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Concept of new water tank for dust collecting equipment controlling the dust hazard

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Abstract:

The article reviews the water reservoirs currently in use, working with wet-type dust collection devices. A shortcoming of current water systems is the problem of waste formation in the form of sludge with a relatively high water content. The article presents the concept and directions of further development of the device, in the context of the treatment of water discharged from the dust collection device, operating in a closed circuit, and the impact of proper operation on the efficiency of the dust collection device, affecting the protection of the upper respiratory tract of workers who are in the area of increased dustiness. The use of a special design of the bottom of the tank makes it possible to separate the resulting pollution and direct it towards a drain hole or an inspection window. An important advantage of the presented solution is its modular design, which allows to adapt the development of the tank in conditions of limited space, and the way of its location and movement.

Keywords: dust collection, dust, dust removal, reservoir, sedimentation



1. Introduction

Dust collecting equipment, which include a set of tank/tanks, can be used in mining plants (in according to Polish rules), where there are methane hazards (workings are classified regarding the methane hazard in categories I-IV) and coal dust explosion hazards (workings of class "A" and "B" hazard) [1]. Devices of this type belong to group I of the M2 category and can operate stationary or mobile [2]. The place of operation of the dust collecting device has a significant impact on the structure of the tank (stationary tank placed on the floor or suspended by chains from a suspended railway).

The tank, in the case of wet dust collection equipment, is an essential part of the closed water system. Water from the tank is pumped, with the help of a centrifugal pump, toward the spray nozzles, forming a water-air-dust mixture. The air is then separated from the water-dust mixture in a drop separator. The cleaned air is discharged into the environment. The water-dust mixture, returns to the tank of the dust collection device.

In the tank, sedimentation of impurities (rock or coal dust) takes place. Due to the use of the wet method for dust separation, sludge is formed in the tank [3]. According to the DTR of dust collection equipment, it should be periodically removed, and the device should be filled with clean water. Existing designs provide the sludge to be manually removed out of the tanks, using a shovel, on run of mine transportation devices, i.e. onto a belt conveyor, scraper conveyor or into mine trucks, and directed along with the run of mine to the processing plant, or by flushing out the contents of the tank through the bottom drain hose (Fig. 1 item 10). To date, no other method of dust (sludge) management has been found in any of the designs analyzed, and no installations were used to thicken the sludge and treat the circulating water in the dust collector [4, 5, 6, 7].

2. Materials review

Dust control devices of the following types: BSA, OD and UO use tanks developed by the KOMAG Institute of Mining Technology. ITG KOMAG has developed various types of water tanks over the years, but their designs did not differ significantly from each other [8, 9, 10].

The water tank (Fig. 1, 2) is made as a welded structure and is equipped with:

- a stand in which the P-1BA-N-Ex or P 2BA-W-Ex water pump is placed,
- a bracket in which the CP-2d/1 or CPC-2 water level sensor is installed,
- float valve.

Each dust collector is equipped with one (Fig. 3) or two tanks (Fig. 4, 5), connected to each other by three leveling up pipes. In addition, each tank has a drain line ended by a spigot with a catch.

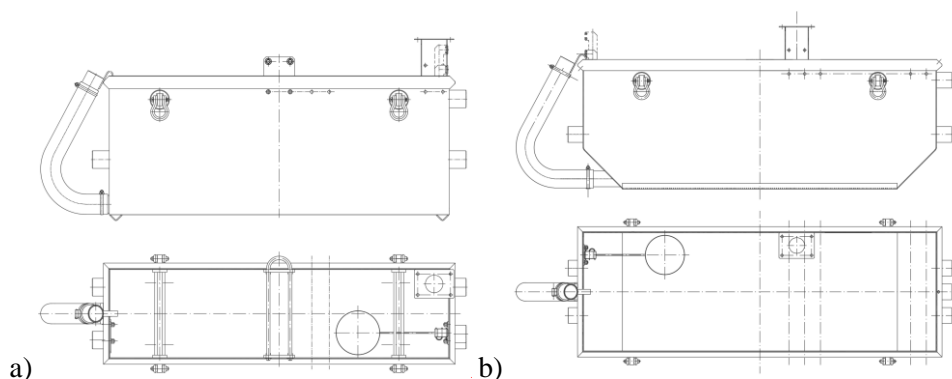


Fig. 1. Examples of tank versions for dust collection equipment

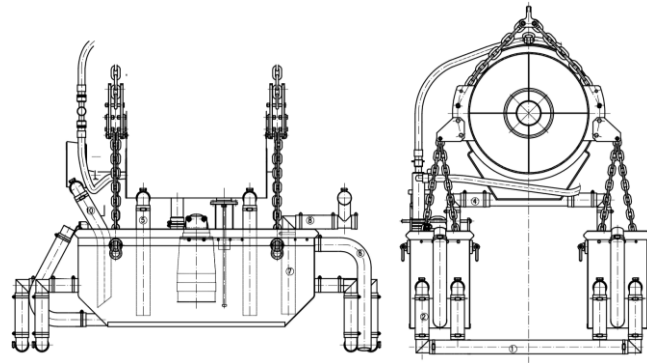


Fig. 2. Mobile (suspended) method of installing the tank with a BSA device

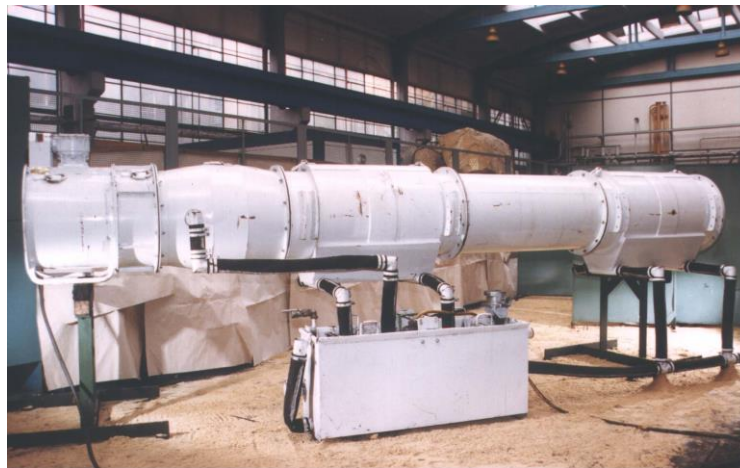


Fig. 3. UO-630 type device in a stationary version



Fig. 4. OD type device in a stationary installation

Water tanks are located on one (Fig. 3) or both sides (Fig. 2) of the dust collector, at the height of the drop separator. The solution with tanks on both sides of the dust collector allows to reduce the longitudinal dimensions of the device, at the expense of free space in the cross section. However, if a single tank is used, not mounted in the center of gravity of the cross section of the device, a counterweight is required to stabilize it. The location of the tank under the drop separator allows free flow of dirty water, so the device is equipped with only one water pump. There are also the solutions on the market of other manufacturers of dust collectors (OMV, CFT), using tanks of their own design (Fig. 5, 6, 7), but these solutions are rarely used.

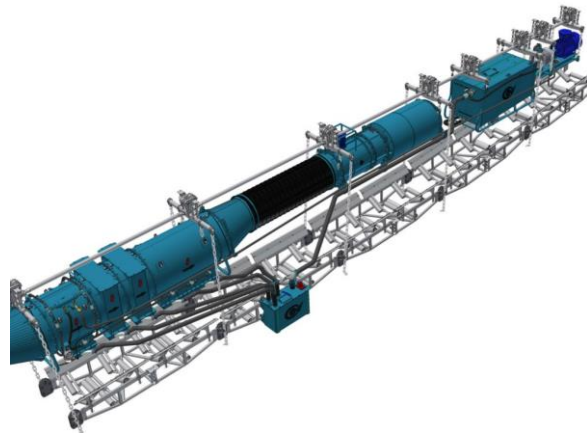


Fig. 5. OMV-SERWAL wet dust collector by Sigma [11]

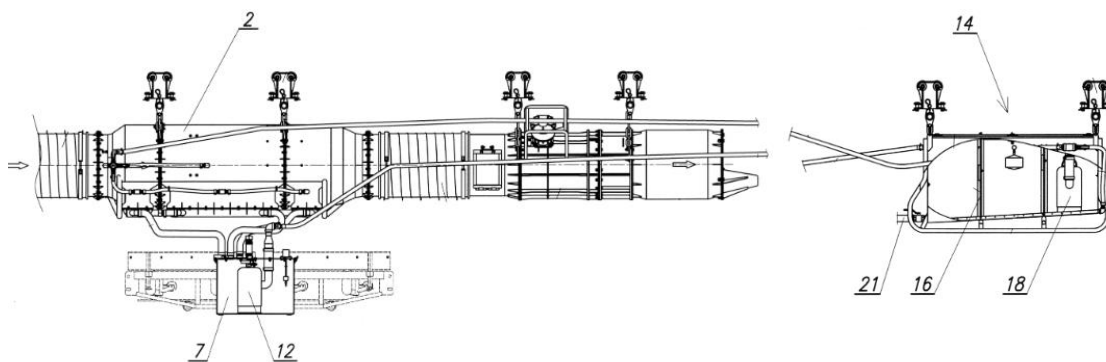


Fig. 6. Diagram of the OMV-SERWAL device: 2- dust collector, 7 – I water tank, 12 – I pump, 14 – II water tank, 16 - vertical baffles, 18 - II pump, 21- drain valve [11]

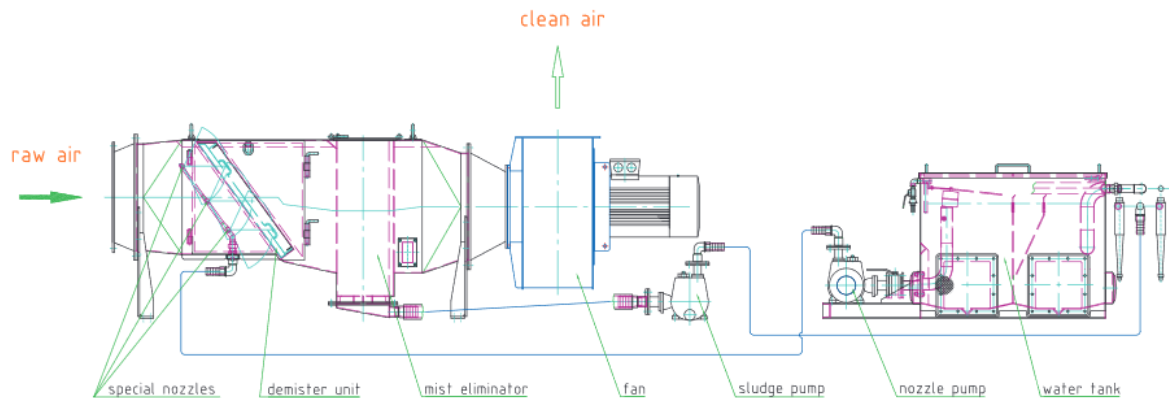


Fig. 7. Diagram of a CFT wet dust collector [12]

The solutions presented above are characterized by the axial design of the tanks. The first dust collector (OMV-SERWAL) uses two water tanks. The first one (Fig. 6, item 7), mounted to the side of the conveyor belt route, acting as a collector equipped with a pump (Fig. 6, item 12), transporting the contaminated water to the second tank (Fig. 6, item 14). The second tank serves as a clarifier, inside of which there are vertical baffles (Fig. 6, item 16), behind which there is a second pump

(Fig. 6, item 18) feeding the spray nozzles in the dust collector (Fig. 6, item 2). A drain valve is installed at the bottom of the second tank to remove the settled sludge (Fig. 6, item 21).

The second dust collector presented, by CFT (Fig. 7), uses a very similar solution (the first tank was abandoned). Both solutions use two pumps for water transport and the main water tank is located in the axis of the dust control device, on its outlet side. The advantage of this solution is the reduction of the cross-sectional area of the dust control device as well as the elimination of the counterweight in the case of using a tank on one side only. The advantages also include easier transportation, due to the direct suspension of the tank to the overhead rail carriage. Disadvantages of the solution include using two pumps and more water pipes. In the case of the OMV-SERWAL device, the disadvantage is also that the tank is located in the outlet line of the air jet, disrupting its flow. In addition, the location of the tank increases the longitudinal dimensions of the dust collection device.

In addition to the previously described features of the solutions, regarding the location of the tanks, the number of water pumps or the number of tanks, there is another very important aspect. The main tasks of the water tank, in addition to supplying and storing water in a closed circuit, include the separation of the solid fraction (captured dust particles in the dust removal process are mixed with water) from the liquid phase. In ITG KOMAG's existing solutions [4], the tank assembly does not have any systems or solutions that allow the solid phase to thicken and settle at the bottom of the tank, apart from using its falling under gravity. The runoff pipes from the drop separator gravitationally feed the contaminated water directly into the vicinity of the inlet of the submersible pump, which transports the water to the spraying system. The incoming medium agitates the settled dust at the bottom of the tank, which is then sucked up by the water pump. Water contaminated with dust particles negatively affects the efficiency of dust removal and the life of the entire closed water circuit (pump, nozzles, pipes). The DTR attached to dust collection equipment recommends that the tank be serviced every shift, i.e. clean the bottom of the tank of settled dust and refill the water to the indicated level.

In practice, in order to empty the tank of accumulated sludge, it is necessary to collect it, using a shovel, and winnow it out. This process is time-consuming and non-ergonomic [4]. Fig. 8 shows the condition of the tank after 30 minutes of dust collector operation, with an average dust load of 5 kg/h (during bench tests at ITG KOMAG). As can be seen, there is an accumulation of "scum" on the surface of the water table, which over time, due to sedimentation, sinks to the bottom. Fig. 8 also shows the outlet spigots leading from the drop separator. They discharge contaminated water directly at the pump's suction opening, through which water with contaminants that have not had time to sink to the bottom is drawn in. In addition, the drain stubs, bringing contaminated water under pressure (gravity) into the tank, agitate the sludge formed by sedimentation, at the bottom of the tank.



Fig. 8. The main components of the tank: water pump, water level sensor and float (tank condition after 30 min of operation)

3. Results

Based on the available solutions and the experience of using the dust collection equipment, the following assumptions were made for the new solution of the water tank assembly:

- development of a structure "base" allowing for installation: stationary or mobile,
- development of the design of a single tank as well as a set of tanks,
- improvement of liquid flow between tanks,
- redesigning the bottom of the tank for better accumulation of sludge,
- enabling efficient cleaning of the tank from sludge.

A solution of water tank assembly for dust collection equipment is presented. Based on one main tank, which is the "base", the design can be adapted to the user needs. "Base" of the tank has a new optimized longitudinal trapezoidal shape (Fig. 9), with a gabled bottom of an opening angle equal to 120° .

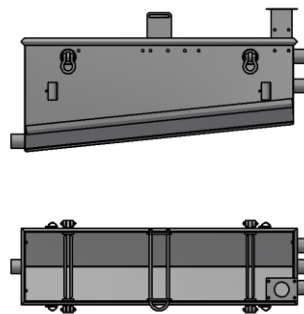


Fig. 9. "Base" of the water tank with a capacity of 314 liters

The tank (Fig. 9, 10), due to its specific design (shape), has a capacity of about 40l less than a rectangular tank of similar dimensions. The tank, depending on the free space in the roadway cross-section, can be adjusted by increasing its longitudinal or transverse dimensions.

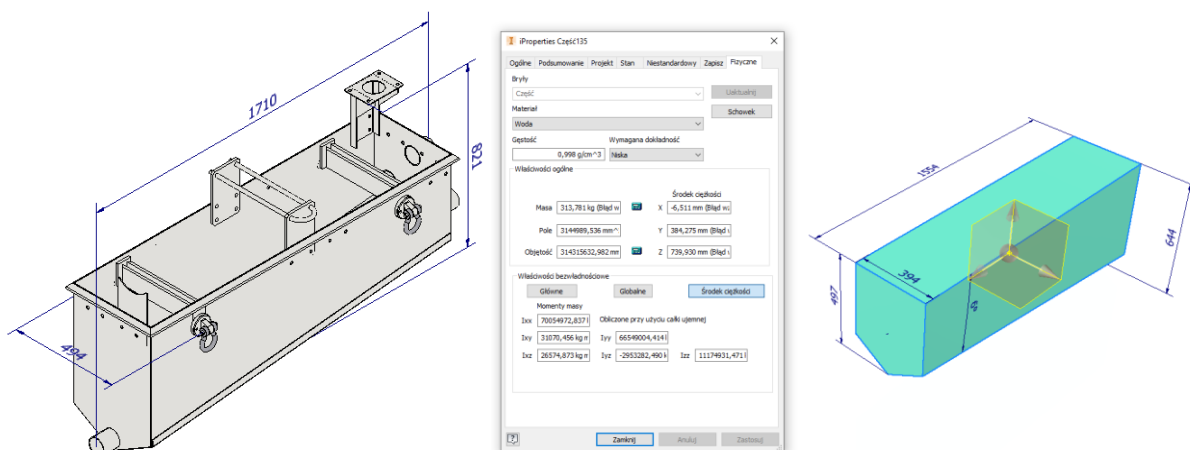


Fig. 10. The overall dimensions of the new base tank (314 liters) 1710x494x821 mm), and the coordinates of its center of gravity

The use of a broken, gabled bottom of the tank, along with a longitudinal slope of 6° , allows the sludge to be concentrated at the bottom of the tank and directed toward the drain hole, located at the lowest point of the tank. This solution eliminates the need for manual scraping of the sludge and prevents its accumulation within the suction opening of the water pump.

The tank is equipped with many technological slots that allow optimal location of water level sensor, water pump and float (Fig. 11). In Fig. 11, sequentially marked: 1- tank body, 2- supporting frame fixation, 3- transport shackles, 4- water level sensor fixation, 5- water pump fixation, 6- float fixation, 7- drain hole.

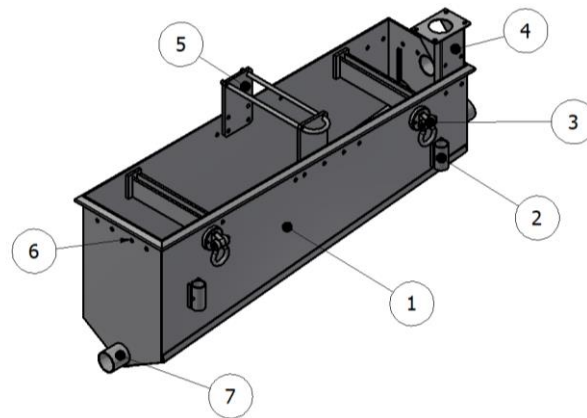


Fig. 11. "Base" of water tank adapted to install the necessary components

In standard solutions, a drain hole allows the tank to be emptied through a rubber hose, suspended from the tank edge (Fig. 12). During servicing, the hose is detached from the tank edge and the sludge flows by gravity from the bottom of the tank to the floor or a conveyor belt. In the suggested solution, a drain valve is installed in the drain hole (Fig. 13), or a service window will be made in the tank wall (Fig. 14). The advantage of the service window is that the tank can be cleaned with tools such as a shovel or spade, without having to lower the tank to the bottom. The solution described in the article suggests a service window (Fig. 14), based on either a screw connection or a central pivot bolt.

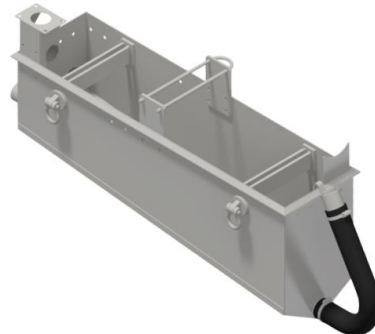


Fig. 12. Rubber hose attached with hose clamps to the drain hole

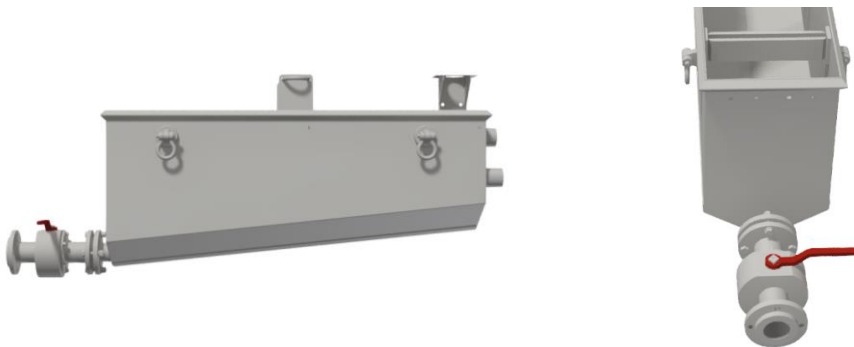


Fig. 13. Tank with built-in drain valve



Fig. 14. Tank with a service window: a) using screw connection, b) central pivot bolt

Dust collection devices can operate as stationary or mobile. The "base" design of the tank (Fig. 11) allows it to be suspended, using chains, from the dust collection device. The new water tank, due to the characteristic shape of the body, does not allow it to be directly founded on the floor. For this purpose, a special supporting frame was developed (Fig. 15). The supporting frame allows the height of the tank to be adjusted and ensures that the tank can be stably located on the floor or any surface. Fig. 16 shows another solution of the supporting frame, allowing the tank to be moved along the floor. The supporting frame is equipped with skids and a transport shackle, behind which the tank can be pulled.



Fig. 15. Base water tank with adjustable support frame



Fig. 16. Base water tank with sliding support frame

The concept for the new tank also includes the cooperation of two water tanks. Fig. 17 shows the two cooperating tanks. The first one acts as the main settling tank, where the contaminated water from the first drops separator (if at least two drops separators are used) is fed, through rubber hoses. The second tank is connected to the first by rubber hoses. Pre-treated circulating water flows into it.

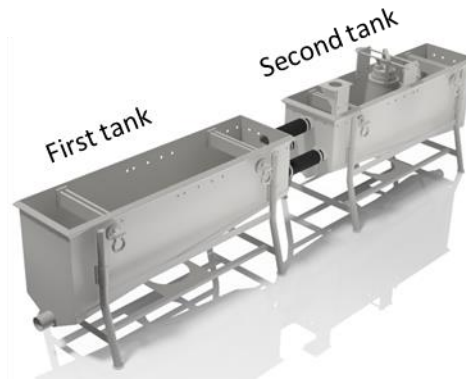


Fig. 17. A set of two cooperating water tanks

Better sludge accumulation and its separation from the water pump that supplies the spraying nozzles is the advantage of using two water tanks. In addition, total capacity of tanks is doubled. The set of tanks was built on the basis of universal "bases", which can be equipped, depending on the needs, with: skids, adjustable stands, valves, drain hoses, service holes, etc. Figures 18 and 19 show the possibilities of connecting two tanks using flexible hoses. The previously used connection was 3 $\Phi 80$ mm hoses. The new solution proposes to modify the connection by extending the two extreme hoses and ending them with elbows. This solution allows for more accurate filtration of the liquid flowing into the second tank. Depending on environmental conditions, it may also be advantageous to use a single hose connecting the tanks. The triple connection, due to its stiffness, hinders the relative movement of the two tanks (the hoses bend). The new solution proposes a single hose with a diameter of $\Phi 150$ mm.

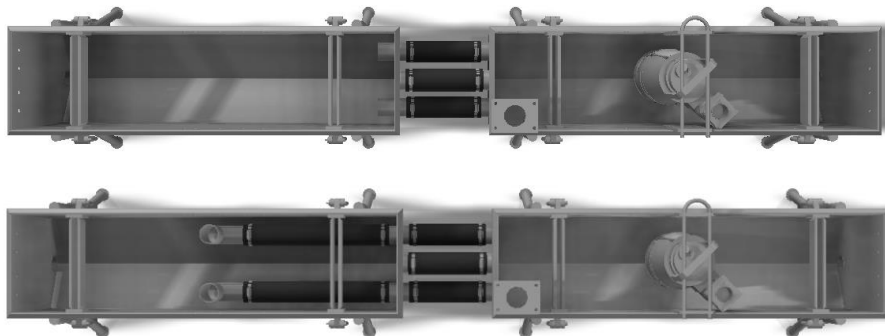


Fig. 18. Tank without additional equipment and with rubber hoses ending in elbows

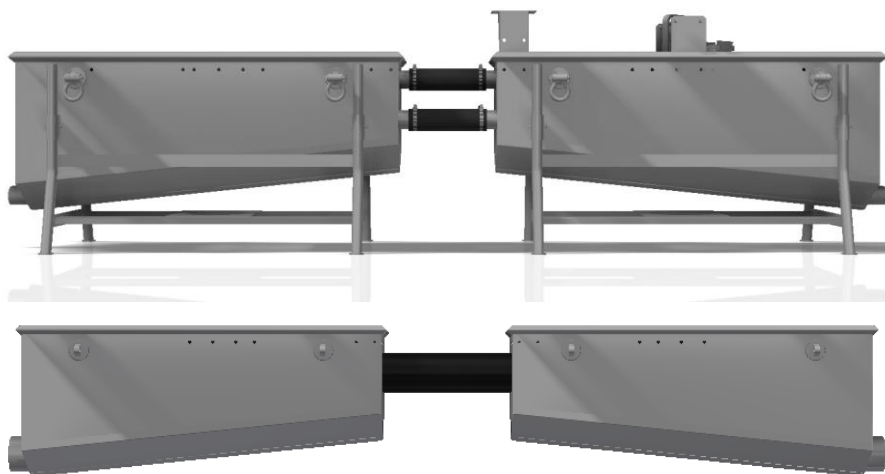


Fig. 19. Two variants of connecting tanks with hoses: 3x $\Phi 80$ mm and 1x $\Phi 150$ mm

4. Conclusions

The concept of the "base" of the new water tank is presented. The advantage of modular design of the tank is its versatility. The "base" enables adapting the tank or set of water tanks to the specific requirements of a customer. The use of new innovative solutions should eliminate problems such as:

- hindered flow of liquid between tanks when using a single hose,
- accumulation and separation of sludge in the tank:
 - by using the gabled tank bottom with a longitudinal slope of 6°,
 - by the using two tanks with an elbow connection, limiting the entry of debris into the tank with the pump,
- removal of accumulated sludge from the tank, by using of an inspection window allowing servicing without the need for platforms or lowering the tank to the floor.

The possibility of using various types: skids, adjustable legs, or transport handles, allows using the tank in a stationary or mobile system. The use of the above solutions will speed up and facilitate the work associated with servicing the dust collection devices, in addition, a non-obvious added value of the presented solution is the increased efficiency of the dust collection device, which directly affects protection of the respiratory tract of workers. The new dust collection devices have dust collection efficiency of 99%. During the operation of the device, without regular cleaning of the tank, the contaminated water, fed by the pump, can reduce the efficiency of removing the small dust fractions, and consequently the efficiency of dust collection by the device, and in special cases can lead to clogging of the spraying nozzle.

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