

**PROTOCOL FOR EQUIPMENT VERIFICATION TESTING  
FOR PHYSICAL CHEMICAL REMOVAL OF NITRATE FROM CONTAMINATED  
WATER SUPPLIES  
DRAFT as of April 11, 1997**

Prepared by:  
NSF International  
3475 Plymouth Road  
Ann Arbor, MI 48105

**DISTRIBUTION STATEMENT A**  
Approved for public release;  
Distribution Unlimited

Recommended by  
the Steering Committee for the Verification of  
Package Drinking Water Treatment Systems/Plants  
on (insert date)

**DTIC QUALITY INSPECTED 2**

With support from  
the U.S. Environmental Protection Agency  
Environmental Technology Verification Program

Copyright 1997 All Rights Reserved

19980224 020

INTERNET DOCUMENT INFORMATION FORM

**A . Report Title:** Protocol for Equipment Verification Testing: For Physical Chemical Removal of Nitrate From Contaminated Water Supplies

**B. DATE Report Downloaded From the Internet** 2/21 /98

**C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #):** U. S. Environmental Protection Agency  
Las Vegas, Nevada

**D. Currently Applicable Classification Level:** Unclassified

**E. Distribution Statement A:** Approved for Public Release

**F. The foregoing information was compiled and provided by:**  
**DTIC-OCA, Initials:** vjm **Preparation Date:** 2/21/98

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.

## NSF INTERNATIONAL

### **Mission Statement**

NSF International (NSF) is an organization dedicated to public health safety and protection of the environment by developing standards, by providing education and by providing superior third-party conformity assessment services while representing the interest of all stakeholders.

### **NSF Purpose and Organization**

NSF *International* (NSF) is an independent not-for-profit organization. For more than 52 years, NSF has been in the business of developing consensus standards that promote and protect public health and the environment and providing testing and certification services to ensure manufacturers and users alike that products meet those standards. Today, millions of products bear the NSF Name, Logo and/or Mark symbols upon which the public can rely for assurance that equipment and products meet strict public health and performance criteria and standards.

### **Limitations of use of NSF Documents**

This protocol is subject to revision; contact NSF to confirm this revision is current. The testing against this protocol does not constitute an NSF Certification of the product tested.

## U.S. ENVIRONMENTAL PROTECTION AGENCY

Throughout its history, the U.S. Environmental Protection Agency (EPA) has evaluated technologies to determine their effectiveness in preventing, controlling, and cleaning up pollution. EPA is now expanding these efforts by instituting a new program, the Environmental Technology Verification Program---or ETV---to verify the performance of a larger universe of innovative technical solutions to problems that threaten human health or the environment. ETV was created to substantially accelerate the entrance of new environmental technologies into the domestic and international marketplace. It supplies technology buyers and developers, consulting engineers, states, and U.S. EPA regions with high quality data on the performance of new technologies. This encourages more rapid availability of approaches to better protect the environment.

### **ETV's Package Drinking Water Treatment Systems Pilot Project:**

Concern about drinking water safety has accelerated in recent years due to much publicized outbreaks of waterborne disease and information linking ingestion of high levels of regulated contaminants to cancer incidence. The U.S. EPA is authorized through the Safe Drinking Water Act to set numerical contaminant standards and treatment and monitoring requirements that will ensure the safety of public water supplies. However, small communities are often poorly equipped to comply with all of the requirements; less costly package treatment technologies may offer a solution. These package plants can be designed to deal with specific problems of a particular community; additionally, they may be installed on site more efficiently---requiring less start-up capital and time than traditionally constructed water treatment plants. The opportunity for the sales of such systems in other countries is also substantial.

### **Partnerships:**

The U.S. EPA and NSF International (NSF) are cooperatively organizing and developing the ETV's Package Drinking Water Treatment Systems Pilot Project to meet community and commercial needs. NSF and the Association of State Drinking Water Administrators have an understanding to assist each other in promoting and communicating the benefits and results of the project.

## **ORGANIZATION AND INTENDED USE OF PROTOCOL AND TEST PLANS**

NSF encourages the user of this protocol to also read and understand the policies related to the verification and testing of package drinking water treatment systems and equipment.

The first Chapter of this document describes the Protocol required in all studies verifying the performance of equipment or systems removing nitrate from contaminated water supplies, the public health goal of the Protocol. The remaining chapters describe the additional requirements for equipment and systems using specific technologies to attain the goals and objectives of the Protocol: the removal of nitrate from contaminated water supplies.

A "Field Operations Document" (FOD) is necessary prior to the verification testing of a package drinking water treatment systems, plants and/or equipment. The FOD developer may need this protocol and the test plans herein and other NSF Protocols and Test Plans depending on the treatment technologies used in the unit processes or treatment train of the equipment or system. More than one protocol and/or test plan may be necessary to address the equipment's capabilities in the treatment of drinking water and to complete an FOD.

## TABLE OF CONTENTS

	Page
<b>NSF International</b> .....	ii
<b>Organization and Intended Use of Protocol and Test Plans</b> .....	iii
<b>Table of Contents of Protocol Document</b> .....	iv
<b>Chapter 1: Protocol for Equipment Verification Testing for Physical Chemical Removal of Nitrate By Ion Exchange and Membrane Processes: Requirements for All Studies</b> .....	1-1
<b>Chapter 2: NSF Equipment Verification Testing Plan - Ion Exchange for the Removal of Nitrates From Contaminated Water</b> .....	2-1
<b>Chapter 3: NSF Equipment Verification Testing Plan - Membrane Processes (Electrodialysis and Reverse Osmosis) for the Removal of Nitrates From Contaminated Water</b> .....	3-1
<b>Chapter 4: NSF Equipment Verification Testing Plan - Biological Processes for the Removal of Nitrates From Contaminated Water</b> .....	4-1

**CHAPTER 1**

**PROTOCOL FOR EQUIPMENT VERIFICATION TESTING  
FOR PHYSICAL CHEMICAL REMOVAL OF NITRATE BY ION EXCHANGE AND  
MEMBRANE PROCESSES**

**REQUIREMENTS FOR ALL STUDIES**

**DRAFT 4/11/97**

## TABLE OF CONTENTS

	Page
<b>1.0 INTRODUCTION</b> .....	1-4
1.1 Background .....	1-5
1.2 Objectives of Verification Testing .....	1-6
1.3 Scope of Verification Process and Testing .....	1-9
1.4 Scope of the Manufacturer FOD .....	1-9
1.5 General Content of Manufacturer FOD .....	1-9
<b>2.0 EQUIPMENT VERIFICATION TESTING RESPONSIBILITIES</b> .....	1-10
2.1 Verification Testing Organization and Participants .....	1-10
2.2 Organization .....	1-11
2.3 Verification Testing Site Name and Location .....	1-11
2.4 Site Characteristics .....	1-11
2.5 Responsibilities of Participating Agencies .....	1-12
<b>3.0 EQUIPMENT CAPABILITIES AND DESCRIPTION</b> .....	1-14
3.1 Equipment Capabilities, Water Quality Objectives .....	1-15
3.2 Equipment Description .....	1-15
<b>4.0 EXPERIMENTAL DESIGN</b> .....	1-16
4.1 Objectives of Experimental Testing .....	1-17
4.2 Equipment Characteristics or Factors to be Tested .....	1-17
4.2.1 Qualitative Factors .....	1-17
4.2.2 Quantitative Factors .....	1-18
4.2.3 Quantitative Factors: Definitions .....	1-19
4.2.4 Quantitative Cost Factors .....	1-19
4.2.5 Quantitative Plant Performance Factors .....	1-20
4.2.6 Quantitative Factors, Plant Health, Safety and Reliability .....	1-21
4.2.7 Cross Connection Control References and Guidelines .....	1-23
4.3 Water Quality Considerations .....	1-23
4.3.1 Feed Water Quality .....	1-24
4.3.2 Treated Water Quality .....	1-25
4.3.3 Wastewater Characteristics, Quality and Quantity .....	1-26
4.4 Recording Water Quality Data .....	1-26
4.5 Instrumentation For Plant Control and Monitoring .....	1-27
4.5.1 Nitrate Measurements .....	1-27
4.5.2 Electrical Conductivity Measurements .....	1-27
4.6 Verification Testing Schedule .....	1-28
<b>5.0 FIELD OPERATIONS PROCEDURES</b> .....	1-29

## TABLE OF CONTENTS (continued)

	Page
5.1	Equipment Operations and Design . . . . . 1-30
5.2	Selection of Analytical Laboratory and Field Testing Organization . . . . . 1-30
5.3	Communications, Documentation, Logistics, and Equipment . . . . . 1-30
5.4	Initial Operations . . . . . 1-31
5.5	Equipment Operation and Water Quality Sampling for Verification Testing . . . . . 1-31
<b>6.0</b>	<b>QUALITY ASSURANCE PROJECT PLAN (QAPP) . . . . . 1-32</b>
6.1	Purpose and Scope . . . . . 1-32
6.2	Quality Assurance Responsibilities . . . . . 1-32
6.3	Data Quality Indicators . . . . . 1-33
6.3.1	Representativeness . . . . . 1-33
6.3.2	Completeness . . . . . 1-34
6.3.3	Accuracy . . . . . 1-34
6.3.4	Precision . . . . . 1-34
6.4	Quality Control Checks . . . . . 1-34
6.4.1	Quality Control for Equipment Operation . . . . . 1-35
6.4.2	Water Quality Data . . . . . 1-35
6.4.2.1	Duplicate Samples . . . . . 1-35
6.4.2.2	Method Blanks . . . . . 1-35
6.4.2.3	Spiked Samples . . . . . 1-35
6.4.2.4	Travel Blanks . . . . . 1-35
6.4.2.5	Performance Evaluation Samples for On-Site Water Quality Testing . . . . . 1-36
6.5	Data Reduction, Validation, and Reporting . . . . . 1-36
6.5.1	Data Reduction . . . . . 1-36
6.5.2	Data Validation . . . . . 1-36
6.5.3	Data Reporting . . . . . 1-37
6.6	Calculation of Data Quality Indicators . . . . . 1-37
6.7	System Audits . . . . . 1-37
6.8	Reports . . . . . 1-37
6.8.1	Status Reports . . . . . 1-37
6.8.2	Audit Reports . . . . . 1-37
6.9	Corrective Action . . . . . 1-38
<b>7.0</b>	<b>DATA MANAGEMENT AND ANALYSIS, AND REPORTING . . . . . 1-39</b>
7.1	Data Management and Analysis . . . . . 1-39
7.2	Report of Equipment Testing . . . . . 1-38
<b>8.0</b>	<b>SAFETY MEASURES . . . . . 1-40</b>

1     **1.0     INTRODUCTION**

2  
3     This first chapter is the protocol for equipment verification testing for the physical chemical and  
4     biological removal of nitrate from contaminated water supplies. Specifically, this protocol discusses  
5     the information and procedures requested from equipment manufacturers who wish to have their  
6     package treatment plants verified and tested under the NSF/EPA verification testing program. In  
7     order to participate in the equipment verification process a Manufacturer Field Operations Document  
8     (FOD) using this study protocol and adhering to the requirements herein is necessary.

9  
10    The contents of the Manufacturer FOD are described in this protocol document. The manufacturer  
11    will include only those items of information that pertain to his specific equipment and testing  
12    objectives. The descriptive material in this protocol represents the format and type of information  
13    which would be required for NSF/EPA verification testing. The Manufacturer FOD should not be  
14    viewed as a promotional document, but as a document which will transfer technical information about  
15    the equipment, the site of the testing and information regarding successful operation to those  
16    unfamiliar with the equipment and location of the test.

17  
18    The testing of new technologies and materials which are unfamiliar to the NSF/EPA will not be  
19    discouraged. For example, resins or membranes or any other material or chemical which have not  
20    been tested under the ANSI/NSF Standard 61 protocol may be employed in the package plant. If so,  
21    these materials must be identified for review by NSF/EPA. The disclosure of the existence or use of  
22    proprietary or patented material and procedures should also be made in the Manufacturer FOD.

23  
24    The final submission of the Manufacturer FOD shall:

- 25  
26    •     include the information requested in this protocol;  
27  
28    •     conform to the format identified herein;  
29  
30    •     and conform to the specific NSF International (NSF) Equipment Verification Testing Plan or  
31    Plans related to the statement or statements of capabilities that are to be verified.

32  
33    The Manufacturer FOD may include more than one Testing Plan. For example, testing might be  
34    undertaken to verify performance of a package plant for both nitrate reduction and removal of  
35    disinfection byproduct precursors.

36  
37    This protocol document is presented in two fonts. The non-italicized font provides background  
38    information that the Manufacturer may find useful in preparation of the Manufacturer FOD. *The*  
39    *italicized text indicates specific study protocol deliverables that are required of the Manufacturer*  
40    *and that must be incorporated in the Manufacturer FOD.*

41  
42    The following glossary terms are presented here for subsequent reference in this protocol:

- 43  
44    •     Distribution System - A system of conduits by which a primary water supply is conveyed to  
45    consumers typically by a network of pipelines.

- 1
- 2 • EIR - An Environmental Impact Report which may be required to construct and operate a
- 3 package treatment plant.
- 4
- 5 • Manufacturer - A business that assembles and/or sells package plant equipment and/or modular
- 6 systems. The role of the manufacturer is to provide the package plant and/or modular system and
- 7 technical support for the verification testing and study. The manufacturer is also responsible for
- 8 providing assistance to the testing organization during operation and monitoring of the package
- 9 plant or modular system during the verification testing and study.
- 10
- 11 • Manufacturer FOD - document of field testing operations and procedures. Document may be
- 12 prepared by Manufacturer or by third party on behalf of Manufacturer and shall include the
- 13 specific details of the experimental approach in the section titled Field Operations Procedures.
- 14
- 15 • Modular System - A functional assembly of components for use in a drinking water treatment
- 16 system or packaged plant, each part of which provides a limited form of treatment of the feed
- 17 water(s). Treated waters may be discharged to another packaged plant module or to the
- 18 distribution system if the modular system includes the final step of treatment.
- 19
- 20 • Package Plant - A complete water treatment system including all components from connection
- 21 to the feed water(s) through discharge to the distribution system. It is the entire system of water
- 22 treatment plant equipment that is provided by the manufacturer. It shall include all equipment and
- 23 materials which an owner/operator requires or is required by permits to install the system, operate
- 24 it and discharge the final product into the distribution system, and to discharge waste into a waste
- 25 disposal system. Any post treatment or blending facilities are included in the package plant. The
- 26 package plant does not include any existing source water facilities, but it may or may not include
- 27 waste discharge or containment facilities.
- 28
- 29 • NSF Equipment Verification Testing Plan - specific testing plan for each technology application,
- 30 such as nitrate package plants or coagulation and filtration package plants. These plans are being
- 31 developed by NSF to assist in development of Manufacturer FODs.
- 32
- 33 • Performance - Various plant operating factors described either quantitatively or qualitatively
- 34 which characterize the plant's ability to meet the objectives of the treatment process.
- 35
- 36 • Permit. Any permit that is required to install and operate a package treatment plant such as
- 37 conditional use permit, a construction permit, a treatment plant operation permit, a waste
- 38 discharge permit or other such permit.
- 39
- 40 • Plant Operator - the person working for a small water system who is certified to operate a water
- 41 treatment plant and who is responsible for operating package water treatment equipment to
- 42 produce treated drinking water. This person also may collect samples, record data and attend to
- 43 the daily operations of equipment throughout the testing periods.
- 44
- 45 • Reclaimed Water - Water that is a byproduct of the treatment process and is discharged as

1 a wastewater and is reused as irrigation water, cooling tower water or to satisfy similar water  
2 demands.

- 3
- 4 • Recycled Water - Water that is a byproduct of the treatment process that is reused in the  
5 process rather than being discharged as wastewater.
- 6
- 7 • Reliability - The ability of a package plant to meet the objectives of the treatment process over  
8 a long term on a consistent basis without excessive maintenance, operator time and down time.
- 9
- 10 • Responsible Water Agency or Owner/Operator - The person or agency (private or public) that  
11 owns the site and facilities where the package plant will be tested. It is likely that the owner will  
12 already be operating some water system facilities, such as a well, pump station, reservoir,  
13 treatment plant etc. at this site. This agency also represents a typical end user or purchaser of a  
14 package plant who has public water purveyor responsibilities under numerous local, State and  
15 Federal regulations.
- 16
- 17 • Study Protocol for Equipment Verification Testing- this document. Protocol shall be used for  
18 reference during Manufacturer participation in verification testing program;
- 19
- 20 • Testing Organization - an organization qualified to perform studies and testing of package plants  
21 or modular systems. The role of the testing organization is to ensure that there is skilled  
22 operation of a package plant during the intense periods of testing during the study and the tasks  
23 required by the Study Protocol for Equipment Verification Testing are performed. The Testing  
24 Organization is responsible for:
  - 25
  - 26 ➤ managing, evaluating, interpreting and reporting on the data produced by the verification  
27 testing and study;
  - 28 ➤ providing logistical support, scheduling and coordinating the activities, e.g., establishing  
29 a communications network, of all participants in the verification testing and study;
  - 30 ➤ advising the Manufacturer on feed water quality, waste disposal requirements and test site  
31 selection, such that locations selected for the verification testing and study have feed  
32 water quality consistent with the objectives of the Study Protocol for Equipment  
33 Verification Testing;
  - 34 ➤ collecting and transporting analytical samples of water from water and wastewater  
35 streams and maintaining chain of custody documents;
  - 36 ➤ collecting all field data on qualitative and quantitative evaluation factors.
- 37
- 38 • Verification - to establish the evidence on the range of performance of equipment and/or  
39 device under specific conditions following a predetermined study protocol.
- 40
- 41 • Waste, Waste Solids, Wastewater - The solid, liquid, or mixture of solid and liquid material  
42 that is produced by the water treatment processing equipment consisting of concentrated  
43 nitrate and other salt brines and rinse water and backwash water.
- 44
- 45 • Waste System - The portion of the package plant that contains, stores, transports, or pumps

1 the produced waste.

- 2
- 3 • Waste Disposal System - A facility, such as a sewer system, irrigated area, waste disposal
- 4 site, ocean outfall, evaporation pond, deep well disposal system or other such system which
- 5 will accept the waste produced by the package plant. This waste disposal system is not a part
- 6 of the package plant.

## 7

### 8 **1.1 Background**

9

10 U.S. Environmental Protection Agency (EPA) has partnered with NSF, a nonprofit testing and

11 certification organization, to verify performance of small package drinking water systems that serve

12 small communities. It is expected that both the domestic and international markets for such systems

13 are substantial. EPA and NSF have formed an oversight stakeholders group composed of buyers,

14 sellers, and states (issuers of permits), to assist in formulating consensus testing protocols. A goal

15 of verification testing is to enhance and facilitate the acceptance of small package drinking water

16 treatment equipment by state drinking water regulatory engineers and consulting engineers while

17 reducing the need for testing of equipment at each location where the equipment use is contemplated.

18

19 NSF will meet this goal by working with equipment Manufacturers and other agencies in planning

20 and conducting equipment verification testing, evaluating data generated by such testing and

21 managing and disseminating information. The Manufacturer is expected to secure the appropriate

22 resources to support their part of the equipment verification process, including provision of

23 equipment and technical support.

24

25 The verification process established by EPA and NSF is intended to serve as a template for

26 conducting water treatment verification tests that will generate high quality data for verification of

27 equipment performance. The verification process is a model process that can help in moving small

28 package drinking water equipment into routine use more quickly. The verification of an equipment's

29 performance involves five sequential steps:

- 30
- 31 1. Development of a verification/Manufacturer FOD;
- 32 2. Execution of verification testing;
- 33 3. Data reduction, analysis, and reporting;
- 34 4. Performance, reliability and cost (labor, chemicals, energy) verification;
- 35 5. Report preparation and information transfer.

### 36

### 37 **1.2 Objectives of Verification Testing**

38

39 The verification testing objective(s) will be defined by the manufacturer. These specific objectives

40 of the equipment verification testing will be different for each Manufacturer, depending upon the

41 statement of capabilities of the specific equipment to be tested. The testing objectives developed by

42 each Manufacturer shall be defined and described in detail in the Manufacturer FOD developed for

43 each piece of equipment. The objectives of the equipment verification testing may include:

- 44
- 45 • Generate field data appropriate for verifying the performance of the equipment; generate field

1 data in support of meeting current or anticipated water quality regulations;

- 2
- 3 • Evaluate new advances in equipment and equipment design;
- 4
- 5 • Generate field data appropriate for verifying the performance of the equipment used in a specific
- 6 environment such as a coastal region where ocean disposal is available;
- 7
- 8 • Generate field data appropriate for verifying the performance of the equipment operating within
- 9 a specific range of untreated water quality;
- 10
- 11 • Generate field data appropriate for verifying the performance of the equipment used for specific
- 12 modes of operation such as continuous or interrupted operation.
- 13

14 Multiple testing objectives may be included in the Manufacturer FOD. The development of specific  
15 objectives is discussed in Section 4.1. Water quality treatment objectives must also be defined in the  
16 FOD. The development of these objectives is discussed in Section 3.1.

17  
18 An important aspect in the development of the verification testing is to describe the procedures that  
19 will be used to verify the statement of performance capabilities made for water treatment equipment.  
20 A verification testing plan document incorporates the QA/QC elements needed to provide data of  
21 appropriate quality sufficient to reach a defensible position regarding the equipment performance  
22 Verification testing conducted at a single site may not represent every environmental situation which  
23 may be acceptable for the equipment tested, but it will provide data of sufficient quality to make a  
24 judgment about the application of the equipment under conditions similar to those encountered in the  
25 verification testing.

26  
27 **It is important to note that verification of the equipment does not mean that the equipment**  
28 **is “certified” by NSF or EPA. Rather, it recognizes that the performance of the equipment**  
29 **has been determined and verified by these organizations.**

### 30 31 **1.3 Scope of Verification Process and Testing**

32  
33 This protocol outlines the verification process for equipment designed to achieve the physical  
34 chemical or biological removal of nitrate from contaminated water. The scope of this protocol  
35 includes Testing Plans for package plants employing ion exchange, reverse osmosis, electro dialysis,  
36 or biological processes as the primary process for treatment. The package plant may consist of a  
37 single process or a combination of these processes. The package plant may also consist of one or  
38 more of these processes combined with a waste treatment process, such as biological denitrification.  
39 This protocol is not an NSF or third-party consensus standard and it does not endorse the products  
40 or technology described herein. An overview of the equipment verification process and the elements  
41 are described in this protocol document.

### 42 43 **1.4 Scope of the Manufacturer FOD**

44  
45 Specifically, the Manufacturer FOD shall include at least the following items:

- 1 • Roles and responsibilities of verification testing participants; (See Section 2.0)
- 2 • A brief statement of the objectives of the test plan;
- 3 • A brief statement of the water quality treatment objectives;
- 4 • Procedures governing verification testing activities such as equipment operation and process
- 5 monitoring; sample collection, preservation, and analysis; and data collection and interpretation;
- 6 (See Section 3.0)
- 7 • Experimental design of the Field Operations Procedures; (See Sections 4.0 and 5.0)
- 8 • Quality assurance (QA) and quality control (QC) procedures for conducting the verification
- 9 testing and for assessing the quality of the data generated from the verification testing; (See
- 10 Sections 6.0 and 7.0) and
- 11 • Health and safety measures relating to biohazard (if present), chemical, electrical, mechanical and
- 12 other safety codes. (See Section 8.0)

### 13 14 **1.5 General Content of Manufacturer FOD:**

15  
16 The remaining sections of this chapter discuss the type of information which is required in the  
17 manufacturer FOD. At the end of each section the italicized textual material will give the required  
18 outline for treating the subjects discussed in the related section followed by a statement of the  
19 responsibilities of the participants. For example, the following is the general outline for the  
20 manufacturer FOD:

21  
22 *The structure of the Manufacturer FOD must conform to the outline below: The required*  
23 *components of the Document shall be described in greater detail in the sections below.*

- 24 • *TITLE PAGE*
- 25 • *FOREWORD*
- 26 • *TABLE OF CONTENTS -The Table of Contents for the Manufacturer FOD shall include the*  
27 *headings provided in this document although they may be modified as appropriate for a*  
28 *particular type of equipment to be tested.*
- 29 • *EXECUTIVE SUMMARY -The Executive Summary describes the contents of the Manufacturer*  
30 *FOD (not to exceed two pages). A general description of the equipment, the testing objectives,*  
31 *and the statement of water quality treatment objectives and capabilities which shall be verified*  
32 *during testing shall be included, as well as the testing locations, a schedule, and a list of*  
33 *participants.*
- 34 • *ABBREVIATIONS AND ACRONYMS - A list of the abbreviations and acronyms used in the*  
35 *Manufacturer FOD shall be provided*
- 36 • *EQUIPMENT VERIFICATION TESTING RESPONSIBILITIES (See Section 2, below.)*
- 37 • *EQUIPMENT CAPABILITIES AND DESCRIPTION (See Section 3, below.)*
- 38 • *EXPERIMENTAL DESIGN (See Section 4, below.)*
- 39 • *FIELD OPERATIONS PROCEDURES (See Section 5, below.)*
- 40 • *QUALITY ASSURANCE TESTING PLAN (See Section 6, below.)*
- 41 • *DATA MANAGEMENT AND ANALYSIS (See Section 7, below.)*
- 42 • *SAFETY PLAN (See Section 8, below.)*

1 **Manufacturer Responsibilities:**

2  
3 *Preparation of a Manufacturer FOD that includes the above information requested and conforms*  
4 *to the requirements stipulated in this protocol document described in the remaining sections of*  
5 *Chapter 1, and the applicable NSF Equipment Verification Testing Plan or Plans.*  
6

7 **2.0 EQUIPMENT VERIFICATION TESTING RESPONSIBILITIES**

8  
9 **2.1 Verification Testing Organization and Participants**

10  
11 This verification testing program is being conducted by NSF International with participation of  
12 manufacturers, under the sponsorship of the EPA Office of Research and Development, National Risk  
13 Management Research Laboratory, Water Supply and Water Resources Division (WSWRD) -  
14 Cincinnati, Ohio. The WSWRD and NSF jointly are administering the Equipment Verification Testing  
15 Program. The NSF's role is to provide technical and administrative leadership and support in  
16 conducting the testing.  
17

18 The specific responsibilities of each participant are discussed in Section 2.6. The required content  
19 of the field operations Document and the Manufacturer Responsibilities are listed at the end of each  
20 section. In the development of a Manufacturer FOD, a table which includes the name, affiliation, and  
21 mailing address of each participant, a point of contact, their role, and telephone, fax and E-mail  
22 address shall be provided.  
23

24 The following participants should be listed in the Participants Table:  
25 NSF, WSWRD, Site Owner, Site Operator, Plant Operator, Field Testing Organization, and any other  
26 responsible parties.  
27

28 **2.2 Organization**

29  
30 The organizational structure for the verification testing showing lines of communication shall be  
31 provided by the Manufacturer.  
32

33 **2.3 Verification Testing Site Name and Location**

34  
35 This section discusses background information on the verification testing site(s), with emphasis on  
36 the quality of the feed water, which in most cases may be the source water at the site. The need for  
37 treatment should be demonstrated. The manufacturer must submit the name and address of the  
38 owner/operator of the proposed site and submit a letter of agreement from the owner/operator of the  
39 site to allow testing of the package plant at the site. The manufacturer should consider listing a site  
40 which would be typical of his intended market not only in terms of the feed water quality but also  
41 in terms of location and environmental conditions. For example, if a manufacturer's market is in mid-  
42 western agricultural regions, the water quality, climate, and waste disposal systems would be  
43 different than those found in temperate coastal regions. If the manufacturer wishes to demonstrate  
44 a membrane package plant, choice of a site with TDS water quality problems would be desirable. It  
45 is likely that the package plant would be tested at a well site owned and operated by a public water

1 agency or private water company. In most cases, the equipment may be demonstrated at more than  
2 one site. In all cases, the equipment should be tested under different feed water quality (or source  
3 water quality) and seasonal weather and extreme climate conditions within the range available at the  
4 site(s).

## 6 2.4 Site Characteristics

7  
8 The Manufacturer FOD must include a description of the test site and the immediately surrounding  
9 environment. Information about the site should be provided to show that it is feasible to adequately  
10 test a package plant(s). This shall include a description of where the equipment will be located. If  
11 available, give the street address, City, State and Zip code. An area location map showing access  
12 from major streets and highways and a site layout drawing with equipment foot prints and dimensions  
13 would be helpful. The drawing should indicate the location of existing facilities, the source of the  
14 feed water and where the treated water will go and where the waste will be discharged. It should  
15 be specifically mentioned if the treated water will go to waste or if it will be introduced into an  
16 existing water supply. It is also important to point out if treated water will be blended with untreated  
17 water before it is sent to waste or distribution. If so, the blending facility must be a part of the  
18 package plant. Indicate if any facilities other than the package plant would be required such as  
19 additional buildings or trailers for sample collection and analyses, electrical power, concrete pads,  
20 drainage facilities, protective coverings etc. Consider the following questions:

- 21 • Will the package plant supply water on a continuous or interrupted basis?
- 22 • If the package plant is down, how will the demand be met?
- 23 • If the feed water is the source water for an existing water treatment plant, describe the raw  
24 water intake, the opportunity to obtain raw water without the addition of any chemicals as  
25 feed water to the package plant equipment being tested, the pattern of operation of the raw  
26 water pumping (is it continuous or intermittent), if source water available from a pressurized  
27 line or from a storage reservoir, and facilities for handling treated water and waste (i.e.,  
28 residuals) from the testing program.
- 29 • Do facilities exist on the site for disposal of wastes? If so, is the capacity large enough to  
30 handle waste from the package plant. Or, will new waste disposal facilities be required? The  
31 package plant will be tested at its maximum sustainable treatment flow rate (gallons per  
32 minute).
- 33 • What is this value and demonstrate it is compatible with the water supply and demand at the  
34 site?
- 35 • Will the operation of the test facility be compatible with the existing uses of the site and the  
36 surrounding land uses?
- 37 • Is it located in a residential area where neighbors may complain? If so, how will this be  
38 handled?
- 39 • Are any construction or conditional use permits required? Is a permit required to operate  
40 the package plant?
- 41 • Is a waste discharge permit required?
- 42 • What will be the ultimate method of waste disposal?
- 43 • Has the manufacturer consulted with the following: The owner/operator, the water agency,  
44 the local or State health organization, the waste discharge agency, local emergency officials  
45 (regarding safe fire flows), responsible health agencies who have jurisdiction?

- 1 • Have alternative sites been considered?
- 2 • Why was this site chosen in preference to other sites?
- 3 • Environmental documentation such as an EIR or environmental impact assessment relative
- 4 to the proposed package plant testing should also be submitted or an explanation of why such
- 5 environmental documentation may or may not be required.

6

7 **Content of Manufacturer Field Operations Document Regarding Equipment Verification**

8 **Testing Responsibilities:**

9

10 *The Manufacturer, in consultation with NSF as the technical lead, shall be responsible for including*

11 *the following elements in the Manufacturer FOD:*

- 12 • *Definition of the roles and responsibilities of appropriate verification testing participants*
- 13
- 14 • *A table which includes the name, affiliation, and mailing address of each participant, a point*
- 15 *of contact, their role, and telephone, fax and E-mail address.*
- 16
- 17 • *Organization of operational and analytical support*
- 18
- 19 • *List of the site name(s) and location(s). Describe the site and the surroundings. Use location*
- 20 *maps and provide other material discussed above.*
- 21
- 22 • *Description of the test site(s), the site characteristics and identification of where the*
- 23 *equipment shall be located (use foot print drawings) and other pertinent material discussed*
- 24 *above. Describe existing facilities on the site, how they will be used. List any permits and*
- 25 *environmental documentation required. Provide other material discussed above.*
- 26

27 **Manufacturer Responsibilities:**

28

- 29 • *Provision of complete, field-ready equipment for verification testing;*
- 30
- 31 • *Provision of logistical, and technical support, as required. Remove equipment and any discarded*
- 32 *items from the site after termination of the test program.*
- 33
- 34 • *Provision of technical assistance to the site owner/operator and the qualified testing*
- 35 *organization during operation and monitoring of the equipment undergoing verification testing*
- 36 *as discussed above.*
- 37

38 **3.0 EQUIPMENT CAPABILITIES AND DESCRIPTION**

39

40 **3.1 Equipment Capabilities, Water Quality Objectives**

41

42 The manufacturer's FOD must state the treated water quality objectives. This objective must include

43 the following:

44

- 45 1. The nitrate levels in blended water must be 80 percent of the MCL or less at all times.

2. Any secondary standard for any other constituent must not be exceeded at any time.
3. Any other objective the manufacturer wishes to include.

The Manufacturer must identify the type of feed water to be treated, the contaminant(s) to be treated for and 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, what advantages it provides over existing equipment and the known limitations of the equipment. The statement of performance capabilities must be specific and be verifiable by a statistical analysis of the data. Examples of satisfactory statements of performance capabilities would be:

"This ion exchange package plant is capable of treating water contaminated with nitrate up to 100 mg NO<sub>3</sub>/L by producing water with a nitrate level equal to or less than 35 mg NO<sub>3</sub>/L in the treated water samples."

"This membrane package plant is capable of treating water having the following composition: TDS = 1200 mg/L (with sulfates = 300 mg/L or greater ) and containing nitrate having a level of up to 100 mg NO<sub>3</sub>/L and will produce water with a TDS level equal to 150 mg/L and a nitrate level equal to or less than 35 mg NO<sub>3</sub>/L in the treated water samples."

Note in the above statement for membrane package plants, the sulfate level must also be stated.

A statement of performance capabilities such as: "This package plant will provide lower nitrate levels than required by the Safe Drinking Water Act on a consistent and dependable basis," would not be acceptable.

The statement of performance capabilities may also indicate the range of water quality with 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 or credible. The statement of performance capabilities forms the basis of the entire equipment verification testing and must be chosen appropriately. Therefore, the design of the Manufacturer FOD shall include a sufficient range of feed water quality to permit verification of the statement of performance capabilities. The water quality treatment objectives will differ from the verification testing objectives discussed in the next section.

### 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. Open/closed indicators shall be clearly visible on all automatic valves as well as direction of flow arrows on all piping. Other information required is :

- 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)
- h. Any proprietary features should be described

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

*The Manufacturer shall be responsible for including the following elements in the Manufacturer FOD:*

- *A statement of the water quality objectives to be achieved by the equipment.*
- *Description of the equipment to be demonstrated. This shall include:*
  - 1. *Brief introduction and discussion of the engineering and scientific concepts on which the water treatment equipment is based;*
  - 2. *Description of the treatment train and each unit process included in the package plant;*
  - 3. *Brief description of the physical construction/components of the equipment. Include general environmental requirements and limitations, weight, transportability, ruggedness, power and other consumables needed, etc.*
  - 4. *Statement of typical rates of consumption of chemicals, a description of the physical and chemical nature of wastes, and rates of waste production concentrates, residues, etc.).*
- *Definition of the performance range of the equipment.*
- *Operation and maintenance manual will be supplied for the equipment. Include a flow diagram, piping and instrumentation diagram, location of sampling points and flow meters, and a description of a typical start up, operation and shut down procedure. Indicate the functioning of alarms and shut down alarms. Indicate plant adjustments required. All valves and controls and similar components are to be clearly marked on the equipment and so identified in the flow diagram.*
- *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. Provide comparisons 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.*

- 1  
2 • *Discussion of the known limitations of the equipment. Include such items as the range of feed*  
3 *water quality suitable for treatment with the equipment, the upper limits for concentrations*  
4 *of regulated contaminants that can be removed to concentrations below the MCL, level of*  
5 *operator skill required to successfully use the equipment.*

6  
7 **4.0 EXPERIMENTAL DESIGN**

8  
9 This section discusses the objectives of the verification testing, factors that must be considered to  
10 meet the performance objectives, and the statistical and other means that the NSF should use to  
11 evaluate the results of the verification testing.

12  
13 **4.1 Objectives of Experimental Testing**

14  
15 The testing program must have well defined objectives. The Manufacturer FOD will include a  
16 statement of the verification testing objectives to evaluate equipment in one or more of the following  
17 areas: (1) performance relative to manufacturer's stated range of equipment capabilities; 2) how well  
18 it performs relative to the requirements of the Safe Drinking Water Act and any other specific or  
19 anticipated water quality regulation; 3) how well it performs relative to the performance  
20 recommendations for water filtration processes in the Partnership for Safe Water; 4) the impacts of  
21 variations in feed water quality (specifically variations in TDS, chloride, sulfate, nitrate and alkalinity  
22 are important) on its performance; 5) the logistical, human, and economic resources necessary to  
23 operate the equipment; 6) the reliability, ruggedness, cost, range of usefulness, safety and ease of  
24 operation and maintenance; 7) how much (or how little) waste is produced by the treatment process;  
25 and 8) the cost of treatment.

26  
27 Although the manufacturer is encouraged to include all parameters listed below in the Manufacturer's  
28 FOD, the Manufacturer shall be responsible for selection of the qualitative and quantitative  
29 parameters which must be evaluated to meet the water quality treatment objectives and the  
30 verification testing objectives. A list of parameters is listed below and in NSF test plans that are  
31 appropriate for most equipment. For example, if equipment is only intended for removal of nitrate,  
32 there would be no need to conduct testing to evaluate the removal of TDS. The manufacturer will  
33 state the verification testing objective that is appropriate for his equipment. For example, the  
34 Manufacturer may wish to focus on wastewater production and thus formulate his stated objective  
35 to include this factor.

36  
37 **4.2 Equipment Characteristics or Factors to be Tested**

38  
39 This section discusses factors that shall be considered in the design and implementation of the  
40 verification testing. These factors will be evaluated either quantitatively or qualitatively during the  
41 verification testing. The factors can include such items as: ease of operation, ease of maintenance,  
42 degree of operator attention required, operator labor (man-hours) required, response of equipment  
43 and treatment process to changes in feed water quality, electrical power requirements, system  
44 reliability features including redundancy of components, feed flow requirements, discharge  
45 requirements, spatial requirements for the equipment (footprint), unit processes included in treatment

1 train, and chemical inventories needed.

#### 2 3 **4.2.1 Qualitative Factors** 4

5 Some factors, while important, are difficult or impossible to test or quantify. Important  
6 factors that cannot easily be quantified are the modular nature of the equipment, the safety  
7 of the equipment toward operators or spectators, the portability of equipment, and the  
8 logistical requirements necessary for using it. Aesthetics, security and compatibility with  
9 surrounding land use are important qualitative factors. For example, a plant located in a  
10 residential area should not appear out of place and it should be protected from and should not  
11 attract vandalism.  
12

13 Maintenance operations such as ease/difficulty of membrane or resin cleaning and replacement  
14 should be discussed although these operations may not be carried out during the test  
15 procedure. The NSF would also require to know what labor would be required to terminate  
16 the tests and remove the package plant from the site.  
17

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

- 21 • Reliability or susceptibility to environmental conditions
- 22 • Equipment safety. Point out any feature or device which could harm the operator if  
23 malfunctions or mishandling occurred, such as chemical handling, high pressures  
24 discharges, unexpected noises, sudden pressure loss or build up.
- 25 • The need for any safety devices (e.g. fire extinguishers, air packs) or clothing which  
26 are required such as special shoes or safety glasses.
- 27 • Effect of operator experience on results. Discuss the level of experience that an  
28 operator should have to successfully achieve reliable and safe operation. Mention if  
29 special training would be required such as handling acids, leaks or spills.
- 30 • Special equipment required for moving or lifting heavy parts or materials.
- 31 • Aesthetics and security.
- 32 • Compatibility with surrounding land use.
- 33 • Health and safety features
- 34 • Alarms and set points
- 35 • Placement of instrumentation and monitoring devices for convenient operator reading,  
36 inspection and replacement.  
37

#### 38 **4.2.2 Quantitative Factors** 39

40 Many factors in this verification testing can be quantified by various means. Some can be  
41 measured and controlled while others such as chemical market prices cannot be controlled  
42 but can be measured. Typical quantitative factors to be considered are listed below, and  
43 others may be added. The Manufacturer FOD shall list and give estimates of these factors  
44 and describe how they can be measured during the field operation of the package plant or the  
45 test equipment. These factors will be also be field tested, measured and verified by the Testing

1 Organization during the testing and verification procedure.  
2

### 3 **4.2.3 Quantitative Factors: Definitions** 4

5 The following definitions apply to the discussion of quantitative factors:  
6

7 Financing Cost - The cost to finance the purchase of the package plant based on the rates of  
8 inflation, borrowed capital, and amortization period. To standardize cost calculations, these  
9 factors will be set by the NSF/EPA.  
10

11 Untreated Water - The raw water which is delivered or available at the site for treatment by  
12 the package plant for nitrate removal.  
13

14 Treated Water - The water stream that has passed through treatment (and post treatment) and  
15 is available from the package plant either for direct injection into a distribution system or for  
16 blending with untreated water before injection into the water supply system.  
17

18 Blended Water - A mixture of treated and untreated water that is suitable for injection into  
19 the distribution system. This is the same as the distributed water.  
20

21 Percent Blend - The percent of treated water that is in the blend. Thus a 75 percent blend will  
22 refer to water composed of 75 percent treated and 25 percent untreated water. A 100 percent  
23 blended water is equal to treated water.  
24

25 Maximum Distribution Flow Rate - The maximum flow rate (gallons per minute) of blended  
26 (distributed) water which the package plant can cause to be injected into the distribution  
27 mains on a continuously operating basis with a nitrate level at or below 80 percent of the  
28 MCL.  
29

30 Maximum Treatment Flow Rate - The maximum flow rate (gallons per minute) of treated  
31 water which the package plant can produce on a continuously operating basis while  
32 maintaining the Maximum Distribution Flow Rate.  
33

34 Plant Factor - A factor used in computing watertreatment cost. It is the fraction of total time  
35 the plant operates or is projected to operate during its period of amortization. NSF will  
36 determine this factor to standardize cost computations.  
37

38 Percent Waste -  $100 \times$  the ratio of the annual wastewater production to the annual amount  
39 of treated water production.  
40

### 41 **4.2.4 Quantitative Cost Factors** 42

43 All cost data must be quantified for verification testing. Cost will be expressed in two ways:  
44 (1) as cents per 1000 gallons for operating costs and amortized capital costs, and (2) as  
45 annual costs for operating expenses and capital costs. Also, wherever it is possible in a

1 discussion of cost it is useful to designate whether it is "O and M ","operating",  
2 "maintenance" "capital" or "total" for clarification. To standardize cost computations, a  
3 plant factor of 50 percent will be used to determine the annual production of the plant. The  
4 basis of the costs will be production of distributed water at the Maximum Distribution Flow  
5 Rate delivered at a pressure of 60 pounds to accommodate distribution system pressure. The  
6 total cost of all cost items will be estimated by the manufacturer for the duration of the testing  
7 period. The following first cost items may be estimated in the Manufacturers FOD:

- 8 • Capital costs of the package plant.
- 9 • Financing Cost.
- 10 • Delivery and transportation charges.
- 11 • Capital costs of any auxiliary equipment or facilities.
- 12 • Installation, start up, and checkout cost.

13 The following operation and maintenance cost items may be estimated in the  
14 Manufacturers FOD:

- 15 • Operating cost of power to operate the plant computed from the cost per  
16 kWhr.
- 17 • Operating costs of power to boost pressure for distribution.
- 18 • Operating cost of chemicals computed from costs as delivered by local  
19 suppliers.
- 20 • Replacement cost of resin and/or membranes.
- 21 • Cost of operator labor computed from direct and indirect labor costs.
- 22 • Cost of replacement parts. (List items)
- 23 • Cost of maintenance. (List items)
- 24 • Cost of service calls by equipment representatives.
- 25 • Capital and operating cost of waste disposal. (In cents/1000 gal of blended  
26 water).

#### 27 28 **4.2.5 Quantitative Plant Performance Factors**

29  
30 Significant quantitative factors relating to plant performance (other than the special water  
31 quality parameters discussed in the next section) must be included in the Manufacturer's  
32 FOD. These parameters relate to the daily and annual quantities of various streams and  
33 discharges and their flow rates. These performance factors must be estimated in the FOD and  
34 will be verified during the testing and verification program. Instrumentation such as flow  
35 meters, pressure gauges, conductivity meters, sampling taps, etc. must be provided as integral  
36 parts of the package plant. A diagram should be provided to illustrate where and how the  
37 factor can be measured and verified. If a multi vessel ion exchange plant is tested, the  
38 instrumentation should be located so the parameters can be checked for each vessel.

39  
40 The following plant performance factors may be measured.

- 41 • Flow rate (gpm), electrical conductivity (e.c.), and pressure of treated water during  
42 normal treatment.
- 43 • Flow rate (gpm), e.c., and pressure of brine stream(s) during production.
- 44 • Flow rate (gpm), e.c., and pressure of backwash water during backwash.
- 45 • Flow rate (gpm), e.c., and pressure of rinse water during rinse.

- 1 • Daily amount of water treated (gallons) and delivered to distribution system.
- 2 • Daily amount of backwash water used.
- 3 • Daily amount of rinse water used.
- 4 • Daily amount of wastewater produced.
- 5 • Daily amount of make up water for brine maker.
- 6 • Daily amount of saturated brine used for regeneration and amount used per
- 7 regeneration.
- 8 • e.c. and quantity of total wastewater produced.
- 9 • Percent of treated water in delivered water.

10  
11 In nitrate treatment, it is very helpful to evaluate **overall plant performance and efficiency**  
12 **factors** which will indicate the amount of chemical added to the environment or the overall  
13 chemical costs associated with the treatment process. For example in ion exchange, sodium  
14 chloride must be purchased, transported and disposed. For a reverse osmosis plant, sulfuric  
15 acid must be added for pH adjustment and waste brines are produced. Indices of efficiency  
16 can include the following:

- 17
- 18 • Chemical equivalents of a specific chemical (e.g. salt or sulfuric acid) required by the
- 19 process to remove one chemical equivalent of nitrate.
- 20
- 21 • Chemical equivalents of salt materials disposed in wastewater or brine reject by the
- 22 process for removal of one chemical equivalent of nitrate.
- 23
- 24 • Operating cost to remove one pound of nitrate.
- 25
- 26 • Amount of wastewater produced by the process to remove one pound of nitrate.
- 27

#### 28 **4.2.6 Quantitative Factors: Plant Health, Safety and Reliability**

29  
30 Health, safety and reliability features are significant in package plant operation and verification  
31 testing. The safety features treated here refer to those items which protect the water supply  
32 and hence the drinking water public from unintended contamination. (Other types of safety  
33 features for on site plant personnel protection are treated in Section 8). The cost  
34 effectiveness of treating water diminishes rapidly if waste products and chemicals cause  
35 dangerous contamination because of poorly designed and/or operated equipment. In the rush  
36 and concern to eliminate the primary contaminant at a low capital cost, the focus on the  
37 importance of these safety features is easily lost. Primary dependence must be placed on the  
38 reliability and quality of the equipment designer, manufacturer, and operator. It is very likely  
39 that these features will be a primary interest of health officials who must review plant designs  
40 and issue operating permits. The field testing personnel should be aware of these sources of  
41 contamination and may need to devise means to check for acceptable operation.

42  
43 The FOD must describe (1) the safety features that have been designed into the package plant,  
44 (2) what contamination problem this feature is used to address, and (3) how the features can  
45 be field tested.

1 In nitrate treatment, the problem areas of concern are:  
2

3 (1) Sudden loss of pressure in a distribution system being fed by a package plant can occur  
4 either by accident or by intention during distribution maintenance procedures. Pressure loss  
5 coupled with other equipment failures could be catastrophic unless reliable safety features are  
6 activated. Any mechanical device presents an opportunity for failure such as valve failures  
7 due to various mechanical causes including wear. Some valves close at slow rates or are  
8 improperly seated upon closure. Failure to properly close can provide pathways for wastes  
9 and brines to unintentionally enter the treated water supply. Treatment equipment pressure  
10 vessels, manifolds and piping often serve two purposes at different times: to contain both  
11 treated water and wastewater. Such an arrangement constitutes a direct cross connection in  
12 the event of isolation valve failure. Connections to distributed water mains for make up  
13 water, rinse water etc. present an opportunity for back siphoning of chemicals and waste into  
14 the distribution system.  
15

16 (2) An ion exchange bed should not be operated too long or beyond its capacity to adsorb  
17 nitrate. The result is not only lack of nitrate adsorption but also a phenomenon called  
18 "dumping" can occur where much of the previously adsorbed nitrate is dumped back into the  
19 treated water supply.  
20

21 (3) An ion exchange bed, after being regenerated with brine, vessels and piping should be  
22 rinsed thoroughly of the waste salt before being put back into service. If not properly rinsed,  
23 excessive TDS and salt could be discharged into the treated water.  
24

25 (4) Introduction of waste rinse water or waste backwash water into the process stream or  
26 treated stream is also a potential source of contamination.  
27

28 In proper plant design and operation, the above areas of concern will be carefully considered,  
29 although increased cost for safety features and extra use of rinse water and production of  
30 more wastewater may result.  
31

32 As each package plant will have a different piping design and operating procedure, the  
33 location and operation of safety devices can only be generally described in this protocol  
34 document.  
35

36 A simple procedure can be implemented to check for trouble spots in the event of loss of  
37 pressure in the distribution system. Use a flow diagram showing sensors and valves as  
38 reference and ask questions regarding any one valve, such as:  
39

40 1. If the valve is normally closed during step 1 (e.g. during treatment) in the treatment  
41 process, could contamination result if the valve remained open? (e.g. a valve in a make up  
42 supply line and a chemical supply tank.)  
43

44 2. If the valve is normally closed during step 2 (e.g. cleaning or rinsing), could contamination  
45 result if the valve remained open? (e.g. a valve to the treated water line)

1 Examples of other operation steps can be resin or membrane cleaning, standby, brine making,  
2 rinsing, etc. Each valve, whether normally opened or closed, can be so addressed during  
3 each different step of the treatment process. The same queries can be made assuming sudden  
4 loss of water pressure in the distribution line.  
5

6 The following devices, piping and valve arrangements have been used to reduce unintentional  
7 contamination in specific cases.  
8

- 9 1. Simple air gaps. The gaps should be frequently inspected for obstructions.
- 10 2. Sensors for shut down or warning alarms. High nitrate and TDS alarms are effective to  
11 detect contamination after it has occurred.
- 12 3. Back flow preventors, check valves and double check valves allow flow in only one  
13 direction. Addition of manually operated valves allow periodic testing by the operator.
- 14 5. Block and bleed valve arrangements. This arrangement consists of two automatically  
15 operated isolation valves in series with a third automatic valve between the two to act as a  
16 bleed valve. Flow from the bleed valve is a visual indication of failure of the blocking valves.  
17

#### 18 **4.2.7 Cross Connection Control References and Guidelines** 19

20 It is likely that each state will have adopted regulations covering the requirements for using  
21 cross connection prevention devices. Although the manufacturer's package plant will be  
22 tested in a given state (or states) it would be to his advantage to adopt measures which  
23 would apply to all states to give the broadest market for the package plant equipment. Useful  
24 publications are available from individual state and local health agencies such as "**Guidance  
25 Manual For Cross Connection Control Programs**" Published by the State of California,  
26 Department of Health Services, Sept 1988, Public Water Supply Branch. Other sources of  
27 information on this subject can be obtained from literature and certification training courses  
28 given by local plumbing unions. For example, "**A Course Of Instruction For Certification  
29 In Cross-Connection Prevention**" Fresno Area Plumbers, Pipe and Refrigeration Fitters  
30 JATC. **The Foundation for Cross Connection Control and Hydraulic Research** at the  
31 University of Southern California, Los Angeles, is another resource of information (213/749  
32 2032).  
33

34 The FOD must describe (1) the safety features that have been designed into the package plant, (2)  
35 what contamination problem this feature will address, and (3) the recommended field testing  
36 procedure and frequency.  
37

#### 38 **4.3 Water Quality Considerations** 39

40 Water treatment equipment is used to treat water and change the quality of feed water (or raw water)  
41 so it meets the requirements of the Safe Drinking Water Act, amendments to the Safe Drinking Water  
42 Act, and the proposed Groundwater Disinfection Rule. In addition, the treated water should be  
43 aesthetically pleasing and palatable. The experimental design shall be developed so the relevant  
44 questions about water treatment equipment capabilities can be answered.  
45

1 Equipment Manufacturers should recognize that it is highly unlikely that any single process employed  
2 within a package plant can successfully treat any conceivable feed water containing all of the  
3 regulated contaminants and produce a treated water that meets the quality requirements for every  
4 regulated contaminant. Although multiple processes could be placed in a treatment train to  
5 accomplish such a goal, for most public water systems such comprehensive treatment capability is  
6 generally not needed and would not be cost effective.

7  
8 The package plant is typically designed to treat only specific contaminants within a defined range of  
9 untreated water quality. Therefore, nitrate treatment is the subject of this protocol. It is, however,  
10 possible to broaden the applicability of treatment in the case of nitrate removal processes. In certain  
11 cases, water quality improvements regarding other constituents such as hardness, sodium, TDS,  
12 chloride, sulfate etc may also be desirable. The manufacturer can use auxiliary ion exchange treatment  
13 or membrane processes to reduce these constituents as well as the nitrate which is the constituent of  
14 primary concern. The manufacturer should state the range of water qualities and contamination that  
15 the equipment can successfully treat and the range of contaminants or water quality problems that can  
16 be addressed. Manufacturers should carefully consider the capabilities and limitations of their  
17 equipment and prepare Manufacturer FODs that challenge their equipment sufficiently to enable the  
18 verification testing to provide a broad market for their products, while recognizing the limitations of  
19 the equipment and not subjecting it to testing for contaminant removal when the outcome is known  
20 in advance to be failure and the testing would be fruitless. The NSF Equipment Verification Testing  
21 Plans shall be used as the basis for the specific Manufacturer FODs.

#### 22 23 **4.3.1 Feed Water Quality**

24  
25 One of the key aspects related to water treatment equipment performance verification is the  
26 range of feed water quality that can be treated successfully, resulting in treated water quality  
27 that meets water quality goals or regulatory requirements. The FOD preparer should consider  
28 the influence of feed water quality on the quality of treated waters produced by the package  
29 plant, such that product waters meet the water quality goals or regulatory requirements. They  
30 should also consider the impact of various water quality parameters on the cost of the  
31 treatment process and the quality and quantity of the waste produced. As the range of feed  
32 water quality that can be treated by the equipment becomes broader, the potential market for  
33 treatment equipment with verified performance capabilities will also increase. The  
34 Manufacturer shall specify in the FOD the specific water quality parameters to be monitored  
35 in the Verification Testing Program. Also, the recommended operating range of these  
36 parameters should be stated. The following feed water quality characteristics are important  
37 in nitrate treatment using ion exchange and membrane processes.

- 38  
39
- 40 • A general mineral analysis including nitrate, nitrite, chloride, sulfate, bicarbonate, carbonate,
  - 41 pH, TDS, hardness, barium, silica, and all other major cations and anions.
  - 42 • turbidity, particle concentration.
  - 43 • temperature, with temperatures near freezing having potential for the most difficult treatment
  - 44 conditions.
  - 45 • dissolved organic carbon (DOC), total organic carbon (TOC), or UV-254 absorbance.
  - biological dissolved organic carbon (BDOC) or assimilable organic carbon (AOC).

- 1 • color.
- 2 • density (concentration) of microorganisms (bacteria).
- 3 • iron and manganese.
- 4 • presence of algae, particularly filter clogging algae.

5  
6 One of the questions often asked by regulatory engineers in approval of package water  
7 treatment equipment is "Has it been shown to work on the water where you propose to put  
8 it?" By providing treatment capability covering a large range of water qualities the  
9 verification testing is more likely to provide an affirmative answer to that question.

#### 10 11 **4.3.2 Treated Water Quality**

12  
13 Treated water quality is the most significant measurement to be made in the testing program.  
14 If a Manufacturer states that water treatment equipment can be used to treat water to meet  
15 specified regulatory requirements, the verification testing must provide data that support such  
16 a statement of capabilities.

17  
18 For nitrate treatment processes the manufacturer must provide a statement of capabilities to  
19 provide nitrate levels as specified in the SDWA and the state counterparts. In addition, the  
20 manufacturer may wish to make a statement about performance capabilities of the equipment  
21 for removal of other regulated contaminants under the SDWA.

22  
23 Furthermore, some water treatment equipment can be used to meet aesthetic goals that are  
24 not included as regulatory requirements of the Safe Drinking Water Act. Water quality  
25 considerations that go beyond regulatory requirements and may be important for some small  
26 systems include:

- 27
- 28 • color, taste and odor
- 29 • total dissolved solids
- 30 • iron and manganese

31  
32 Finally, other water quality parameters are useful for assessing equipment performance  
33 These may include:

- 34
- 35 • particle count or concentration
- 36 • heterotrophic plate count bacteria (HPC)
- 37 • BDOC or AOC

38  
39 Other water quality considerations must also be made. Any treatment process which removes  
40 a contaminant also changes the composition of other constituents. For example in ion  
41 exchange nitrate is removed, sulfate and alkalinity are also removed and chloride is added;  
42 in a membrane process, nitrate is removed as well as other substances. The removal of these  
43 materials may produce a water quality incompatible with an existing distribution system  
44 These items must be addressed in the test plan.

### 4.3.3 Wastewater Characteristics, Quality and Quantity

The quality and quantity of wastewater produced by the package treatment plant is a very important consideration in testing the performance and acceptability of the plant. In many cases these factors can be the major determining considerations in the choice of treatment. In the case of an ion exchange plant treating for nitrate, the waste brine, although small in quantity, will be high in dissolved salts such as sodium chloride, bicarbonate, sulfate and nitrate. The waste discharge regulator or agency which accepts the waste will need to know the exact composition and quantity of waste before accepting it for discharge. Many wastes are discharged into a local sewer line, which, in turn transfers waste to a wastewater treatment facility. Often, the high TDS may impact the process of waste treatment or disposal. Some assessment of this impact should be done by the manufacturer. Often the wastewater treatment agency will charge a fee for accepting the waste into their system. If the nitrate treatment process is reverse osmosis, the wastewater will also contain high TDS as well as be high in volume. The agency accepting the waste must be assured that his facilities are adequate for accepting the waste.

In either case, the Manufacturer's FOD should contain the chemical composition and quantities of the various types of waste produced by the test plant. The methods of waste discharge and disposal should be listed and discussions and requirements of local wastewater disposal agencies should be documented in the FOD.

### 4.4 Recording Water Quality Data

For all nitrate removal tests, data should be maintained on the quality parameters listed in Sections 4.3.1 and 4.3.2 above and any other data required by the plant operating and waste discharge permitting agencies as described in Section 4.3.3. The frequency for each parameter will vary with nitrate measurements being the most frequent. The procedures and sampling requirements shall be provided in detail in the Verification Testing Plan. The following items of information shall also be maintained for each experiment:

- Type of chemical addition, dose and chemical combination, where applicable (e.g., salt, acid, chlorine, scale inhibitor, etc.);
- Water type (raw water, pretreated feed water, product water, waste water);
- Experimental run number (e.g. 1<sup>st</sup> run, 2<sup>nd</sup> run, 3<sup>rd</sup> run, etc.).

The manufacturer must provide labeled sampling taps and locations on the equipment to allow either manual or automatic sampling. The manufacturer must also provide a diagram showing where each labeled sample tap is located and the parameter which can be sampled at that location.

### 4.5 Instrumentation For Plant Control and Monitoring

The membrane and ion exchange equipment used for nitrate treatment are mechanical in nature and allow the use of probes and instrumentation to monitor or control the plant operation. The

1 manufacturers FOD should contain a description of these controls, their function and accuracy. The  
2 following are examples.

#### 3 4 **4.5.1 Nitrate Measurements**

5  
6 Under the SDWA, at no time should the nitrate in the distributed (blended) water exceed the MCL  
7 value. Frequent manual analysis of grab samples or automatic nitrate monitoring is required to assess  
8 the performance of nitrate removal plants. Monitoring this parameter in both the feed, treated and  
9 blended water is very informative of plant performance. Measurement of nitrate on a once or twice  
10 per day basis is not sufficient to detect rapidly changing values which can occur. It is well known that  
11 nitrate levels can change from minute to minute in water supplied by an intermittently operated pump.  
12 Likewise, whenever an ion exchange vessel undergoes a regeneration cycle, potential for high nitrates  
13 exists. Some vessels are regenerated five or more times per day. These potential fluctuations demand  
14 frequent manual or automatic monitoring. (Note: For reliability, plant control of the amount  
15 of water treated by each vessel before a regeneration must be done by reliable flow meters to measure  
16 a set point batch value and signal either to the operator or a control system to start the regeneration.  
17 Automatic plant control must not be based on nitrate measurements because of their rapidly changing  
18 nature).

19  
20 Similarly, if membrane processes are used, nitrate variations can also occur as driving pressure or  
21 current flows change.

#### 22 23 **4.5.2 Electrical Conductivity Measurements**

24  
25 Electrical conductivity measurements (e.c.) can be an indicator of plant performance and can be  
26 measured and recorded on a continuous basis. If ion exchange is the process, this parameter will  
27 indicate if excessive salts from improperly operating equipment has contaminated the water supply.  
28 The excessive salts in the water supply should not exceed the secondary standards for chloride, sulfate  
29 and TDS and should be as close to the feed water electrical conductivity as possible. If a membrane  
30 process is used, the electrical conductivity of the product water will be less than that of the feed water  
31 and will be an indication of properly functioning equipment. The manufacturer's FOD should indicate  
32 the range of conductivities to be expected in the various streams.

#### 33 34 **4.6 Verification Testing Schedule**

35  
36 Verification testing activities include equipment set-up, start up and initial operation, verification  
37 operation, sampling and analysis, maintenance procedures and plant shut down. Initial operations  
38 are intended to be conducted so Manufacturers can test their equipment and be sure it is functioning  
39 as intended. If feed water (or source water) quality influences operation and performance of  
40 equipment being tested, the initial operations period serves as the shake-down period for determining  
41 appropriate operating parameters.

42  
43 For nitrate treatment equipment, specific care must be taken during the start up procedure to disinfect  
44 equipment and media. Both ion exchange resins and membrane materials are sensitive to oxidants  
45 and disinfectants. The manufacturer should provide a procedure to ensure proper disinfection of his

1 equipment for the start up procedure and for subsequent occasions if required.

2  
3 The timing for verification testing shall be designated on the basis of four annual testing episodes in  
4 order to cover a range of water quality conditions and ambient temperatures experienced in an annual  
5 period. For example, climatic changes between rainy and dry seasons or local agricultural practices  
6 may produce substantial variability in feed water nitrate and other water quality parameters. The  
7 timing for verification testing should include cold weather operations because of seasonal water  
8 quality variations and because of the impact of cold temperatures on mechanical devices, filtration  
9 and membrane devices.

- 10  
11 • cold temperatures (1° to 5°C) can have an adverse affect on some water treatment processes due  
12 to the increase in water viscosity at cold temperatures. Cold temperature considerations may be  
13 particularly important for membrane filtration applications;  
14  
15 • water flows treated by many types of package watertreatment equipment are so great (80 to 100  
16 liters/minute, or greater) that use of mechanical refrigeration to attain temperatures of 1° to 5°C  
17 would be prohibitively expensive;  
18  
19 • cold temperatures have an adverse effects on mechanical pumps, chemical feed pumps  
20 compressors and automatically operated valves.

21  
22 Verification testing with operations for which data are collected and used to verify performance  
23 would be done after initial operations are completed. The verification entity is to be notified of the  
24 date when verification testing is scheduled to begin.

25  
26 **Content of Manufacturer Field Operations Document Regarding Experimental Design:**

27  
28 *The Manufacturer shall be responsible for including the following elements in the Manufacture r*  
29 *FOD:*

- 30 • *Statement of the verification testing objectives.*  
31  
32 • *Identification and discussion of the water treatment problem or problems that the equipment*  
33 *is designed to address, how the equipment will solve the problem, and who would be the*  
34 *potential users of the equipment.*  
35  
36 • *Identification of the range of key water quality parameters, given in applicable NSF Testing*  
37 *Plans, which the equipment is intended to address and for which the equipment is applicable.*  
38  
39 • *Identification of the key parameters of treated water quality that shall be used for evaluation*  
40 *of equipment performance. Parameters of significance for treated water quality were listed*  
41 *above in Section 4, and in applicable NSF Testing Plans.*  
42  
43 • *Identification of the key qualitative parameters that shall be used for evaluation of*  
44 *equipment performance. Parameters of significance for treated water quality were listed*  
45 *above in Section 4, and in applicable NSF Testing Plans.*

- 1 • *Identification of the key quantitative parameters that shall be used for evaluation of*  
2 *equipment performance. Parameters of significance for treated water quality were listed*  
3 *above in Section 4, and in applicable NSF Testing Plans.*
- 4
- 5 • *Identification, description and testing procedures for safety components designed to prevent*  
6 *back flow, cross connections, or any unintended contamination of treated water.*
- 7
- 8 • *Detailed outline of the verification testing schedule, with regard to annual testing periods*  
9 *that will cover an appropriate range of annual climatic conditions, (i.e., different*  
10 *temperature conditions, seasonal differences between rainy and dry conditions).*
- 11

## 12 **5.0 FIELD OPERATIONS PROCEDURES**

### 13 **5.1 Equipment Operations and Design**

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

19 Operation and design aspects of water treatment process equipment often provide a basis for approval  
20 or permitting by state regulatory engineers and can be used to pinpoint specific areas of concern  
21 related to operation of the equipment. Specific operation and design aspects to be included in the  
22 Manufacturer FOD are provided in detail, in the Manufacturer Responsibilities section below.

### 23 **5.2 Selection of Analytical Laboratory and Field Testing Organization**

24 To assess the performance of the equipment, the water quality attained using the equipment shall be  
25 determined by on-site analysis or by an NSF-qualified analytical laboratory, by a field operations and  
26 testing organization or by a combination of both. The Manufacturer shall use an NSF-qualified  
27 testing organization (laboratory or engineering company). The NSF may provide a list of qualified  
28 testing organizations from which Manufacturers can select for submission of analytical samples. For  
29 field operations, the Manufacturer shall employ an NSF-qualified field testing organization. These  
30 organizations may include engineering consulting firms, universities, or other qualified scientific  
31 organizations with experience operating pilot plant equipment.

32 In addition to NSF qualification, the analytical laboratories selected must also be certified for analysis  
33 of water samples for Safe Drinking Water Act compliance by one or more states having Safe Drinking  
34 Water Act primacy. Furthermore, the selected analytical laboratory must be certified by the State in  
35 which the verification testing is being performed. Because of the variability of acceptance of  
36 laboratories from state to state, use of an analytical laboratory certified in a large number of states  
37 is recommended. Laboratories approved for sample analysis for the EPA's Information Collection  
38 Rule would have nationally recognized capabilities. Analytical results from the laboratory are to be  
39 provided directly to the NSF to maintain data integrity.

1 The manufacturer and the testing organization will also need to cooperate with the water agency who  
2 accepts water for distribution within their system. Water analyses start up, monitoring and  
3 operational procedures must be performed in accordance with the regulatory permits required to  
4 operate the plant equipment. Periodic reports must be submitted to the regulating agencies according  
5 to permit requirements. *The manufacturer's FOD must designate who will be responsible for the*  
6 *plant operation and their qualifications and verify acceptance of the operator by the other*  
7 *participating members.*  
8

### 9 **5.3 Communications, Documentation, Logistics, and Equipment**

10  
11 NSF shall communicate regularly with the verification testing participants to coordinate all field  
12 activities associated with this verification testing and to resolve any logistical, technical, or QA issues  
13 that may arise as the verification testing progresses. The successful implementation of the verification  
14 testing will require detailed coordination and constant communication between all verification testing  
15 participants.  
16

17 All Manufacturer/NSF field activities shall be thoroughly documented. Field documentation shall  
18 include field logbooks, photographs, field data sheets, and chain-of-custody forms. The qualified  
19 testing organization shall be responsible for maintaining all field documentation. Field notes shall be  
20 kept in a bound logbook. Each page shall be sequentially numbered and labeled with the project name  
21 and number. Field logbooks shall be used to record all water treatment equipment operating data.  
22 Completed pages shall be signed and dated by the individual responsible for the entries. Errors shall  
23 have one line drawn through them and this line shall be initialed and dated.  
24

25 All photographs shall be logged in the field logbook. These entries shall include the time, date,  
26 direction, subject of the photograph, and the identity of the photographer. Any deviations from the  
27 approved final Manufacturer FOD shall be thoroughly documented in the field logbook and provided  
28 to the NSF.  
29

30 Original field sheets and chain-of-custody forms shall accompany all samples shipped to the analytical  
31 laboratory. Copies of field sheets and chain-of-custody forms for all samples shall be provided to the  
32 NSF.  
33

### 34 **5.4 Initial Operations**

35  
36 Initial operations will allow equipment Manufacturers to refine their operating procedures and to  
37 make operation adjustments as needed to successfully treat the feed water. Information generated  
38 through this period of operation may be used to revise the Manufacturer FOD, if necessary. A failure  
39 at this point in the verification testing could indicate a lack of capability of the process equipment and  
40 the verification testing might be canceled.  
41

### 42 **5.5 Equipment Operation and Water Quality Sampling for Verification Testing**

43  
44 The qualified testing organization shall supervise equipment operation and water quality sampling and  
45 analysis during the verification phase of testing, using the procedures described below. The NSF

1 should oversee or audit these activities. All field activities shall conform with requirements provided  
2 in the Manufacturer FOD that was developed and approved for the verification testing being  
3 conducted.

4  
5 If unanticipated or unusual situations are encountered that may alter the plans for equipment  
6 operation, water quality sampling, or data quality, the situation must be discussed with the NSF  
7 technical lead. Any deviations from the approved final Manufacturer FOD shall be thoroughly  
8 documented.

9  
10 During routine operation of water treatment equipment, the total number of hours during which the  
11 equipment was operated each day shall be documented as well as the time required by the operator  
12 to perform various tasks. The qualified Testing Organization will record and verify the number of  
13 hours each day spent by the operator of the treatment plant and provide a description of the daily  
14 tasks performed by the operator of the treatment equipment.

#### 15 16 **Content of Manufacturer Field Operations Document Regarding Field Operations Procedures:**

17  
18 *The Manufacturer shall be responsible for including the following elements in the Manufacture r*  
19 *FOD:*

- 20  
21 • *A table summary of the proposed time schedule for operating and testing,*  
22 • *Field operating procedures for the equipment and performance testing, based upon the NS F*  
23 *Equipment Verification Testing Plan with listing of operating parameters, ranges for feed water*  
24 *quality, and the sampling and analysis strategy.*

#### 25 26 **Manufacturer Responsibilities:**

- 27  
28 • *Provision of all equipment needed for field work associated with this verification testing;*  
29 • *Provision of a complete list of all equipment to be used in the v erification testing. A table format*  
30 *is suggested;*  
31 • *Provision of field operating procedures.*

### 32 33 **6.0 QUALITY ASSURANCE PROJECT PLAN (QAPP)**

34  
35 The QAPP for this verification testing specifies procedures that shall be used to ensure data quality  
36 and integrity. Careful adherence to these procedures will ensure that data generated from the  
37 verification testing will provide sound analytical results that can serve as the basis for performance  
38 verification.

#### 39 40 **6.1 Purpose and Scope**

41  
42 The primary purpose of this section is to outline steps that shall be taken by operators of the  
43 equipment and by the analytical laboratory to ensure that data resulting from this verification testing  
44 is of known quality and that a sufficient number of critical measurements are taken.

1     **6.2     Quality Assurance Responsibilities**

2  
3     The Manufacturer project manager is responsible for coordinating the preparation of the QAPP for  
4     this verification testing and for its approval by the NSF. The qualified testing organization project  
5     manager, with oversight from NSF, should ensure that the QAPP is implemented during all  
6     verification testing activities.

7  
8     The entire Manufacturer FOD including the QAPP must be approved by the Manufacturer and the  
9     NSF before the verification testing can proceed. The NSF must review and either approve the QAPP  
10    or provide reasons for rejection of the QAPP along with suggestions on how to modify the QAPP  
11    to make it acceptable, provided that the Manufacturer has made a good faith effort to develop an  
12    acceptable QAPP (i.e. the QAPP is 75 to 80% acceptable with only minor changes needed to produce  
13    an acceptable plan. NSF will not write QAPPs for Manufacturers.

14  
15    A number of individuals may be responsible for monitoring equipment operating parameters and for  
16    sampling and analysis QA/QC throughout the verification testing. Primary responsibility for ensuring  
17    that both equipment operation and sampling and analysis activities comply with the QA/QC  
18    requirements of the Manufacturer FOD (Section 6) shall rest with the qualified testing organization,  
19    with oversight by the NSF. QA/QC activities for the equipment shall include those activities  
20    recommended by Manufacturer and those required by the NSF to assure the verification testing will  
21    provide data of the necessary quality.

22  
23    QA/QC activities for the analytical laboratory that analyzes samples sent off-site shall be the  
24    responsibility of that analytical laboratory's supervisor. If problems arise or any data appear unusual,  
25    they shall be thoroughly documented and corrective actions shall be implemented as specified in this  
26    section. The QA/QC measurements made by the off-site analytical laboratory are dependent on the  
27    analytical methods being used.

28  
29    **6.3     Data Quality Indicators**

30  
31    The data obtained during the verification testing must be of sound quality for conclusions to be drawn  
32    on the equipment. For all measurement and monitoring activities conducted for equipment  
33    verification, the NSF and EPA require that data quality parameters be established based on the  
34    proposed end uses of the data. Data quality parameters include four indicators of data quality:  
35    representativeness, completeness, accuracy, and precision.

36  
37    Treatment results generated by the equipment must be verifiable for the purposes of this program to  
38    be fulfilled. High quality, well documented analytical laboratory results are essential for meeting the  
39    purpose and objectives of this verification testing. Therefore, the following indicators of data quality  
40    shall be closely evaluated to determine the performance of the equipment when measured against data  
41    generated by the analytical laboratory.

42  
43        **6.3.1   Representativeness**

44  
45        Representativeness refers to the degree to which the data accurately and precisely represent

1 the conditions or characteristics of the parameter represented by the data. In this verification  
2 testing, representativeness will be ensured by executing consistent sample collection  
3 procedures, including sample locations, timing of sample collection, sampling procedures,  
4 sample preservation, sample packaging, sample shipping, and sample equipment  
5 decontamination (Section 5). Representativeness also will be ensured by using each method  
6 at its optimum capability to provide results that represent the most accurate and precise  
7 measurement it is capable of achieving.  
8

9 For equipment operating data, representativeness entails collecting a sufficient quantity of  
10 data during operation to be able to detect a change in operations. For nitrate treatment  
11 processes detecting a +/- 10 percent change in an operating parameter (e.g. headloss) is  
12 sufficient. Flow rates shall also be known within +/- 10 percent.  
13

### 14 **6.3.2 Completeness**

15  
16 Completeness refers to the amount of data collected from a measurement process compared  
17 to the amount that was expected to be obtained. For this verification testing, completeness  
18 refers to the proportion of valid, acceptable data generated using each method. The  
19 completeness objective for data generated during this verification testing is 85 percent.  
20

### 21 **6.3.3 Accuracy**

22  
23 For water quality analyses, accuracy refers to the difference between a sample result and the  
24 reference or true value for the sample. Loss of accuracy can be caused by such processes as  
25 errors in standards preparation, equipment calibrations, loss of target analyte in the extraction  
26 process, interferences, and systematic or carryover contamination from one sample to the  
27 next.  
28

29 For equipment operating parameters, accuracy refers to the difference between the reported  
30 operating condition and the actual operating condition. For water flow, accuracy is the  
31 difference between the reported flow indicated by a flow meter and the flow as actually  
32 measured on the basis of known volumes of water and carefully defined times (bucket and  
33 stopwatch technique) as practiced in hydraulics laboratories or water meter calibration shops.  
34 For mixing equipment, accuracy is the difference between an electronic readout for equipment  
35 RPMs and the actual measurement based on counted revolutions and measured time.  
36 Accuracy of head loss measurement can be determined by using measuring tapes to check the  
37 calibration of piezometers for gravity filters or by checking the calibration of pressure gauges  
38 for pressure filters. Meters and gauges must be checked periodically for accuracy, and when  
39 proven to be dependable over time, the time interval between accuracy checks can be  
40 increased.  
41

### 42 **6.3.4 Precision**

43  
44 Precision refers to the degree of mutual agreement among individual measurements and  
45 provides an estimate of random error.

1     **6.4     Quality Control Checks**

2  
3     This section describes the QC requirements that apply to both the treatment equipment and the on-  
4     site water quality analyses. It also contains a discussion of the corrective action to be taken if the  
5     QC parameters fall outside of the evaluation criteria.  
6

7     The quality control checks provide a means of measuring the quality of data produced. The  
8     Manufacturer may not need to use all the ones identified in this section. The selection of the  
9     appropriate quality control checks depends on the equipment, the experimental design and the  
10    performance goals. The selection of quality control checks shall be based on discussions among the  
11    Manufacturer and the NSF. Some types of quality control checks applicable to operating water  
12    treatment equipment were described in Section 6.3.4.  
13

14           **6.4.1     Quality Control for Equipment Operation**

15  
16    This section will explain the methods to be used to check on the accuracy of equipment  
17    operating parameters and the frequency with which these quality control checks shall be  
18    made. A key aspect of the Equipment Verification Testing Program is to provide operating  
19    results that will be widely accepted by state regulatory engineers. If the quality of the  
20    equipment operating data can not be verified, then the water quality analytical results may be  
21    of no value. Because water can not be treated if equipment is not operating, obtaining valid  
22    equipment operating data is a prime concern for verification testing.  
23

24    An example of the need for QC for equipment operations is an incident of state rejection of  
25    test data because the treatment equipment had no flow meter to use for determining  
26    engineering and operating parameters related to flow.  
27

28           **6.4.2     Water Quality Data**

29  
30    After treatment equipment is being operated and water is being treated, the results of the  
31    treatment are interpreted in terms of water quality. Therefore the quality of water sample  
32    analytical results is just as important as the quality of the equipment operating data. Most QA  
33    plans emphasize analytical QA. The important aspects of sampling and analytical QA are  
34    given below:  
35

36           **6.4.2.1     Duplicate Samples:** Duplicate samples must be analyzed to  
37           determine the precision of analysis. The procedure for determining  
38           samples to be analyzed in duplicate shall be provided with the  
39           frequency of analysis and the approximate number.  
40

41           **6.4.2.2     Method Blanks:** Method blanks are used to evaluate analytical  
42           method-induced contamination, which may cause false positive  
43           results.  
44

45           **6.4.2.3     Spiked Samples:** The use of spiked samples will depend on the

1 testing program, and the contaminants to be removed. If spiked  
2 samples are to be used specify the procedure, frequency, acceptance  
3 criteria, and actions if criteria are not met.  
4

5 **6.4.2.4 Travel Blanks:** Travel blanks shall be provided to the analytical  
6 laboratory to evaluate travel-related contamination.  
7

8 **6.4.2.5 Performance Evaluation Samples for On-Site Water Quality**  
9 **Testing:** Performance evaluation (PE) samples are samples whose  
10 composition is unknown to the analyst that are used to evaluate  
11 analytical performance. Analysis of PE samples shall be conducted  
12 before pilot testing is initiated. PE samples shall be submitted by the  
13 field testing organization to the analytical laboratory and also to the  
14 equipment testing organizations if appropriate. The control limits for  
15 the PE samples shall be used to evaluate the equipment testing  
16 organization's and analytical laboratory's method performance. One  
17 kind of PE sample that would be used for on-site QA in most studies  
18 done under this protocol would be a turbidity PE sample.  
19

20 PE samples come with statistics about each sample which have been  
21 derived from the analysis of the sample by a number of laboratories  
22 using EPA-approved methods. These statistics include a true value of  
23 the PE sample, a mean of the laboratory results obtained from the  
24 analysis of the PE sample, and an acceptance range for sample values.  
25 The analytical laboratory is expected to provide results from the  
26 analysis of the PE samples that meet the performance objectives of the  
27 verification testing.  
28

## 29 **6.5 Data Reduction, Validation, and Reporting**

30  
31 To maintain good data quality, specific procedures shall be followed during data reduction, validation,  
32 and reporting. These procedures are detailed below.  
33

### 34 **6.5.1 Data Reduction**

35  
36 Data reduction refers to the process of converting the raw results from the equipment into  
37 concentration or other data in a form to be used in the comparison. The procedures to be used  
38 will be equipment dependent. The purpose of this step is to provide data which shall be used  
39 to verify the statement of performance capabilities. These data shall be obtained from  
40 logbooks, instrument outputs, and computer outputs as appropriate.  
41

### 42 **6.5.2 Data Validation**

43  
44 The operator shall verify the completeness of the appropriate data forms and the completeness  
45 and correctness of data acquisition and reduction. The field team supervisor or another

1 technical person shall review calculations and inspect laboratory logbooks and data sheets to  
2 verify accuracy, completeness. Calibration and QC data shall be examined by the individual  
3 operators and the laboratory supervisor. Laboratory and project managers shall verify that all  
4 instrument systems are in control and that QA objectives for accuracy, completeness, and  
5 method detection limits have been met.  
6

7 Analytical outlier data are defined as those QC data lying outside a specific QC objective  
8 window for precision and accuracy for a given analytical method. Should QC data be outside  
9 of control limits, the analytical laboratory or field team supervisor shall investigate the cause  
10 of the problem. If the problem involves an analytical problem, the sample shall be reanalyzed.  
11 If the problem can be attributed to the sample matrix, the result shall be flagged with a data  
12 qualifier. This data qualifier shall be included and explained in the final analytical report.  
13

### 14 **6.5.3 Data Reporting**

15  
16 This section contains a list of the water quality and equipment operation data to be reported.  
17 At a minimum, the data tabulation shall list the results for feed water and treated water quality  
18 analyses and equipment operating data. All QC information such as calibrations, blanks and  
19 reference samples are to be included in an appendix. All raw analytical data shall also be  
20 reported in an appendix. All data shall be reported in hard copy and electronically in a  
21 common spreadsheet or database format.  
22

## 23 **6.6 Calculation of Data Quality Indicators**

24  
25 The equations for any data quality indicator calculations employed shall be provided. These include:  
26 precision, relative percent deviation, standard deviation, accuracy, and completeness.  
27

## 28 **6.7 System Audits**

29  
30 On-site system audits for sampling activities, field operations, and laboratories shall be conducted as  
31 specified by the NSF Equipment Verification Testing Plan. These audits will be performed by the NSF  
32 to determine if the NSF Equipment Verification Testing Plan is being implemented as intended  
33 Separate audit reports will be completed after the audits and provided to the participating parties  
34 through the NSF.  
35

## 36 **6.8 Reports**

### 37 **6.8.1 Status Reports**

38  
39  
40 The equipment testing organization shall prepare periodic reports for the NSF project  
41 managers. These reports shall discuss project progress, problems and associated corrective  
42 actions, and future scheduled activities associated with the verification testing. When  
43 problems occur, the Manufacturer and equipment testing organization project managers shall  
44 discuss them with the NSF technical lead, estimate the type and degree of impact, and  
45 describe the corrective actions taken to mitigate the impact and to prevent a recurrence of the

1 problems. The frequency, format, and content of these reports shall be outlined in the  
2 Manufacturer FOD.

### 3 4 **6.8.2 Audit Reports**

5  
6 Any QA audits or inspections that take place in the field or at the analytical laboratory while  
7 the verification testing is being conducted shall be formally reported by the equipment testing  
8 organizations to the NSF project manager who will forward them to the Manufacturer and  
9 NSF QC Manager for appropriate actions.

### 10 11 **6.9 Corrective Action**

12  
13 Each Manufacturer FOD must incorporate a corrective action plan. This plan must include the  
14 predetermined acceptance limits, the corrective action to be initiated whenever such acceptance  
15 criteria are not met, and the names of the individuals responsible for implementation.

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

- 17 • Performance evaluation audits
- 18 • Technical systems audits

### 19 20 **Content of Manufacturer Field Operations Document Regarding Quality Assurance Project** 21 **Plan:**

22  
23 *The Manufacturer shall be responsible for including the following elements in the Manufacture r*  
24 *FOD:*

- 25 • *Description of methodology for measurement of accuracy.*
- 26 • *Description of methodology for measurement of precision.*
- 27 • *Description of the methodology for use of b lanks, the materials used, the frequency, the criteria*  
28 *for acceptable method blanks and the actions if criteria are not met.*
- 29 • *Description of any specific pro cedures appropriate to the analysis of the PE samples. It has to*  
30 *be clear how these samples are going to be used in the verification testing. One use of PE*  
31 *samples is in the conduct of a performance audit (see Section 6.7.1).*
- 32 • *Outline of the procedure for determining samples to be a nalyzed in duplicate, the frequency and*  
33 *approximate number.*
- 34 • *Description of the procedures used to assure that the data are correct.*
- 35 • *Listing of equations used for any necessary data quality indicator calculations. These include:*  
36 *precision, relative percent deviation, standard deviation, accuracy, and completeness.*
- 37 • *Outline of the frequency, format, and content of reports in the Manufacturer FOD.*
- 38 • *Development of a corrective action plan in the Manufacturer FOD.*

### 39 40 **Manufacturer Responsibilities:**

- 41 • *Provision of all QC information such as calibrations, blanks and reference samples in a n*  
42 *appendix. All raw analytical data shall also be reported in an appendix.*
- 43 • *Provision of all data in hard copy and electronic form in a common spreadsheet or databas e*  
44 *format.*

1     **7.0     DATA MANAGEMENT AND ANALYSIS, AND REPORTING**

2  
3     **7.1     Data Management and Analysis**

4  
5     The Manufacturer, the qualified testing organization and the NSF each have distinct responsibilities  
6     for managing and analyzing verification testing data. The equipment testing organization is  
7     responsible for managing all the data and information generated during the verification testing. The  
8     Manufacturer is responsible for furnishing those records generated by the equipment testing  
9     organization. The NSF will be responsible for analysis and verification of the data

10  
11     A variety of data may be generated during a verification testing. Each piece of data or information  
12     identified for collection in the NSF Equipment Verification Testing Plan shall be provided to the NSF.  
13     The data management section of the Manufacturer FOD shall describe what types of data and  
14     information needs to be collected and managed. It shall also describe how the data shall be reported  
15     to the NSF for evaluation.

16  
17     Laboratory Analyses: The raw data and the validated data must be provided to the NSF. These data  
18     shall be provided in hard copy and in electronic format. As with the data generated by the innovative  
19     equipment, the electronic copy of the laboratory data shall be provided in a spreadsheet, and a data  
20     dictionary shall be provided. In addition to the sample results, all QA/QC summary forms must be  
21     provided.

22  
23     Other items that must be provided include:

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

27  
28     **7.2     Report of Equipment Testing**

29  
30     The qualified testing organization shall prepare a draft report describing the verification testing that  
31     was carried out and the results of that testing. This report shall include the following topics:

- 32  
33     • Introduction  
34     • Executive Summary  
35     • Description and Identification of Product Tested  
36     • Procedures and Methods Used in Testing  
37     • Results and Discussion  
38     • Conclusions and Recommendations  
39     • References  
40     • Appendices  
41     • Manufacturer FOD  
42     • QA/AC Results

43  
44     The NSF will review the draft report, the results of testing, the QA/QC results, and will prepare a  
45     final report.

1 **Content of Manufacturer Field Operations Document Regarding Data Management and**  
2 **Analysis, and Reporting:**  
3

4 *The Manufacturer shall be responsible for including the following elements in the Manufacture r*  
5 *FOD:*  
6

- 7 • *Description of what types of data and information needs to be collected and managed.*  
8 • *Description of how the data will be reported to the NSF for evaluation.*  
9

10 **8.0 SAFETY MEASURES**  
11

12 The safety procedures shall address safety considerations which relate to the health and safety of  
13 personnel required to work on the site of the test equipment and persons visiting the site. Many of  
14 these items will be covered by site inspections and construction and operating permits issued by  
15 responsible agencies. They will include:  
16

- 17 • regulations covering the storage and transport of chemicals.  
18  
19 • conformance with the National Electric Code.  
20  
21 • provision of parking facilities, sanitary facilities.  
22  
23 • provision of and access to fire extinguishers.  
24  
25 • regulations covering site security.  
26  
27 • conformance to any building permit requirement such as provision of handicap access or other  
28 health and safety requirements.  
29  
30 • ventilation and air conditioning of equipment or of trailers or buildings housing equipment, if  
31 gases generated by the equipment could present a safety hazard.  
32

33 **Content of Manufacturer Field Operations Document Regarding Safety:**  
34

35 *The Manufacturer FOD shall address safety considerations that are appropriate for the equipment*  
36 *being tested, if any, being used in the verification testing.*  
37  
38  
39  
40  
41  
42