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Occupational Safety Management Aspects on Municipal Waste Water Treatment Plant

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Abstract. **There are new municipal waste water treatment plants being constructed in Latvia in the framework of the projects implemented with the EU co-financing. New modern equipment requires certain approach to occupational safety provision. This paper discloses aspects for occupational safety increasing on newly constructed municipal waste water treatment plants within several samples of WWTP designs, actuated in Latvia. WWTP occupational issues are examined from two aspects: operational safety and designed-in safety. The paper reviews several tender requirements for WWTP construction, Latvian Cabinet of Ministers regulations, EU-OSHA materials and abstracts of some medical researches in WWTP occupational health risks. Finally, recommendations to WWTP occupational safety increasing via project owner specification to design and via project owner staff operational safety trainings are presented.**

Keywords: **waste water treatment plant, sewage treatment plant, occupational risk, occupational safety.**

I. Introduction

The perfect opportunity to improve environmental infrastructure appeared since Latvia has joined the European Union. A lot of new municipal waste water treatment plants are built thanks to Cohesion Fund co-financing.

By exception of the five major cities of the Rpublic of Latvia other cities have the number of population below 50 000 inhabitants [1]. Having examined over fifty design projects of municipal waste water treatment plants, the authors came to the conclusion that specific Latvian urban population distribution leads to urban waste water treatment plant (WWTP) concept unification in Latvia. The most part of Latvian WWTP implements the following technological processes:

- raw waste water intake;
- waste water pretreatment (screening and grit / sand separation);
- waste water aeration;
- waste water clarification;
- sludge dewatering;
- sludge drying beds;
- wastewater testing laboratory.

International Hazard Datasheet on Wastewater Treatment Plant Operator Occupation [2] encounters the following types of hazards:

- accident hazards;
- physical hazards;
- chemical hazards;
- biological hazards;
- ergonomic, psychosocial and organizational factors.

Latvian employment protection legislation [3] defines employer as the person, who is responsible for labour protection measures. Employer shall perform labour protection measures in accordance with such general principles as [3]:

- setting up of the work environment in such a way to avoid environmental risks or reduce them;
- preventing the causes of Working environment risks;
- taking into account technical, hygiene and medical developments;
- performing employee instruction and training in the field of labour protection.

Since the major part of Projects for waste water treatment plant construction in Latvia is being performed in accordance with FIDIC Yellow Book rules, project owners can substantially impact the designing and construction output by specifying all necessary conditions for working rooms and equipment.

Farther in this paper the two-sign-pointed observation of WWTP operational safety is made. Firstly Latvian WWTP designing and construction common practices are observed in operational safety layer. The operational safety aspects could be expressed in the following two general areas:

Designed and built-in operational safety aspect might be defined as construction structures and operational environment fitting to provide as high level of safety as possible. In order to provide the best understanding and implementation of safety rules and principles, the regular training and instruction of staff is required

II. WWTP Processes Observation

A. Sewage intake

The first technological process, performed on waste water treatment plant is waste water intake. Municipal sewage pipe network collects and delivers waste water from the city to WWTP. Since the waste water treatment plants are situated out the inhabited districts, wastewater should be transported there through the network of pumping stations. Finally, the intake water pumping station collects all the wastewater income before transmitting that to treatment processes. Because of input flow balancing, generally, WWTP intake pumping station has the bigger volume, then other pumping stations in the network.

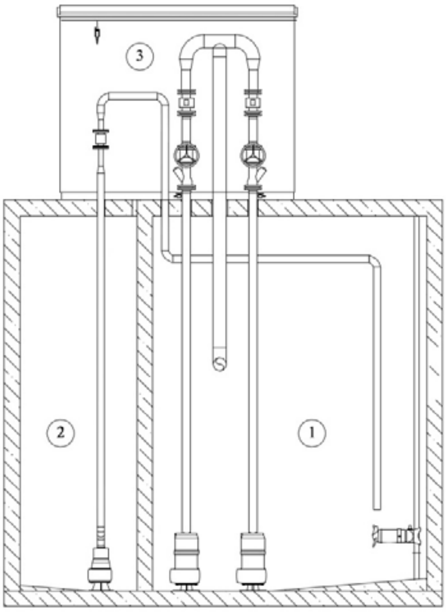

Fig.1. Intake station design sample [4]

There are two principal designs for a WWTP intake pumping station: built in pretreatment equipment structure or stand-alone pumping station.

Actually, safety issues for both of these designs are similar, therefore, we observe the case with stand-alone pumping station only. Such stations are placed either nearby WWTP general structures or somewhere in the city's lowest point to collect all the sewage and then transmit them to the pretreatment stage.There are wet pumps' chamber is usually used in medium and small Latvian cities [4].

As we can see on Figure 1, typical stand-alone intake waste water pumping station consists of inflow chamber (1), septic sludge intake chamber (2) and control and instrumentation above-curb structure (3).

The following machineries are used in the sewage intake pumping station chambers [5]:

- submersible sewage centrifugal pumps;
- submersible septic sludge pump;
- submersible sewage agitator;
- ultrasonic level sensors.

The following equipment is placed in the intake pumping station above-curb structure [5]:

- flow meters;
- display units of the level sensors;

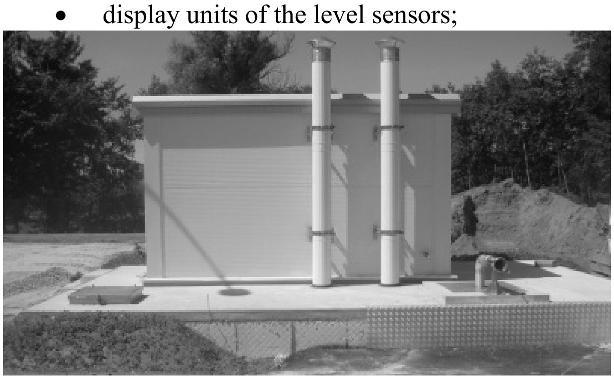
Fig. 2. WWTP sewage intake pumping station above-curb structure

- electrical controlling equipment (frequency invertors, HMI etc.);
- pipework fixtures.

As we can see on the Figure 2, sewage intake chamber and septic sludge intake chamber both are equipped with natural ventilation.

WWTP operator performs at least the following routine functions in sewage intake pumping station:

- monitors control panels and adjusts sewage pumps locally or by remote control to regulate flow of sewage;
- observes variations in operating conditions and interprets meter and gauge readings and tests results to determine load requirements;
- starts and stops intake sewage pumps to control flow of raw sewage through filtering, settling and aeration processes;
- collects inflowing sewage samples, using dipper or bottle to conduct laboratory tests;
- septic sludge reception from sewage truck operators;
- operates and maintains power-generating equipment in case of remote WWTP sewage intake pumping station remote situation.

Since municipal services do not have big staff in small Latvian cities, WWTP operators usually perform not only the activities of sewage worker, but also the functions of technical service specialists.:

- periodic cleaning of intake chambers;
- periodic cleaning of metering sensors;
- getting faulty pumps and mixers from intake chambers;
- checking electrical equipment condition

Because of the variety of duties WWTP operators in small Latvian cities are exposed to many occupational hazards. The following hazards are possible while processing intake pumping station maintenance:

- Falls in to inflow chamber or septic sludge intake chamber during visual inspection of pumps (accidental hazard);
- Slips and falls on floors made slippery by wastewater after pumps lifting to the control and instrumentation structure level, during septic sludge receiving from sewage trucks, or after floor washing (accidental hazard);
- Diseases caused by infectious agents present in the raw domestic wastewater (mainly from human origin), risk of poisoning (biological and chemical hazards);
- Electric shock caused by contact with faulty electrical equipment, cables, etc. (accidental hazard).

The hazards mentioned above could be avoided or, at least their risks could be strongly decreased, by using protective clothes, respirators, gasmasks, safety goggles, gloves, safety boots and safety strips. However there is one more very well-known hazard of psychological origin: discomfort and psychological problems related to prolonged wear of protective clothing [2].

Fig. 3. Sewage intake pumping station manholes

Further the possible changes in designing and construction as well as technical specifications for safety improvement are observed.

Falls in to sewage intake station chambers

Operational safety: wear securing straps before opening manholes for maintenance. Never perform such type of works alone. Two more persons should be assisting in the operations in the open manhole. So, in case one is fallen in, others could lift him upstairs to the ground level.

Designed and built-in safety: the absence of protective barriers around the manhole for the sewage pumps immersion into sewage pumping station wet chamber is a common negative practice of such kind of pumping station design.

This can be explained by the lack of the room because of small sewage intake pumping station above-curb structure (see Figure 3)

Thus, project owner should include into the technical specifications list for design and construction of WWTP structures the requirement to provide the protective barrier of certain construction around wastewater intake pumping station manholes.

- Slips and falls on floors made slippery by any wets

Since the above-curb structure is constructed above sewage pumping station wet chamber, the problem of glaze or clear ice does not persist while maintaining equipment. However, the risk persists during manual sewage sampling and after pumps lifting for service. Actually, modern floor coating technologies provide safe floor to avoid slips and falls on slippery floor. Effective floor drainage also helps to reduce slippery risks

- Risk of diseases caused by agents present in the raw domestic wastewater. Risk of poisoning.

The concentration of bio-aerosols in the wet chamber of sewage intake pumping station is frequently above the recommended values of occupational exposure [7]. Besides that, the aerosols extrusion into above-curb structure is performing while previous sewage network pumping station delivers wastewater to WWTP intake chamber.

Untreated domestic water normally contains group 1 biological agents according to the classification of Latvian Ministry of Welfare [11]. However, in case any disease epidemic is performed, the danger class of biological agents in the waste water can be risen up to class 3 according to the classification of Latvian Ministry of Welfare [11]. This paper is not aimed to evaluate outstanding “force majeure” situations, so only a case of standard waste water contaminants is studied.

Operational safety: wear protective masks to avoid bio-agent to enter the human organism via mucosal membranes and airways.

Management safety: All workers should undergo periodic examinations performed by occupational physician to reveal early symptoms of possible chronic effects or allergies caused by biological agents [2].

Designed and built-in safety: build in the chambers and structure ventilation channels automated ventilation fans. The fans should be actuated before staff entering the structures for equipment maintenance. This substantially reduces the concentration of bio-aerosols in the sewerage intake pumping station and normally lets the staff operate without heavy protection masks. The ventilation designed should provide the air flow velocity sufficient to blow bio-aerosols up to high atmospheric layers to decrease substantially the concentration and hazard of the ones [11].

- Electric shock caused by contact with faulty electrical equipment, cables, etc.

Operational safety: check electrical equipment for safety before use; verify that all electric cables are properly insulated; take faulty or suspect electrical equipment to a qualified electricity technician for testing and repair.

Designed and built-in safety: installing highly protected control cabinets could reduce the risk of automation devices failure because of corrosive evaporations from inlet wastewater. Extracting control box into separate room in the structure could bring even better effect, since the aggressive evaporations will not affect the electrical equipment and thus will not decrease the operational terms of them.

Project owner can increase WWTP operational safety for wastewater intake pumping station by simple including the above mentioned requirements into technical specifications for designers and constructors.

B. Waste water pretreatment, pre-conditioning and sludge dewatering

Good mechanical pretreatment of the waste water is important for protection of subsequent waste water treatment processes from clogging, stressing and abrasion. It is a necessaru precondition for reliable operation, with little wear and maintenance, of the entire plant. Mechanical pretreatment includes screens for removal of debris and other disturbing solids, grit traps for removal of mineral solids (stones, grit and sand) and grease traps for removal of fat, oil and grease. The main waste generated in a municipal waste water treatment plant is the wastewater sludge that is removed from mechanical, biological and chemical wastewater treatment processed. Chemicals for inflowing water pH-regulation and polyelectrolytes for sludge flocculation are used in the processes above mentioned.

The mechanical screens and aerated grit separators are generally used to pre-treat wastewater before aeration reactors. There are two different designs basically performed: combined equipment in one housing (fig.4) or separately installed screen (fig.5) and grit separator.

Fig. 4. Pretreatment equipment: mechanical screen and aerated grit separator

Sludge dewatering machines of different design are used in waste water treatment plants.

The hazards enumerated in pretreatment and sludge dewatering:

- Slips and falls on floors made slippery by spilled liquids (accidental hazard);
- Irritation of mucous membranes (in particular of the respiratory tract) by acid or alkaline vapors or aerosols, by hydrogen sulfide, and other substances during preparation chemical solutions (chemical hazard);
- Risk of diseases caused by agents present in the bio-aerosols generated via pretreatment and sludge dewatering (biological hazard);
- Electric shock caused by contact with faulty electrical equipment, cables, etc. (accidental hazard);
- Musculoskeletal injuries caused by overexertion while handling containers of chemicals, etc.

Let's observe the situation on each above mentioned risk.

- Slips and falls on floors made slippery by spilled liquids (accidental hazard).

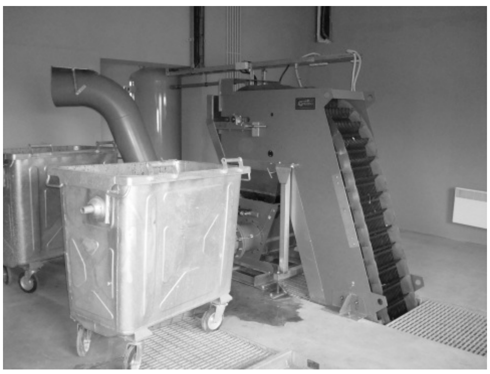

Fig. 5. Separate open pretreatment screen

Polyelectrolyte liquid concentrate is usually used in flocculent preparation for sludge dewatering. Awkward operation with container of concentrate can lead to liquid spilling on the floor. Polyelectrolyte concentrate is very lubricous, so, it should be collected and the rest of it should be flushed with the big quantity if water before continue any operations in the room.

Designed and built-in safety: the polyelectrolyte preparation machine with concentrate suction pump in order to avoid lifting and overturning the containers of concentrate into chemical preparation reservoir.

To prepare pH-regulating solutions the dry reagents are normally used, and the process seemed to be safer against slips. However, soda, for the instance, is supplied as hard crystals of spherical form, which, being poured on the floor, make it slippery as well as liquid substances.

- Irritation of mucous membranes (in particular of the respiratory tract) by acid or alkaline vapors or aerosols, by hydrogen sulfide, and other substances during preparation chemical solutions (chemical hazard);

Preparation of many chemicals is accompanied with evaporation or with suspended matter extrusion on air. Ventilation of consequent rooms could certainly decrease the risk, however really small particles expand over the accessed room anyway. Unfortunately, the only dependable way to protect staff is to wear goggles and respirators to avoid the malicious agents' ingression into human organism via mucous membranes.

Another good solution is to require avoidance of waste water treatment technologies using harmful reagents.

- Risk of diseases caused by agents present in the bio-aerosols generated via pretreatment and sludge dewatering.

Waste water pretreatment equipment in Latvia is placed in covered buildings because of air temperature fluctuations during the seasons. Thus, by exception of standard machinery hazards the hazard of bio-aerosols extremely increases. Studies of researchers in some European countries discovered that there is the higher concentration of hazardous bio-aerosols in the pretreatment structure, which usually comprises also sludge dewatering equipment [7], [8], [9]. Psychological hazard of wicked smell is also present [2].

Therefore carefully designed ventilation system is very important for pretreatment and sludge dewatering machinery placement structures [12].

- Electric shock caused by contact with faulty electrical equipment, cables, etc. (accidental hazard).

Waste water pretreatment equipment and sludge dewatering equipment is equipped with certain quantity of electrical drives. Controlling equipment units (control boxes) are standing separately and are connected to the motors with wires. Damaged electrical cables and damaged electrical equipment are the reasons for electrical shock.

Operational safety: check electrical equipment for safety before use; periodically verify that all electric cables are properly insulated; take faulty or suspect electrical equipment to a qualified electricity technician for testing and repair.

Designed and built-in safety: use automotive self-diagnostic equipment (frequency invertors with PLC, voltage leakage relays etc.) to drive and protect any electrical motors. Use plated cables during open installation in the pretreatment structure to avoid accidental mechanical damage of them.

- Musculoskeletal injuries caused by overexertion while handling containers of chemicals, etc.

Chemicals are used to condition water before aeration and while sludge dewatering. There are special machines used to prepare chemical solutions from dry or liquid concentrates. Concentrates are filled manually to these machines. The weight of concentrate container varies between 25 and 50 kg. Handling and especially lifting of such load manually can cause musculoskeletal injuries of the staff.

Latvian Cabinet of Ministers regulation No. 344 puts the responsibility of heavy loads movement on employer [13]. So, project owner should study the possibilities to increase heavy loads moving safety or to exclude it form technological process if possible.

To avoid lifting containers of liquid concentrate special suction pumps are used. To fill powder bunkers of dry concentrate the vacuum elevators could be used as well.

C. Aeration and clarification of waste water

Waste water aeration and clarification reservoirs are traditionally designed as open-air constructions without any roof. Aeration and clarification reservoirs are designed as concentric round construction. It means that there is no protection against the weather influence.

The following machineries are used in the aeration and clarification basins:

- submersible sewage centrifugal pumps;
- submersible sewage agitator;
- sediments scraper bridge for clarifier;
- ultrasonic level sensors.

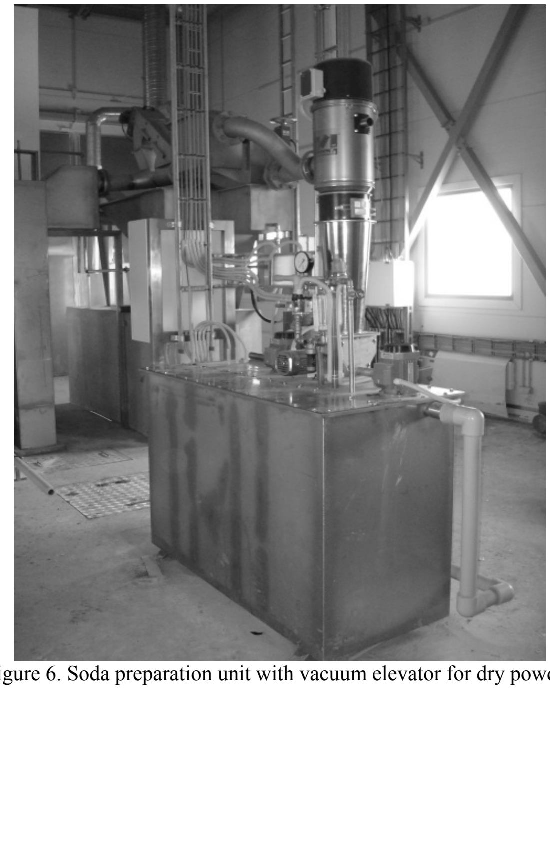

Figure 6. Soda preparation unit with vacuum elevator for dry powder

Figure 7. Combined aeration and clarification concentric reservoirs

Aeration air blowers are placed in separate room to restrict noise influence on workers.

The following hazards are possible while performing aeration and clarification maintenance:

- Falls in to aeration basin or clarification chamber (accidental hazard);
- Exposure to adverse weather (low or high temperature, rain, snow, storms, etc.) (physical hazard);
- Diseases caused by infectious agents present in the bio-aerosols, expanded from aeration basins (biological and hazards);
- Exposure to excessive noise levels from aeration blowers (physical hazard);
- Electric shock caused by contact with faulty electrical equipment, cables, etc. (accidental hazard).
- Falls in to aeration basin or clarification chamber.

Generally, the protective barriers are used to reduce risk of falling in the basins. Basin outer wall is at least 1.5 m higher then earth surface. These simple built-in measures effectively reduce risk of falls in to the open reservoirs.

- Exposure to adverse weather.

Operator should take regular readings form measurement instruments, placed in the aeration basin. Certain regulation of sludge circulation is needed as well.

Operational safety: employer should provide the staff personnel with protective wears corresponding to the season.

Designed safety: usage of remote control and monitoring aids.

Operator should be able to make measurements and operate equipment from conditioned control room.

- Diseases caused by infectious agents present in the bio-aerosols, expanded from aeration basins (biological and hazards).

The studies of several researchers indicate aeration basins as the biggest source of bio-aerosols [7], [8], [9]. However, the concentration of harmful bio-agents is lower, then in the intake chamber, or as in the pretreatment structure because of intensive dilution via continuous fresh air from around. No any additional protective designs or measures are needed.

- Exposure to excessive noise levels from aeration blowers.

Latvian employment protection legislation for Protection of Employees from the Risk Caused by the Noise in of the Working Environment indicates noise exposure level over 87 dB(A) as harmful and needed to be protected from [15]. The level of noise exposure of one 22 kW powered air blower with hood is approximately 73 dB(A) [16], [17]. The level of noise exposure of one 22 kW powered air blower without hood is approximately 100 dB(A) [16], [17].

Operational safety: avoid performing blowers without protective hood. Use hearing protective aids in case blowers are operated without hoods.

Designed safety: place air blowers in the separate noise-insulated room. Provide blower-room with good ventilation to avoid over-heating, since overheating is the main reason to operate blowers without hoods.

- Electric shock caused by contact with faulty electrical equipment, cables, etc.

Operational safety: check electrical equipment for safety before use; verify that all electric cables are properly insulated; take faulty or suspect electrical equipment to a qualified electricity technician for testing and repair.

Designed and built-in safety: placing motors controlling equipment in to separate controlling and distribution room. It is a good idea to collect all motor drives and contactors in the safe room having conditioned air. Separate room protects controlling equipment from any corrosive exposure of evaporations from aeration basins.

D. Sludge drying beds

Sludge drying beds are normally used to dry dewatered sludge. Sludge is transported from sludge dewatering unit in containers and poured on the bottom of the bed. Sludge is dried up to one year, that is why insects and rodents gain the habitation place there. So, besides slips and weather exposure, diseases caused by insects or rodents are additional risk expanded on the sludge drying beds.

E. Office building

Office building consists at least of the following rooms:

- Control room;
- WC;
- Shower room;
- Resting room;
- Laboratory;
- Locker room.

As some researches show [8], bio-aerosols settle on protective wears. It means that the operator brings potentially unsafe bio-agents entering the office rooms. To avoid that, it is recommended to establish separate room to un-wear protective and working wears and put them to washing machine. Then the operator through the shower room gets to the clean locker room. Such kind of a lock chamber substantially decreases the risk of secondary biological hazard.

According to Labour Protection Requirements in Workplaces [18], microclimate temperature in the room for category I (the work is not associated with physical efforts or requires very slight or slight physical efforts) work should be between +19°C and +25° in the cold time of the year and temperature frames for the warm time of the year is between +20°C and +28°. Obviously, heating and air conditioning equipment should be required in the office control rooms.

III. Conclusion

The authors of the paper observed about fifty design projects and pre-design specifications for waste water treatment plants in Latvia. No one of these pre-tender requirements has contained special occupational safety part, which could cover specifications required for designed constructions and equipment from the occupational safety opinion.

As we could see in the observation presented, designed and built-in safety significantly reduces risks of occupational hazards and the effect of them could serve the topic of separate research.

Authors would like to pay attention to the fact how simple it is to improve occupational safety by including several additions to pre-design specifications.

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Jeļena Sulojeva, Aleksejs Percovs, Jeļena Maļukova, Valentīna Urbāne. Darba drošības vadības aspekti sadzīves notekūdeņu attīrīšanas iekārtās
Jaunas municipālās notekūdeņu attīrīšanas stacijas tiek būvētas Latvijā ar Eiropas līdzfinansējumu. Jaunās modernās iekārtas prasa attiecīgu pieeju darba drošības nodrošināšanai. Šis dokuments parāda darba drošības paaugstināšanas aspektus uz dažu NAI projektu piemēriem, kas tiek īstenoti Latvijā. Notekūdens attīrīšanas staciju darba drošības situācija tiek apskatīta divos aspektos: darbības drošība un ieprojektētā drošība. Dokuments pārskata dažu NAI izbūves tenderu pasūtītāju prasības, Latvijas MK noteikumus, EU-OSHA materiālus, kā arī mediķu pētījumus NAI operatora darba risku jomā.
Šajā pētījumā tiek uzsvērti sekojoši darba drošības aspekti: ekspluatācijas drošība, kura ir atkarīga no personāla iemaņām, kā arī ieprojektētās un iebūvētās drošības, kura, pieņemot lēmumus uzlabot konstrukcijas un būvju ergonomiku, nodrošina drošu darba vidi, samazinot profesionālos riskus. Darba autori konstatēja, ka Latvijas pašvaldību notekūdeņu attīrīšanas sistēmu staciju projektēšanas un tehniskajās specifikācijās pilnībā trūkst speciālu prasību darba drošībai, kas turpmāk paredz nodrošināt drošu notekūdeņu staciju apkalpošanu.
Dokumenta autori uzstāj, lai normatīvos, kas regulē pašvaldību notekūdeņu attīrīšanas staciju projektu prasības, tiek iekļautas īpašas tehniskas prasības par ieprojektētu drošību.
Nobeigumā tiek sniegtas darba drošības paaugstināšanas rekomendācijas, precizējot projektu pasūtītāju prasības un veicot pasūtītāja (projekta īpašnieka) personāla apmācību darba drošībā. Autori rekomendē iekļaut projektā tehniskās prasības par ieprojektētu drošību kā neatņemamu sastāvdaļu katrā pašvaldību konkursā, kas paredz notekūdeņu attīrīšanas staciju projektēšanu un celtniecību.

Елена Сулоева, Алексей Перцов, Елена Малюкова, Валентина Урбане. Аспекты организации безорасности труда на муниципальных сооружениях очистки сточных вод
В Латвии с использованием Европейского софинансирования строятся новые станции очистки сточных вод.
Новое современное оборудование требует нового подхода к обеспечению безопасности труда.
Документ открывает аспекты повышения безопасности труда на вновь проектируемых станциях очистки сточных вод на примере некоторых реализуемых в Латвии проектов.
Безопасность труда на станциях очистки сточных вод рассмотрена в двух аспектах: безопасность работы и безопасность проектирования.
Данная работа рассматривает требования заказчиков по нескольким тендерам на строительство СОСВ, правила Кабинета министров Латвии, материалы EU-OSHA, а также результаты некоторых медицинских исследований в области рисков профессиональных заболеваний у работников СОСВ.
В этом исследовании выделяются следующие аспекты безопасности труда: эксплуатационная безопасность, которая как правило, зависит от навыков персонала, и запроектированная и встроенная безопасность, которая путём решений по улучшению конструкций и эргономики сооружений, обеспечивает более безопасные условия труда, уменьшая профессиональные риски.
Авторы работы обнаружили полное отсутствие в проектно-технических спецификациях станций очистки сточных вод латвийских самоуправлений специальных требований по защите труда, предназначенных обеспечить будущее безопасное обслуживание станций по очистки сточных вод.
Авторы документа настаивают на включении особых технических требований по встроенной безопасности в нормативы, регулирующие требования к муниципальным проектам станций очистки сточных вод.
В заключение приводятся рекомендации по повышению безопасности труда путём уточнения требований заказчиков по проектам и обучения по безопасности труда персонала заказчика (владельца проекта). Авторы рекомендуют включать технические требования по встроенной безопасности как непременный компонент в каждый муниципальный тендер на проектирование и строительство станций очистки сточных вод.