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AUTOMATED MODULAR SYSTEM FOR INTERIOR WASHING OF PETROLEUM TANK RAILCARS

1. System performance

This fully automated stationary modular system performs high quality interior cleaning of tank railcars used for transportation of various petroleum products or crude oil with any quantity of the residual product.
This system is able to clean each day up to 30 tank cars used for carrying light petroleum products (light motor oil, diesel, gasoline, jet fuel) or up to 15 tank cars used for carrying heavy petroleum (crude oil, fuel oil, heavy lubricants).
Compliance with the safety requirements is achieved by using mostly hydraulically driven equipment inside the tank. The system utilizes a closed washing cycle that excludes the personnel presence inside the tank during the washing process, increasing safety and efficiency of operation. Cleaning solutions are recycled for multiple use, that drastically reduces the wastewater discharge.
The system requires one operator to control it and two supporting persons to install auxiliary equipment and connect hoses. Control panel is located on the service platform, allowing the operator to communicate directly with the supporting persons. Movable gangway allows easy access to the tank manway. Operating the system does not require any previous experience. Two-day training program allows the personnel, upon completion, to operate the system with no supervision.

2. Washing process options

One washing station is able to wash, at a time, two tank cars placed on parallel tracks along its two sides. While these two cars are washed, other two tank cars are prepared. The operator selects pre-programmed washing cycle determined by the transported product.
The tank conditions and the amount of a residual product is inspected by the operator before choosing the washing cycle, to specify the required washing time and other settings. The automated system excludes the personnel presence inside the tank during washing.

Tank cars used for light petroleum transportation are washed in 2 stages, using a washing solution (detergent or caustic) and then rinsing with hot water, as follows:
- Wash for 15-20 minutes with washing solution at 160°F
- Rinse for 15-20 minutes with water at 160°F
- Allow to air-dry and cool before closing and sealing the manway

Tank cars used for heavy petroleum transportation are washed in 3 stages, starting with cutter stock (diesel fuel), then following with the washing solution (detergent or caustic), and finally rinsing with hot water, as follows:
- Pre-heat by steam (if necessary)
- Wash for 45-60 minutes with cutter stock at 160°F
- Wash for 15-20 minutes with washing solution at 160°F
- Rinse for 15-20 minutes with water at 160°F
- Allow to air-dry and cool before closing and sealing manway

Using cutter stock (diesel fuel) in the first stage of washing cycle for heavy petroleum allows nearly full recovery of the residual oil product. This reduces the cost of the wastewater disposal and can bring additional revenue from selling recovered product as heating oil.

As an option, instead of using cutter stock, low-emulsifying non-caustic heavy-duty detergent solution can be used in this washing cycle, allowing partial recovery of the residual oil product.

3. Telescopic apparatus with two washing heads

After the tank car is set for washing, the top manway is opened and a special manway adapter with a telescopic washing apparatus is installed, using a pneumatic crane (see Photos 1a and 1b), and then the telescopic apparatus is unfolded and extended inside the tank with hydraulic actuators (see Photos 2 and 3 and Picture 1).

Photos 1a and 1b. Installing telescopic washing apparatus in tank car manway

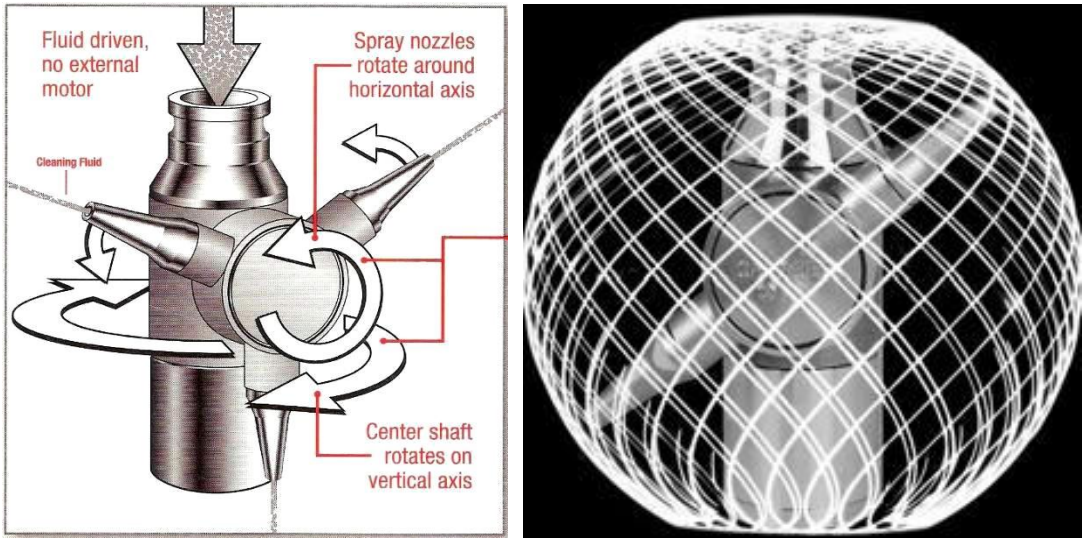
Photo 2. Unfolding telescopic apparatus

Photo 3. Extending telescopic apparatus

Picture 1. Unfolded and extended telescopic apparatus inside tank car

The telescopic washing apparatus is equipped with two orbital washing heads at its ends (see Photo 4). Each orbital washing head is rotating around the horizontal and vertical axes, driven by pressure of the washing liquid (see Pictures 2a and 2b). Pattern formed by the liquid jets covers all interior surface of the tank. High-pressure hot liquid jets provide strong cleaning effect to remove any residual product and sedimentation from the tank.

Photo 4. General view of orbital washing heads with three or two nozzles



Pictures 2a and 2b. Principle of action of orbital washing head

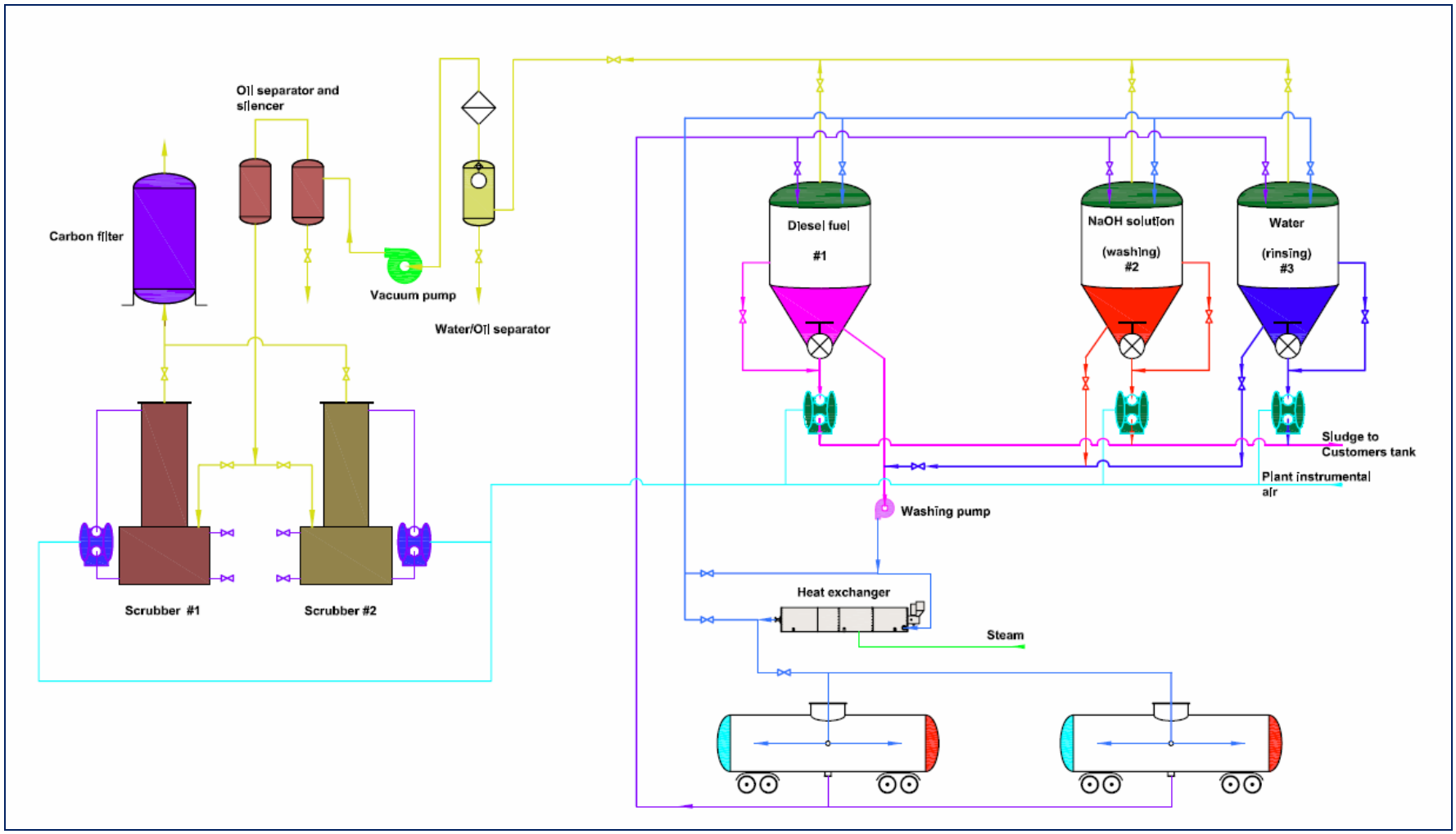
The telescopic apparatus is specially designed to efficiently and safely wash the tank car interior up to the end parts of the tank. Before this telescopic apparatus was developed, a regular manway adapter with a single washing head was used. Such approach is not effective for the end parts of the tank car, because the kinetic energy of liquid jets decreases with the distance from the washing head. Thus, the washing efficiency of a system with one central washing head is declining toward the tank ends. To complete the cleaning, the personnel had to enter inside the tank and do the work manually by scraping and using a handheld pressure washer. Such method was not safe and required long hours of manual labor.
Hydraulically actuated telescopic apparatus with two washing heads simplifies and speeds up the cleaning process, providing high efficiency and cleaning quality up to the tank ends by delivering the washing heads closer to the ends of the tank.
Washing cycle can be started as soon as the telescopic apparatus is unfolded, while it slowly extends to a maximum length, that also reduces the washing time. After washing cycle ends, the telescopic apparatus retracts and folds in reverse order, and then is lifted from the tank.

4. Washing process description

Cleaning sequence for tank cars carrying heavy petroleum is described below (see Picture 3).

In the 1st stage, cutter stock (diesel fuel) is moved by washing pump from tank #1 through strainer and heat exchanger to washing heads on the telescopic apparatus installed in the tank car. Heated cutter stock sprayed by orbital washing heads at high pressure softens and washes away sedimentation sludge from interior surfaces of the tank car. Then, cutter stock with dissolved residues of heavy oil and suspended sediments is returned from the tank car to tank #1 due to vacuum created in it by the vacuum pump.
After cutter stock is returned to tank #1, dense phase with sediments is separated due to gravity and collected in the conical bottom part of tank #1, from where it is periodically removed by diaphragm pump (to sludge collection tank for disposal).
Because, in repeated washing cycles, cutter stock becomes saturated with heavy oil, this saturated solution is periodically removed (to oil collection tank, for selling as heating oil) and replaced with fresh cutter stock.
Exhaust from the vacuum pump is cleaned in one of the scrubbers (depending on the product carried by the tank car). Oil vapors are condensed in the scrubber by continuous spraying of cold water with active agents, and then the oil condensate is moved to oil collection tank. Exhaust gases can be additionally cleaned after the scrubber by carbon filter before being discharged to atmosphere.

In the 2nd stage, the tank car is washed off residual cutter stock (containing some heavy oil and some suspended sediments) with heated washing solution (detergent or caustic) from tank #2, with a process similar to the 1st stage. In addition, when this washing solution is returned to tank #2 by vacuum, rising to its surface part of cutter stock is skimmed by weir plates in this tank and then is moved to oil collection tank Because, in repeated cycles, washing solution becomes saturated with emulsified in it part of cutter stock, this saturated solution is periodically removed (to wastewater collection tank for disposal) and replaced with fresh washing solution. To reduce this waste, a low-emulsifying non-caustic detergent solution of sufficient strength can be used in this stage.



Picture 3. Diagram of washing process for tank cars carrying heavy petroleum

In the 3rd stage, the tank car is rinsed off residual washing solution with heated water from tank #3, with a process similar to the 2nd stage.

As an option, instead of using cutter stock (diesel fuel) in the 1st stage of washing cycle for heavy petroleum, low-emulsifying non-caustic heavy-duty detergent solution can be used with a process similar to using washing solution in the 2nd stage, including the collection of sellable oil rising to the surface (and removal of sediments as in the 1st stage).

Cleaning sequence for tank cars that carried light petroleum products consists of the 2nd and 3rd stages of the described above sequence for heavy petroleum.

5. Factory ready modules

All equipment is grouped in modules mounted on frames (see Photos 5 and 6). This allows easy transportation without damaging the equipment. When modules are delivered to the site, they can be easily assembled utilizing easy access to piping and cable connections. Time required to complete the assembly is less than a week.
Factory module pre-assembly and vigorous testing guaranties high quality and reliability of the system and reduction of the time for final assembly and startup. Highest quality parts are used during the equipment production.

Photo 5. Factory tested module ready for shipment

Photo 6. Washing system module installed in a wash shop

6. Safety of operation

Presented washing system practically excludes the personnel exposure to petroleum products. Telescopic apparatus with orbital washing heads using heated solutions with high pressure effectively replaces manual labor.
Intrinsically safe and fire-proof equipment is used in order to guarantee safety of the system dealing with petroleum products. Hydraulic motors and actuators are mostly used in the system, while only explosion-proof electric motors are used in it.
The housing building must comply with national and local fire-safety and environmental requirements for industrial buildings.

7. Process automation

The washing cycle is fully automated, with a programmable controller that allows to exclude errors by the personnel. Operator determines the type of the product carried by the tank car and enters the corresponding program using the touch screen (see Photo 7) with control buttons on its top. Then the system will carry out an automated washing cycle depending on the transported product. All major parameters (such as temperature and level of washing solutions in the tanks) are displayed on the operator screen, as well as the current state of the equipment (pumps, automated valves, etc.). If emergency conditions are detected, alarm message will be displayed on the screen, along with a possible operator action to resolve it. Control panel is equipped with a device recording the operator input and washing process in real time.

Photo 7. Control panel with touch screen

Control panel for two-car washing system has two screens to control washing of two tank cars simultaneously.

8. Environmental compliance

All equipment is designed in compliance with the requirements of the US EPA .

8.1. Vapor and gas processing

The system is equipped with the exhaust cleaning and filtering unit that includes two scrubbers and a carbon filter. Oil vapors are condensed in the scrubber by continuous spraying of cold water with active agents. Exhaust gases are additionally cleaned by a carbon filter before being discharged to the atmosphere.

8.2. Product recovery

The amount of residual petroleum product in tank cars depends on the product type and the ambient temperature at the product unloading. For heavy petroleum, residual amount can reach up to 5% of the railcar tank volume at winter time and up to 2% at summer time. Most of this residual product can be recovered in this tank cleaning system, minimizing waste and reducing the environmental impact.
This recovered product can be utilized as heating oil.

9. System dimensions

The tank car washing system requires a placement lot with dimensions of 50 feet by 15 feet.

10. Warranty

The system is covered by 12 months warranty starting from the system startup day but not more than 18 months from the date the system is shipped, whichever comes first.

11. Delivery time

The system delivery time is 7 months starting from the date the first payment is received according to the contract signed.

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