Storage and transport of ion-exchange resins

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Abstract

A combination of storage and transport of ion-exchange resins could simplify life of the nuclear facility operator. Due to its mobility and relative small dimensions, it can be an alternative for large and fixed storage systems.

Often storage or transport of these ion-exchange resins are necessary before treatment or before they can be introduced into standard radioactive waste streams. Loading ion-exchange resins in/out of storage or transport tanks can be difficult due to the high dose rate and the behaviour of these resins.

Since 2015, a type IP-2 packaging (named TNB 182) consisting out of an ISO 20' high cube container with two shielded tanks inside, is used for interim storage and transport of ion-exchange resins. A vertical configuration with a sieve in the bottom of the tank, piping from bottom to top and connections and valves on top are used for the transport and/or storage of used radioactive ion-exchange resins.

These high dose rate resins are remotely loaded/unloaded using water as a transport medium. Resins are injected with water inside the tank but are stopped by and remain on top of the sieve in the bottom of the tank. The dimensions of the sieve spacing can be adapted to meet the requirements of the ion-exchange resins. To remove all the resins out of the tank a resin/water flow from below is created. All the external connections are made on top of the tank with specific connectors.

Introduction

Ion-exchange resins are used in several processes in the nuclear power plants. Some of the applications are cleaning of reactor coolant, control of reactivity, purification of effluent streams or cleaning of spent fuel storage pools.

The resins, used as a filter, capture the ions present in the water. Within time, the ion-exchange resins are accumulated with radioactive ions and their dose rate increases and can become a problem for the operators in the vicinity of the columns. As the activity is distributed throughout the resins, they often can be characterized as LSA-II material. Because of the relatively high specific activity of the ion-exchange resins, special precautions is needed when handling, treating and conditioning these materials for interim storage and disposal.

The TNB 182 is a storage/transport solution to allow the safe transport and storage of ion-exchange resins. The design of this packaging is based on the TNB 181A, see figure 1. This packaging concept has proven its reliability and effectiveness for many years.

Figure 1. TNB 181A

The aim of the new package design is to increase the storage capacity of ion-exchange resins for nuclear facilities and at the same time, to create a mobile transport solution in case of further processing of ion-exchange resins in other nuclear facilities.

The packaging is suitable for on-site and off-site transport while no additional transfers are required prior to transport. The packaging can be stored on the most favourable location, on-site or off-site. On-site storage is possible because the design can be customised to take into account on-site regulations.

Materials and Methods

The packaging TNB 182

TNB 182 is a type IP-2 packaging for the transportation and storage of used ion-exchange resins. The packaging consists of an ISO 20' high cube container with two identical tanks each with a useful capacity of 2,41 m^3. The container has four crane lifting eyes for hoisting/manipulation with its dedicated lifting beam. Due to removable roof panels, a working platform and access door, the packaging is easily accessible for the loading and unloading operations.

All the materials are physically and chemically compatible between each other and with the allowed content of the TNB 182 packaging. This package solution has been used for transporting radioactive materials for many years and the construction is done in collaboration with Montiar. All the materials are compatible with the temperature extremes which can occur under normal transport conditions: -40 °C to +70 °C. In figure 1 an image of the packaging is shown.

Figure 1. The packaging TNB 182

Classification

TNB 182 is an IP-2 type packaging in accordance with the IAEA SSR-6 2012 edition for transportation by road and sea, and carries used ion-exchange resins. This packaging is also UN-approved in accordance to ADR/IMDG 2015.

The ion-exchange resins are characterised as LSA-II material. But transport of resins not characterised as LSA-II could also be possible via 'Special Arrangement', in combination with compensatory measures.

To allow the transport packaging to be classified as type IP-2, shielding calculations were made based on known ion-exchange densities and radioactive properties. Taking into account this data, the biological shielding of the packaging was calculated and optimised for LSA-II material.

The exact content description, including fissile material, total activity and dose rate limitations are all included in the packaging design safety report.

Dimensions and Weight specifications

The maximum volume of each tank is 2,68 m^3, but the filling volume cannot, however, exceed 90% of the maximum volume because of ADR regulations. As a results, the authorised volume of resins per internal chamber is 2,41 m^3.

An overview of the dimensions, volume and weights is given in table 1.

Nominal dimensions	***TNB 182***
Overall height	3.110 mm
Overall external diameter	2.438 mm
Body height (with its lid; without impact limiters)	6.058 mm
Volume	*TNB 182*
Authorised volume	2 x 2,41 m³
Masses	*TNB 182*
Content	2 x 3.060 kg
Max gross weight	47.630 kg

Table 1. An overview of dimensions, volume and weights

Description of the tanks

A vertical configuration with the sieve (5) in the bottom of the tank (1), piping from bottom to top (3, 4), and connections and valves (6) on top will be used for the transport and/or storage of used radioactive ion-exchange resins. An example of a typical tank design is shown in figure 2. Resins will be injected with water inside the tank but will be stopped by and remain on top of the sieve in the bottom of the tank. The dimensions of the sieve can be adapted to meet the requirement of the ion-exchange resins. Water can pass through the sieve and can be drained trough the drainage tube (4) after loading the resins. To unload the resins, the tank is first completely filled with water. After filling a resin/water flow is created to remove all the resins out of the tank. All the external connections will be made on top of the tank with specific connectors. A buffer volume is present to meet the regulatory volume requirement during transport.

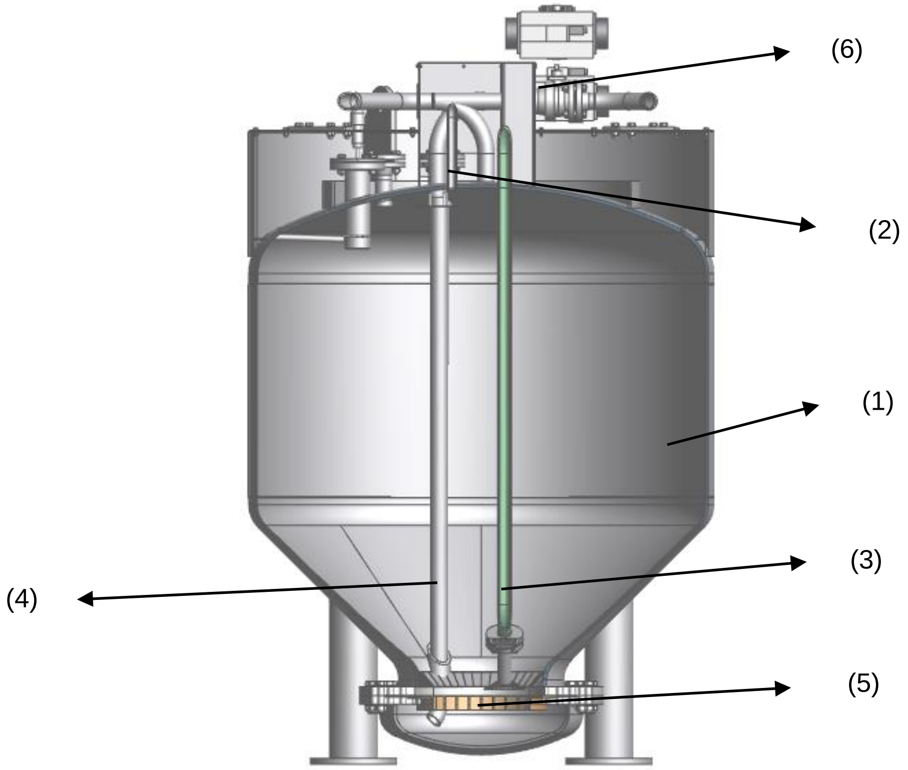

Figure 2. Section view of a typical tank design for resins

Shielding

The two internal chambers are each placed in an outer casing which acts as a retention reservoir. The two outer casings have been built to a size so as to fit the whole of the volume contained in the internal chamber if a leak were to occur. The two outer casings are each provided with a leakage sensor. The detector is shown in figure 3. This packaging also has a back-up leak retention and detection in the base of the ISO 20' container.

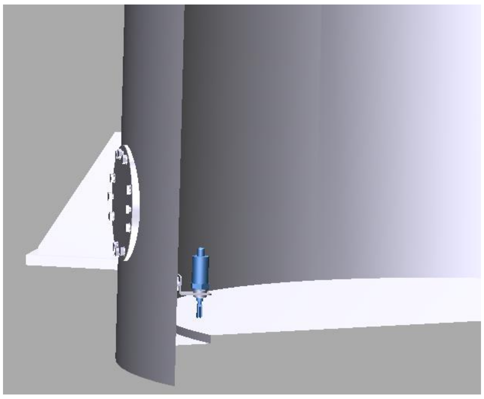

Figure 3. Leak detection

Connections/operation

The loading and unloading of wet resins will be done with pipes supplied with ARGUS connections which are compatible with those of the internal chambers. The loading of resins will be done via an ARGUS DN 50 connection (see figure 4). A sensor notifies the operator when maximum loading capacity is reached.

All the welds, flanges and valves of the internal chambers will be verified under a 15 bar pressure test.

Furthermore, the internal chambers are also equipped with:

- a pipe for bringing in resins
- a pipe for emptying out resins
- pipes for the transport of water
- a ventilation system

Figure 4. ARGUS connection

The two internal tanks can be loaded/unloaded remote controlled with a control box which will open or close the pneumatic controlled valves. These operations are always performed in collaboration with the installation which controls the operation of the resin flow.

Loading/unloading resins

The loading and unloading of used radioactive ion-exchange resins will be done with hoses supplied with specific connectors which are compatible with those on the top of the tank.

The loading of the tanks is done by the following steps:

1. Filling the chamber with water
2. Internal chamber completely filled with water
3. Filling with resins / water
4. Internal chamber charged with resins / water
5. Draining the water
6. Water removed from chamber
7. On-site transportation towards storage or further treatment

The unloading of the tanks is done by the following steps:

1. Starting situation (storage)
2. Filling with water and emptying the air
3. Resin / water draining
4. Rinsing with water
5. Drain the water
6. Empty tank

Operational challenges

The packagings are currently equipped with ARGUS couplings for loading, but an installation for unloading and further processing of the ion-exchange resins still needs to be selected. In the future it is uncertain that ARGUS couplings still are available to buy on the market. The availability of these very specific ARGUS couplings is very important to guarantee a safe, leak tight transfer into or out of the tanks.

During loading, the ratio between ion-exchange resins and water is important. If too little water is added to the resins, there is a risk that the pipes or connectors will become clogged. This blockage can be released by compressed air, but only if the compressed air connections are present on the filling installation.

The detection of the tank being completely filled is done by a specific level detection. If this equipment fails, there is a risk of ion-exchange resins being transported through the outlet pipes. At the end of the loading operation when the couplings are disconnected. The operator can come in contact with the ion-exchange resins and is exposed to radiation. Another risk is that the ion-exchange resins will be further transported throughout pipes of the installation and to water waste streams. This should be avoided at all time. To solve this issue, a sieve can be added to the outlet water connection. But it is also possible to time the loading process, if the flow rate of the filling installation is well known.

Results

With this packaging, we provided a solution to allow the safe transport and storage of ion-exchange resins. This packagings allows nuclear facilities to increase the storage capacity of ion-exchange resins and at same time makes the further processing of ion-exchange resins off-site possible. The packaging can be stored on the most favourable location, on-site or off-site and no additional transfers are required prior to transport.