

## ON-LINE STEAM QUALITY AND PURITY INSTRUMENTS

Process and turbine inlet steam contains impurities, such as silica, sodium, chloride, iron and solid particulates, which can cause corrosion, scaling and erosion of power plant equipment, especially steam turbines. Impurities such as sodium, chloride and silica may be present as dissolved species in liquid water, or as particulate material, such as solid NaCl. Volatile silica and chloride may exist in high-temperature or superheated steam, but dissolves rapidly in liquid water. In order to determine the amount of these impurities in steam, isokinetic sampling is required.

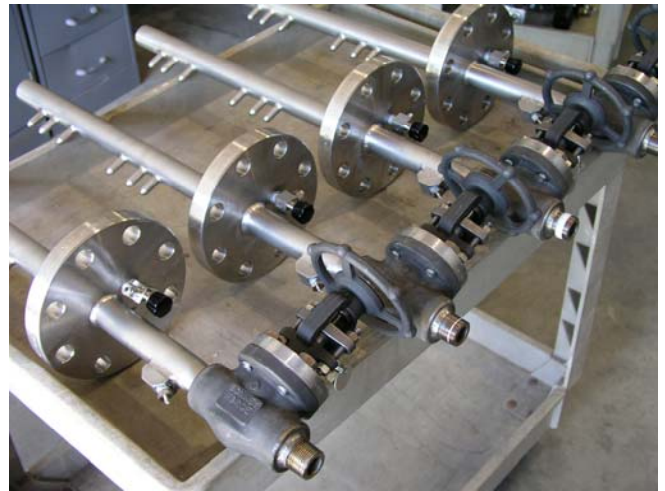
The isokinetic steam sampling system incorporates a probe with isokinetic nozzles to obtain representative steam samples across the pipeline diameter. Isokinetic sampling minimizes errors due to non-representative collection of particles and droplets relative to the bulk vapor phase.

### Thermochem's Multi-Nozzle Isokinetic Probe & On-line Analyzers

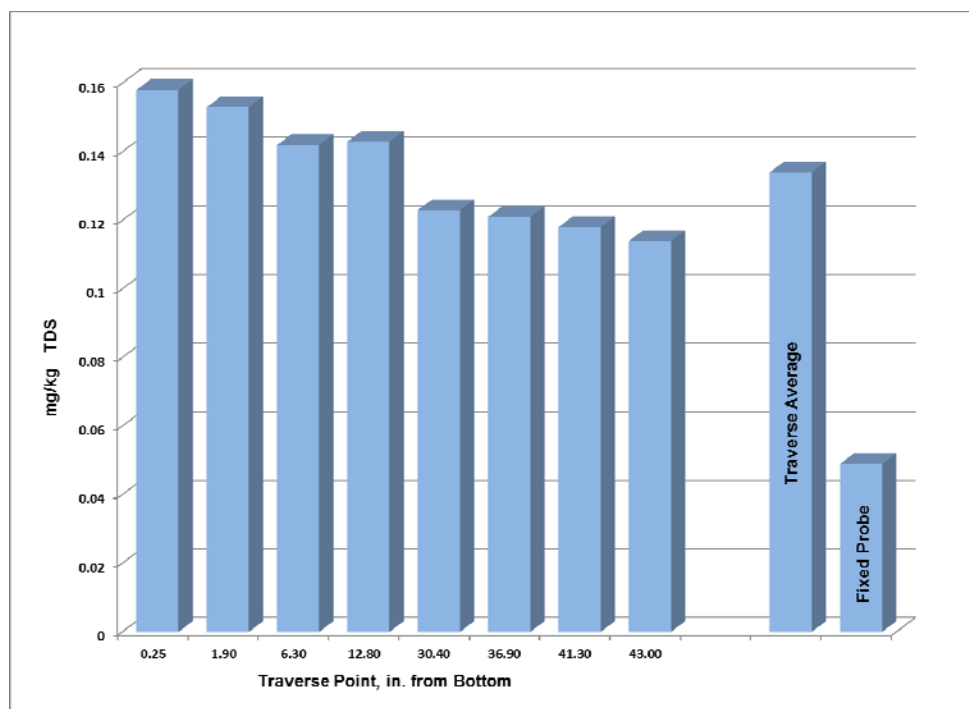
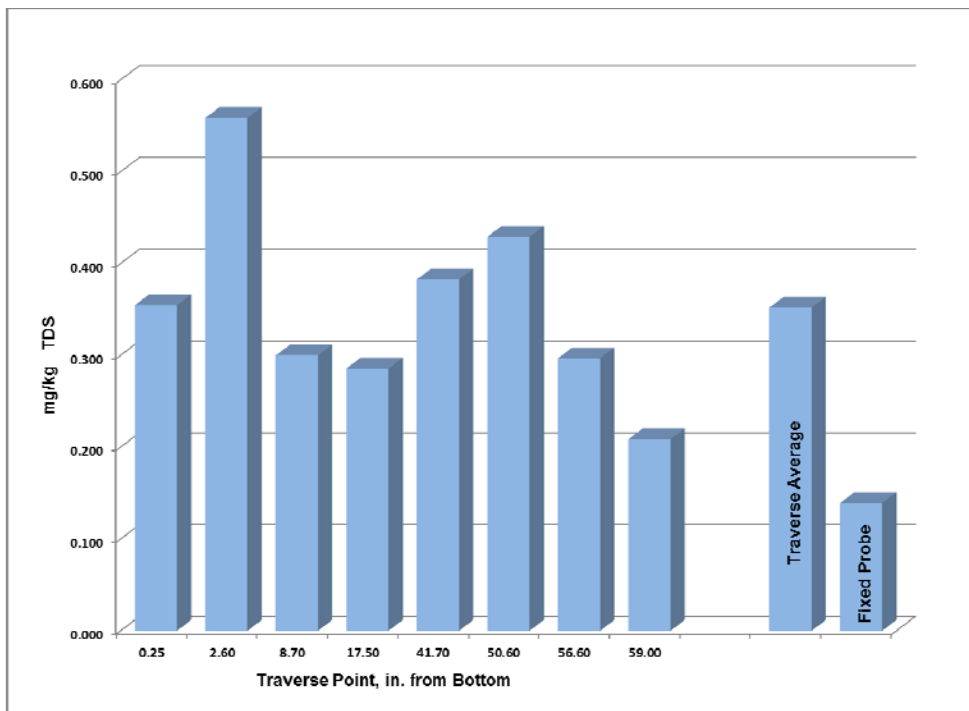
Thermochem has designed a Multi-Nozzle Isokinetic Sampling Probe (MNP2000) for steam quality and purity applications. The probe can be interfaced to the Thermochem Vacuum-Jacketed Calorimeter (SQ2000) for on-line steam quality monitoring, and/or to our sample conditioning system (SSCC) for steam purity monitoring with on-line analyzers for sodium, chloride, silica and NCG analysis.

Key design features and benefits of the Thermochem Multi-Nozzle Isokinetic Sampling Probe include:

- A profile composite of steam and entrained liquid by obtaining a true weighted average of 6 or more points across the pipeline.
- Multiple knife-edged nozzles are raised above the probe shaft and protrude into the steam flow where the sample can be extracted isokinetically with minimal flow disturbance.
- The probe shaft is off-set towards the steam flow to minimize flow disturbances by the flange assembly.
- The internal probe bore has a stepped diameter to maintain a constant, high sample velocity through the probe. This minimizes liquid hold-up and loss.
- Fully compliant with ASME PTC 19.11 for Steam Sampling and Analysis in the Power Cycle
- Superior to ASTM D1066-97 probe which suffers from stagnation boundary effects due to poor aerodynamic design, and a large internal bore causing sample hold-up and deposition of impurities.
- Superior to ASTM D1066-06 (EPRI/Jonas Single-Nozzle probe) which only collects from a single point near pipe wall and cannot obtain a representative profile of wet steam across the entire pipe diameter.



As Shown below from actual data collected at a power plant, multiple-point sampling (by a traversing probe) can produce data substantially different from the EPRI/Jonas Single-Nozzle probe which is plotted to the far right, compared to the profile average across pipeline. Multiple-point sampling produces equivalent results to the Thermochem Multi-Nozzle fixed sampling probe.



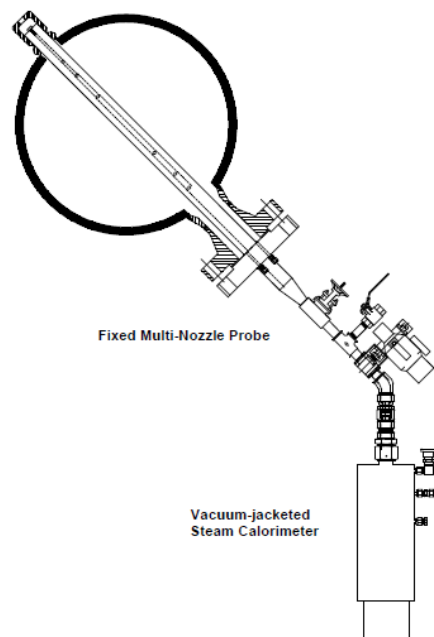
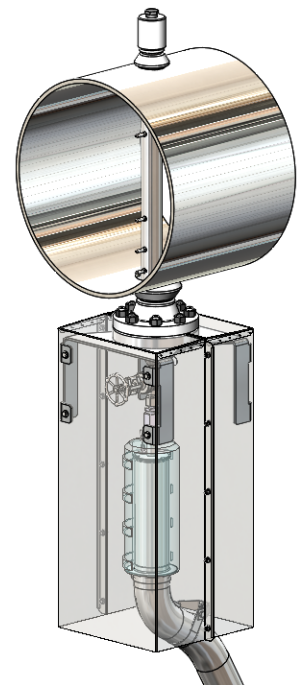
## Steam Quality

When used in the applicable range of about 98% to 99.95% steam quality, accurate entrained moisture measurements can be obtained from the Thermochem vacuum-jacketed throttling Steam Calorimeter attached to the Multi-Nozzle Isokinetic Sample Probe. The calorimeter determines the enthalpy of the steam by rapidly dropping the pressure to barometric conditions and measuring the temperature of the resulting superheated steam. The system can include automatic isokinetic flow control and is interfaced to the plant DCS or local PLC data processor.

## Applications

Steam Quality / Purity Testing Systems are used for:

- On-line measurements downstream of wellfield production separators
- Monitoring downstream of steam wash and scrubbers at plants upstream of turbines
- Early warning of steam field upset conditions such as brine carry-over and NCG spikes
- Verification of delivered steam quality and purity to power plants per contract requirements



## References

- The American Society of Mechanical Engineers, PTC-19.11 "Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle", 2008
- American Society for Testing and Materials, Method D 1066-97, "Standard Practice for Sampling Steam", 2001
- American Society for Testing and Materials, Method D 1066-06, "Standard Practice for Sampling Steam", 2007
- American Society for Testing and Materials, Method D 1192-70 (Reapproved 1977), "Standard Specification for Equipment for Sampling Water and Steam"
- Peña, J. M., and Campbell, H. E., (1987); "Steam Wetness Measurement Using a Transversable Retractable Probe", Geothermal Resources Council TRANSACTIONS, Vol. 11, October 1987, pp. 53-58
- Hirtz, P. N., Miller, J., and Prabhu, E. (1990); "Operational Results of a Dry-Steam Resource Chloride Corrosion Mitigation System", Geothermal Resources Council TRANSACTIONS, Vol. 14, Part II, August 1990, pp. 1667-1675
- Hirtz, P. N., Buck, C. L., and Kunzman, R. J. (1991); "Current Techniques in Acid-Chloride Corrosion Control and Monitoring at The Geysers", Proceedings, Sixteenth Workshop on Geothermal Reservoir Engineering., Stanford Geothermal Program, Stanford, CA, Workshop Report SGP-TR-134, pp. 83-95
- Stockman, E., McLean, D., Mathur, R., Jonas, O., and Hirtz, P. (1993), "Measuring Steam Impurities in a Geothermal Pipeline System Using Real Time Instrumentation", Geothermal Resources Council TRANSACTIONS, Vol. 17
- von Hirtz, P. N., and Kunzman, R. J. (2019); "Advanced On-Line Steam Purity Analyzer for Geothermal Power Plants", Geothermal Resources Council TRANSACTIONS, Vol. 43.
- von Hirtz, P. "Steam Sample Concentrator and Conditioner for on-line Steam Purity Analysis". United States Patent Application No. 16,246,961, (2019).