

I. INTRODUCTION

This report discusses the QuikWater® natural gas-fired direct-contact water heater (technology) model 2500 rated at 2.8 million British thermal units per hour (MMBtu/hr), model 3500 rated at 3.8 MMBtu/hr, and model 5000 rated at 5.0 MMBtu/hr. QuikWater is a Division of Webco Industries, Inc. The report also discusses the performance claims to be verified by the Air Resources Board (ARB), the emissions testing results, and the findings and recommendations of the ARB staff concerning this technology.

This report is organized into several sections. The General Information section provides background information on the ARB's Equipment and Process Precertification (Precertification) Program. The next three sections (Summary of Scope, Statement of Claims, and Description of Technology) discuss the breadth of our evaluation, the performance claims, and a description of the QuikWater technology.

The Technical Evaluation and the Evaluation of Claims sections present detailed information on the ARB staff's technical review and assessment of the QuikWater technology. The Quality Management and Environmental Benefits sections provide supporting information on the QuikWater technology and a brief assessment of the potential air quality impacts of the technology.

The Recommendations section discusses the ARB staff's determination of the performance of the QuikWater technology relative to the company's claims. The Suggested Operating Conditions section provides the ARB's staff evaluation of the South Coast Air Quality Management District's (SCAQMD) certified equipment permit conditions. The Precertification Conditions section provides guidance with respect to the specific conditions that must be met for the certificate to remain valid for three years.

Appendix A contains a listing of the information that we relied upon to conduct our evaluation. The remaining appendices contain the detailed information that supports the evaluation in this report.

II. GENERAL INFORMATION

On June 14, 1996, the ARB adopted section 91400, California Code of Regulations, which included the criteria for the Equipment and Process Precertification Program. This regulation became effective on November 30, 1996.

Under this regulation, equipment or processes eligible for the Precertification Program must:

- 1) have an air quality benefit;
- 2) be commonly-used or have the potential to be commonly-used in the near future (market ready); and
- 3) not pose a significant potential hazard to public health and safety or the environment.

Furthermore, applicants must demonstrate that they have sufficient control over the manufacturing of the equipment or

process to ensure that they can consistently and reliably produce equipment that performs at least as well as equipment used in this evaluation.

A. ARB's Equipment Precertification Program Background

The Equipment Precertification Program is a voluntary statewide program for manufacturers of commonly-used equipment or processes. A condition for entry into the program is that the equipment has an air quality benefit.

Under the Precertification Program, manufacturers request that the ARB conduct an independent third-party verification of performance claims which focus on the air quality benefits of the equipment or process. If the claims are verified, the manufacturer is free to refer to the results of the ARB staff's evaluation in its marketing literature. Upon successful completion of the verification process, the ARB staff notifies air pollution control and air quality management districts (Districts) in California of its determination. As a result of the ARB's notification, the Districts have an advanced opportunity to become familiar with the performance of the equipment or process.

On July 7, 1998, QuikWater submitted an application requesting the ARB to precertify their water heater models 2500, 3500, and 5000. The ARB staff determined that the QuikWater technology was eligible for the Precertification program. However, QuikWater later

requested that the ARB staff stop the evaluation clock because they wanted to conduct additional emissions testing. After conducting new emissions tests, QuikWater re-submitted their application package to the ARB staff and the evaluation clock was restarted March 8, 2001.

B. Relationship to Air Quality

1. Oxides of Nitrogen (NOx)

Emissions

NOx are the by-product of the combustion of fossil fuels. NOx can cause adverse effects on the human respiratory system. Through a complex series of atmospheric reactions, NOx contributes to the formation of ground-level ozone, secondary particulate matter, and acid rain.

2. Carbon Monoxide (CO)

Emissions

CO is a by-product of incomplete combustion. CO can adversely affect the ability of blood to deliver adequate amounts of oxygen to the human body.

3. Control of NOx and CO

Emissions from Water Heaters

The SCAQMD's Rule 1146.1 (Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters) applies to existing boilers and heaters that are greater than 2 MMBtu per hour and less than 5 MMBtu per hour rated heat input capacity. The rule specifies NOx emissions limitations on these boilers and heaters of not greater than 30 parts per million (ppm), dry and corrected to 3 percent oxygen,

or 0.037 pounds per MMBtu of heat input, and no greater than 400 ppm of CO, effective July 1, 1994. The SCAQMD's rule 1146 (Emissions of Oxides of Nitrogen from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters) applies to existing boilers and heaters that are equal to or greater than 5 MMBtu per hour rated heat input capacity. The rule specifies NOx emissions limitations of not greater than 40 ppm, dry and corrected to 3 percent oxygen, or 0.052 pounds per MMBtu of heat input and no greater than 400 ppm of CO for units rated less than 40 MMBtu per hour. Effective January 1, 2002, the NOx limitation is reduced to 30 ppm, dry and corrected to 3 percent oxygen, or 0.036 pounds per MMBtu of heat input.

New boilers and heaters are required to have Best Available Control Technology (BACT). The current BACT limits for NOx and CO emissions for this technology in the SCAQMD are 12 ppm and 50 ppm, respectively.

C. Health and Environmental Impacts

As part of the evaluation, the ARB staff conducted a review of the potential environmental impacts associated with QuikWater technology. Based on this review, we concluded that QuikWater technology would not likely present health impacts significantly different from those associated with other similar technologies that are currently in wide use throughout

California. In fact, the QuikWater technology results in lower NOx and CO emissions levels than those required by District rules and regulations. QuikWater's distributors and installers are required to meet all applicable health and safety standards with respect to the manufacture, installation, operation, and maintenance of QuikWater technology.

D. Manufacture/Ownership Rights

The ARB precertification is contingent upon QuikWater having the legal rights to produce and/or market QuikWater technology. QuikWater provided written documentation to the ARB staff of its ownership rights on March 2, 2001.

III. SUMMARY OF SCOPE

The QuikWater claims involve three different models (2500, 3500, and 5000) of natural gas-fired direct-contact water heaters. When these water heaters are operated at specific loads according to manufacturer's instructions, these models demonstrated values that are no greater than 8.5 parts per million volume (ppmv) NOx and 6.8 ppmv CO for model 2500, 7.7 ppmv NOx and 10.2 ppmv CO for model 3500, and 7.1 ppmv NOx and 12.1 ppmv CO for model 5000. Both NOx and CO emissions are measured on a dry basis, and corrected to 3 percent oxygen for each model.

IV. STATEMENT OF CLAIMS

The following are the claims verified by the ARB staff concerning QuikWater technology. The verification of these claims are predicated on the presumption that

the technology is tested, manufactured, installed, and maintained in accordance with the instructions contained in the QuikWater Installation, Operation, and Maintenance Manual (SO0001203).

Model 2500

The QuikWater natural gas-fired direct-contact Water Heater Model 2500, rated at 2.8 million British thermal units per hour (MMBtu/hr), when operated at 57 percent, 76 percent, or 100 percent load, has oxides of nitrogen emissions no greater than 8.5 parts per million volume, measured on a dry basis (ppmvd), corrected to 3 percent oxygen and carbon monoxide emissions no greater than 6.8 ppmvd, corrected to 3 percent oxygen when the equipment is operated and maintained, in accordance with the QuikWater Installation, Operation, and Maintenance manual for this water heater.

Model 3500

The QuikWater natural gas-fired direct-contact Water Heater Model 3500, rated at 3.8 million British thermal units per hour (MMBtu/hr), when operated at 48 percent, 73 percent, or 95 percent load, has oxides of nitrogen emissions no greater than 7.7 parts per million volume, measured on a dry basis (ppmvd), corrected to 3 percent oxygen and carbon monoxide emissions no greater than 10.2 ppmvd, corrected to 3 percent oxygen when the equipment is operated and maintained, in accordance with the QuikWater

Installation, Operation, and Maintenance manual for this water heater.

Model 5000

The QuikWater natural gas-fired direct-contact Water Heater Model 5000, rated at 5.0 million British thermal units per hour (MMBtu/hr), when operated at 50 percent, 66 percent, or 95 percent load, has oxides of nitrogen emissions no greater than 7.1 parts per million volume, measured on a dry basis (ppmvd), corrected to 3 percent oxygen and carbon monoxide emissions no greater than 12.1 ppmvd, corrected to 3 percent oxygen when the equipment is operated and maintained, in accordance with the QuikWater Installation, Operation, and Maintenance manual for this water heater.

V. DESCRIPTION OF TECHNOLOGY

A. QuikWater Direct-Contact Water Heaters

Direct-contact water heating technology does not use tubes to isolate hot combustion gases from the water to be heated. The exhaust gases are allowed to come into direct-contact with water in a totally non-pressurized environment so that all heating occurs at atmospheric conditions.

The outer shells of direct-contact water heaters are constructed of stainless steel using a vertical hollow chamber in which water is sprayed at the top of the chamber. The upper portion of the chamber is filled with stainless steel rings which provide a

large surface area for the heat of the hot rising exhaust gases to be transferred to the water. This “heat transfer zone” is approximately 24 inches to 36 inches deep and is where most of the hot water production occurs. Figure 1 shows a schematic of models 2500, 3500, and 5000 QuikWater direct-contact water heaters.

The QuikWater burner is separated by a patented long dry firing chamber such that the combustion gases do not contact the water until complete combustion is accomplished. This patented feature allows the efficiency of direct-contact water heating without degrading the water quality. The burner uses a variable speed motorized fan. Since no positive pressure exists inside this heater, the water pressure is lost when the water enters the heater. After the water has been heated, it is collected in a storage tank at the bottom of the water heater.

While the tank sizes for the three precertified models are 170 gallons, 280 gallons, and 330 gallons respectively, any tank size is available from QuikWater, upon request. Electric pumps are used to re-pressurize the water in the tank and move the water to the needed application. Direct-contact water heaters can heat the water to a maximum temperature of 180 degrees Fahrenheit from an ambient temperature of 60 degrees Fahrenheit at sea level. The times required to achieve the maximum

temperatures for the three models are 5.3 minutes, 6.0 minutes, and 5.4 minutes respectively.

VI. TECHNICAL EVALUATION

A. Description of Emissions Testing

QuikWater natural gas-fired direct-contact water heater models 2500, 3500, and 5000 were tested by Air Hygiene International, Inc. (AHI) under the direction of Pacific Environmental Services, Inc. on August 11, 2000. Source testing was conducted at the QuikWater Sand Springs, Oklahoma facility by using natural gas that was rated at 1,024 Btu per cubic foot (pipeline quality gas in California is rated at 1,050 Btu per cubic foot). The objectives of the source test were: 1) determine NO_x and CO emissions under variable load conditions; and 2) demonstrate compliance with the SCAQMD Rules 1146 and 1146.1.

For each model, the SCAQMD Test Method 100.1 was used to determine NO_x and CO emissions in the flue gas from the water heater. The SCAQMD Test Methods 1.1 and 2.1 were also used to determine flow rate. An API model 200AH Chemiluminescent Analyzer was used to determine the NO_x emissions, and an API model 300 Non-Dispersive Infrared Analyzer was used to determine the CO emissions.

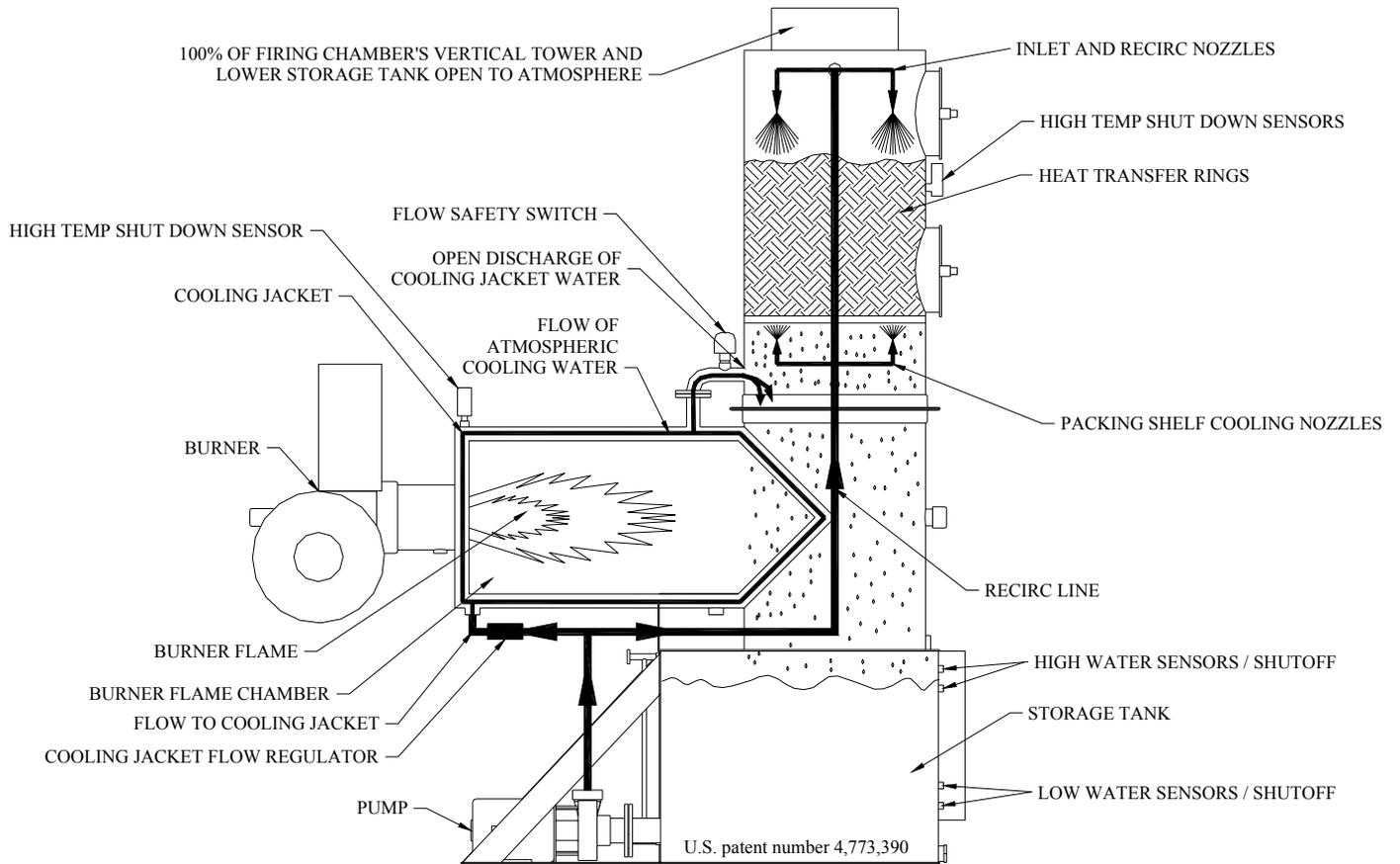


Figure 1 – Schematic of Natural Gas-Fired Direct-Contact Water Heaters Models 2500, 3500, and 5000

The monitoring train consisted of a 3/8-inch stainless steel sampling probe, a 3/8-inch heated Teflon sampling line, a Peltier type sample refrigeration system, a glass fiber filter in a 47 millimeters stainless steel holder, a diaphragm vacuum pump, and a sample distribution manifold. The distribution manifold was equipped with a series of 3-way valves with flow meters. One flow meter acted as a bypass, and the others were connected to the individual analyzers. The output of each analyzer was logged every second on a Logic Beach Hyper Logger. In addition, a Yokogawa multi-channel strip-chart recorder collected instrument data at a five-second-sample rate. The strip-chart recorder monitored the output of each individual analyzer on a separate channel.

A pre-test and a post-test leak check were made at the beginning and at the end of the testing day. The sampling bias of the system was found to be within allowable tolerance. Zero and bias drift errors were minimized by using average zero and bias values to correct the data.

B. Description of Test Results

AHI tested each QuikWater's model under various load conditions to measure NOx and CO emissions. The summary results for the three models can be found in Appendix B, Table B-1.

Three tests were conducted for the model 2500 direct-contact water heater using natural gas. Three runs were conducted at each of the three

loads -- 57 percent, 76 percent, and 100 percent. At each condition, the emissions measured (on a dry basis and corrected to 3 percent oxygen) for NOx and CO were no greater than 8.5 ppmv and 6.8 ppmv respectively. The calculated AHI summary data, and test results of the model 2500 can be found in Appendix B, Table B-2.

Three tests were conducted for the model 3500 with the direct-contact water heater using natural gas. Three runs were conducted at each of the three loads -- 48 percent, 73 percent, and 95 percent. In each condition, the emissions measured (on a dry basis and corrected to 3 percent oxygen) for NOx and CO were no greater than 7.7 ppmv and 10.2 ppmv respectively. The calculated AHI summary data and test results of the model 3500 can be found in Appendix B, Table B-3.

Three tests were conducted for the model 5000 with the direct-contact water heater using natural gas. Three runs were conducted at each of the three loads -- 50 percent, 66 percent and 95 percent. In each condition, the emissions measured (on a dry basis and corrected to 3 percent oxygen) for NOx and CO were no greater than 7.1 ppmv and 12.1 ppmv respectively. The calculated AHI summary data and test results of model 5000 can be found in Appendix B, Table B-4.

C. Site Visit

As part of the evaluation, the ARB staff visited a fabric finishing plant in Los Angeles, California, where a (Model 3500) Quikwater heater was

installed in August 2000. The temperature maintained in the heater was 180 degrees Fahrenheit under operating conditions with an average load of 50 to 95 percent. During the site visit, the ARB staff observed that the direct-contact water heater performed satisfactorily. In addition, the facility operator claimed that he was satisfied with the performance of the QuikWater direct-contact water heater.

VII. EVALUATION OF CLAIMS

This section presents additional information relating to claims verified by the ARB as part of this evaluation. The ARB staff verification of the claims is based on the evaluation of the information listed in Appendix A. As stated earlier, the ARB staff evaluation and recommendations presented in this report are based on the expectation that QuikWater direct-contact water heaters are manufactured, installed, and maintained in accordance with the instructions contained in the QuikWater's user manual. The claim language, which is defined earlier under the "Statement of Claims" section is precise because it directly correlates with the supporting documentation included with the application package.

The source test data reviewed by the ARB's Monitoring and Laboratory Division was found to support the claims made by QuikWater regarding its natural gas-fired direct-contact water heater models 2500, 3500, and 5000. The test methods and equipment described in the test reports are consistent with the SCAQMD Test Method 100.1, and

are equivalent to the ARB Test Method 100 and to the U.S. Environmental Protection Agency (U.S. EPA) Test Method 7E for NOx and the U.S. EPA Test Method 10 for CO. The SCAQMD Test Method 4.1 was used for moisture content determination and is equivalent to the ARB Test Method 4 and the U.S. EPA Test Method 4. The test data verified that when these water heaters are operated at specific loads according to manufacturer's instructions, these models demonstrated values that are no greater than 8.5 parts per million volume (ppmv) NOx and 6.8 ppmv CO for model 2500, 7.7 ppmv NOx and 10.2 ppmv CO for model 3500, and 7.1 ppmv NOx and 12.1 ppmv CO for model 5000. Both NOx and CO emissions are measured on a dry basis, and corrected to 3 percent oxygen for each model.

VIII. QUALITY MANAGEMENT

A. Practices and Standards

QuikWater has extensive quality management practices and standards for its direct-contact water heaters. The standards are described in detail in the Quality Management Manual, Revision 2.1, October 8, 2001. QuikWater's Quality Management Program Manual contains established quality management practices for the following areas:

- Mission, Core Values, Quality Commitment
- Quality Program Responsibilities, Organization
- Resources, Management Review, Documentation

- Quality Planning, Continuous Improvement
- Contract Review, Document and Data Control
- Purchasing, Sub-Contracting, Process Control
- Process Monitoring and Operator Instructions
- Inspection and Testing, Quality Record Control
- Internal Quality Audits, Quality of Service, Training

The ARB staff reviewed the QuikWater’s quality management practices and standards as a part of the evaluation of the direct-contact water heaters. As a result of the review, the ARB staff has determined that the quality management program is sufficiently comprehensive to support precertifying the QuikWater’s direct-contact water heaters.

B. Other Certifications/Approvals

QuikWater direct-contact water heater models 2500, 3500, and 5000 are certified by the SCAQMD (Identification Number 117098, December 15, 2000). QuikWater obtained the National Sanitation Foundation (NSF), Standard 5, International certification (certificate no. 76020/76020B, May 18, 1999) under NSF’s Food Equipment Program.

C. Installation and Maintenance Requirements

The requirements for the installation and maintenance of QuikWater technologies are contained in the QuikWater’s Installation, Operation, and Maintenance (IOM) Manual (SO0001203). This manual provides

detailed installation procedures, which include local codes and regulations, location of heater installation, electrical schematic and connections, control and control system design, combustion air supply, water, fuel connection, and insulation. The manual also provides heater commissioning (start-up), heater system maintenance, and trouble shooting steps to assist the customer in properly installing and operating the system. QuikWater heaters require periodic maintenance to ensure proper operation.

D. Warranties

QuikWater provides a one-year warranty for the material and workmanship on its manufactured products.

IX. ENVIRONMENTAL BENEFITS

As part of our review, we evaluated the potential air quality impacts of QuikWater direct-contact water heaters. We have determined that the use of this technology, in accordance with manufacturer’s instructions, will result in compliance with the SCAQMD rules to limit NOx and CO emissions from water heaters. It should also be noted that under certain conditions, NOx and CO emissions reductions resulting from the use of QuikWater direct-contact water heaters may be eligible for emissions reduction credits. However, individual Districts in California should be consulted to determine the eligibility for emissions reduction credits.

X. ARB's RECOMMENDATIONS

After evaluating the information discussed in this report, we recommend that the QuikWater technology be precertified under the ARB's Precertification Program. Specifically, we have independently verified the claims of QuikWater concerning its QuikWater technology, as presented in the claims section of the report.

By accepting Precertification under the ARB's program, QuikWater assumes, for the duration of the three years Precertification period, responsibility for maintaining the quality of the manufactured equipment and materials at a level equal or better than was provided to obtain this Precertification. Precertification under the ARB's program is also contingent on the recipient agreeing to be subject to quality monitoring by the ARB, as provided by law.

The ARB makes no express or implied warranties as to the performance of the manufacturer's product or equipment. Nor, does the ARB warrant that the manufacturer's product or equipment is free from any defects in workmanship or material caused by negligence, misuse, accident, or other causes. The ARB staff believes, however, that QuikWater technology will achieve the performance levels presented in the claims section of this report. Our determination is based on our evaluation of the data submitted by QuikWater, as well as the other information identified in this report. Our recommendations are

predicated on the expectation that installation and maintenance are performed in accordance with QuikWater's IOM manual (SO0001203).

XI. SUGGESTED OPERATING CONDITIONS

On December 15, 2000, the SCAQMD certified the QuikWater direct-contact water heaters. The following suggested operating conditions are based on the ARB's staff evaluation of the SCAQMD's certification conditions.

1. This technology shall be fired with utility-grade quality natural gas only. Propane may be utilized as a backup fuel.
2. This technology shall be equipped with a control system to automatically regulate combustion air and fuel as the load varies. This automatic control system shall be adjusted and tuned commencing from start-up, according to the manufacturer's specifications to assure its ability to repeat the same performance at the same firing rate.
3. Records of adjustments, tune-ups, and calibrations as described in condition (2) shall be kept for at the minimum time period specified by the Districts and shall be made available to District personnel and/or the ARB staff upon request.

XII. PRECERTIFICATION CONDITIONS

The recommendations in this report are conditional upon QuikWater technology being manufactured, installed, operated, and maintained, in accordance with QuikWater technology's instructions as contained in the QuikWater technology's IOM manual. A copy of these instructions must be provided to each user of QuikWater technology prior to installation. In order for the Precertification to remain valid, QuikWater must retain the manufacturing rights for its technology.

Precertification does not relieve the person constructing, installing or operating the equipment at each specific site from the requirement to obtain an authority to construct and permit to operate. Precertification does not relieve the person from compliance with any local air district rules or regulations.

Any manufacturer's modification that affects the claimed performance or emissions of models 2500, 3500, and 5000 shall void this precertification. This precertification is valid only for the equipment designed and tested for this evaluation.