



Standard Practice for Sampling Two-Phase Geothermal Fluid for Purposes of Chemical Analysis¹

This standard is issued under the fixed designation E1675; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The purpose of this practice is to obtain representative samples of liquid and steam as they exist in a pipeline transporting two-phase geothermal fluids.

1.1.1 The liquid and steam samples are collected and properly preserved for subsequent chemical analysis in the field or an off-site analytical laboratory.

1.1.2 The chemical composition data generated from the analysis of liquid and steam samples may be used for many applications important to geothermal energy exploration, development, and the long-term managed exploitation of geothermal resources. These applications include, but are not limited to, resource evaluations such as determining reservoir temperature and the origin of reservoir fluids, compatibility of produced fluids with production, power generation and reinjection hardware exposed to the fluids (corrosivity and scale deposition potential), long-term reservoir monitoring during field exploitation, and environmental impact evaluations including emissions testing.

1.1.2.1 To fully utilize the chemical composition data in the applications stated in 1.1.2, specific physical data related to the two-phase discharge, wellbore, and geothermal reservoir may be required. Mathematical reconstruction of the fluid chemistry (liquid and steam) to reservoir conditions is a primary requirement in many applications. At a minimum, this requires precise knowledge of the total fluid enthalpy and pressure or temperature at the sample point. Fluid reconstruction and computations to conditions different from the sample collection point are beyond the scope of this practice.

1.2 This practice is limited to the collection of samples from two-phase flow streams at pressures greater than 70 kPa gauge (10 psig) and having a volumetric vapor fraction of at least 20 %. This practice is not applicable to single-phase flow streams such as pumped liquid discharges at pressures above the flash point or superheated steam flows. Refer to Specification E947 for sampling single-phase geothermal fluids.

1.3 The sampling of geothermal fluid two-phase flow streams (liquid and steam) requires specialized sampling equipment and proper orientation of sample ports with respect to the two-phase flow line. This practice is applicable to wells not equipped with individual production separators.

1.4 In many cases, these techniques are the only possible way to obtain representative steam and liquid samples from individual producing geothermal wells. The sampling problems that exist include the following:

1.4.1 Unstable production flow rates that have a large degree of surging,

1.4.2 Unknown percentage of total flow that is flashed to steam or is continuously flashing through the production system,

1.4.3 Mineral deposition during and after flashing of the produced fluid in wellbores, production piping, and sampling trains,

1.4.4 Stratification of flow inside the pipeline and unusual flow regimes at the sampling ports, and

1.4.5 Insufficient flash fraction to obtain a steam sample.

1.5 This practice covers the sample locations, specialized sampling equipment, and procedures needed to obtain representative liquid and steam samples for chemical analysis.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*²

E947 Specification for Sampling Single-Phase Geothermal Liquid or Steam for Purposes of Chemical Analysis

2.2 *Other Document:*

ASME Code Section VIII, Division 1(1986), Pressure Vessel Design, Fabrication and Certification³

¹ This practice is under the jurisdiction of ASTM Committee E44 on Solar, Geothermal and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.15 on Geothermal Field Development, Utilization and Materials.

Current edition approved Dec. 1, 2012. Published December 2012. Originally approved in 1995. Last previous edition approved in 2004 as E1675 – 04^{ε1}. DOI: 10.1520/E1675-04R12.

² *Annual Book of ASTM Standards*, Vol 12.02.

³ Available from American Society of Mechanical Engineers 345 E. 47th St. New York, NY 10017.

3. Summary of Practice

3.1 Samples are collected from a pipeline carrying two-phase geothermal fluids by using a sampling separator that separates liquid and steam phases through centrifugal force. A fraction of the separated steam is condensed and a fraction of the separated liquid is cooled. Portions of the condensed steam and cooled liquid are collected in appropriate sample containers for subsequent chemical analysis.

4. Significance and Use

4.1 The objective of this practice is to obtain representative samples of the steam and liquid phases as they exist in the pipeline at the sample point, without allowing steam condensation or additional liquid flashing in the separator. A significant feature of the practice is the use of a cyclone-type separator for high-efficiency phase separation which is operated at flow rates high enough to prevent significant heat loss while maintaining an internal pressure essentially the same as the pipeline pressure.

4.2 Another significant feature of the practice is to locate the sampling separator at a point on the pipeline where the two-phase flow is at least partially stratified to aid in the separation process. It is neither necessary nor possible to pass representative proportions of each phase through the sampling separator to obtain representative samples. The separator is usually attached to an appropriately oriented port to collect each specific phase—normally on top of the line for steam and at the bottom for liquid. In some cases, piping configurations can generate unusual flow regimes where the reverse is required. If the ratio of one phase to another is not extreme,

representative samples of each phase can often be obtained from a horizontal port on the side of the pipeline.

4.3 This practice is used whenever liquid or steam samples, or both, must be collected from a two-phase discharge for chemical analysis. This typically includes initial well-testing operations when a well is discharged to the atmosphere or routine well production when a well discharges to a fluid gathering system and power plant. The combined two-phase flow of several wells producing through a common gathering system may also be sampled in accordance with this practice.

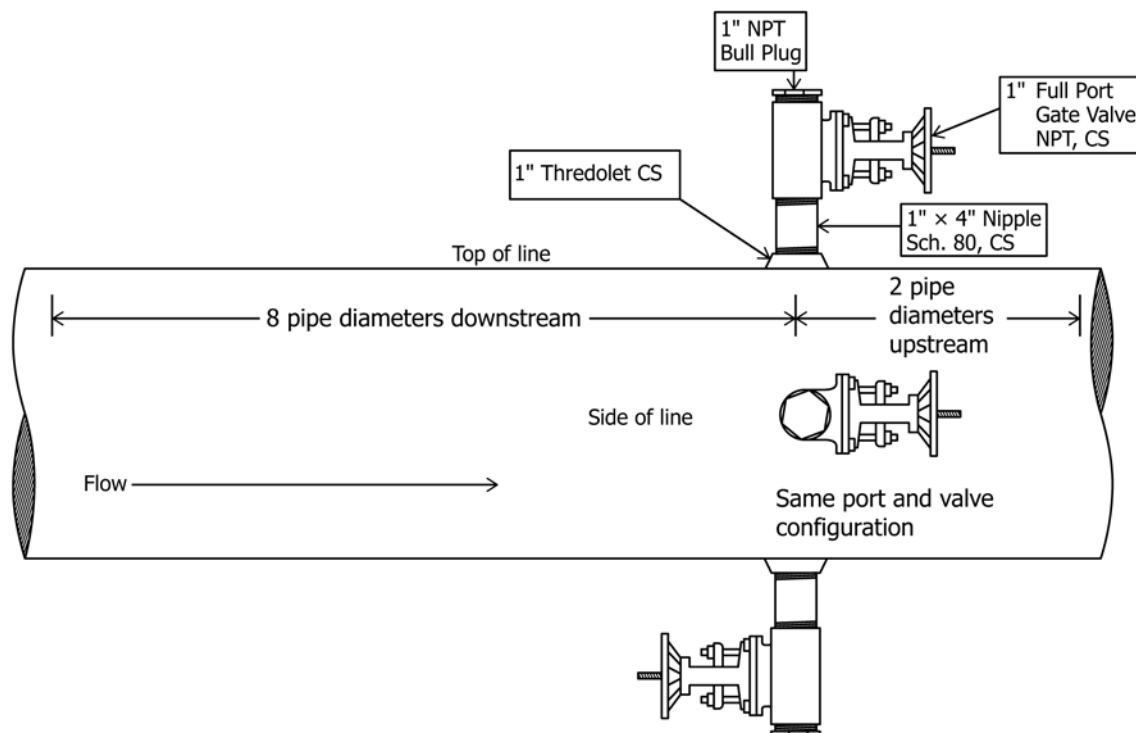
4.4 This practice is not typically employed when individual wells produce to dedicated production separators. In these cases, the separated steam and liquid at the outlet of the production separator is sampled in accordance with single-phase sampling methods (Specification E947).

5. Sample Location

5.1 Sample locations vary and are dependent upon the gross quantities of each phase at the sample point. If sample ports are properly oriented on the two-phase pipeline, a certain degree of phase stratification will have occurred prior to sampling, facilitating further separation of the target phase through the sampling separator.

5.2 Ports are ideally located on the top and bottom of the pipeline at least eight diameters downstream and two diameters upstream of major flow disturbances such as pipe bends, reductions, valving, etc. (see Fig. 1).

5.2.1 In cases where the fluid contains substantial quantities of solid debris that may plug the sample port, the liquid port



NOTE 1—Minimum pipe diameters required upstream and downstream of major flow disturbances (piping bends, reductions).

FIG. 1 Two-Phase Flowline Sampling Separator Ports

can be located at a 45° angle from the bottom, provided that a sufficient liquid phase is present.

5.2.2 If the flow regime is known, the number of ports may possibly be reduced to a single port located either on the side, top, or bottom of the two-phase pipeline. Sufficient quantities of each phase must be available at the single port to allow collection of representative steam and liquid samples.

5.2.3 The sample ports must be at least 1-in. diameter and configured with a full-open port ball or gate valve. This requirement is necessary to ensure that only a minimal pressure drop occurs through the port valve and associated piping. Scale and debris often reduce the effective inner diameter of the port, therefore smaller ports are not recommended. The port size restriction also provides a safety margin given the weight of the separator and force needed to install and remove fittings from the port.

5.3 Sample ports should never be located on side-stream piping from the main flow line unless only the side-stream fluids are to be characterized. The proportions of each phase are not likely to remain the same in a flow stream split off from the main flow line. Any pressure reduction in the side stream piping will change the steam and liquid compositions to an unknown degree.

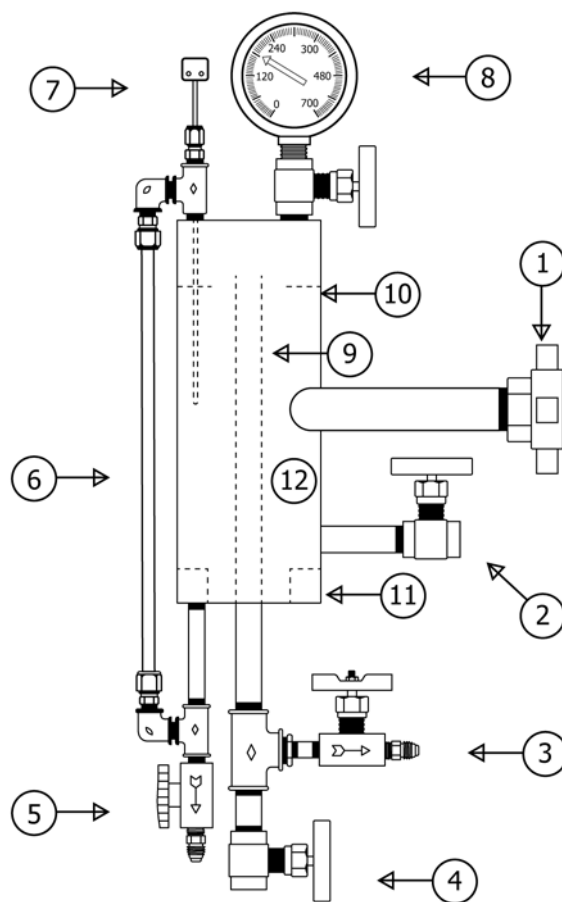
6. Equipment

6.1 *Sampling Separator*—A cyclone-type separator rated to the pipeline pressure at the sample point, including a pressure gage, temperature probe, and sight glass (optional). The separator should be designed to attach directly to the sample port to minimize heat loss and pressure drop.

6.1.1 A typical sampling separator is shown in Fig. 2. This is a cyclone-type separator with a 1-in. pipe inlet attached at a tangent to the separator body. The separator is rated to 3 500 kPa gauge at 260°C (500 psig at 500°F). A pressure gage and thermocouple are located at the top of the separator, and steam and liquid sample valves are located at the bottom. Steam is drawn from the top of the separator through an axial pipe extending up from the bottom of the vessel. Liquid is drawn directly off the bottom. Internal baffles prevent liquid films from rising up the inner walls of the vessel with the steam flow to the sample valves. Vortex breakers are placed in the bottom of the vessel to prevent steam entrainment in the liquid flow to the sample valves.

6.1.1.1 The vent valve on the side of the sampling separator (No. 2 in Fig. 2) can be used to maintain an excess flow of steam and liquid through the separator, beyond the amount needed for sample collection. If sufficient quantities of each phase are present, the side vent valve will maintain a liquid level about 50 mm (2 in.) above the liquid sample valve (No. 5 in Fig. 2). This allows collection of both steam and liquid samples from the separator without the need to adjust the liquid level.

6.1.1.2 An optional sight-glass (PFA-fluorocarbon) for liquid level is located along one side of the separator to aid in proper separator operation and confirm the position of the liquid level. The sight glass is only rated to 1 700 kPa gauge (250 psig) and must be removed for higher pressure operation.



- 1) 1 in. Two-Phase Inlet (Hammer Union)
 - 2) ½ in. Vent Valve (Regulating Valve or Ball Valve)
 - 3) ¼ in. Steam Sample Valve (Regulating Valve)
 - 4) ½ in. Steam Bleed Valve (Regulating Valve)
 - 5) ¼ in. or ⅜ in. Liquid Sample Valve (Ball Valve)
 - 6) ⅜ in. Teflon Sight Glass (250 psi limit: ⅛ in. wall, Teflon PFA)
 - 7) ¼ in. x 12 in. Type K Thermocouple
 - 8) Pressure Gage with Surge Protector Valve
 - 9) ½ in. x Steam Outlet Pipe
 - 10) Baffle Ring
 - 11) Vortex Breaker Plates
 - 12) Separator Body, 4 in. I.D. x 12 in.
- Material specification: All metal components 304 or 316 stainless steel

FIG. 2 Sampling Separator

6.2 *Sample Hoses*—Sample hoses are PFA-lined stainless steel braided hoses rated to 500 psig and 450°F. JIC type fittings or quick-disconnect fittings attach hoses to the separator and condenser. Hoses are dedicated to either steam or liquid service to prevent cross-contamination. The inner diameter of the hose should not exceed 0.375 in. Stainless steel tubing may also be used (0.25 to 0.375-in. outside diameter), although it is less convenient. Convuluted, flexible stainless steel hose is specifically excluded due to potential entrapment and contamination problems caused by the internal convolutions.

6.3 *Condenser*—A sample condenser configuration with two sets of stainless steel tubing coils is recommended. One set of coils is dedicated for condensing steam and the other is dedicated for cooling liquid. The steam condenser coil has a pressure/vacuum gage located at the sample outlet and a regulating valve at the inlet. The steam flow is controlled by