



# Protecting Critical Assets During High-Velocity Steam Blows

White Paper

Engineering Analysis and Risk Mitigation  
for Thermowell Vibration in SigmaBlow™  
Operations

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# Executive Summary



Thermowells—the protective sleeves housing temperature sensors in your steam systems—can potentially fail when exposed to the high-velocity conditions required for effective steam blow cleaning. Failure could damage equipment, delay schedules, and create safety concerns.

FQE Power's engineering team evaluates every thermowell before steam blows begin, using industry-standard calculations to predict whether vibration forces will remain within safe limits. If potential issues are identified, we work with you to implement protective measures—whether temporary removal, reinforcement, or operational adjustments.

**The result:** You gain confidence that your instrumentation will survive the cleaning process, avoiding costly surprises and maintaining your critical path schedule.

# Objective: Addressing the Industry's Growing Concern

## Why EPCs and OEMs Are Questioning Thermowell Survival During Steam Blows

FQE Power routinely performs steam blows using our patented SigmaBlow™ process, which maximizes cleaning effectiveness through precisely engineered high-velocity steam conditions. While these elevated velocities far exceed normal operating parameters, they create optimal cleaning forces that save time, reduce costs, and ensure superior system cleanliness.

Recently, EPCs and equipment manufacturers have raised valid concerns about potential thermowell failure under steam blow conditions. **FQE Power addresses this risk proactively through comprehensive pre-blow thermowell vibration analysis**—evaluating all failure modes per ASME PTC 19.3 TW-2010 and predicting potential issues before they occur. This engineering service protects your assets, maintains project schedules, and provides documented assurance for all stakeholders.



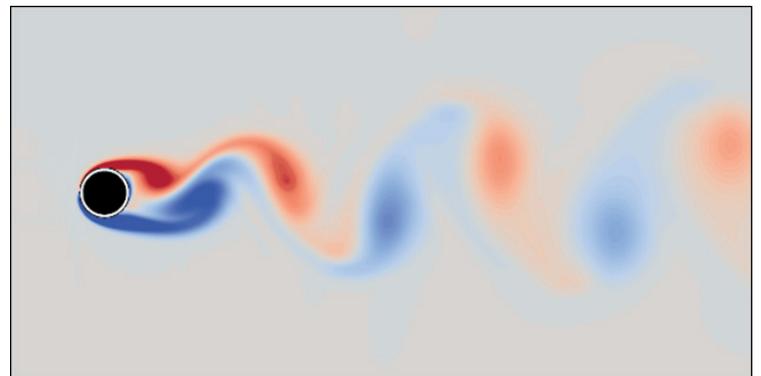
# Why Thermowell Failure Can't Be Ignored

## Understanding the MONJU Incident and the Evolution of ASME Standards

Thermowell failure can be detrimental. In December 1995, a major fire was caused by a sodium leak at the MONJU Nuclear Power Plant (MONJU) in Japan. An investigation of the failure concluded that the cause was due to a thermowell failure due to its vibration. The vibration caused the thermowell failure inside the pipe which was carrying a sodium coolant. The thermowell fracture was likely along a defective weld point. The resulting failure caused sodium to leak out of the pipe. The sodium ignited with oxygen and moisture in the air, generating caustic fumes and temperatures around a few hundred degrees Celsius. Fortunately, the sodium coolant was not part of the nuclear plant radioactive cooling system; but had it occurred in that system, the consequences of failure would have been even more severe. Thermowells are usually designed according to the industry standard ASME PTC 19.3 TW. Due to the findings of the incident at the MONJU Nuclear Power Plant, the ASME standard was revised in 2010 to address specific areas of flow induced vibration and cyclic stress contributions to thermowell vibration failure.

**Why must a thermowell need to be designed for process conditions which may cause vibration and stress forces?** A thermowell is practically a circular cylinder inserted into the process fluid. The cylinder behaves like a cantilever beam. When the process fluid flows around the thermowell, low pressure vortices are generated on the downstream side. The flow induced vibration phenomenon is known as Von Karman Street, shown in Image 1 on the right. The vortices are areas of lower pressure that are created and displaced downstream in an alternating pattern above and below the thermowell or object in the fluid path.

The alternating pattern vortices produce alternating drag and lift forces on the thermowell which results in alternating stresses on the thermowell. These alternating stresses create the potential for fatigue induced mechanical failure of the thermowell. When the steam velocity is increased, the vortex shedding increases linearly but the magnitude of the oscillating drag and lift forces increase with the square of the fluid velocity. Additionally, if the vortex shedding frequency and the thermowell natural frequency coincide, there will be resonance resulting in an increase in dynamic bending stresses on the thermowell. The ASME standard evaluates the potential for this vortex shedding phenomena and other possible modes of thermowell failure due to flow induced vibration.

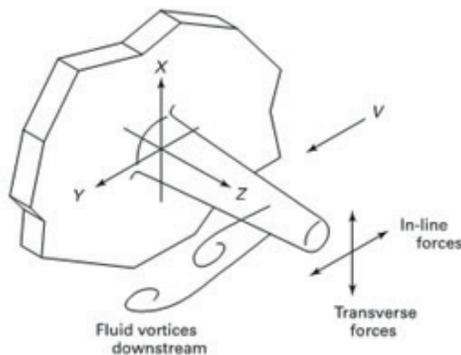


*Image 1. Von Karman Vortex (Reproduced from A stroll down the Kármán vortex street by Andrew Yeckel)*

The ASME standard provides a quantitative measurement for determining if the thermowell will fail given the process conditions. The standard primarily evaluates the following four potential mechanisms of thermowell failure for a wide variety of thermowell designs and installation types<sup>1</sup>.

# Why Thermowell Failure Can't Be Ignored

1. **Frequency Limit:** the resonant frequency of the thermowell must be high enough to prevent oscillating forces that can cause thermowell failure. The frequency limit is determined by calculating the Strouhal number, which is a function of the Reynolds number.
2. **Dynamic Stress Limit:** the maximum primary dynamic stress must be lower than the allowable fatigue stress limit. The thermowell may pass through the in-line resonance, provided that there is fatigue check at resonance.
3. **Static Stress Limit:** the maximum steady-state stress on the thermowell does not exceed the maximum allowable stress.
4. **Hydrostatic Pressure Limit:** the external pressure must not exceed the pressure ratings of the thermowell tip, shank, and flange (or threads).



*Image 2. Thermowell Forces (Reproduced from ASME PTC 19.3 2010)*

The ASME standard does not address vibration caused by external structures, such as flow induced vibration by the pipe itself. However, FQE Power engineering can also determine pipe flow induced vibration and routinely perform flow vibration analysis of temporary steam blow piping according to the Energy Institute standard "Guideline for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework." ASME PTC19.3 2010 standard places the responsibility of designing the thermowells for steam blow conditions upon the designer, stating that "design calculations

shall take into account the possibility of flow increases above the design rating<sup>1</sup>." The standard goes on to state that examples of these abnormal conditions include "start-up, shut-down, process upset," and "pre-start up conditions such as steam blows for pipe clean out shall also be considered<sup>1</sup>." However, the steam blow conditions are usually left to a third-party contractor specialist in steam blows. Consequently, steam blow conditions are often unknown at the time of thermowell specification and procurement.

If the steam blow conditions, which are normally at high steam velocities, predict that the thermowell will pass through the in-line resonance, the ASME standard allows this operation mode provided that the cyclic stresses at resonance conditions are small and that the following conditions are also satisfied<sup>2</sup>:

1. The fluid is a gas (steam in the case of steam blows).
2. Resonance occurs only at infrequent conditions such as start-up, shut down, or other transient velocities.
3. The sustained or steady state peak stress is less than the fatigue limit.
4. The process fluid does not cause metallurgical changes to the thermowell material that result in reduced fatigue resistance.
5. The potential for thermowell failure to the equipment or personnel is an acceptable small risk with low consequences.

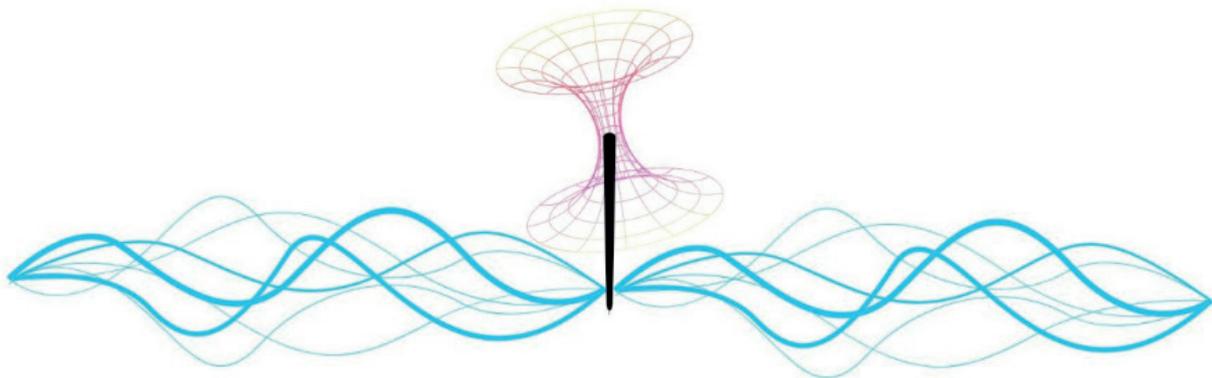
Steam blows may be considered transient conditions. Traditional steam blows exhaust steam to the atmosphere, consequently, the consequences of thermowell failure are low for damage to equipment or harm to personnel. FQE Power's patented SigmaBlow™ also includes a patented design for surface condenser tube protection allowing closed cycle steam blow operation in the unlikely event that thermowell failure occur.

# Why SigmaBlow™ Enables Safer High-Velocity Operations

FQE Power's patented SigmaBlow™ process includes proprietary condenser tube protection, allowing closed-cycle operation even if thermowell failure were to occur. This design advantage means:

- Lower consequence risk compared to atmospheric exhaust methods
- Continued operation capability if unexpected issues arise
- Superior cleaning effectiveness without compromising safety
- Environmental benefits through closed-cycle operation

Traditional atmospheric steam blows create higher risks because any component failure immediately impacts the surrounding environment. Our closed-cycle approach provides multiple layers of protection for both equipment and personnel.



# How FQE Power Protects Your Investment



## Our thermowell vibration analysis service includes:

- 1. Pre-Blow Assessment** – Complete ASME PTC 19.3 TW-2010 evaluation of all four failure modes
- 2. Risk Quantification** – Detailed calculations showing safety margins or identifying at-risk installations
- 3. Mitigation Recommendations** – Practical solutions if concerns are identified
- 4. Documentation** – Comprehensive reports for EPC, owner, and OEM stakeholders
- 5. Integration with SigmaBlow** – Coordinated analysis ensures both optimal cleaning forces and equipment protection

## The FQE Power Advantage:

Unlike contractors who simply perform steam blows, FQE Power engineers the entire process—combining our patented SigmaBlow™ technology with comprehensive fluid dynamics expertise. Our closed-cycle condenser protection system provides an additional safety layer should any unexpected issues arise.

**Contact FQE Power’s engineering team to discuss thermowell analysis for your upcoming commissioning project.**

## References:

1. ASME PTC 19.3 TW 2010, Section 7-1.
2. ASME PTC 19.3 TW 2010, Section 6-8.5

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