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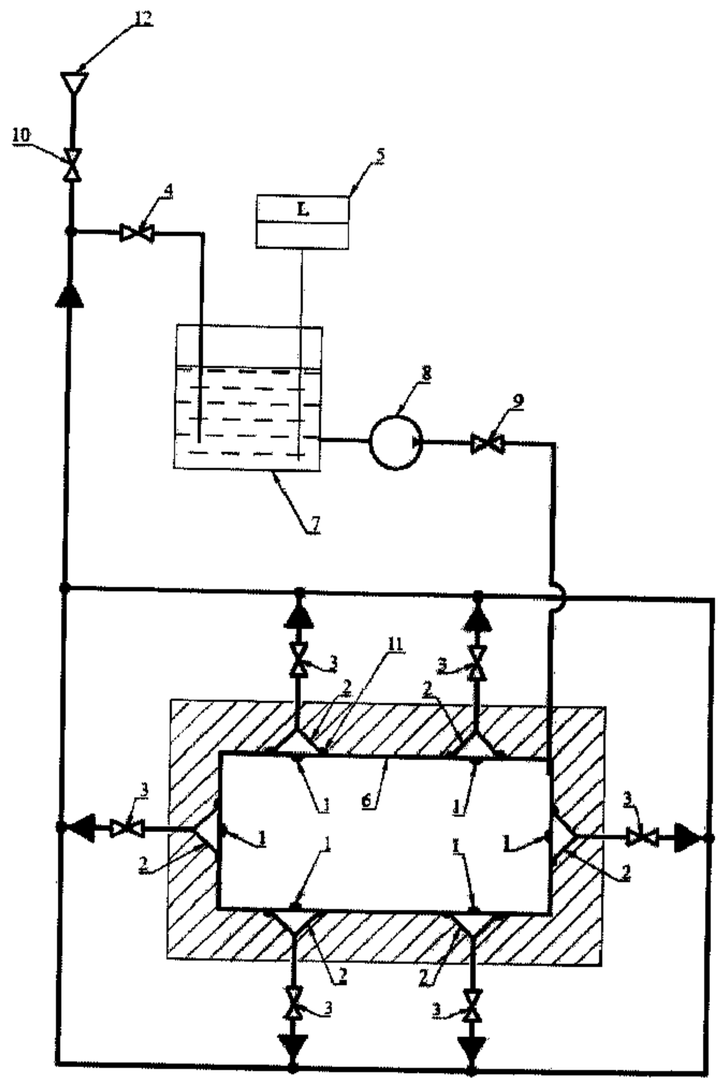
(54) Titre : SYSTEME POUR CONTROLER LES FUITES DE LIQUIDE D'UN BASSIN DE RETENTION DE COMBUSTIBLE USE

(54) Title: LEAKAGE CONTROL SYSTEM FOR SPENT FUEL COOLING POOL



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(57) Abrégé/Abstract:
A system for detecting leaks of liquid from a spent fuel pool relates to the field of measuring and testing equipment and is intended for monitoring leaks in tanks, primarily in the storage pools of nuclear power plants. In the system for detecting leaks of liquid from a

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(57) Abrégé(suite)/Abstract(continued):
spent fuel pool, the weld seams of the storage pool are additionally provided with a hermetic metallic barrier connected by valved tubes to a pipeline, the two ends of which are connected via a collection valve and a return valve respectively to a leak collection tank equipped with a liquid level sensor. The system for detecting leaks of liquid from a spent fuel pool makes it possible to monitor the leak tightness of the weld seams of a spent fuel pool and to identify weld seams that have lost their leak tightness without first drying the storage pool, thus raising the radiation safety of storage pools and reducing their repair time.

Abstract

A leakage detection system for spent fuel cooling pools is related to the field of testing and measurement instrumentation and is aimed at monitoring leakages in the storage facilities, mostly in spent fuel cooling pools at NPPs.

In the leakage detection system for spent fuel cooling pools the welded joints in the pool are additionally fenced with a metal guard which are connected via valve installed tubes to the pipeline, which, in turn, is connected on both of its sides to the leakage collector tank via a receiving valve and a return valve. The leakage collector tank is equipped with a level control sensor.

A leakage detection system for spent fuel cooling pools ensures control over airtightness of welded joins in the pool and allows for detection of leaking welded joints without preliminary emptying the pool which enhances the radiation safety of the pool and reduces the maintenance time.

Leakage control system for spent fuel cooling pool

Field of the invention

The invention is related to testing and measurement equipment and is aimed at monitoring leakages in spent fuel cooling pools at NPPs.

Background of the invention

As it is known, spent nuclear fuel storage at NPPs is done in water pools made of metal sheets tightly welded together. However the NPP operational experience shows that despite the fact that the pool steel lining is subject to airtightness tests during production, corrosion and high concentration of stresses in welded joints during operation often cause leakages of radioactive water through the welded joints. The leakages are collected in a drain pan located under the bottom of the pool with the pan flanges adjoining the walls. Moreover, radioactive leakages are adverse due to their environmental hazard and need to be eliminated, so monitoring leakages and detection of a welded joint section where the leakages occurred are necessary. Such detection of leakages is complicated because the metal lining of the pool is connected to the concrete wall surrounding it and acting as a load-bearing member to persist pressure of liquid contained in the pool. This concrete wall also acts as protection from radiation, which makes any visual inspection or contact sensing of welded joints' integrity impossible. Several technical solutions were offered to resolve the above task.

For example, one of the proposed leakage monitoring systems included upper and lower level gauges placed in the cooling pool. Another solution was removal of leakages through the pipe from the drain pan to a storage container with subsequent level sensing upon the return of the liquid to the pool. Those solutions make it possible to detect the fact that leakages occurred and approximately evaluate dynamics of leakage volume change within given unit time. The disadvantages of this solution were as below: it was impossible to detect which exactly welded joint was leaking without preliminary radioactivity removal; radioactive leakages could penetrate the concrete side walls of the cooling pool; a drain pan under the pool bottom was necessary, however, radioactive safety was still not sufficient due to the fact that it was impossible to control the tightness of the drain pan.

Some attempts were taken to improve the accuracy of evaluation of leakage volume changes due to enhanced accuracy of calculation of evaporation and condensation volume within the system. For example, there is information about a leakage detection system applicable for detection of leakages inside NPP

premises by means of controlling aerosol activity (utility model patent RF No 100817, IPC F24K 3/14, published on 27.12.2010). This patented system includes an appliance which provides for the separation of air inside the monitored room into condensate and aerial environment. The appliance is connected via an aerial pipe to the measuring unit which measures volumetric aerosol activity, and via a condensate drain pipe - to the measuring module which measures volumetric activity of gamma radioactive nuclides contained in the liquid. At this point the module for measuring volumetric aerosol activity is connected to a negative pressure conduit, and the module for measuring volumetric activity of gamma radioactive nuclides is connected to a condensate discharge pipe which delivers the condensate directly to a special wastewater disposal system. The distinguishing feature of this system is that for separation of air inside the monitored room in condensate and aerial environment it uses the air dehumidifier which consists of one air cooling chamber and at least one air heating chamber located inside the air cooling chamber. On the inner surface of the air cooling chamber there are radiators with their heat removal elements looking inside the air cooling chamber. Peltier elements are installed between the air cooling chamber and the air heating chamber, at that. There is a temperature sensor to measure the temperature of dried air inside the air heating chamber, and under the air cooling chamber there is a container for collection of condensate with a condensate level gauge installed inside. There is a flow meter integrated in the system.

This system for monitoring coolant leakages is quite complicated and oversized, for it requires additional piping connections for regular flushing and drying of measuring vessels of demineralized water circuits and compressed air circuits, so with this scope of equipment this system cannot be used for detection of leakages in NPP cooling pools. Besides, such a system cannot help in detection which exactly welded joint is leaking.

There is also information about a system of coolant leakage detection inside NPP rooms (utility model patent RF No 111709, IPC G21C 17/02, published on 20.12.2011). This system includes an ambient air sampling line and cooler, a moisture separator with a condensate drain pipe, gas flow heater, flow meter and flow booster sequentially installed therein. A two-way flow regulator is installed in the sampling line upstream the cooler. One of the outlets of this regulator is connected to the gas inlet of the cooler, and to the humidity and temperature measuring unit which installed in the sampling line downstream the heater, and the bypass line. One of the bypass outlets is connected to the second outlet of the two-way flow regulator and the other outlet - to the sampling line downstream the heater. The system includes a module for measuring aerosol volumetric activity integrated in the sampling line downstream the flow meter, and the

module for measuring the quality of condensate which is located downstream the flow meter. The system also has two temperature sensors and one pressure sensor.

However, the system, like the one previously described in a similar patent, is too much complicated and oversized because of a vacuum pump and a compressor-based refrigerator unit integrated in the system. Besides, such a system cannot help in detection which exactly welded joint is leaking.

The closest equivalent of the proposed invention is a detection system for monitoring leakages in the cooling pool at NPPs (RF patent for invention No 2589726, IPC G21C17/022, G01M3/00, published on 10.07.2016), where the leakage monitoring system for cooling pools is represented as a combination of the following sensors: a flow gauge for the water supplied through the cleaning system pipeline, a level control sensor installed on the standard installation points of fuel elements, two temperature and humidity sensors located one in the outlet and the other one in the inlet of ventilation system at the reactor room; a high level alarm for radioactive water leakages; all outputs of the above sensors are electrically connected via an input device to the controller; the controller output is connected to the input of high level alarm for radioactive water leakages and to the computer; the controller has an input device designed to add data about the number of service personnel and fuel elements; the system is equipped for uninterruptible power supply unit for continuous power supply.

This solution makes the detection system for monitoring leakages in the cooling pools not so much oversized due to the use of automation facilities. The disadvantages of this solution were as below: it was impossible to detect which exactly welded joint was leaking without preliminary radioactivity removal; radioactive leakages could penetrate the concrete side walls of the cooling pool; a drain pan under the pool bottom was necessary, however, radioactivity safety was still not sufficient due to the fact that it was impossible to control the airtightness of the drain pan. At this point, as it is clear from all the above solutions described in the background of the invention, the lack of information about exact location of leakage points in the cooling pool results in longer maintenance intervals required for the repair of the cooling pool after emptying and water removal, as those leakage points require additional measures for detection.

Summary

The objective of this invention is to develop a leakage control system for monitoring leakages in the cooling pool. This system is expected to enhance safety of spent fuel storage in the pool because as it makes it possible to detect leaking welded joints with no need to remove radioactivity and avoid penetration of radioactive water to the side walls of the cooling pool. It will also provide for a shorter maintenance time due to the possibility of preliminary detection of leaking welded joints.

The technical result of this invention is the enhanced safety of spent fuel storage in the pool due to the possibility to detect leaking welded joints with no need to remove radioactivity and avoid penetration of radioactive water to the side walls of the cooling pool. It will also provide for a shorter maintenance time due to the possibility of preliminary detection of leaking welded joints during operation.

The technical result is implemented with the help of a leakage detection system for monitoring leakages in the spent fuel pool which includes the following components: a pipeline, a liquid level gauge connected to a control module; welded joints in the spent fuel cooling pool are additionally fenced with a metal guard connected to the pipeline by means of two tubes with valves. The pipeline is connected on both sides to the leakage collector which is equipped with a liquid level gauge; a control module is connected to all the valves and designed to provide a possibility to control the valves.

It is recommended to integrate a compressed air supply unit with a compressed air supply valve into the leakage control system. The compressed air supply unit is connected to the pipeline by means of the compressed air supply valve. The compressed air supply unit is designed to supply compressed air via the compressed air supply valve. The pipeline and the compressed air supply valve are integrated in the metal fence around the welded joints as an additional means of leakage detection.

It is recommended to integrate a coloured water supply unit with a coloured water supply valve into the leakage control system. The coloured water supply unit is connected to the pipeline by means of the coloured water supply valve. The coloured water supply unit is designed to supply coloured water via the coloured water supply valve. The pipeline and the coloured water supply valve are integrated in the metal fence around the welded joints as an additional means of leakage detection.

It is recommended to install a receiving valve in the outlet of the leakage collector tank, and a return valve - at its outlet.

It is recommended to install a pump between the leakage collector tank and a return valve.

It is feasible to use a pressure sensor as a liquid level gauge.

It is recommended to use a conductivity transmitter as a liquid level gauge.

It is recommended to have a control module connected to all the valves integrated in the system and to the pump with the use of wired or wireless connections.

It is feasible to add a pressure sensor for the compressed air to the compressed air supply unit.

Brief description of figures

The core idea of the proposed invention is represented in Figure where the embodiment of the leakage control system is shown: it includes the metal lining of the cooling pool (6) with the welded joints (1) and surrounded with a concrete wall (shaded area), each welded joint (1) is fenced with a metal guard (2) which are secured against the cooling pool (6) with external welded joints (11) and connected with the valve installed tubes (3) to the pipeline designed with the possibility of discharging potential leakages via a receiving valve (4) to the leakage collector tank (7) which is equipped with a level gauge (5). The leakage water can go back from the leakage collector tank (7) to the cooling pool (6) with the help of the pump (8) via the return valve (9). The system also includes a compressed air supply valve (10) designed to supply either compressed air or coloured water to the system, and equipped also with a compressed air pressure sensor (12). All valves and the pump are connected to the control module (not shown on the Figure) via wired and wireless connections, and the control module is designed to control all the valves and the pump.

Embodiments

The functioning of the leakage control system for spent fuel cooling pool can be described as follows: In the period when the spent nuclear fuel is stored in the pool (6) the operator uses the control module for regular opening of the valves (3), when one of the valves is open, the rest of the valves are closed, at this point the operator should check the indications of the level control sensor (5) with the return valve (9) closed and with the pump (8) OFF. In case the indications displayed by the level gauge (5) remain without changes, the operator understands that the welded joint (1) which corresponds to the opened valve (3) is free of leakages. In case the level gauge (5) indicates that the level in the leakage collector tank (7) has increased, the operator understands that the welded joint (1) which corresponds to the opened valve (3) is leaking. After that the operator applies the same procedure to check the rest of the welded joints. When the inspection is completed or the leakage collector tank (7) is full, the operator gets the liquid from the leakage collector tank (7) back to the pool by opening the return valve (9) and using the pump (8). Then the operator closes the valves (3) which correspond to those welded joints (1) for which the leakage was detected during the inspection, in order to prevent any radioactive water to penetrate the side walls of the cooling pool. It should be noted that radioactive water which leaked out of the pool (6) through the faulty welded joint (1) is prevented from penetrating the side walls by metal guards (2), this makes it possible to continue using the pool up to the scheduled maintenance, the duration of the maintenance will also be reduced because the location of leakages on the welded joints (1) has already been detected.

In its preferable embodiment the leakage control system for the spent fuel cooling pool is additionally equipped with a compressed air supply valve (10) designed to supply compressed air, for example, from a compressed air cylinder. In this embodiment the operator supplies the compressed air to the system by opening the compressed air supply valve (10) and all or part of the valves (3), with the receiving valve (4) and the return valve (9) shut off. At this point the compressed air goes through the pipelines and through the open valves (3), gets to the cooling pool (6) through the leaking welded joints (1) and can be identified by slight bubbles which clearly show how airtight each welded joint is, and where exactly the joint is leaking. Use of telemetric facilities makes it possible to detect the leakages without emptying the pool (6). Instead of compressed air in one of the embodiments the coloured water is used, as it provides for the same result.

Moreover, if an additional pressure sensor (12) for the compressed air is integrated in the compressed air supply unit (10) it will be possible to check the airtightness of external welded joints (11) which secure the metal guards (2)

against the cooling pool (6). To do this, the operator should initiate the compressed air supply to the pipeline, for example, with one of the valves (3) open and the rest of the valves (3), receiving valve (4) and return valve (9) closed. If no bubbles appear near the internal surface of the corresponding welded joint (1), the operator should check the indications of the compressed air pressure sensor (12). In case the pressure has dropped, the operator understands that this welded joint securing the metal guard (11) is leaking.

Industrial applicability

The system for detection of leakages in the spent fuel cooling pools ensures improved radioactive safety and reliable storage of spent nuclear fuel in the cooling pools, as well as allows reducing the duration of maintenance for the cooling pools, so it can be widely used in nuclear power generation.

Claim

1. The leakage detection system for monitoring leakages in the spent fuel pool which includes the following components: a pipeline, a liquid level gauge connected to a control module; welded joints in the spent fuel cooling pool are additionally fenced with a metal guard connected to the pipeline by means of two tubes with valves. The pipeline is connected on both sides to the leakage collector which is equipped with a liquid level gauge; a control module is connected to all the valves and designed to provide a possibility to control the valves.

2. The leakage control system for spent fuel cooling pool as per para 1 characterised by an additional compressed air supply unit with a compressed air supply valve. The compressed air supply unit is connected to the pipeline by means of the compressed air supply valve. The compressed air supply unit is designed to supply compressed air via the compressed air supply valve. The pipeline and the compressed air supply valve are integrated in the metal fence around the welded joints as an additional means of leakage detection.

3. The leakage control system for spent fuel cooling pool as per para 1 characterised by an additional coloured water supply unit with a coloured water supply valve. The coloured water supply unit is connected to the pipeline by means of the coloured water supply valve. The coloured water supply unit is designed to supply coloured water via the coloured water supply valve. The pipeline and the coloured water supply valve are integrated in the metal fence around the welded joints as an additional means of leakage detection.

4. The leakage control system for spent fuel cooling pool as per para 1 characterised by a receiving valve installed in the outlet of the leakage collector tank, and a return valve - at its outlet.

5. The leakage control system for spent fuel cooling pool as per para 1 characterised by an additional pump installed between the leakage collector tank and a return valve.

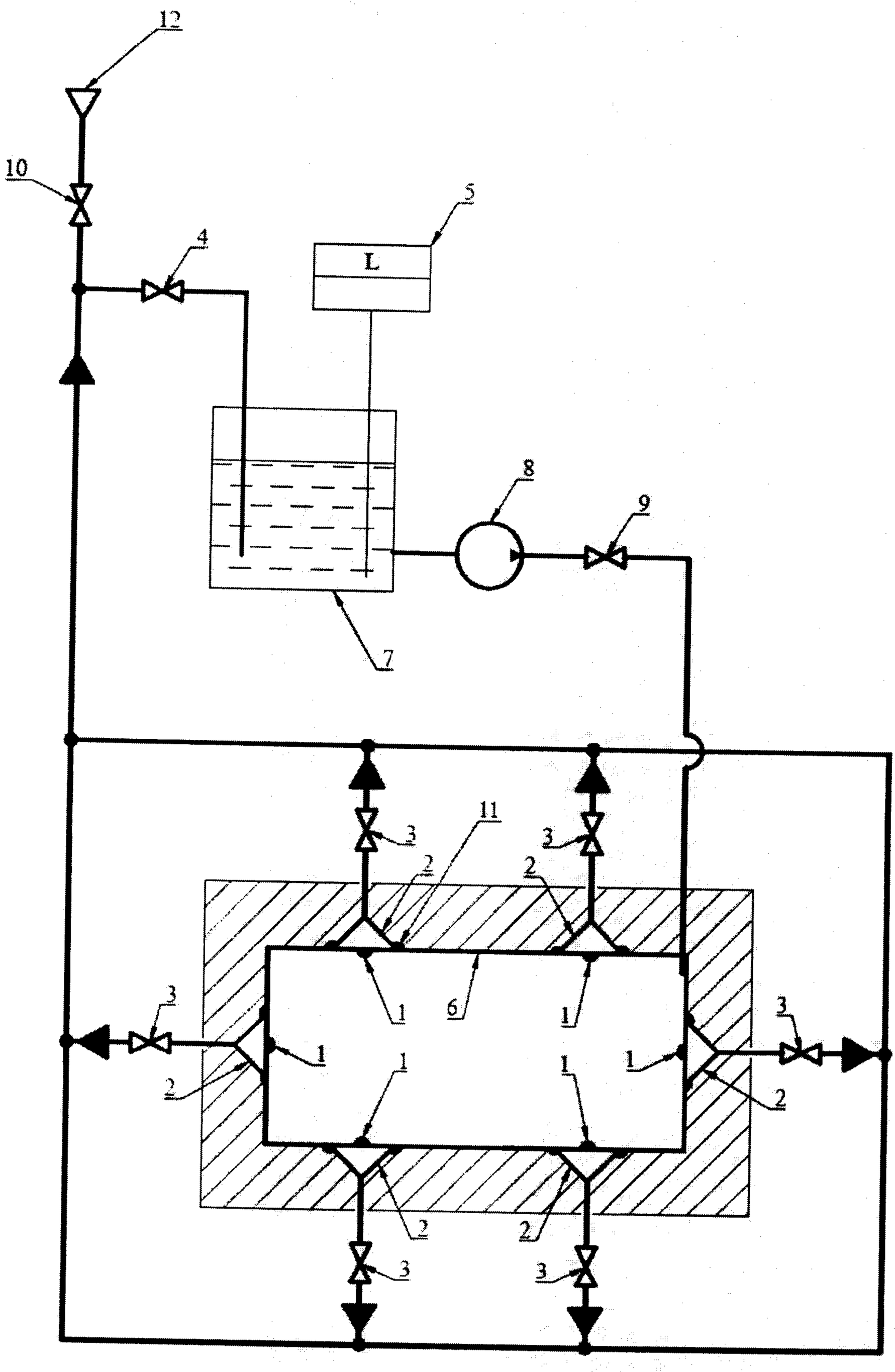
6. The leakage control system for spent fuel cooling pool as per para 1 characterised by level control sensor designed as a pressure sensor.

7. The leakage control system for spent fuel cooling pool as per para 1 characterised by level control sensor designed as a conductivity sensor.

8. The leakage control system for spent fuel cooling pool as per para 1 characterised by the control module connected to all the valves in the system and

to the pump either via wired or wireless communication and designed to control all of them.

9. The leakage control system for spent fuel cooling pool as per para 1 characterised by a compressed air supply unit additionally fitted with compressed air pressure sensor.



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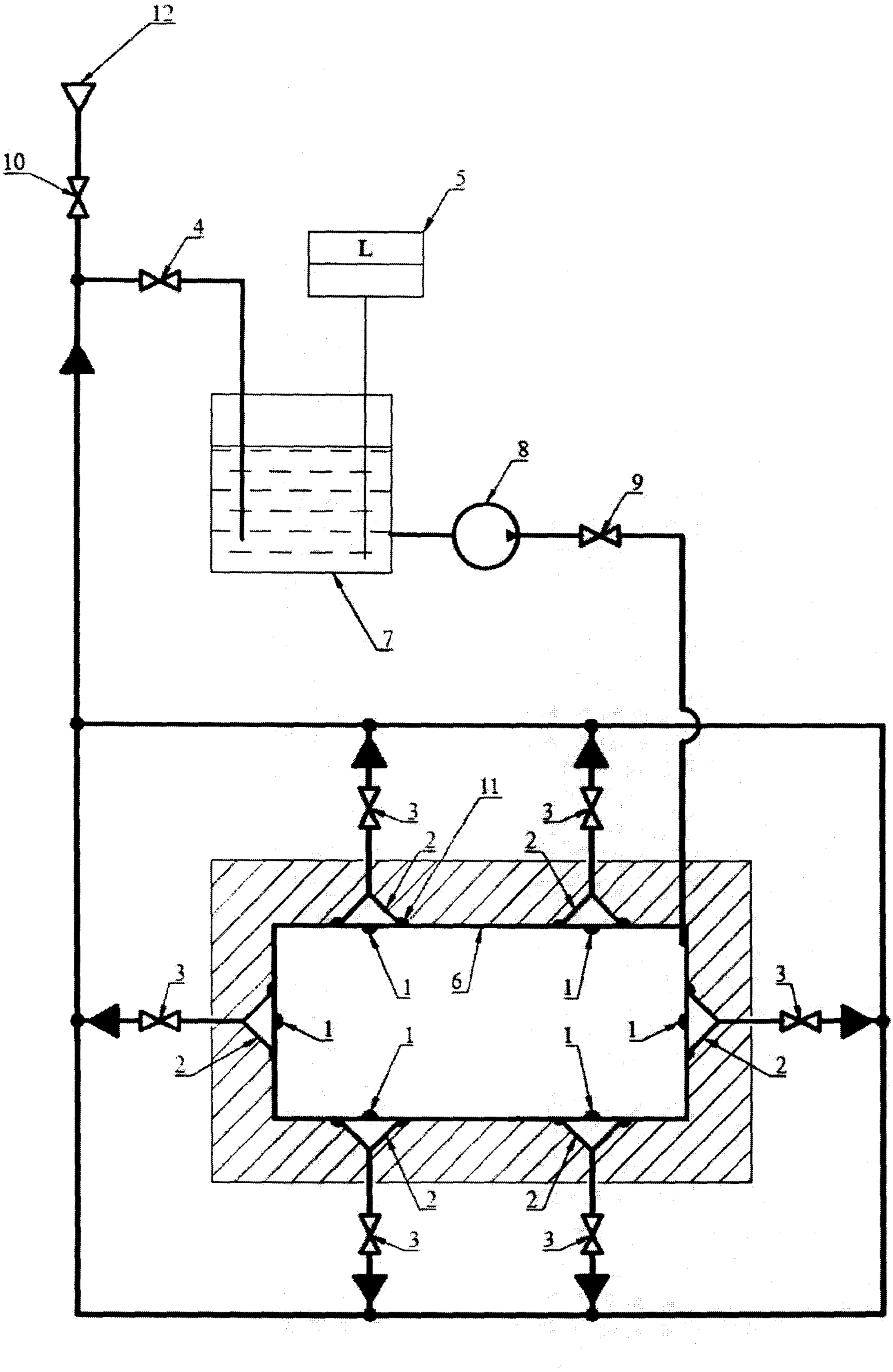

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