ANSI/AWWA E102-17
(Revision of ANSI/AWWA E102-06)

American Water Works Association

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AWWA Standard

Submersible Vertical Turbine Pumps

Effective date: July 1, 2017.
First edition approved by AWWA Board of Directors June 11, 2006.
This edition approved Jan. 14, 2017.
Approved by American National Standards Institute Feb. 23, 2017.

AWWA Standard

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ISBN-13, print: 978-1-62576-228-3 eISBN-13, electronic: 978-1-61300-425-8

DOI: http://dx.doi.org/10.12999/AWWA.E102.17

Committee Personnel

The AWWA Standards Committee on Submersible Vertical Turbine Pumps, which reviewed and approved this standard, had the following personnel at the time of approval:

Anthony M. Naimey, *Chair*

General Interest Members

E.P. Butts, 4B Engineering and Consulting LLC, Keizer, Ore. (AWWA)
F.H Hanson, Albert A. Webb Associates, Riverside, Calif. (AWWA)
T. McCandless,* Standards Engineer Liaison, AWWA, Denver, Colo. (AWWA)
A.M. Naimey, CH2M, Santa Ana, Calif. (AWWA)
J.F. Schultes, A.C. Schultes Inc., Woodbury Heights, N.J. (GWI)

Producer Members

K. Adams, Flowserve Corporation, Norman, Okla. (AWWA)
G. Smith, Smith Pump Company Inc., Waco, Texas (AWWA)

User Members

C.R. Dugan, East Lansing–Meridian Water and Sewer Authority, East Lansing, Mich. (AWWA)
S.M. Hamelink, Lansing Board of Water & Light, Grand Ledge, Mich. (AWWA)
J. Heath, Denver Water, Denver, Colo. (AWWA)
B.D. Steglitz, City of Ann Arbor Water, Ann Arbor, Mich. (AWWA)

* Liaison, nonvoting

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Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

Foreword

This foreword is for information only and is not a part of ANSI/AWWA E102.*

I. Introduction.

I.A. *Background.* This standard describes the minimum requirements for submersible vertical turbine pumps utilizing a discharge column pipe assembly for installation in wells, water treatment plants, water transmission systems, and water distribution systems. Pumps described in this standard are intended for pumping fresh water. This standard is applicable for a driver power range from 5 hp (3.8 kW) to 250 hp (186.5 kW).

I.B. *History.* The original standard for vertical line-shaft turbine pumps presented the composite findings from studies conducted from 1949 to 1986 by committees consisting of manufacturers, consumers, and engineers. The first standard was published in 1955. In 1961, the standard was revised to include standards for submersible vertical turbine pumps. Additional technical changes were added in the 1971 revision. Solid shaft motors were added in the 1977 revision, together with numerous editorial changes and conversions to the international system of units. The 1977 standard was reaffirmed in 1982 without revision. Additional revisions were made in 1988. ANSI/AWWA E101-88 was withdrawn in 2000. A subsequent edition was approved on June 11, 2006. This edition was approved on Jan. 14, 2017.

In 1994, AWWA's Standards Council approved development of a new standard for Horizontal Centrifugal Pumps. The new standard was assigned to AWWA Standards Committee 276 for Horizontal Centrifugal Pumps. Upon review of pump standards development in 1996, AWWA's Standards Council modified the development process to include two new pump standards to replace ANSI/AWWA E101-88, Standard for Vertical Turbine Pumps—Line Shaft and Submersible Types. As part of this action, two committees were renamed. AWWA Standards Committee 276 for Horizontal Centrifugal Pumps was changed to AWWA Standards Committee 276 for Horizontal and Vertical Line-Shaft Pumps. Committee 276 was charged with development of a standard for horizontal and vertical line-shaft pumps. AWWA Standards Committee 375 for Vertical Turbine Pumps was changed to AWWA Standards Committee 375 for Submersible Vertical Turbine Pumps. Committee 375 was charged with development

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

of a standard for submersible vertical turbine pumps. During development of these two replacement standards, ANSI/AWWA E101-88 was withdrawn effective June 2000.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.* Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. Specific policies of the state or local agency.

2. Two standards developed under the direction of NSF†: NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.

3. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,‡ and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdictions. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

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* Persons outside the United States should contact the appropriate authority having jurisdiction.

† NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

‡ Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20001.

ANSI/AWWA E102 does not address additives requirements. Thus, users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.
2. Determine the status of certifications by parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

NSF/ANSI 372, Drinking Water System Components—Lead Content, specifies restrictions for a maximum lead content of materials in contact with drinking water. The user shall specify NSF/ANSI 372 when applicable in the purchase documents. Currently compliance with NSF/ANSI 372 is mandatory in some states and meets the new low-lead requirements of the US Safe Drinking Water Act, which went into effect January 2014.

II. Special Issues.

II.A. *General.* A pumping system consists of several components: the pump, the driver, the discharge column pipe and discharge elbow, the baseplate, the foundation, the controls, and the discharge piping and in most cases the well casing or suction barrel. This ANSI/AWWA E102 standard discusses only the pump unit that consists of the pump, motor, column piping, and discharge head. Users of this standard should review other publications such as the Hydraulic Institute (HI) standards. Users should especially review the HI standards and other publications for information on baseplates, foundation design, connection into discharge piping systems, and component alignment recommendations. Conditions under which a pump will operate must be carefully evaluated and described by the purchaser.

II.A.1 Fluid Ambient Temperature Range. Equipment selection criteria are dependent upon the fluid temperature in which the equipment operates. Pump component part dimensions and tolerances can change in extremely cold or hot fluid environments. Different lubricant fluids are used in submersible motors in extreme ambient temperature conditions. The purchase documents should identify the ambient temperature range of the fluid environment in which the pumping unit is to be installed.

II.A.2 Operating Range. Evaluations that define the operating range of the pump should include the determination of the hydraulic characteristics of the pump system at the rated flow and head condition and the extremes (maximum and minimum) of heads and flow capacities under which the pump will be required to operate. Users of this standard should determine the operating range for each application and select the pump that best fits within the Hydraulic Institute standards' limits for

preferred operating range (POR). Operation outside of the POR is common. However, continuous operation within the allowable operating range (AOR) is necessary for success. The AOR limit is defined in the Hydraulic Institute standards, but the values are defined by the pump manufacturer.

II.A.3 Inlet Conditions. Pump field performance and service life can be significantly reduced if pump inlet conditions, including net positive suction head available (NPSHA), are not appropriate. Anticipated pump performance curves, including net positive suction head required (NPSHR) curves provided by manufacturers (the accepted industry standard is a 3 percent drop in head, termed "NPSH3"), are based on a flow pattern at the pump inlet being uniform, steady, and free from swirls and vortices. Inadequate pump inlet conditions can result in damaging vibrations, excessive component stresses, and reduced performance. ANSI/HI 9.8 and ANSI/HI 9.6.1 provide recommendations for pump intake conditions.

II.A.4 Performance Operating Region. This standard does not require pumps to be furnished that will operate within a preferred operating region (POR) or within an allowable operating region (AOR) as defined by the Hydraulic Institute (HI) standard ANSI/HI 9.6.3. Operating outside these regions will have an adverse effect on the life of the pump. Purchasers should be aware of the pump manufacturer's recommended operating limits when specifying pumps and should, as a minimum, define the maximum and minimum anticipated operating head and flow rates. Purchasers may require submittal of data by manufacturers defining the operating regions and advising anticipated bearing life and vibration when operating within these regions.

II.A.5 Nonreturn Valves. This standard does not provide requirements for nonreturn valves, nor does it require pumps to be furnished with nonreturn valves. Nonreturn valves are used in pumping systems to prevent reverse flow or to prevent flow opposite to the intended direction. Flow opposite to the intended direction can cause the pump and motor to spin backward at damaging speeds and cause other harm to the pumping system. Various types of nonreturn valves exist such as check valves and pump control valves. For systems with high operating pressures and flows, the rapid closure of a nonreturn valve can create transient-surge pressures that may damage the connecting piping system and related components. Systems with deep water wells may require more than one nonreturn valve. The purchaser should give particular attention to the spacing and quantity of the nonreturn valves. Consideration of column weight and the capability to drain the column pipe to facilitate maintenance, as well as the duration the pump can run against low system head (empty column pipe), should be considered when applying nonreturn valves. Nonreturn valves should be carefully

selected by the purchaser depending on the specifics of the pumping system and the recommendations of the pump manufacturer.

II.A.6 Column Centralizers. This standard does not require pump discharge column piping or the pump to be furnished with centralizers. Some water wells may significantly deviate in vertical alignment, which can lead to submersible power cable abrasion during installation and removal and can affect flow at the pump intake (including flow around the motor) during operation. At the discretion of the user, column pipe centralizers may be installed on the column piping. It is recommended that the design and installation of column pipe centralizers be performed by the pump manufacturer and thus be included in the purchase documents if required.

II.A.7 Pump Size. It is recommended that the maximum motor diameter and the minimum inside diameter (ID) of the well be sized such that under any operating condition the water velocity past the motor should not exceed 10 ft/sec (3.0 m/sec) nor be less than 1.0 ft/sec (0.3 m/sec). For this purpose, a minor irregularity in the motor shape, such as that caused by the cable connection, can be excluded in the motor-diameter measurement. For flow velocity conditions other than those recommended above, a shroud may be recommended by the manufacturer. The pump manufacturer should verify motor shroud requirements based on operating flow characteristics provided by the purchaser.

II.B. *Advisory Information on Product Application.* This standard does not cover all applications or manufacturing technologies. Some waters may have high conductivity levels well in excess of 200 microohms/cm, where it may be advisable to consult with a metallurgist or corrosion expert to determine whether special materials or techniques to deal with galvanic corrosion are required. The purchaser should identify special requirements and deviations from this standard and include appropriate language in the purchase documents.

II.B.1 Materials. Materials required by this standard are selected based on suitability for operation with water as described in the scope. Selection is based on successful experience in the waterworks industry and local code and regulation requirements for suitable materials.

II.B.1.1. Treatment Chemicals. The potential for corrosion because of chemicals added to the water should be considered. Materials, including some bronzes and rubber compounds exposed to water containing chlorine, chloramines, or other chemicals, may not be suitable. If such problems are anticipated, purchase documents should identify the maximum expected concentrations of these chemicals and other factors, such as pH and temperature ranges, that may affect the corrosivity of these chemicals.

The purchaser and manufacturer should be aware that at times the pump may be used to disperse chemicals into the system that may result in local concentrations much higher than normal concentrations intended for the system. The purchaser should consult with the manufacturer and, if appropriate, specify special requirements for these materials in the purchase documents.

II.B.1.2. Disinfection Chemicals. Pumps are often disinfected prior to being placed in service initially or after repair. During the disinfection process, wetted surfaces are exposed to liquids far more corrosive than that allowed by the scope of this standard. Materials required by this standard may not be suitable for prolonged exposure to corrosive chemicals, including chlorine and sodium hypochlorite. Therefore, these chemicals should be removed and surfaces flushed with water meeting scope requirements immediately after disinfection.

II.B.1.3. Dealloying. Some waters promote dealloying corrosion of some copper alloys in the form of dezincification or dealuminization, particularly when the material is exposed to water at high velocity. If this is a concern, the purchaser should consult with the manufacturer and, if appropriate, require alternate materials in the purchase documents.

II.B.1.4. Coatings. This standard requires that ferrous (except for stainless) surfaces of pumps exposed to water be coated. The purchase documents should delete this requirement if coatings are not required.

II.C. *Pump Tests.*

II.C.1 Factory Tests.

II.C.1.1. Procedures. This standard requires factory tests to be performed in accordance with the current version of ANSI/HI 11.6. Acceptance grade should be identified in the purchase documents.

II.C.1.2. Extent. This standard requires nonwitnessed hydrostatic testing only for the bowl assembly and discharge head.

II.C.1.3. Additional Factory Tests. Additional factory tests, including hydrostatic tests of an assembled pump, vertical pump column sections, performance, NPSH3, mechanical, and witnessed tests, may be included by the purchase documents.

II.C.2 Field Tests. This standard does not include field performance testing requirements. The following can be used to define field-test requirements.

1. ANSI/HI test standards, as described above for factory tests, may be used for field testing at the discretion of the purchaser. ANSI/HI test standards require minimum pipe lengths, internal straightening vanes, and other criteria that, while practical in a controlled test loop, may not be available in the field. Application of this

standard for field testing requires parties to agree on the scope and protocol of the test prior to the test.

2. Appendix B included with this standard.

II.D. *Vibration Limits.* The vibration characteristics of a pumping system depend on a combination of pump and driver design and construction, column piping design and construction, baseplate or mounting plate design and construction, support foundation design and construction, balancing requirements, the pump installation, component alignment requirements, and operating flow rate relative to the pump's operating best efficiency point. This standard does not require a structural natural frequency response analysis be performed for the pump and motor, complete column piping assembly, the discharge head, or other critical components incorporated into the mounting system. It is recommended that the purchase documents provide requirements for the pump manufacturer to evaluate the structural natural frequencies of the pump, discharge column piping, and discharge head and perform a natural frequency modal analysis to determine the piping system displacement response and forces associated with excitation frequencies generated by the required operating speed range of the pump. Users of this standard should review various HI and other standards regarding these subjects and provide requirements within the purchase documents regarding vibration limits and vibration limit verification.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered. Users of submersible vertical turbine pumps should not expect long-lasting or reliable service unless all aspects of the pump application are defined: operating conditions, environmental conditions, and local ambient conditions. Additionally, the pump and driver unit, discharge column piping, discharge head assembly, mounting plate, foundation system, and connecting discharge piping must be designed, installed, and aligned as an integral system.

III.A. *Information for Manufacturers.* Pump manufacturers require basic data in order to provide pumps meeting purchasers' needs. These include as a minimum a definition of required operating conditions. When placing orders for pumps to be manufactured in accordance with this standard, the purchaser should specify the following items:

1. Standard to be used—that is, ANSI/AWWA E102, Submersible Vertical Turbine Pumps, of latest edition.

2. Water properties:

    a. Temperature range

b. pH range
c. Percent solids
d. Chlorine injection location and concentration

3. Datum (elevation):
    a. Setting
    b. Static water level
    c. Maximum and minimum pumping water level
    d. Drawdown
    e. Well casing inner diameter
    f. Well screen levels
    g. Well screen dimensions
4. Design point:
    a. Capacity
    b. Head
    c. Efficiency
    d. Net positive suction head available (NPSHA)
5. Motor:
    a. Revolutions per minute (rpm) of pump and motor
    b. Voltage
    c. Number of electrical phases
    d. Horsepower
    e. Frequency
6. Nonreturn valve(s) to be used:
    a. Style (solid or bleed back)
    b. Material
    c. Pressure rating
    d. Location(s)
7. Materials:
    a. Documentation of materials of construction used in the manufacture of the pumping unit, including materials testing documentation certifying compliance with the referenced ASTM standard and grade
8. Drinking water requirements: Refer to Sec. 4.1. The purchaser should state whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, and/or NSF/ANSI 372, Drinking Water System Components—Lead Content, is required. If compliance is required, the purchase documents should note, "This product shall be certified as suitable for contact with drinking water by

an accredited certification organization in accordance with NSF/ANSI 61, Drinking Water System Components—Health Effects, and/or NSF/ANSI 372, Drinking Water System Components—Lead Content."

Purchasers should be aware that the availability of NSF/ANSI 61–certified pumps may be very limited, and this requirement may limit competition and add to the cost and delivery time of the pumps. Purchasers should also be aware that some states may allow installation of noncertified pumps, based on submittal and acceptance of materials used to construct the pump, especially if suitable certified pumps are not available.

Compliance with NSF/ANSI 372 meets the new low-lead requirements of the US Safe Drinking Water Act, which went into effect January 2014. Most pump manufacturers are able to certify compliance to NSF/ANSI 372.

9. Alternative materials: Purchase documents may require alternative materials or limit manufacturer's choices of materials listed in this standard. For example, this standard lists silicon bronze, aluminum bronze, and stainless steel as impeller materials. Silicon bronze may not be suitable if the water contains a significant concentration of chlorine or chloramine. Aluminum bronze and stainless steel components may be more costly and difficult to fabricate than silicon bronze components. Purchasers should be aware that alternatives or limitations on manufacturer's selections may increase costs and delivery time.

10. Details of other federal, state or provincial, and local requirements (Sec. 4.1.1):

    a. Operating regions: Computations and data or curve showing the preferred operating region (POR) and allowable operating region (AOR) prepared using methods described in HI 9.6.3 or as required in the purchase documents.

    b. Materials of construction: Documentation of materials of construction used in the manufacture of the pumping unit, including materials testing documentation certifying compliance with the referenced ASTM standard and grade.

III.B. *Purchaser Options and Alternatives.* The following items should be provided by the purchaser:

1. Allowable operating region requirements (Sec. III.A, Item 10).
2. NPSHR requirements (Section 3, Item 19).
3. Replaceable wear rings requirements (Sec. 4.2.1.7.3).
4. Hardened sleeves under bearings requirements (Sec. 4.2.1.9.6).
5. Reduced-voltage-stopping and continuous operation requirements (Sec. 4.3.3).
6. Type of seals required (Sec. 4.3.6).

7. Extra cable requirements (Sec. 4.4.4).
8. Coating material requirements (Sec. 4.9.1).
9. Surface preparation requirements (Sec. 4.9.2).
10. Witness requirements for hydrostatic testing (Sec. 5.2.1).
11. Notification period for witness testing (Sec. 5.2.2).
12. Capacity point requirements (Sec. 5.3.1).
13. Pump test report requirements (Sec. 5.3.2).
14. Laboratory arrangements and test requirements (Sec. 5.4).
15. Measured pump capacity requirements (Sec. 5.5).
16. Pump bowl assembly test requirements (Sec. 5.6.1).
17. Meter and gauge requirements (Sec. 5.8.2).
18. Test head requirements (Sec. 5.9.1).
19. Hydrostatic test pressure requirements (Sec. 5.9.2).

III.C. *Modification to Standard.* Any modification of the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions.

1. All sections of the foreword were revised to reflect present conditions.
2. Scope was revised to cover 5-hp to 250-hp drivers.
3. Sec. 4.1, Materials, Sec. 4.2, General Design, and requirements in Sec. 4.3, Submersible Motor, were extensively revised.
4. The following sections from the previous edition were deleted and/or moved to revised Sec. 4.2, General Design, in this edition: Sec. 4.3, Inspection and Certification by Manufacturer; Sec. 4.4, Information to Be Supplied by Manufacturer; Sec. 4.5, Materials and Sanitary Codes; Sec. 4.6.7, Pump Size; Sec. 4.11, Pump Bowls; Sec. 4.12, Bowl Bearings; Sec. 4.13, Impellers; Sec. 4.14, Wear Rings; and Sec. 4.15, Shaft.
5. Additional materials were added to Table 1.
6. Added requirement that materials shall comply with NSF/ANSI 61 or NSF/ANSI 372.
7. Added definition of *Net Positive Suction Head Required* to Section 3.
8. Sec. 5.3.3, Test Method, was added to Section 5, Verification.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603; write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098; or email at standards@awwa.org.

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American Water Works Association

Dedicated to the World's Most Important Resource®

AWWA Standard

Submersible Vertical Turbine Pumps

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard provides minimum requirements for submersible vertical turbine pumps utilizing a discharge column pipe assembly for installation in wells, water treatment plants, water transmission systems, and water distribution systems. Electric motors are the only type of prime movers addressed in this standard.

1.1.1 *Service.* Pumps described in this standard are intended for pumping fresh water having a pH range between 5.5 and 10.0, a temperature range from 33°F to 125°F (14°C to 50°C), a maximum chloride content of 250 mg/L, and a maximum suspended solids content of 1,000 mg/L, and that is either potable or will be treated to become potable.

1.1.2 *Pumps covered by this standard.*

1.1.2.1 Driver power range: 5 hp (3.8 kW) to 250 hp (186.5 kW), three phase, 60 Hz.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for submersible vertical turbine pumps.

Sec. 1.3 Application

This standard can be referenced in purchase documents for submersible vertical turbine pumps. Purchasers of submersible vertical turbine pumps that are