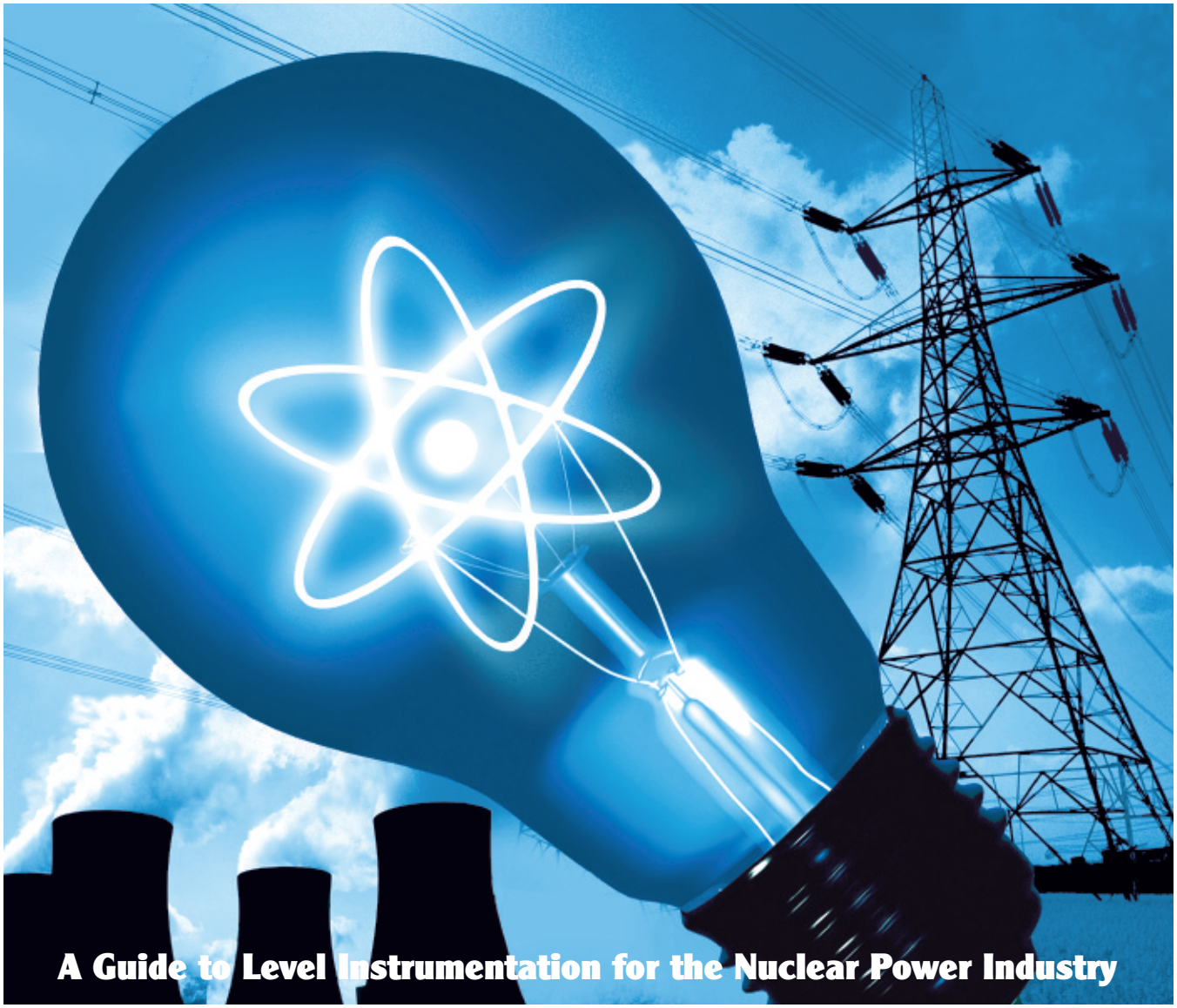
MAGNETROL®

INDUSTRY APPLICATIONS SERIES

NUCLEAR POWER



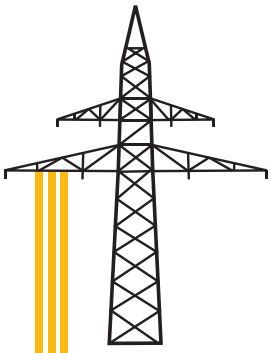
A Guide to Level Instrumentation for the Nuclear Power Industry

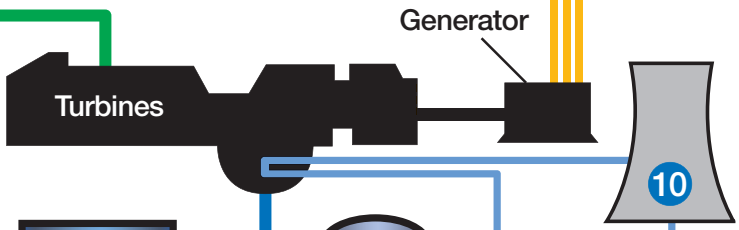
LEVEL APPLICATIONS

These applications utilize level instruments for process control. A separate alarm using a different technology often serves as a back-up for spill detection.

For a discussion of the major applications in conventional steam turbine power generation see the Magnetrol® PowerGen Applications brochure.

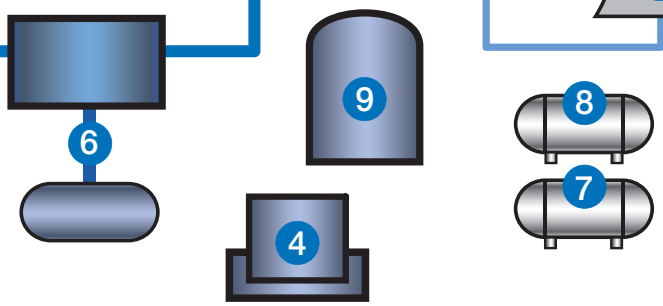
STEAM TURBINE POWER GENERATION UNITS

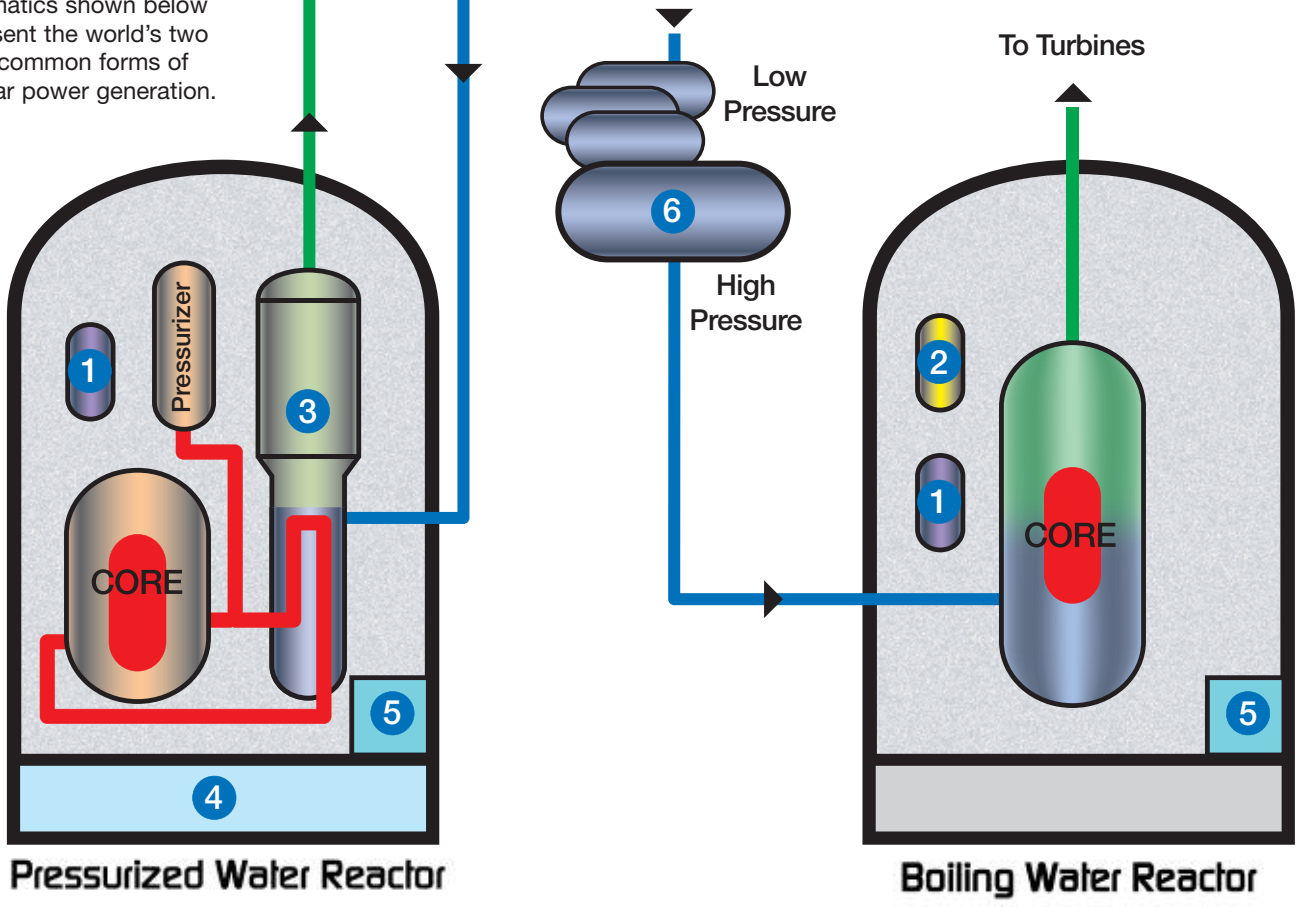




REACTOR CONTAINMENT STRUCTURES

The Pressurized Water Reactor (PWR) and the Boiling Water Reactor (BWR) schematics shown below represent the world's two most common forms of nuclear power generation.





Pressurized Water Reactor

Boiling Water Reactor

1 EMERGENCY COOLANT TANKS

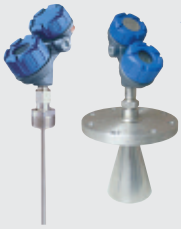
Coolant Tank

Application: The Emergency Core Cooling System (ECCS) supplies cooling water to the reactor during an interruption of the reactor's normal cooling system. Upwards of 250,000 gallons of emergency make-up water is drawn from Refueling Water Storage Tanks (RWST) during the injection phase and from a containment sump during the second recirculation phase.

Challenges: Level control of Refueling Water Storage Tanks is essential for emergency cooling operations. Low levels in these tanks can trigger actuation of pumps which bring additional coolant from accumulators, deaerators, de-mineralized water tanks, and treated condensate tanks. The ECCS can be tripped by an indication of coolant pressure loss or by low level of reactor coolant.

INSTRUMENTATION

▲ **Point Level:** Models A10 or B10 Displacer-Actuated Switches



▲ **Continuous Level:** Eclipse® Model 706 Guided Wave Radar Transmitter or Pulsar® Model R86 Pulse Burst Radar Transmitter

▲ **Visual Indication:** Atlas™ or Aurora® Magnetic Level Indicators can be supplied with switches or transmitters

2 SCRAM DISCHARGE VOLUME TANKS


SCRAM Tanks

Application: A SCRAM is a rapid shutdown of a nuclear reactor whereby control rods are inserted between the fuel rods in the reactor core to discontinue the fission reaction. The SCRAM is actuated manually by an operator or automatically when parameters are exceeded. When control rods are inserted, radioactive coolant is displaced by the rods and routed to a storage tank. This "hot" coolant is later processed and routed back to the recirculation system.

Challenges: Level instrumentation in the Discharge Volume Tank is an important control in the Reactor Protection System (RPS). The level controls must be approved for radioactive service in a steam environment. Conventional float switches are frequently specified as they meet these requirements with high reliability.

INSTRUMENTATION

▲ **Point Level:** Model B40 Float-Actuated External Cage Switch

▲ **Continuous Level:** E3 Modulevel® Displacer Transmitter (remote version only)

▲ **Visual Indication:** ATLAS Magnetic Level Indicator

3 STEAM GENERATOR


Steam Generators

Application: Primary coolant circulating in a PWR is heated under extremely high pressures to prevent boiling. The heated coolant enters two or more boilers called Steam Generators (SG) and boils the secondary loop coolant in a heat transfer process accomplished without mixing the fluids together. The coolant turns to steam which drives the turbine-generator.

Challenges: 30% of emergency PWR shutdowns are attributable to SG level control problems. Controls balance feedwater to steam flow under all operating conditions. High-high levels can trip the turbine. Abnormally low levels can actuate emergency feedwater or a reactor shutdown. Measurement accuracy is challenged by thermal reverse effects known as “shrink and swell” and by static pressure effects.

INSTRUMENTATION

▲ **Point Level:** Series 3 Float-actuated External Cage Level Switch or B40 Float-Actuated Level Switch

▲ **Continuous Level:** E3 MODULEVEL Displacer Transmitter or ECLIPSE Model 706 Guided Wave Radar Transmitter

▲ **Visual Indication:** ATLAS or AURORA Magnetic Level Indicators can be supplied with switches or transmitters

4 CONTAINMENT & DRAINAGE SUMPS

Application: A plant has many low-lying drainage reservoirs known as sumps. Small sumps include pump enclosures and tank rupture basins that contain leakage. The reactor’s large, containment sump is an essential reservoir of the ECCS whose function is to continuously circulate coolant through the reactor once all coolant storage tanks are depleted.

Challenges: Small sumps are monitored for leak detection with simple, float-operated level switches designed for bracket mounting in floor level sumps or troughs. These switches detect leaks or spills from pumps, valves, vessels, and pipelines. Levels of the large containment sump, or ECCS sump, are monitored during the recirculation phase of residual heat removal when the reactor’s primary coolant system is down.

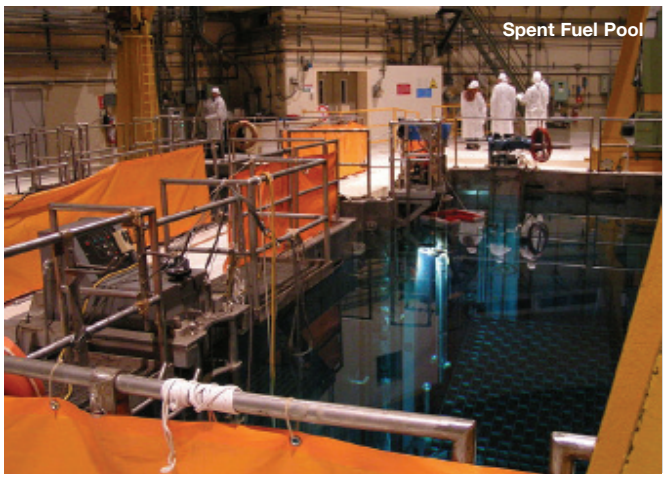
INSTRUMENTATION

▲ **Point Level:** Models A10 or B10 Displacer-Actuated Switches

▲ **Continuous Level:** ECLIPSE Model 706 Guided Wave Radar Transmitter with Single Rod Probe (remote version only)

▲ **Visual Indication:** ATLAS Magnetic Level Indicator

5 SPENT FUEL POOL


Spent Fuel Pool

Application: One-third of the total fuel load of a reactor is removed from the core every 12 to 18 months and replaced with fresh fuel. Spent fuel rods generate intense heat and high radiation and are stored underwater in pools with depths of 20 to 40 feet. The water cools the fuel and provides radiation shielding. Spent fuel is later sent for reprocessing or dry cask storage.

Challenges: Without cooling, the spent fuel pool water will heat up and boil. Exposed fuel assemblies will overheat, melt or combust. Pool level is tightly controlled and water is continuously cooled by recirculation to heat exchangers and then back to the pool to resume cooling. High and low level alarms as well as redundant continuous level indication are typically required.

INSTRUMENTATION

▲ **Point Level:**
Models A10 or B10 Displacer-Actuated Switches

▲ **Continuous Level:**
PULSAR Model R86 Radar Transmitter

▲ **Visual Indication:**
Not applicable

6 FEEDWATER HEATERS AND STORAGE


Feedwater Tank

Application: Low and High Pressure Feedwater Heaters use extraction steam from the turbine to pre-heat feedwater destined for steam generation. The primary water sources for the heaters are the Condensers and Condensate Storage Tank. The Emergency Service Water System or the Ultimate Heat Sink (usually a river or lake) provides back-up feedwater to the SGs in the event of an interruption in the primary feedwater system.

Challenges: Redundant control loops manage feedwater heater level to prevent liquid from rising into the extraction steam; keep tubes in the condensing zone immersed; keep the drain cooler flooded, and optimize heater performance. The primary and back-up feedwater sources are typically equipped with level switches for valve actuation and alarms.

INSTRUMENTATION

▲ **Point Level:**
Series 3 Float-Actuated External Cage Level Switch or B40 Float-Actuated Level Switch

▲ **Continuous Level:**
E3 MODULEVEL Displacer Transmitter or ECLIPSE Model 706 Guided Wave Radar Transmitter

▲ **Visual Indication:**
ATLAS or AURORA Magnetic Level Indicators can be supplied with switches or transmitters

7 DIESEL FUEL STORAGE TANKS


Diesel Storage Tanks

Application: Diesel-powered engine-generator sets provide emergency power to operate critical nuclear plant systems in the event of a loss of station service power. The main diesel fuel storage tank provides a fuel capacity for one to seven days of full-load generator operation. The main storage tank is connected to an indoor day tank holding less than 1,000 gallons.

Challenges: Main storage tanks typically require a fuel level indicator with a remote indication transmitter. Sensors actuating electrical pumps connected to the main tank continuously monitor day tank fuel level. Day tank high-level alarms can lock out supply pumps until a system reset. Low levels and critical low-levels actuate alarms and the system will display the low-level conditions.

INSTRUMENTATION

▲ **Point Level:** Models A10 or B10 Displacer-Actuated Switches or Echotel® Model 961 Ultrasonic Switch

▲ **Continuous Level:** ECLIPSE Model 706 GWR Transmitter, PULSAR Model R86 Radar Transmitter, or Jupiter® Magnetostrictive Level Transmitter

▲ **Visual Indication:** ATLAS or AURORA Magnetic Level Indicators can be supplied with switches or transmitters

8 LUBRICATION OIL STORAGE


Lube Oil Tanks

Application: Nuclear plants operate many machines that require lubrication. Lubricants prevent damage caused by excessive friction and prolong equipment life. Oil is stored in stainless steel and carbon steel tanks. A generator gearbox lube oil system may have a reservoir with a capacity of 3,000 gallons and a turbine oil system may have a capacity of 150 gallons.

Challenges: Level monitoring of oil reservoirs will ensure the proper functioning of pumps, gearboxes, drives, compressors, materials handling equipment, generators and turbines. Temperature shifts in oil reservoirs affect media density that excludes some technologies, such as dP devices. Because ISO cleanliness levels increase oil change frequency, controls should be easy to remove.

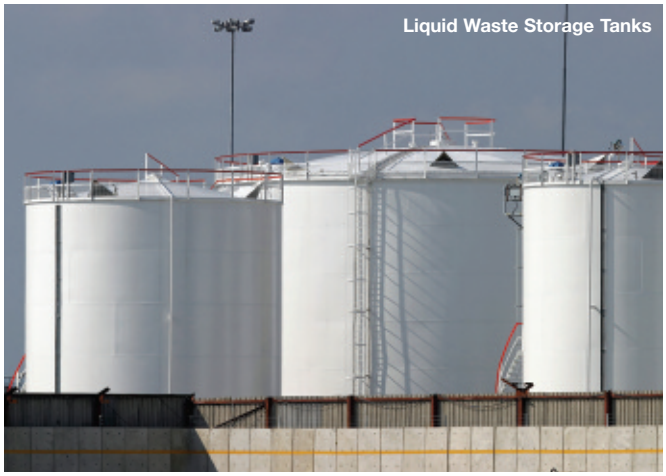
INSTRUMENTATION

▲ **Point Level:** ECHOTEL Model 961 Ultrasonic Switch or Tuffy® II Float-Actuated Switch

▲ **Continuous Level:** ECLIPSE Model 706 Guided Wave Radar Transmitter or PULSAR Model R86 Radar Transmitter

▲ **Visual Indication:** ATLAS or AURORA Magnetic Level Indicators can be supplied with switches or transmitters

9 LIQUID WASTE STORAGE


Liquid Waste Storage Tanks

Application: Waste liquids from sumps, radioactive leakage collectors, the Reactor Cooling System (RCS), and allied systems are collected, stored and processed. Inactive wastes are discharged or reused; active wastes are collected for processing. Radioactive liquids can provide make-up to the RCS, the ECCS, and the spent fuel storage pool.

Challenges: Waste liquids are collected and stored in large single- and double-walled tanks designed to suit radioactivity levels. Tanks are monitored for activity levels and their contents are processed, released or reused. Tank level instruments, frequently of redundant design, indicate inventory levels and protect against overfilling or underfilling that cavitates pumps. Prevention of tank overfilling.

INSTRUMENTATION

▲ **Point Level:** Models A10 or B10 Displacer-Actuated Switches

▲ **Continuous Level:** Not applicable due to possible radioactivity

▲ **Visual Indication:** ATLAS or AURORA Magnetic Level Indicators can be supplied with switches or transmitters

10 COOLING TOWER INTAKE & BASIN LEVELS


Cooling Tower Water Pumps

Application: The hyperbolic cooling tower releasing clouds of water vapor is the iconic image of nuclear power. Warm water from the condenser is pumped to the natural draft cooling tower, distributed to remove waste heat to the ambient atmosphere through evaporation, and collected in a basin prior to being recycled back to the condenser.

Challenges: The cooling tower's intake structure, typically a vertical wet pit, requires level sensing and pump control. Water basin level controls maintain level through the addition of make-up water and are frequently configured with high and low level alarms.

INSTRUMENTATION

▲ **Point Level:** ECHOTEL Model 961 Ultrasonic Switch

▲ **Continuous Level:** ECLIPSE Model 706 GWR Transmitter, PULSAR Model R86 Radar Transmitter or ECHOTEL Model 355 Non-Contact Ultrasonic Transmitter

▲ **Flow & Pump Protection:** Thermatel® Model TD1/TD2 Thermal Dispersion Switch

NUCLEAR POWER

AN INDUSTRY GUIDE TO LEVEL MEASUREMENT AND CONTROL FROM ***MAGNETROL***

Other industry and special application brochures from MAGNETROL include:

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- ***Life Science***
- ***Mass Flow Measurement***
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- ***Natural Gas Processing***
- ***Petroleum Refining***
- ***Power Generation***
- ***Pulp & Paper Mills***
- ***Renewable Energy***
- ***Steam Generation***
- ***Tank Bridle Level Measurement***
- ***Tank Overfill Prevention***
- ***Understanding Safety Integrity Level (SIL)***
- ***Water & Wastewater***

PLEASE NOTE: The instruments recommended in these brochures are based on field experience with similar applications and are included as a general guide to level and flow control selection. Because all applications differ, however, customers should determine suitability for their own purposes.

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