Thermowell Sizing and Selection

30 common interview questions and answers

Part 1: Fundamental Concepts

1. What is a thermowell?

A thermowell is a permanent, pressure-tight receptacle designed to protect a temperature sensor (like an RTD or thermocouple) from the process fluid. It is essentially a closed-end tube installed in a pipe or vessel, allowing the sensor to be inserted and removed without disrupting the process.

2. What are the three primary reasons to use a thermowell?

1. **Process Isolation:** It allows the temperature sensor to be removed for calibration, repair, or replacement **without shutting down and draining the process**.
2. **Sensor Protection:** It shields the delicate sensor from **high pressure, high velocity, and corrosive or erosive process fluids**.
3. **Process Integrity:** It prevents a potential leak path that could occur if a sensor were installed directly into the process.

3. When might you not use a thermowell?

You might not use a thermowell in very low-pressure, low-velocity, non-corrosive applications where a fast response time is critical, such as measuring air temperature in an HVAC duct. In most industrial process applications, a thermowell is mandatory.

4. What is the main disadvantage of using a thermowell?

The main disadvantage is that it **slows down the sensor's response time**. The thermowell's metal mass creates a thermal lag, meaning it takes longer for a change in the process temperature to be detected by the sensor.

5. How do you improve the response time of a sensor inside a thermowell?

- Use a **thermowell with a smaller tip diameter** (stepped or tapered).
- Ensure a **snug fit** between the sensor and the thermowell's inner bore.
- Use a **heat transfer fluid** (thermal grease or oil) to fill the small air gap between the sensor and the thermowell wall.

Part 2: Thermowell Types & Construction

6. What are the three main types of thermowells based on their process connection?

1. **Threaded:** Screws directly into a threaded tapping point (a "threadolet") on the pipe or vessel.
2. **Flanged:** Welded to a flange, which is then bolted to a mating flange on the process equipment. This is the most common type in the chemical and oil & gas industries.
3. **Weld-in:** Welded directly into the pipe or vessel. Used for very high-pressure, high-temperature, or critical applications where a potential leak path must be eliminated.

7. What are the three main thermowell stem profiles?

1. **Straight Shank:** The diameter is uniform along the entire length. It has high strength but a slower response time.
2. **Stepped Shank:** The diameter is smaller at the tip (the last ~2.5 inches). This provides a **faster response time** due to less mass at the sensing point.
3. **Tapered Shank:** The diameter gradually decreases from the base to the tip. This is the **strongest design** and is the preferred choice for high-velocity or high-vibration services.

8. Why is a tapered shank thermowell considered the strongest?

The tapered design gives it a very high natural frequency and superior resistance to bending forces caused by fluid flow. This makes it much less susceptible to **vortex-induced vibration**, which is a primary cause of thermowell failure.

9. What materials are thermowells made from?

The material must be compatible with the process fluid's temperature, pressure, and corrosivity. Common materials include:

- **316 Stainless Steel:** The most common general-purpose choice.
- **Carbon Steel:** For general services where corrosion is not a concern.
- **Monel:** For corrosive services, such as hydrofluoric acid.
- **Hastelloy C:** For excellent resistance to a wide range of corrosive chemicals.
- **Chrome-Moly Steels:** For high-temperature, high-pressure hydrocarbon services.

10. What is the difference between a bar stock and a built-up thermowell?

- **Bar Stock:** Machined from a single solid piece of metal bar. This is the most common and robust construction.
- **Built-up:** Fabricated by welding several pieces together. This is a less common and generally less reliable construction method.

Part 3: Sizing & Dimensional Parameters

11. What is the "U-length" or "insertion length"?

The **U-length** is the length of the thermowell from the underside of the mounting threads or flange to the tip of the well. It is the length that is actually "inserted" into the process flow.

12. How do you determine the correct insertion length?

The goal is to place the tip of the sensor in a **representative part of the flow stream**.

- The tip of the thermowell should be fully immersed in the fluid.
- A common rule of thumb is to have the tip located between the **outer 1/3 and the center** of the pipe.
- The sensor's sensitive portion (typically the bottom 1-2 inches) must be fully past the pipe wall.

13. Why is it bad to have a thermowell that is too short?

A short thermowell will suffer from **"stem conduction" error**. The cooler temperature of the pipe wall and nozzle will conduct along the thermowell's stem, causing the tip to be at a different temperature than the actual fluid. This leads to an inaccurate, often low, temperature reading.

14. Why is it bad to have a thermowell that is too long?

A very long thermowell can act as a significant obstruction to the flow and is much more susceptible to bending forces and flow-induced vibration. It can also be more difficult to install and remove.

15. What is the "bore diameter" of a thermowell?

The bore diameter is the inner diameter of the thermowell's bore. It must be selected to be slightly **larger than the diameter of the temperature sensor probe** that will be inserted into it. A common bore size is 0.260 inches to accommodate a standard 1/4-inch probe.

16. What is the "lagging extension" or "T-length"?

The lagging extension is the extra length on the "cold" side of the thermowell, between the process connection and the instrument connection. Its purpose is to extend the head of the thermowell out past any pipe insulation ("lagging"), allowing easy access to the sensor terminals.

Part 4: Wake Frequency Calculation (WFC)

17. What is vortex-induced vibration (VIV)?

As a fluid flows past the thermowell, it sheds vortices from alternate sides. This creates a periodic sideways force on the well, causing it to vibrate. This is known as **vortex-induced vibration**.

18. Why is VIV a major concern for thermowells?

If the frequency of the vortex shedding (**wake frequency**) gets close to the **natural resonant frequency** of the thermowell itself, the vibration can be amplified dramatically, leading to **mechanical fatigue and failure**. This can cause the thermowell to bend or even break off completely.

19. What is a Wake Frequency Calculation (WFC)?

A WFC is an engineering calculation performed to ensure that a thermowell's design is robust enough to withstand the forces of the process fluid and avoid failure due to vibration.

20. What is the standard that governs this calculation?

The industry standard is **ASME PTC 19.3 TW - 2016**. This standard defines all the required calculations and acceptance criteria.

21. What are the key inputs needed for a WFC?

- **Fluid Properties:** Density and viscosity at operating conditions.
- **Flow Conditions:** Fluid velocity.

- **Thermowell Dimensions:** All dimensions, including root and tip diameter, insertion length, and unsupported length.
- **Material Properties:** The material's modulus of elasticity, allowable stress, etc.

22. What are the four main criteria that a thermowell must pass according to the ASME standard?

1. **Frequency Limit:** The resonant frequency of the thermowell must be high enough to avoid resonance with the wake frequency.
2. **Dynamic Stress Limit:** The stress on the thermowell from the oscillating lift forces must be below the material's fatigue limit.
3. **Static Stress Limit:** The stress from the steady-state fluid drag must be below the material's allowable stress limit.
4. **Pressure Limit:** The external process pressure must not exceed the pressure rating of the thermowell tip.

23. What can you do if a thermowell fails the WFC?

Several design changes can be made:

- **Shorten the insertion length (U-length).** This is the most effective change.
- **Increase the root diameter.**
- **Change the stem profile** to a tapered design.
- **Add a velocity collar** for support (less common).
- **Change the material** to one with a higher strength or modulus of elasticity.

Part 5: Installation & Application

24. How should a thermowell be oriented in a pipe?

Whenever possible, a thermowell in a pipe with elbows should be installed **at the elbow, facing against the flow**. This ensures the tip is in a well-mixed region of the fluid and minimizes the insertion length needed. In a straight pipe run, it is typically installed at a 45-degree angle or, if necessary, at a 90-degree angle to the pipe.

25. Why is it important that the sensor be bottomed out in the thermowell?

The temperature sensor probe should be inserted until it makes firm contact with the bottom of the thermowell bore. This ensures the best possible heat transfer from the thermowell tip to the sensor's sensitive area. Many sensors are spring-loaded to maintain this contact.

26. Can you use a thermowell for a solids (e.g., powder) application?

No, a standard thermowell is not suitable for solids. The abrasive nature and mechanical forces of the flowing solid material would quickly damage or break the well. Special surface-mount or flush-mount temperature sensors are used instead.

27. What is a "velocity collar"?

A velocity collar is a thick, supporting ring that is welded around the shank of a very long thermowell. It is designed to change the unsupported length and increase the stiffness and natural frequency of the well. Its use is now discouraged by the ASME PTC 19.3 TW standard in favor of a properly designed well without a collar.

28. What is a common mistake during the installation of a flanged thermowell?

Using the wrong type or size of **gasket**. The gasket must be rated for the process temperature and pressure and must be the correct size for the flange to prevent leaks.

29. What is a Van Stone thermowell?

A Van Stone, or lap-joint, thermowell is a special two-piece design. The thermowell itself (the wetted part) is made of an exotic, corrosion-resistant alloy, while the flange is made of a cheaper material like carbon steel. This provides the necessary corrosion resistance at a much lower cost than making the entire assembly from the exotic alloy.

30. In your opinion, what is the most critical step in thermowell selection?

The most critical step is performing the **Wake Frequency Calculation (WFC)** according to the latest ASME standard. While selecting the right material and insertion length is important, a failure to perform the WFC can lead to a catastrophic mechanical failure of the thermowell, which can have severe safety, environmental, and economic consequences. It is a non-negotiable step for any pressurized or high-velocity application. 🔧