# Plan 53B

## Barrier Plan

Double Seal, Pressurized

## Plan Overview:

API Plan 53B supports **Arrangement 3** seals, requiring a **pressurized barrier fluid** to ensure **zero process leakage.** It is specifically used for **contacting wet** containment seals with **3CW-FB, 3CW-FF,** and **3CW-BB** configurations. Unlike Plan 52, which uses an unpressurized buffer system, Plan 53B maintains the barrier fluid at a pressure that is at least **1.4 bar (20 psi) higher** than the seal chamber pressure.

This is achieved using a reservoir with a nitrogen-charged **bladder accumulator** that maintains stable system pressure. It prevents process fluid ingress, making Plan 53B ideal for **hazardous, toxic,** or **flammable** services. Barrier fluid circulation via a **Pumping Ring** and **Heat Exchanger** ensures effective cooling, lubrication, and reliable operation.

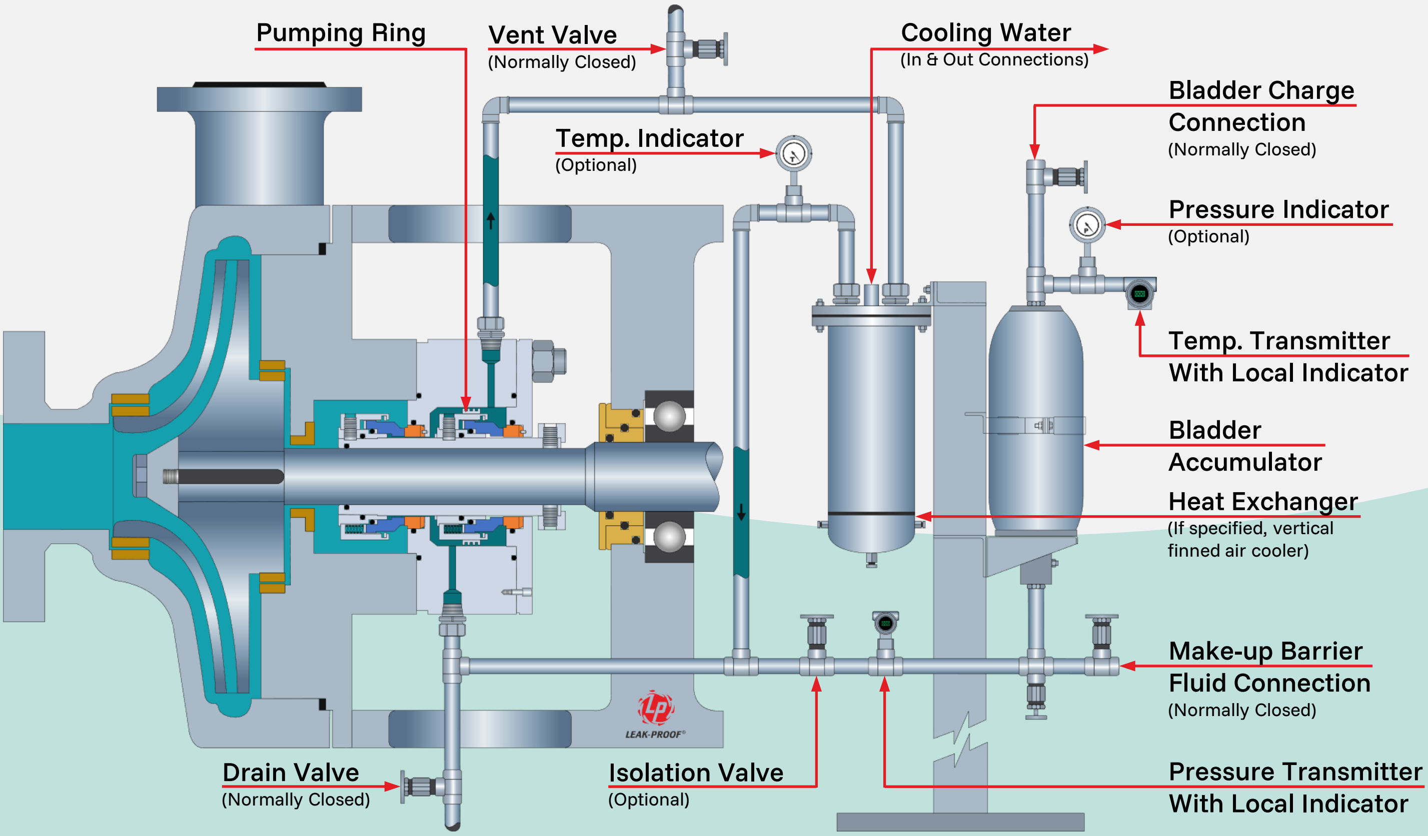


*Image: Pump c/s with **API Plan 53B***

## Features

1. **Zero Process Emissions:** Plan 53B maintains the barrier fluid at a pressure at least **1.4 bar (20 psi) higher** than the seal chamber pressure, ensuring any leakage flows from the barrier fluid into the process—not the reverse. This prevents process fluid from escaping to the atmosphere, making Plan 53B an ideal solution for **hazardous**, **toxic**, or **environmentally sensitive** applications. By ensuring complete containment, it supports zero process emission, meeting the reliability and compliance demands of modern industry.
2. **High Pressure Capability:** Plan 53B is suitable for applications requiring high barrier fluid pressures, making it the preferred choice over Plan 53A. Plan 53A is **limited** to barrier pressures up to **10 bar (150 psi)** due to the risk of **nitrogen absorption** into the barrier fluid, as it relies on a nitrogen-pressurized reservoir that can affect stability and circulation. On the other hand, Plan 53B uses a nitrogen-charged **bladder accumulator** that separates nitrogen from barrier fluid, eliminating the risk of nitrogen absorption and ensuring reliable operation at high pressure.
3. **Heat Dissipation:** Plan 53B ensures continuous circulation of barrier fluid between the seal and the external **heat exchanger** using the mechanical seal's **pumping ring.** The heat exchanger removes heat absorbed by the barrier fluid from the seal faces, maintaining **thermal stability** within the sealing interface. This controlled cooling prevents **excessive**

temperature rise, reducing the risk of **thermal distortion**, barrier fluid **degradation**, and **premature seal wear** in high-temperature services.

4. **Pressure Monitoring:** Plan 53B enables seal failure detection through continuous barrier pressure monitoring. A sudden drop in pressure indicates a loss of barrier fluid, typically due to failure of either the inboard or outboard seal. Equipped with a pressure transmitter and alarm, the system provides **real-time alerts** for immediate corrective action.

5. **Stand-Alone System:** Plan 53B operates as a stand-alone system, using a nitrogen-charged bladder accumulator to maintain barrier pressure. Unlike Plan 53A, it does not rely on an **external** nitrogen source or pressure regulation system, eliminating risks associated with supply fluctuations or control failures. This independence makes Plan 53B more reliable in remote or critical applications, where equipment uptime and safety rely on uninterrupted seal support.

6. **Seal Face Lubrication:** As a barrier plan, Plan 53B allows the seal faces to be **lubricated by the barrier fluid** rather than the process fluid. This provides a major advantage in applications involving **suspended solids**, **polymerizing fluids**, **contaminants**, or process media with **poor lubricating properties.** By isolating the inboard seal face from the process side, the Plan 53B ensures a **clean**, and **stable** lubricating film, while improving seal face life and overall system reliability in challenging service conditions.

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## Applications

1. Recommended for applications where process fluid is **highly toxic**, **hazardous**, or **flammable**, requiring zero leakage to the atmosphere.
2. Recommended for applications involving fluids with suspended solids, contaminants, polymerizing or solidifying tendencies, or poor lubricating properties, where product **dilution** is acceptable.
3. Recommended for applications where Plan 53A is unsuitable:
   A. High-pressure services requiring barrier pressures above **10 bar (150 psi).** (In some cases, with proper selection of the barrier fluid, Plan 53A may be used above the **API 682** recommended limit, but generally not beyond **15 bar (217 psi)**)
   B. Installations where a reliable nitrogen source at the required pressure is not available.
4. Recommended for applications where the equipment may operate dry, requiring independent lubrication for seal faces.

## Precautions

1. **Fluid Suitability:** Plan 53B is not suitable for applications where product dilution is **unacceptable**, as the barrier fluid is always maintained at a higher pressure and continuously enters the process through the inboard seal. In such cases, alternative solutions such as an **Arrangement 2** mechanical seal with a containment seal **(2CW-CS)** using gas buffer plans **(Plan 75 or Plan 76)** should be considered, depending on the sealing requirements and containment expectations.
2. **Barrier Fluid Selection & Compatibility:** The barrier fluid must be **chemically compatible** with the process fluid to avoid unwanted reactions. It should have suitable **viscosity**, excellent **lubricating** properties, and good **heat transfer** characteristics to protect seal faces under high-pressure and high-temperature conditions. Fluids prone to polymerizing, solidifying, or degrading at operating temperatures **must be avoided**, as they can impair circulation, reduce cooling efficiency, and lead to **seal failure**.
3. **Barrier Pressure Management:** Maintaining the correct pressure differential is critical for Plan 53B to operate reliably. As per **API 682**, the barrier fluid pressure must be maintained between **1.4 bar (20 psi)** and **4.1 bar (60 psi)** above the seal chamber pressure. The bladder accumulator must be properly pre-charged with nitrogen to ensure stable pressure throughout operation. A drop in barrier pressure may indicate seal failure or nitrogen leakage and should

trigger immediate inspection. Installing a pressure **transmitter with alarms** is recommended for **real-time** monitoring and to prevent operation under underpressurized conditions, which can lead to process contamination or seal damage.

4. **Alarm Strategy:** In Plan 53B, the accumulator is isolated from the nitrogen supply during operation. Over time, the pressure inside the accumulator gradually **drops** as barrier fluid is **lost** due to normal seal leakage. To avoid running the seal at low pressure, it's important to monitor this drop and refill the system before the pressure falls below the required margin.

   Instead of using a **fixed** (low-pressure) alarm (which can be inaccurate due to temperature effects), a **floating** (temperature-compensated) alarm is recommended. This **alarm strategy** adjusts the alarm set point based on ambient or gas temperature, ensuring more accurate detection of pressure loss. It also **maximizes** the usable fluid volume in the accumulator and reduces **false alarms**.

5. **Accumulator Placement & Thermal Protection:** Since accumulator pressure is influenced by ambient temperature, physical location and protection are critical. Exposure to direct **sunlight** can lead to **over-pressurization**, while **cold** conditions may **reduce** barrier pressure below safe limits. To reduce these risks, install the accumulator in a **shaded area**, and consider **insulating** or **heat-tracing** it in an extreme climates. These measures help maintain pressure stability.

6. **Barrier Fluid Refill:** Over time, barrier fluid is lost due to normal leakage across the seal faces, gradually lowering the system pressure. Although API 682 suggests a minimum refill frequency of **28 days,** this interval depends on factors like seal **leakage rate**, **accumulator size**, and **alarm strategy**. Operators should monitor barrier fluid loss trends and establish a proactive refill schedule to **avoid** low-pressure operation and ensure continuous seal protection. Proper planning also minimizes unnecessary shutdowns and extends seal life.
7. **Accumulator Sizing:** An undersized accumulator can lead to frequent barrier fluid refills, reduced pressure stability, and ineffective alarm management. The working liquid volume inside the accumulator should typically be **15% to 25%** of its **total volume**, allowing adequate pressure variation range between alarm and refill points. Proper sizing must account for **expected seal leakage**, **ambient conditions**, and **desired refill intervals**. Oversizing may increase cost, but under-sizing compromises system reliability and increases operational burden.
8. **Pressure Relief Provision:** Plan 53B systems must be protected against **over-pressurization** caused by **gas expansion**, **incorrect charging**, or **thermal effects**. Installing a pressure relief valve in the barrier fluid piping provides a fail-safe mechanism to release excess pressure and protect the seal and support system components.

9. **Heat Exchanger Design:** In Plan 53B, a heat exchanger—either water-cooled or air-cooled—is an essential part of the system design to control barrier fluid temperature. The seal manufacturer is **responsible** for confirming that the selected cooling arrangement meets the **thermal duty** requirements under actual site conditions. According to **API 682**, the maximum allowable temperature rise across the barrier fluid, measured near the seal chamber, should not exceed:

   - **8 °C (15 °F)** for glycol/water or water-based fluids
   - **16 °C (30 °F)** for oil-based barrier fluids

   Exceeding these limits can result in **fluid degradation, reduced lubrication**, and accelerated **seal face wear**. Proper cooling system selection and **thermal sizing** are critical to ensure reliable and long-term Plan 53B performance.

10. **Venting & Gas Bubble Elimination:** Effective circulation in Plan 53B can only be achieved if the system is completely free of gas and air pockets. All gas bubbles must be purged from the **heat exchanger** and interconnecting piping during **commissioning**. Failure to remove trapped gases can severely disrupt the **thermodynamic stability** and **flow** of the barrier fluid, leading to **localized overheating** and compromised seal performance. Always ensure proper venting at **startup** to maintain reliable seal operation throughout the system's lifecycle.

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Leak-Proof Engineering — Since 1973

## Barrier Fluids

In Plan 53B, proper barrier fluid selection is essential for seal reliability, thermal control, and long-term system performance. The fluid must be **chemically compatible** and **thermally stable** across the operating range. **Viscosity** should remain below **500 cSt** at the lowest ambient temperature.

1. **Hydrocarbon-based fluids:**
   - Acceptable viscosity: **< 100 cSt** at operating temperature
   - Ideal range: **2–10 cSt** at operating temperature
2. **Non-hydrocarbon (aqueous) fluids:**
   - Water/glycol mixtures are **suitable**
   - **Avoid** automotive antifreeze

Although barrier fluid is typically refilled every **28 days,** it must remain chemically and physically stable for up to **3 years** in service—without polymerizing, sludging, or degrading.

Below is a table of commonly used barrier fluids with their applications and temperature limits.

**Table: Recommended Barrier Fluids – Applications & Temperature Limits**

| Fluid Family | Fluid / Solution / Grade | Application | Temp Limit °C (°F) |
|---|---|---|---|
| **Glycol Solutions** | 50% Ethelene Glycol + 50% Water | Light Hydrocarbons | -35 to 100 (-30 to 210) |
| **Hydrocarbons** | Kerosene or Diesel | Light Hydrocarbons & Medium Duty | -10 to 80 (15 to 175) |
| **Lubricating Oils** | Below ISO Grade 32 | General Purpose & Heavy Duty | -20 to 150 (-5 to 300) |
| **Synthetic Oils** | ISO Grade 5 to Grade 20 | General Purpose & Heavy Duty with High Temp. | -30 to 250 (-20 to 480) |
| **Heat Transfer Fluids** | Therminol VP-1, Dowtherm A or Equivalent | Very High Temperature | -30 to 400 (-20 to 750) |