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INSTALLATION FOR TREATMENT OF LIQUID LLW RESULTED FROM DECONTAMINATION OF INDUSTRIAL FACILITIES IN CHERNOBYL REGIONS

Alexandre Grebenkov*, Antonina Verzhynskaja, Vitaly Troubnikov, Anatoly Dashouk
Institute of Power Engineering Problems, Minsk, Belarus

Alexander Tishounets
Ministry of Emergencies, Minsk, Belarus

Gennady Yakimchenko
POLESJE State Specialized Enterprise, Gomel, Belarus

ABSTRACT

The Chernobyl Accident caused significant contamination of ventilation systems in many industries located in the southern regions of Belarus exposed by radioactive fallout. The scale of practical decontamination of this equipment was limited in the absence of the relevant installations for treatment of the resulting radioactive waste. In 1998-1999, IPEP developed and built an experimental-industrial plant that enables to process and immobilize the liquid and solid LLW generated as a result of decontamination. Recently, shakedown and test run of this installation was accomplished. The results of test shows that the designed parameters of the employed technologies have been achieved and the plant can effectively treat the complex LLW containing acids, alkalis, detergents, oil-like suspensions, and other impurities characterizing the decontaminating agents used.

INTRODUCTION

In addition to the acute problems related to contamination of forests, agricultural lands and residential areas, the radioactive fallout from the exploded unit of Chernobyl Nuclear Power Plant has caused significant contamination of industrial equipment operated in the affected regions. This equipment mainly represents the large ventilation systems installed at different workshops. The ventilation facilities that collected radioactive dust and aerosols during operation for more than 10 years are now an immediate cause of additional radioactive exposure to the workshop personnel.

In order to ensure practical decontamination in Belarus two specialized enterprises, "POLESJE" and "RADON" were established. The scale of practical decontamination provided by these enterprises is limited because of lack of the relevant WM equipment and installations. Until recently, there was no technique for liquid radioactive waste treatment. This resulted in high cost of waste management activity and additional occupational exposure. The present study was performed to provide POLESJE Enterprise with necessary installation capable for treatment of liquid LLW to reduce its volume and immobilize radioactive liquids into a waste form suitable for further safe transportation and disposal.

CHARACTERISTICS OF TARGET LIQUID LLW

The liquid LLW arising from decontamination of large industrial ventilation systems are distinguished by (i) variation of specific activity ranging from 0.4 to 400 kBq/l, (ii) high variation of alkalinity and acidity, and (iii) different composition and structure that makes them difficult to segregate. The target radioactive liquids to be treated represent the decontamination solutions containing a wide variation of content of salts (including zincates and aluminates), acids, alkalis and ammonia nitrate. In addition, they contain detergents, surfactants, oil-like suspensions, and residues of rust and paint coats, *etc*. The radionuclides, particularly ^{137}Cs, are present in both the solid and the liquid phases. The main characteristics of the target waste are presented in Table I.

Table I. Characterization of liquid LLW to be treated

Waste Structure	Composition
Liquids with presence of solid polydisperse waste (paint coat, calx, rust, concrete crumbs, bits of plastic films, rags, *etc*.)	up to 10% wt of solid fractions
Saline wastes	1-200 kg/m^3
Detergents, surfactants, oil-like suspensions	up to 0.5 kg/m^3
Specific activity	up to 0.01 Ci/m^3

The annual volume of this liquid LLW currently generated in a medium size industrial company is about 50 tons. The number of such industries liable to decontamination is some hundreds only in Gomel Province, Belarus.

PROCESS SCHEME OF INSTALLATION

The complex content of the waste to be processed requires the functional scheme of installation to include several reliable and easy to operate technologies. The purpose is to segregate different waste flows, localize radionuclides, and reduce volume of the waste before disposal. The technologies used consist of the following components:

- sedimentation and coprecipitation,
- filtration,
- aeroflocculation flotation,
- evaporation,
- ionite and adsorption, and
- immobilization.

The process chart is shown in Fig. 1. The batch of waste is analyzed before treatment to determine physicochemical and radiological content. Such analysis is also performed after each technological stage to evaluate whether the next treatment stage is needed. The outlet-purified water is checked against the existing regulations and norms related to effluent discharge. The cementing quality control must be carried out before a final waste form is directed to repository.

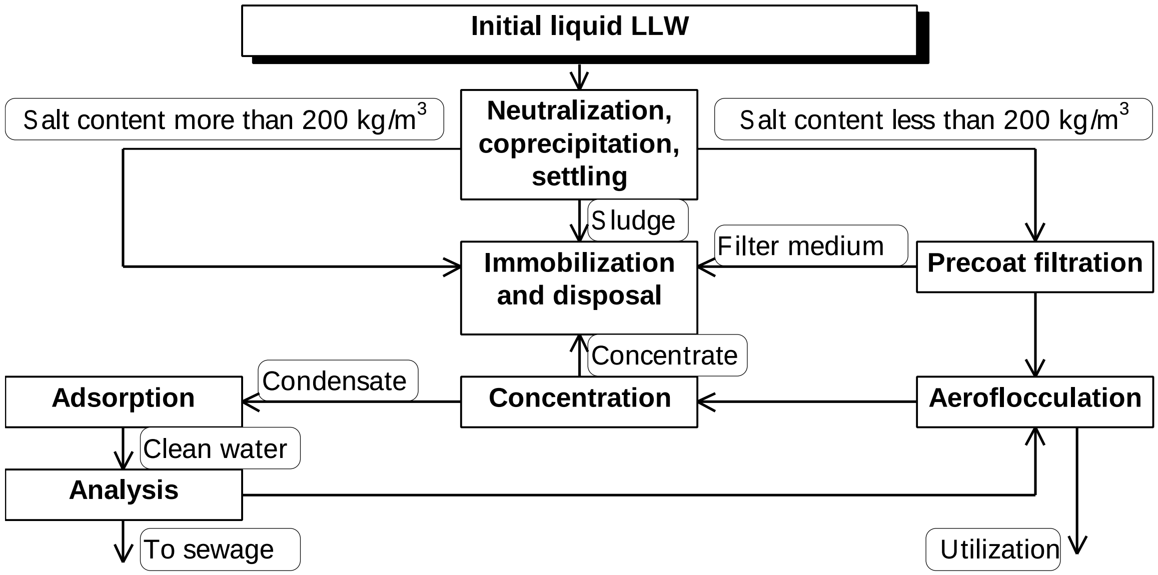

Fig. 1. Process chart

DESIGN AND TECHNICAL PARAMETERS

The functional scheme of the WM plant is shown in Fig. 2. The installation is arranged in three modules: batch intake and pretreatment module, concentration module, and immobilization module. The last module is to solidify the concentrates and sludge resulted from the liquid LLW treated in the former two modules. The intake module consisted of the receiving tanks, one input filter and three precoat coarse filters. The batch of the waste is preliminary cleared with the input filter to separate the big solid fragments, and then accumulated in the receiving tank. In the tank, the first stage of treatment is performed involving chemically neutralization of waste content, addition of necessary reagents for coprecipitation, partial defecation of the obtained solutions by settling, and further delivery of the resulting coarsely dispersed sludge into immobilization module by means of a mortar-pump. The clarified solutions containing also fine dispersed sludge are passed through the precoat sand filters and entered the concentration module. A vacuum system is used to transport the liquids between the different treatment stages. The concentration module consists of four elements:

- coalescing filter to collect some portion of oil-like suspensions,
- vacuum flotator to localize and bind detergents, surfactants, and oil-like suspensions,
- evaporator coupled with steam generator (patent pending) where the process of volume boiling is provided along with centrifugal separation, and
- two final filters with sorbent.

During this final stage, the waste stream is segregated into three flows: dense salt residues, organic suspensions (surfactants, oily emulsions), and condensate. The later, depending on the results of analysis, can either be returned back for additional treatment or be directed to sewage. The concentrated salt solution is pumped into the emptied receiving tank and then directed to immobilization module. The organic suspensions can be vitrified, if necessary, or disposed of. In some cases, they can be also immobilized.

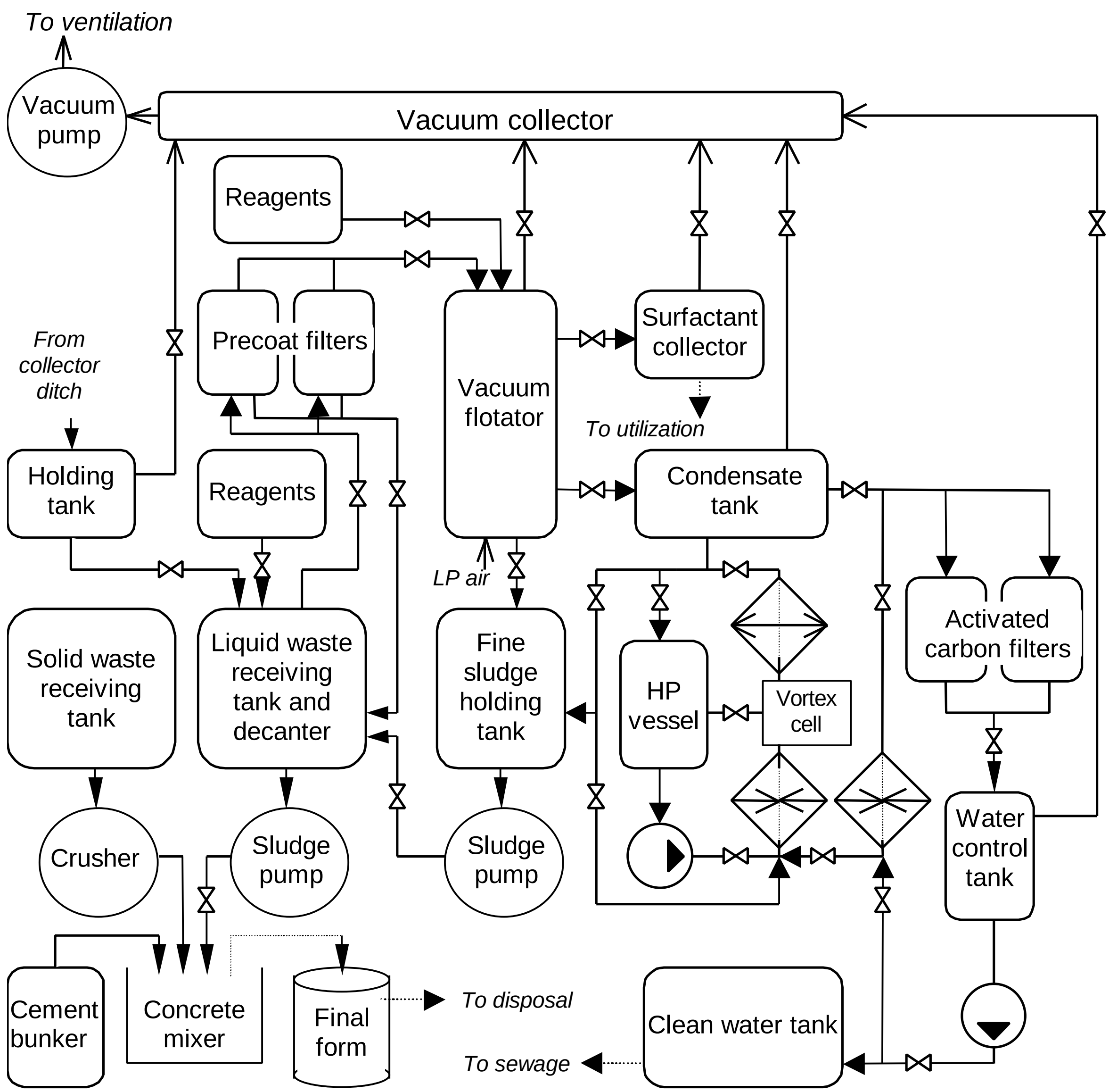

Fig. 2. Functional scheme of installation

RESULTS OF TEST TRIAL AND DISCUSSIONS

The above installation was designed and built by IPEP in cooperation with a number of Belarussian organizations and was commissioned at POLESJE State Specialized Enterprise in Gomel in December 1998. The maximal ^{137}Cs content in the target LLW is limited to 0.01 Ci/m^3. The planned capacity of the facility depends on the LLW treated and may reach 5000 liters per day.

Several test regimes were performed with different salt and surfactant content in the solutions of decontaminating agents. The parameters of the main components of installation were as follow:

- Batch volume of initial liquid LLW: 0.52 m^3
- Volume of liquid LLW arrived to vacuum flotator: 0.49 m^3
- Airflow rate through flotator: 12.2-12.5 $m^3h^{-1}m^{-2}$)
- Airflow head pressure: 0.2 bar
- Temperature in vortex cell: 112-120^{o}C
- Pressure in HP vessel: 2.05 bar
- Steam rate in condenser: 0.03 m^3/h

Some results of test treatment are presented in Table II. As one can assume form the data obtained, the reduction of surfactant content by a factor of 30 has been achieved, that assures a normative value of bio-active organic waste released to sewage. The purification efficiency of 99.9% has been achieved in terms of radionuclide and salt content during evaporation stage of treatment. The purified water, directed to sewage, contained the acceptable level of ^{137}Cs (less than 10^{-5} Ci/m^3) and normative value of salt content. The sludge and concentrated salts were imbedded in concrete matrix with the fill factor of about 0.32. The liquid waste volume reduction factor of 15 has been indicated.

Table II. Results of running-in test

Regime #	Surfactant concentration, g/m^3			Salt concentration, g/m^3		
	Initial	after 720 min	after 1440 min	Initial	after 30 min	after 120 min
I	0			103.8	0.76	0.19
IV	207.9	17.4	8.4	5.6	0.4	0.2
VIII	0			77.7	0.26	0.08
X	98.1	6.1	3.0	77.7	0.18	0.02

The facility, which is the first WM plant in Belarus, can be used both as an effective waste management installation and as a research tool. The further trials are planned (i) to optimize the process regimes, (ii) to investigate the efficiency of different reagents, and (iii) to test different matrix for immobilization (link to BNL-IPEP project under USDOE/IPP Program).

CONCLUSION

The wide variation of liquid LLW compositions derived from decontamination of industrial ventilation systems requires a flexible technological chain of treatment. The treatment plant installed in Gomel region, Belarus is designed to safely handle and condition this liquids into stabilized waste form. During the running-in test, the facility showed the expected results. The information obtained during construction and test of the present installation will be used to address the further development of efficient liquid LLW treatment facility(s) of a larger scale in Chernobyl regions.

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* phone: +375 17 246-7542, fax: +375 17 246-7055, e-mail: greb@sosny.bas-net.by