NUCLEAR ENERGY DEPARTMENT
UNIVERSITY OF KANTGOWRONG

OPERATING MANUAL AND INSPECTION AND SERVICE MANUAL
ENERGY NUCLEAR REACTOR NR-1001

SEPTEMBER 1972

V1.0

XCM 201

OPERATING MANUAL
REACTOR NR-1001

NUCLEAR ENERGY DEPARTMENT
UNIVERSITY OF KANTGOWRONG

REVISION: SEPTEMBER 1972

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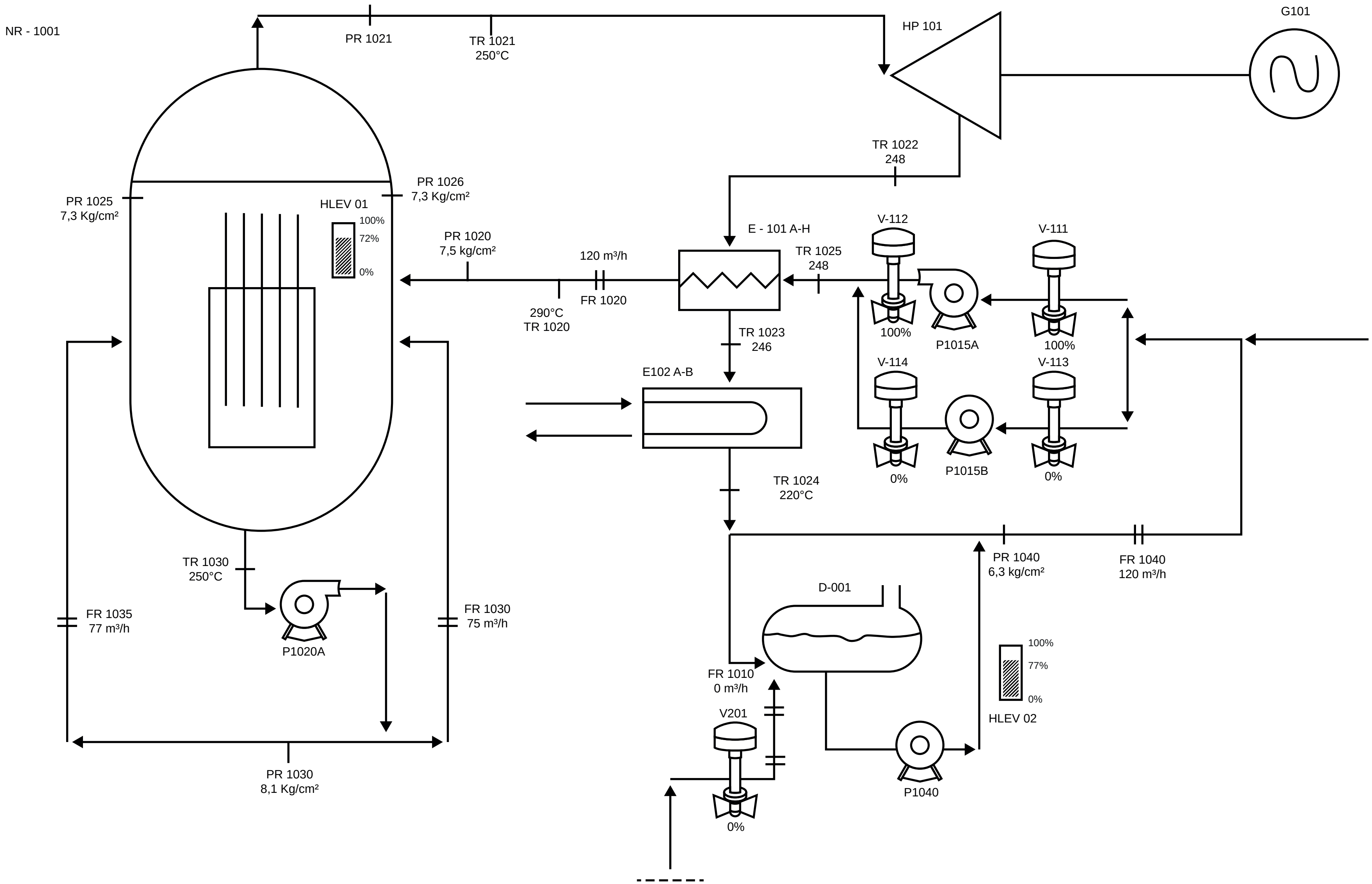
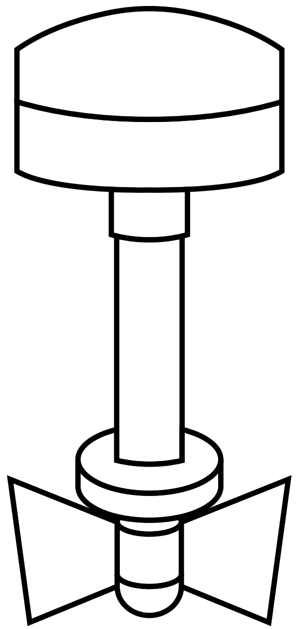
CENTRAL MAP


NR - 1001
PR 1021
TR 1021
250°C
HP 101
G101
TR 1022
248
PR 1025
7,3 Kg/cm²
PR 1026
7,3 Kg/cm²
HLEV 01
100%
72%
0%
PR 1020
7,5 kg/cm²
120 m³/h
FR 1020
290°C
TR 1020
E - 101 A-H
TR 1025
248
V-112
V-111
100%
P1015A
100%
V-114
V-113
TR 1023
246
E102 A-B
0%
P1015B
0%
TR 1024
220°C
PR 1040
6,3 kg/cm²
FR 1040
120 m³/h
TR 1030
250°C
FR 1035
77 m³/h
P1020A
FR 1030
75 m³/h
D-001
100%
77%
0%
HLEV 02
FR 1010
0 m³/h
V201
0%
P1040
PR 1030
8,1 Kg/cm²

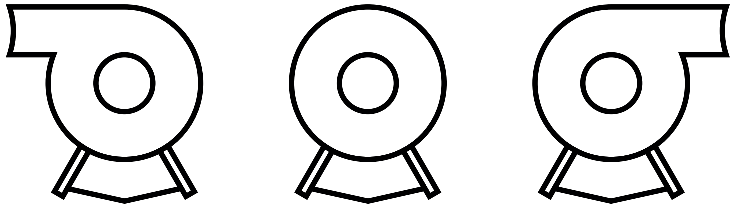
VALVE

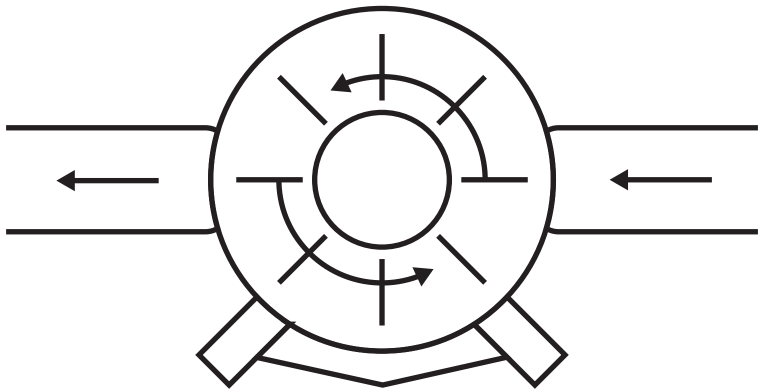


Code: V

The valve is an essential mechanical device that allows the regulation, initiation, interruption, or diversion of fluid flow within a system. In a nuclear power plant, valves play a crucial role in ensuring the safety, efficiency, and control of various circuits. They can be installed in primary circuits (which transport the coolant from the reactor to the steam generators), in secondary circuits (which carry steam to the turbines), in emergency cooling systems, and in auxiliary installations.
Valves can be operated manually or automatically through electric, pneumatic, or hydraulic actuators, controlled by sensors or operators in the control room. Some valves are designed to react autonomously to critical conditions, such as overpressure or sudden temperature changes, activating to protect the integrity of the plant.
There are various types: gate valves, suitable for full opening and closing; globe valves, used to precisely regulate flow; ball and butterfly valves, appreciated for their quick operation. Each type has specific characteristics depending on the fluid, operating pressure, and required function.
Valves must undergo regular maintenance and thorough inspections to ensure they open and close correctly. A valve failure can disrupt the system's balance and, in some cases, endanger the plant's safety. For this reason, their condition is constantly monitored and recorded in control systems.

PUMP

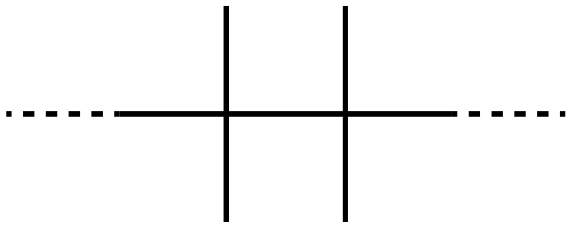




Code: P

The pump is a mechanical device designed to move a fluid from one point of the system to another, increasing its pressure to make it circulate within the circuits. In a nuclear power plant, pumps play a central role: they ensure the constant flow of water or other fluids in the cooling systems, the primary and secondary circuits, and the auxiliary systems.
In the primary circuit, for example, the coolant pumps are responsible for continuously transporting high-pressure water from the reactor to the steam generators. This flow allows the heat produced by the core to be absorbed and transferred to the secondary circuit, without direct contact between the radioactive water and the steam that drives the turbine.
Pumps must operate continuously and reliably, even under extreme temperature and pressure conditions. They are usually powered by powerful electric motors and are designed with redundancies: each critical pump has one or more backup units ready to take over in case of failure. Emergency pumps also exist in safety systems, activated automatically in the event of an accident or power outage, and can be powered by independent generators.
There are different types of pumps, including centrifugal pumps, which use centrifugal force to push the fluid outward and make it flow through the pipes, and positive displacement pumps, which are more precise and used when exact amounts of liquid need to be moved.
Pumps are constantly monitored. Dedicated sensors measure parameters such as pressure, temperature, vibrations, and flow rate to detect early signs of wear or malfunction.
Preventive maintenance is essential: a pump out of service can compromise the entire cooling system and pose a risk to the plant's safety.

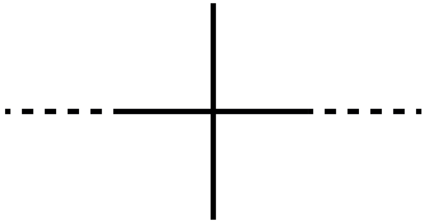
FLOW METER



Code: FR

The flow meter is a device used to determine the amount of fluid passing through a section of piping within a given time interval. In a nuclear power plant, flow rate is a key parameter for system control and safety, as it verifies whether fluids—such as the water in the primary circuit, steam in the secondary circuit, or cooling liquids—are circulating at the expected speed and volume.
Proper flow ensures that the heat generated by the reactor core is efficiently transferred and dissipated. A flow rate that is too low may indicate a problem, such as a blockage, pump malfunction, or a leak. Conversely, an excessive flow rate can cause abnormal pressure and mechanical stress on structures. Continuous flow monitoring is therefore essential to keep the plant in safe and stable operating conditions.
Various types of flow meters are used in nuclear power plants, each suited to specific operating conditions. The most common include differential pressure meters (such as orifice plates, Venturi tubes, or diaphragm flow meters), which calculate flow based on the pressure difference created as the fluid passes through a constriction. Other models use ultrasonic or electromagnetic technologies, offering accurate readings without moving parts—ideal for high-temperature environments or radioactive fluids.
The flow meter is connected to the plant’s control systems and transmits real-time data to the control room. Flow rate variations are recorded, analyzed, and, if necessary, trigger alarms or automatic responses to correct anomalies. In some cases, redundant systems are installed—multiple meters on the same pipe section—to allow cross-checking of readings and increase overall reliability.
Regular maintenance and calibration of flow meters is essential to ensure long-term measurement accuracy. An incorrect reading can compromise the system’s thermal balance and, in the worst cases, lead to dangerous operating conditions. For this reason, technical personnel constantly check the performance of these instruments and intervene promptly in the event of drift or failure.

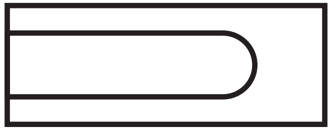
PRESSURE GAUGE

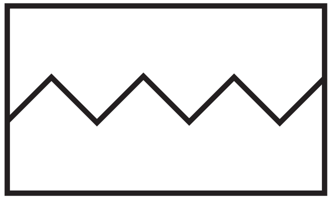


Code: PR

The pressure gauge is an essential instrument for monitoring fluids within the various systems of a nuclear power plant. Pressure is a critical parameter, as it directly affects the safety, efficiency, and mechanical integrity of the facility. Monitoring pressure in the primary and secondary circuits, tanks, steam generators, and auxiliary systems allows for early detection of anomalies, prevention of structural damage, and operation within design limits.
Pressure gauges detect the force exerted by the fluid on the internal surfaces of the system. These devices are installed at strategic points and transmit continuous readings to the control systems, where the data is compared with expected values. In the case of significant deviations, the system may trigger alarms, adjust valve positions, or initiate emergency procedures.
Common technologies include pressure transducers, which convert pressure into a proportional electrical signal. Other instruments use deformable mechanical elements—such as Bourdon tubes, diaphragms, or elastic capsules—to measure pressure directly. In modern systems, digital sensors offer high precision and are designed to withstand extreme conditions of temperature, radiation, and vibration.
The pressure gauge is particularly critical in the primary circuit, where water is kept under very high pressure to prevent boiling, even at temperatures above 300°C. A pressure drop in this circuit may indicate a coolant leak, a rupture, or a pump failure. In the secondary circuit, steam pressure must be controlled to ensure optimal turbine efficiency and to avoid overpressure in the generators.
Regular calibration of pressure gauges is mandatory. Even minor inaccuracies can compromise the system's ability to respond correctly to critical situations. For this reason, sensors are tested and replaced periodically according to strict protocols. Additionally, in the most sensitive areas of the plant, redundant systems are often installed to allow cross-verification of readings.
In a complex environment like a nuclear power plant, the pressure gauge is not just a measurement tool but an active control barrier, essential for the safe and stable operation of the entire facility.

HEAT EXCHANGER

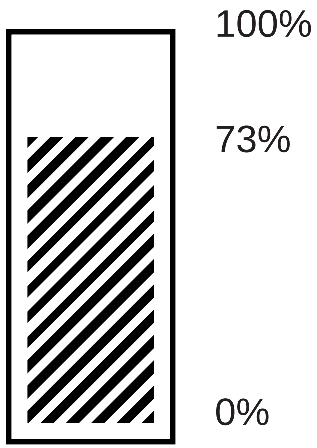




Code: E

The heat exchanger is a fundamental component in the thermo-hydraulic systems of a nuclear power plant. Its main function is to transfer thermal energy from a hot fluid to a colder fluid without allowing the two to come into direct contact.
In most pressurized water reactors (PWRs), the main heat exchanger is the steam generator, which transfers heat from the primary circuit (radioactive water) to the secondary circuit (non-radioactive water), producing steam that powers the turbine.
The operating principle is based on thermal conduction through metallic surfaces: the heat exchanger's tubes separate the two fluids and allow for controlled and efficient heat transfer. High-temperature water from the reactor flows inside the tubes, while water from the secondary circuit flows outside, absorbing heat and turning into steam. This process keeps radioactivity confined within the primary circuit, ensuring the secondary circuit remains clean and safe.
The structure of a heat exchanger is designed to withstand very high pressures and temperatures, as well as the corrosive effects of chemically treated water. The materials used must have high thermal conductivity and excellent mechanical properties. The tubes are often made of nickel alloy or stainless steel to ensure durability and long-term reliability.
Proper functioning of the heat exchanger is essential for the overall efficiency of the plant. If its heat transfer capacity decreases—due to fouling, tube damage, or leaks—steam production is reduced, and the reactor cooling system may be compromised. For this reason, the exchanger is equipped with monitoring instruments and is subjected to regular inspections, including visual checks, leak tests, and thermal performance analyses.
Damage to internal walls could cause direct contact between the two fluids, posing a risk of radioactive contamination in the secondary circuit. In such cases, isolation and drainage procedures are activated, followed by specialized technical interventions. The presence of redundant systems and shut-off valves allows for rapid containment of any operational or environmental consequences.
The heat exchanger is therefore a critical point in the plant's thermal cycle. Its efficiency and structural integrity are key factors for both the plant's energy performance and its overall safety.

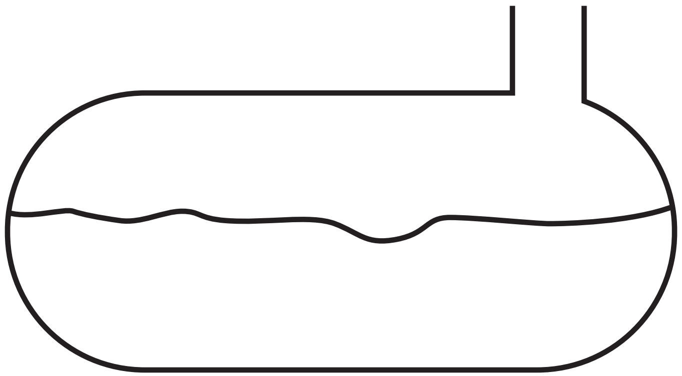
LEVEL GAUGE



Code: HLEV

The level gauge is an essential device for monitoring the volume of fluid contained in tanks, reservoirs, and steam generators within a nuclear power plant. Specifically, the water level in cooling systems and steam generators must be consistently maintained within precise operational limits to ensure the plant’s safety and efficiency. An abnormal variation may indicate a leak, pump malfunction, a blockage in the lines, or an error in the control systems.
In the steam generator, for example, the water level must be high enough to absorb heat from the primary circuit, yet not so high as to impair steam formation or turbine operation. A level that is too low could cause overheating and damage the piping, while a level that is too high risks sending liquid water into the turbine, compromising its integrity.
Level gauges can operate using various technologies. Common systems include differential pressure transducers, which measure changes in the hydrostatic pressure of the fluid. Other devices rely on optical, capacitive, ultrasonic, or radar principles, enabling non-contact measurement—ideal for high-temperature or radioactive environments. In some cases, visual float indicators are also used, but only in secondary circuits or service tanks.
The sensors are connected to the supervisory and control systems and transmit real-time readings. In case of abnormal variations, the system can trigger alarms, adjust pump speed, or regulate valve openings to restore the correct level. Threshold values are established during design and tested during drills and scheduled maintenance.
A critical aspect is redundancy: in critical locations like steam generators or borated water storage tanks, multiple independent sensors are installed to ensure continuous operation even if one device fails. Consistency among received signals is constantly verified, and in case of discrepancies, an automatic diagnosis is initiated.
The level gauge is not just a reading instrument—it is an integral part of the plant’s control logic. It provides essential data that directly influences automatic and manual regulation decisions. Its proper function is ensured through regular maintenance, precise calibration, and functional tests as required by nuclear safety protocols.

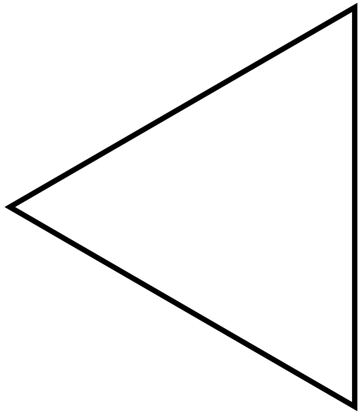
ACCUMULATOR



Code: D

The accumulator is a large-capacity container used for the safe and controlled storage of liquids within a nuclear power plant. Specifically, the tanks may hold cooling water, borated water solutions, service fluids, or, in some cases, condensates from the secondary circuit. Their primary function is to ensure the constant availability of fluids necessary for the operation and safety of the plant, even under extraordinary or emergency conditions.
There are different types of accumulators in a nuclear facility: some are atmospheric and not pressurized, while others operate under pressure to preserve the physical and chemical properties of the fluid. The borated water storage tank, for example, is a critical element of the reactor's emergency shutdown system. In case of an anomaly or the need for rapid shutdown, borated water is injected into the primary circuit to absorb neutrons and stop the nuclear chain reaction.
The structure of the accumulator is made of materials highly resistant to corrosion, such as stainless steel or special alloys, to ensure sealing and long-term durability. The walls are often thermally insulated or shielded, depending on the type of fluid contained and the operating context. The tank bottom is sloped or equipped with drainage conduits to allow complete emptying during maintenance or draining phases.
Each accumulator is equipped with level, temperature, and pressure sensors connected to the supervision system. This allows real-time monitoring of fluid conditions and automatic activation of associated pumps or valves. The presence of safety valves and vents helps manage possible overpressure or thermal anomalies. Additionally, some tanks are connected to recirculation circuits for continuous water treatment, including demineralization, filtration, or chemical additive dosing.
From a safety standpoint, accumulators are considered controlled-risk components. For this reason, they are subject to periodic inspections, structural integrity tests, and non-destructive testing such as ultrasound or radiography. Any leaks or malfunctions must be reported immediately, and intervention must follow specific protocols established in the plant’s emergency plan.
Finally, accumulators also play an important role during reactor start-up and shutdown phases, when large amounts of fluid must be handled gradually and safely. Their correct use contributes to maintaining thermal balance, keeping reactivity under control, and protecting the surrounding environment from potential contamination.

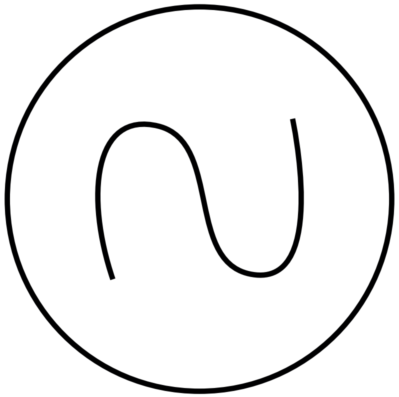
TURBINE



Code: HP

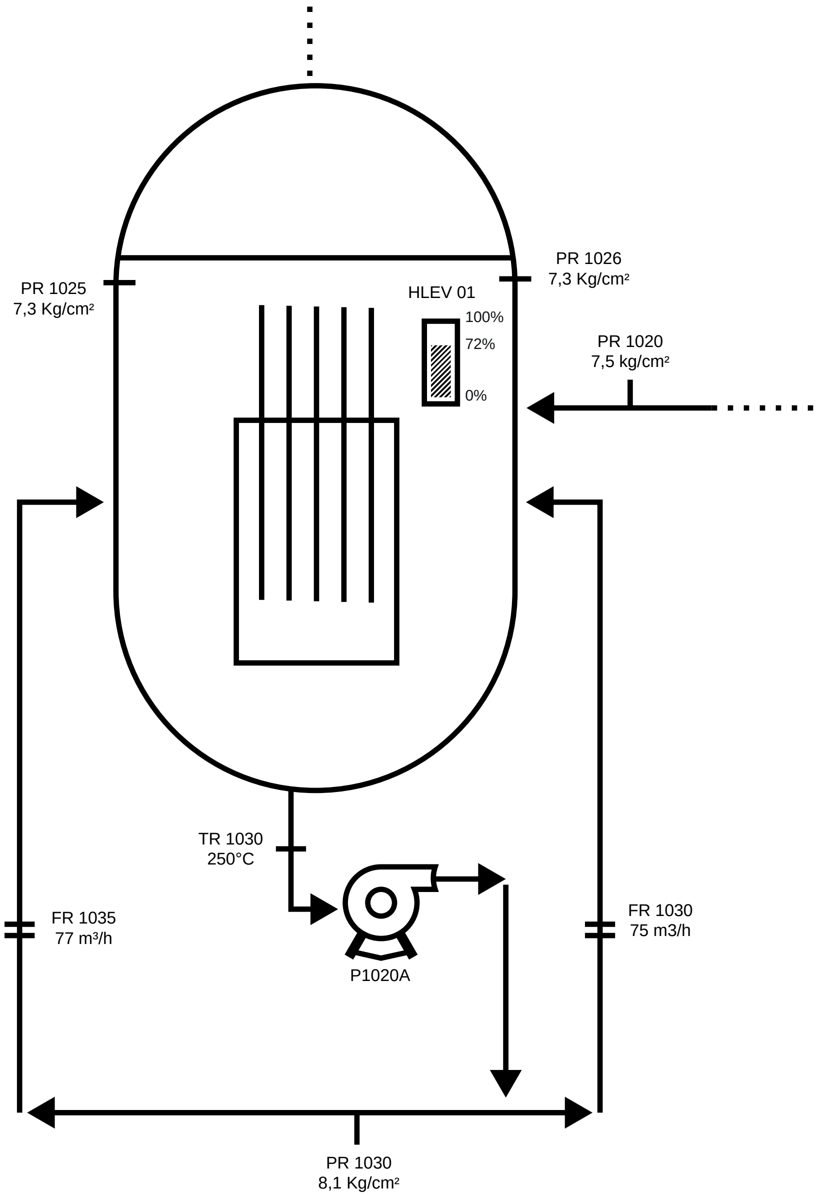
The turbine is one of the fundamental components of the system that converts thermal energy into mechanical energy within a nuclear power plant. Its main function is to transform the energy of high-pressure, high-temperature steam—produced in the steam generator—into rotational energy, which is then used to drive the electric generator. The turbine is located in the secondary circuit of the plant, meaning it never comes into direct contact with the radioactive fluids of the primary circuit, thereby ensuring greater operational safety and easier maintenance.
Generally, turbines used in nuclear applications are steam turbines composed of several stages: high-pressure, intermediate-pressure, and low-pressure sections. The steam first enters the high-pressure section, where part of its energy is converted into mechanical energy. It then passes through the other sections, gradually losing pressure and temperature until it reaches the condenser. This multi-stage setup maximizes the energy extracted from the steam and improves the overall efficiency of the machine.
Turbines consist of a rotor that spins at high speed inside a fixed housing (the stator), and rows of blades arranged in sequence to guide and accelerate the steam flow. Each stage of the turbine is designed to optimally exploit the pressure difference between inlet and outlet. The turbine is controlled by regulating valves that modulate the amount of steam admitted, allowing the power output to be adjusted to the plant's operating conditions.
Nuclear turbines are built to extremely tight tolerances, both in terms of mechanical balance and the materials' resistance to thermal and mechanical stresses. The internal components operate at high temperatures and must withstand repeated thermal cycles, constant vibrations, and significant centrifugal forces. For this reason, they are made of special metal alloys and are subject to frequent inspections and scheduled maintenance.
Turbine operation is continuously monitored using sensors for vibration, temperature, pressure, and speed, all connected to the plant's control systems. Any abnormal variation in operational parameters can indicate a mechanical issue or a change in the steam flow, requiring immediate intervention or a controlled shutdown of the machine.
Finally, the turbine is firmly coupled with the alternator, forming the drive shaft of the power generation system. The entire turbine-generator assembly is housed in a dedicated hall, equipped with soundproofing systems, fire protection, and safety devices to protect both personnel and the facility.

GENERATOR/ ALTERNATOR



Code: G

The generator, also known as the alternator, is the component responsible for converting mechanical energy into electrical energy within the nuclear power plant. It is mechanically coupled to the turbine shaft and operates based on the principle of electromagnetic induction: when a conductor moves within a magnetic field, an electric current is generated. In a nuclear power plant, this process is carried out on a large scale and with very high efficiency.
The alternator consists mainly of two parts: the rotor and the stator. The rotor is the moving element that rotates with the turbine and is equipped with electromagnets or windings powered by direct current. As the rotor spins, it generates a rotating magnetic field. The stator, the stationary part of the generator, is composed of copper windings arranged to capture this rotating magnetic field, thereby inducing a high-voltage three-phase alternating current.
The generator is designed to operate at extremely high power levels, with output voltages that can exceed 20,000 volts and power ratings reaching thousands of megawatts. For this reason, ensuring the mechanical and thermal stability of the system is essential. The generator is equipped with cooling systems—often using hydrogen or forced air—to dissipate the heat generated during continuous operation. In some cases, liquid cooling is also used for the stator.
The generated voltage is sent to a power transformer, which steps it up for transmission through the national power grid. Before this stage, the generator is continuously monitored by sensors that detect critical parameters such as winding temperature, shaft vibrations, cooling gas pressure, and electrical insulation.
In terms of safety and reliability, the generator is protected by automatic shutdown systems that are triggered in the event of overload, short circuit, or mechanical failure. In critical situations, it can be decoupled from the turbine by a safety coupling or stopped in an emergency with a dedicated braking system.
The turbine-generator assembly is subject to scheduled maintenance, which includes non-destructive testing of the windings, insulation testing, and verification of dynamic balancing. Due to its strategic importance to the operation of the plant, the alternator is one of the most monitored and protected components of the entire facility.



REACTOR

Code: α (alpha)

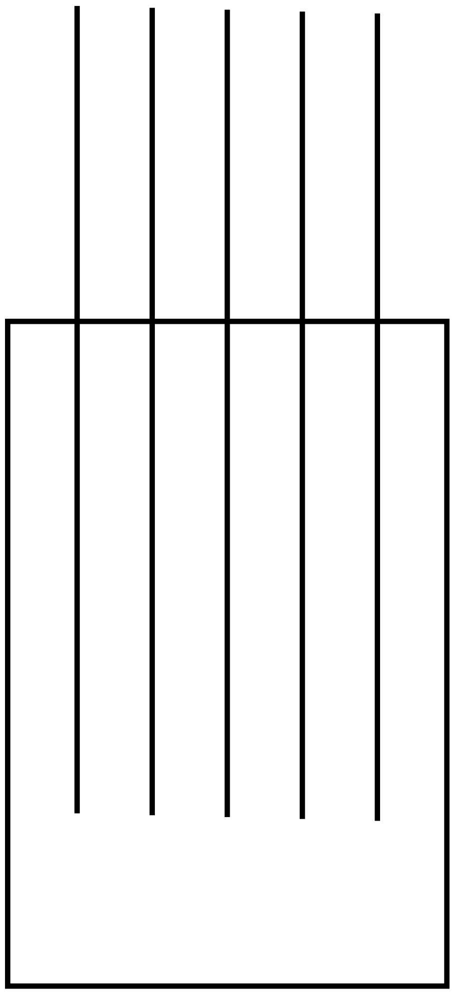
Valves

Sensors:
FR1030, FR1035, FR1040, PR1030, PR1025, PR1026, HLEV01, PR1020, TR1020, TR1030, FR1030

Pumps:
P1020A

Reactor:
NR1001

The reactor is the heart of the nuclear power plant. This is where thermal energy is produced through the controlled fission of nuclear fuel. The reactor receives steam from the recovery system, which is used to feed its internal circuit. Here, the heat generated by the nuclear process further increases the temperature of the fluid, which is then converted into high-energy steam. This superheated steam is channeled and directed toward the turbine, where it will be converted into mechanical energy. The reactor's internal circuit is designed to ensure maximum isolation, reactivity control, and process safety.



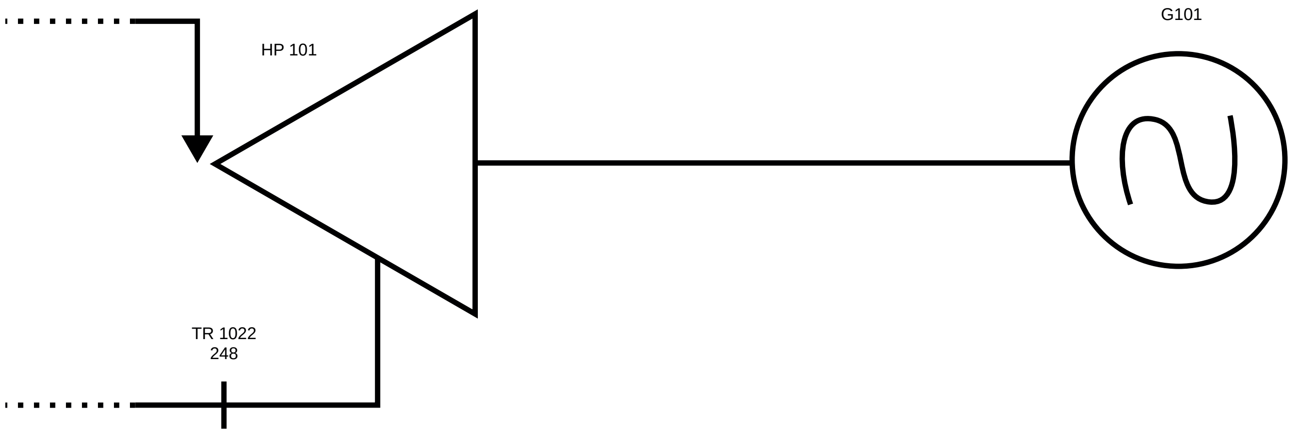
CONTROL RODS

Code: ω (omega)

Valves:
V1001

Control rods are essential devices for managing the nuclear reaction inside the reactor. They are made of materials capable of absorbing free neutrons, such as boron, silver, cadmium, or special alloys. By inserting them into the core, the rods reduce the number of neutrons available for fission, thereby slowing down or stopping the chain reaction. Raising them allows more neutrons to pass through, increasing reactivity. Their vertical movement is controlled with extreme precision by automatic or manual systems and is crucial at every stage: startup, operation, load changes, and emergency shutdown. In abnormal conditions, full and rapid insertion of the rods enables the immediate shutdown of the reactor (SCRAM), ensuring the safety of the plant.

POWER GENERATION



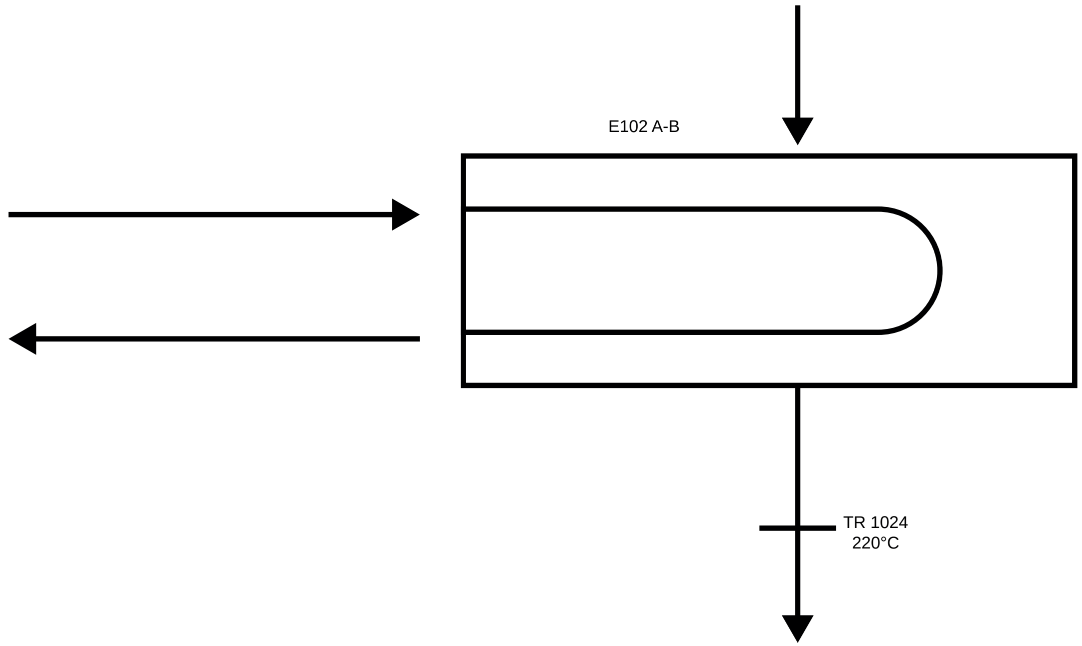
Code: β (beta)

Valves:

Sensors:
R1021, TR1022
Turbine:
HP101
Generator:
G101

The power generation area is where thermal energy is converted into electrical energy. High-temperature steam, around 250°C, coming from the reactor enters the turbine and causes its blades to rotate, converting the steam's energy into mechanical energy. The turbine is firmly coupled to an alternator, which generates electricity through the principle of electromagnetic induction. After passing through the turbine, the steam, still very hot (around 248°C), is directed to the circulation water pumping circuit, where a new cycle of energy transfer and recovery begins. The system's efficiency depends on the proper balance between steam pressure, temperature, and flow rate.

HEAT RECOVERY



Code: γ (gamma)

Valves:

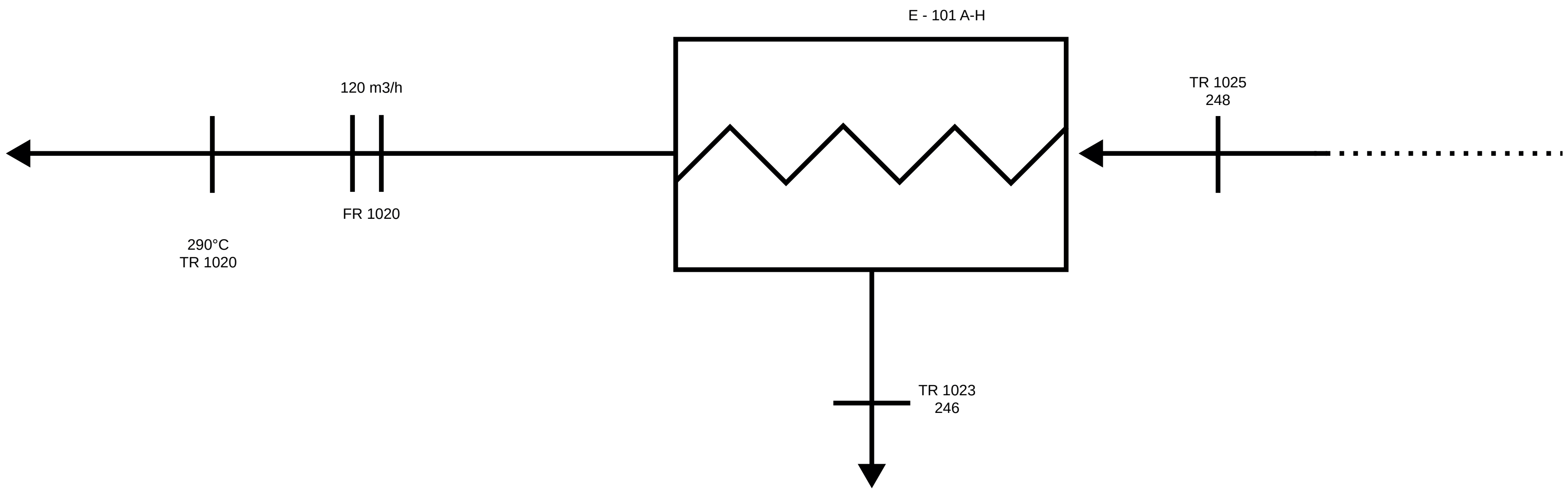
Sensors:
TR1025 , TR1023,FR1020, TR1020

Pumps:

Systems:
E101

The heat recovery system is responsible for optimizing the use of residual thermal energy from the steam exiting the turbine. It receives the steam at around 248°C and separates it based on temperature. The hottest portion, which remains close to 248°C, is reintroduced directly into the reactor to feed its internal circuit, thus helping to maintain the core temperature and reduce the initial energy demand. Steam that drops below 246°C is instead diverted to the condensation system, where the cooling and water conversion process begins. This system enables efficient recovery of residual thermal energy and dynamic control of the reactor's operating conditions.

CONDENSATION



Code: ε **(epsilon)**

Valves:

V111, V112

Sensors:

TR1025, TR1023,FR1020, TR1020

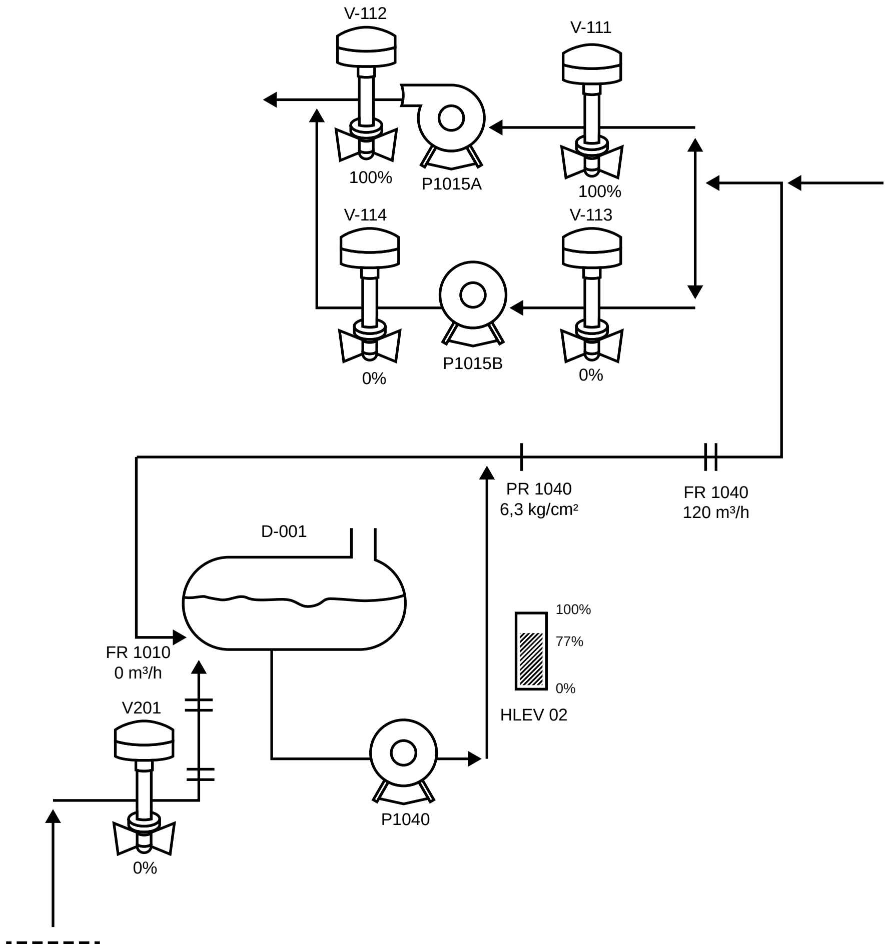
Pumps:

Systems:

E101

The condensation system functions to cool the residual steam coming from the heat recovery system, reducing its temperature until it completely transitions to the liquid state. Steam at a temperature below 246°C is directed into heat exchangers or surface condensers, where it transfers heat to a cooler fluid, often technical water or water from cooling towers. The steam condenses and returns to the liquid state, ready to be reintroduced into the circuit via the pumping system. The condensation process is essential for maintaining the closed cycle, saving energy, and reducing thermal losses. Temperature and pressure control at this stage is crucial for the stability of the entire plant.

CIRCULATION WATER PUMPING CIRCUIT



Code: ζ **(zeta)**

Valves:
V111, V112, v114,v115, XV107, V201
Sensors:
FR1030, FR1040, PR1030, HLEV02
Pumps:
P1040, P1015A, P1015B
Accumulator:
D001

The circulation water pumping circuit is responsible for ensuring the continuous movement of the heat transfer fluid within the plant. In a nuclear power plant, this circuit is essential for transferring the heat generated in the reactor to the recovery system, ensuring that the fluid continuously flows through the core, steam generators, and other heat exchangers. The pumps used must maintain a high flow rate under pressure, with continuous reliability even under variable temperature and load conditions. The system is redundant, monitored by sensors, and integrated with safety devices to ensure the thermohydraulic stability of the plant.

TEMPERATURE SENSORS

- **TR1020**

Measures the temperature of steam from the pumping circuit to the reactor circuit.

  - **Operating temperature: 230°C**
  - **235°C: The reactor is producing too much heat: investigate.**
  - **<220°C: Plant operating temperature too low: investigate.**

- **TR1030**

Measures the steam inlet temperature inside the core.

  - **Operating temperature: 250°C**
  - **255°C: Reactor producing too much heat: adjust control rods.**
  - **<245°C: Plant temperature too low: adjust control rods.**

- **TR1021**

Measures the temperature of steam exiting the reactor toward the turbine.

  - **Operating temperature: 250°C**
  - **255°C: Reactor producing too much heat: adjust control rods.**
  - **<245°C: Plant temperature too low: adjust control rods.**

- **TR1022**

Measures the steam temperature exiting the turbine.

  - **Operating temperature: 248°C**
  - **250°C: Reactor producing too much heat: investigate.**
  - **<245°C: Plant operating temperature too low: investigate.**

- **TR1023**

Measures the steam temperature exiting the heat recovery system.

  - **Operating temperature: 246°C**
  - **248°C: Reactor overheating or heat recovery system misdirecting steam: investigate.**
  - **<240°C: Plant operating temperature too low: investigate.**

- **TR1024**

Measures water temperature exiting the condensation system.

  - **Operating temperature: 220°C**
  - **248°C: Reactor overheating or heat recovery system misdirecting steam: investigate.**
  - **<240°C: Plant operating temperature too low: investigate.**

- **TR1025**

Measures steam temperature from the pumping circuit entering the heat recovery system.

  - **Operating temperature: 210°C**
  - **248°C: Reactor overheating or heat recovery system misdirecting steam: investigate.**
  - **<240°C: Plant operating temperature too low: inves tigate.**

PRESSURE SENSORS

- **PR1030**

Measures pressure in the internal reactor circuit. If abnormal readings occur, check PR1025 and PR1026. If they show no issues, sensor failure is likely. Field check required.
    - **Operating pressure: 8.1 kg/cm^2**
    - **9.5 kg/cm^2**
    - **<7.5 kg/cm^2**

- **PR1025**

Measures pressure on reactor core walls.
    - **Operating pressure: 7.3 kg/cm^2**
    - **9.0 kg/cm^2: Check PR1026. If same reading, reactor may be overheating or failing to release steam. Check valve V1021.**
    - **<6.5 kg/cm^2: Reactor too cold. Adjust control rods.**

- **PR1026**

Measures pressure on reactor core walls.
    - **Operating pressure: 7.3 kg/cm^2**
    - **9.0 kg/cm^2: Check PR1025. If same reading, reactor may be overheating or failing to release steam. Check valve V1021.**
    - **<6.5 kg/cm^2: Reactor too cold. Adjust control rods.**

- **PR1040**

Measures pressure at accumulator outlet.
    - **Operating pressure: 6.3 kg/cm^2**
    - **8.0 kg/cm^2: Also check FR1040.**
        - **If abnormal: reduce P1040 output.**
        - **If normal: field check.**
            - **If field sensor abnormal: reduce P1040 output.**
    - **<5.5 kg/cm^2: Accumulator water level may be low. Field check HLEV02.**
        - **If below 60%: open V201.**

FLOW SENSORS

- **FR1030**

Measures water flow in the reactor's internal circuit. If readings are abnormal, check PR1035. If PR1035 is normal, suspect sensor fault.
  - **Operating flow: 75 m³/h**
  - **80 m³/h: Check PR1035.**
    - **If also abnormal: reduce P1030.**
    - **If normal: field check.**
      - **If field meter abnormal: reduce P1030.**
  - **<5.5 m³/h: Risk of overheating. Increase P1020A output.**

- **FR1035**

Same as FR1030: monitors flow in the reactor’s internal circuit.
  - **Operating flow: 75 m³/h**
  - **80 m³/h: Check PR1030.**
    - **If also abnormal: reduce P1030.**
    - **If normal: field check.**
      - **If field meter abnormal: reduce P1030.**
  - **<5.5 m³/h: Risk of core overheating. Increase P1020A output.**

- **FR1020**

Measures water flow exiting the heat recovery system.
  - **Operating flow: 120 m³/h**
  - **135 m³/h: Check TR1030.**
    - **If abnormal: reduce P1015A.**
    - **If normal: field check.**
      - **If field meter abnormal: reduce P1015A.**
  - **<110 m³/h: Possible failure of P1015A. Check and activate backup system P1015B, V114, and V115 if needed.**

- **FR1010**

Measures new water flow to the accumulator system. Water injection is an emergency procedure for loss recovery. During normal operation, flow must be 0.0 m³/h.
  - **Operating flow: 0.0 m³/h**
  - **0.0 m³/h: Check if V201 is closed.**
    - **If open: close immediately!**
    - **If closed: ignore the anomaly.**

- **FR1040**

Measures flow in the circulation water pumping circuit.
  - **Operating flow: 120 m³/h**
  - **130 m³/h: Check PR1040.**
    - **If also abnormal: reduce P1040.**
    - **If normal: field check.**
      - **If field meter abnormal: reduce P1040.**
  - **<100 m³/h: Accumulator level may be low. Check HLEV02.**
    - **If below 60%: open V201.**

LEVEL SENSORS

- **HLEV01**

Measures water level inside the core.
  - **Operating level: 73%**
  - **75%: Excess fluid. Possible pressure increase in the core container. Investigate.**
  - **<65%: Deficient fluid. Possible system leak. Investigate.**

- **HLEV02**

Measures water level in the accumulator.
  - **Operating level: 71%**
  - **77%: Excess fluid. Increase P1040 power.**
  - **<60%: Deficient fluid. Decrease P1040 power.**

PUMPS

- **P1020A**

Main pump of the reactor internal circuit. Maintains constant water flow through the core.
  - **Operating status: 70%**

- **P1020B**

Auxiliary pump to P1020A. Maintains flow in the reactor circuit.
  - **Operating status: 0%**

- **P1015A**

Main pump of the circulation water pumping circuit.
  - **Inlet valve: V-111**
  - **Outlet valve: V-112**
  - **Operating status: 70%**

- **P1015B**

Auxiliary pump of the circulation water pumping circuit.
  - **Inlet valve: V-113**
  - **Outlet valve: V-114**
  - **Operating status: 70%**

- **P1040**

Circulation pump at the accumulator outlet.
  - **Operating status: 70%**

VALVES

- **V-111**

Inlet valve of the main circulation water pumping circuit. Open together with V-112 if P1015A is deactivated.
  - **Operating status: 100%**

- **V-112**

Outlet valve of the main circulation water pumping circuit. Open together with V-111 if P1015A is deactivated.
  - **Operating status: 100%**

- **V-113**

Inlet valve of the auxiliary circulation water pumping circuit. Open together with V-114 if P1015B is activated.
  - **Operating status: 0%**

- **V-114**

Outlet valve of the auxiliary circulation water pumping circuit. Open together with V-113 if P1015B is activated.
  - **Operating status: 0%**

- **V-201**

New water inlet valve. Open in case of a drop in accumulator level due to system leaks.
  - **Operating status: 0%**