and correctness of data acquisition and reduction. The field team supervisor or another technical person shall review calculations and inspect laboratory logbooks and data sheets to verify accuracy, completeness. Calibration and QC data will be examined by the individual operators and the laboratory supervisor. Laboratory and project managers shall verify that all instrument systems are in control and that QA objectives for accuracy, completeness, and method detection limits have been met.

Analytical outlier data are defined as those QC data lying outside a specific QC objective window for

precision and accuracy for a given analytical method. Should QC data be outside of control limits, the analytical laboratory or field team supervisor will investigate the cause of the problem. If the problem involves an analytical problem, the sample will be reanalyzed. If the problem can be attributed to the sample matrix, the result will be flagged with a data qualifier. This data qualifier will be included and explained in the final analytical report.

6.6.3 Data Reporting

The Field Testing Organization shall provide to the NSF a list of all water quality and equipment operation data to be reported. At a minimum, the data tabulation shall list the results for feed water and treated water quality analyses and equipment operating data. All QC information such as calibrations, blanks and reference samples are to be included in an appendix to the report submitted to NSF. All raw analytical data shall also be reported in an appendix. All data shall be reported in hardcopy and electronically in a common spreadsheet or database format.

6.7 Calculation of Data Quality Indicators

The equations for any data quality indicator calculations employed shall be provided. These include: precision, relative percent deviation, standard deviation, confidence interval, accuracy, and completeness.

6.8 System Audits

On-site system audits for sampling activities, field operations, and laboratories shall be conducted as specified by the NSF Equipment Verification Testing Plan. These audits will be performed by the NSF to determine if the NSF Equipment Verification Testing Plan is being implemented as intended. At a minimum, NSF shall conduct one audit of the sampling activities, field operations program and laboratories during the Verification Testing Study. The number of audits performed during a study shall be specified by the pertinent Equipment Verification Testing Plan. Separate audit reports will be completed after the audits and provided to the participating parties through the NSF.

6.9 Reports

6.9.1 Status Reports

The equipment testing organization shall prepare periodic reports for the NSF project managers. These reports shall discuss project progress, problems and associated corrective actions, and future scheduled activities associated with the verification testing. Each report shall include an executive summary at the beginning of the report to introduce the salient issues of the testing period. When problems occur, the Manufacturer and equipment testing organization project managers shall discuss them with the NSF technical lead, estimate the type and degree of impact, and describe the corrective

actions taken to mitigate the impact and to prevent a recurrence of the problems. The frequency, format, and content of these reports shall be outlined in the Manufacturer FOD.

6.9.2 Audit Reports

Any QA audits or inspections that take place in the field or at the analytical laboratory while the verification testing is being conducted shall be formally reported by the equipment testing organizations to the NSF project manager who will forward them to the Manufacturer and NSF QC Manager for appropriate actions.

6.10 Corrective Action

Each Manufacturer FOD must incorporate a corrective action plan. This plan must include the predetermined acceptance limits, the corrective action to be initiated whenever such acceptance criteria are not met, and the names of the individuals responsible for implementation.

Routine corrective action may result from common monitoring activities, such as:

- Performance evaluation audits
- Technical systems audits

Content of Manufacturer Field Operations Document Regarding Quality Assurance Project Plan:

The Manufacturer shall be responsible for including the following elements in the Manufacture Field Operations Document:

- *Description of methodology for measurement of accuracy.*
- *Description of methodology for measurement of precision.*
- *Description of the methodology for use of blanks, the materials used, the frequency, the criteria for acceptable method blanks and the actions if criteria are not met.*
- *Description of any specific procedures appropriate to the analysis of the PE samples. It has to be clear how these samples are going to be used in the verification testingOne use of PE samples is in the conduct of a performance audit (see Section 6.7.1).*
- *Outline of the procedure for determining samples to be analyzed in triplicate, the frequency and approximate number.*
- *Description of the procedures used to assure that the data are correct.*
- *Listing of equations used for any necessary data quality indicator calculations . These*

include: precision, relative percent deviation, standard deviation, confidence interval calculation; accuracy, and completeness.

- *Outline of the frequency, format, and content of reports in the Manufacturer Field Operations Document.*
- *Development of a corrective action plan in the Manufacturer Field Operations Document.*

Manufacturer Responsibilities:

- *Provision of all QC information such as calibrations, blanks and reference samples in an appendix. All raw analytical data shall also be reported in an appendix.*
- *Provision of all data in hardcopy and electronic form in a common spreadsheet or database format.*

7.0 DATA MANAGEMENT AND ANALYSIS, AND REPORTING

7.1 Data Management and Analysis

The Manufacturer, the qualified testing organization and the NSF each have distinct responsibilities for managing and analyzing verification testing data. The equipment testing organization is responsible for managing all the data and information generated during the verification testing. The Manufacturer is responsible for furnishing those records generated by the equipment testing organization. The NSF will be responsible for analysis and verification of the data.

A variety of data will be generated during a verification testing. Each piece of data or information identified for collection in the NSF Equipment Verification Testing Plan will need to be provided to the NSF. The data management section of the Manufacturer FOD shall describe what types of data and information needs to be collected and managed, and shall also describe how the data will be reported to the NSF for evaluation.

Laboratory Analyses: The raw data and the validated data must be provided to the NSF. These data shall be provided in hard copy and in electronic format. As with the data generated by the innovative equipment, the electronic copy of the laboratory data shall be provided in a spreadsheet, and a data dictionary shall be provided. In addition to the sample results, all QA/QC summary forms must be provided.

Other items that must be provided include:

- field notebooks;
- photographs, slides and videotapes (copies);
- results from the use of other field analytical methods.

7.2 Report of Equipment Testing

The qualified testing organization shall prepare a draft report describing the verification testing that was carried out and the results of that testing. This report shall include the following topics:

- Introduction
- Executive Summary
- Description and Identification of Product Tested
- Procedures and Methods Used in Testing
- Results and Discussion
- Conclusions and Recommendations
- References
- Appendices
- Manufacturer FOD
- QA/AC Results

The NSF will review the draft report, the results of testing, the QA/QC results, and will prepare a final report.

Content of Manufacturer Field Operations Document Regarding Data Management and Analysis, and Reporting:

The Manufacturer shall be responsible for including the following elements in the Manufacturer Field Operations Document:

- *Description of what types of data and information needs to be collected and managed.*
- *Description of how the data will be reported to the NSF for evaluation.*

8.0 SAFETY MEASURES

The safety procedures shall address safety considerations, including the following as applicable:

- conformance with electrical code
- biohazards
- ventilation of equipment or of trailers or buildings housing equipment, if gases generated by the equipment could present a safety hazard (one example is ozone).

Content of Manufacturer Field Operations Document Regarding Safety:

The Manufacturer Field Operations Document shall address safety considerations that are appropriate for the equipment being tested and for the chemicals employed in the verification testing.