Treatment of Radioactive Liquid Waste by the Forced-Air Circulation System

Tae-Kuk Kim, Il-Sik Kang, Jong-Sik Shon, Young-Gerl Ryu, Won-Hyuk Jang, Sang-Min Bae, Young-Yong Ji, Dae-Seok Hong, Kyung-Kil Kwak
Korea Atomic Energy Research Institute, 1045 Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Korea
ntkkim@kaeri.re.kr

1. Introduction

This facility is a natural evaporation type with a forced exhaust having a vertical array of cloth as an evaporation bank. Synthetic textile was used as an evaporation medium with a forced air circulation system that brought air from the outside. In this system, liquid effluent flows down the vertical array, having a total area of 11,250 m^2. The intake of outdoor air through the air filter arises and flows into the bottom of the vertical array through exhaust fans at the top of the facility, contacting with the liquid stream counter currently, and discharging into the outdoors. In this experiment, we investigated the influence of climate condition (mainly atmospheric humidity and temperature) on the amount of evaporation in a Forced-Air Circulation System. We determined the range of atmospheric conditions using regional atmospheric data for the optimum operation of the facility.

Key Words: Radioactive Liquid Waste, Forced-Air Circulation System, Decontamination Factor.

2. Material and Methods

Constructed in concrete, the facility has four floors above ground and one floor underground, with a total area of 1150 m^2. There is a liquid effluent storage pool in the basement with a capacity of 960 m^3. The first floor consists of a room for drying sludge and a pump room. An evaporation zone is located from the second to the third floor, and in evaporation zone, there are 1040 cloth sheets 1 m × 5.4 m in size vertically arrayed. Liquid effluent is pumped up from the underground storage pool to a buffer tank on the first floor through a make-up pump (3HP, 15m^3/hr).A circulation pump (15HP, 120m^3/hr) supplies liquid effluent arising from the Radioactive Waste Treatment Facility (RWTF), which is mainly condensation from the evaporation process, or very low-level liquid waste that is treated using an ion exchanger.

The liquid effluent in the underground storage pool is pumped to the buffer tank, and the circulation pump supplies this effluent to the trough. The liquid effluent in the trough gravitationally flows down to the evaporation zone. The experiment applied the mentioned theory to a vertical evaporation surface.A forced-air circulation system produces a mass transfer of liquid at the Natural Evaporation Facility. In the treatment of radioactive liquid waste using a forced-air circulation system, the main variables that influencethe evaporation rate are natural and engineering variables.The natural variables are the temperature of the air and air humidity.The engineering variables are the interval and length of the evaporation media and the liquid waste supply flux. These are located inside the system's air speed distribution and in dead space.

The experiment used a direct, low level radioactive liquid waste and experimental devices were installed for the rectangular evaporation media cloth sheet. Evaporation occurring on the surface of the evaporation zone was due to the differences between the saturation vapor pressure of the liquid and the vapor pressure of the air.

3. Conclusion

The evaporation rate is the difference between air speed and vapor pressure. The difference in vapor pressure confirms the relationship between air humidity and liquid temperature. This study showed that the evaporation rate increased, and that when the humidity of air inflow is low, the speed of the air, temperature, and flux of the liquid waste also increases. As to the relative humidity of the supplied air, the evaporation rate increases as the relative humidity decreases.

Data were collected for humidity, temperature, and air velocity according to Dalton's evaporation equation.

$$E_h = (0.0168 + 0.0141\ V)\ \triangle H \quad (1)$$

As a result of the radioactivity from discharged air that went through the stack, the decontamination factor reached the standard at $1.1\times10^3 \sim 5.1\times10^3$. The radioactivity of the air released was ^{137}Cs and ^{60}Co, and the air out flow was $1.7\times10^{-2} \sim 1.7\times10^{-3}$ Bq/mℓ.The air was a standard amount of^{60}Co , less the air 7×10^6Bq/mℓ . air.

As a result of the experiments, the effective operating condition was above 5℃of relative humidity.

The optimal work conditions were determined while considering the weather conditions, and the evaporation processing capacity as 70% less than the humidity of the air inflow. The optimized evaporation conditions for the flux and temperature of the supplied liquid waste were 3.4 ℓ/hr.m^2, over 10℃and 1.14~1.47 m/sec. The maximum evaporation condition of the flux of the supplied liquid waste was 4.6 ℓ/hr, and the air speed was 1.47 m/sec

4. References

[1] K. BALU, S.C. BHATIA, Management of Radioactive Wastes, Bhabha Atomic Research Centre, Bombay(1979).

[2] T. Nejat Veziroglu "Alternative Energy Sources Ⅵ Vol 1. PP. 369~401.

[3] H.L.Penman, "Natural Evaporation from open water" , Proc. Roy., Soc., London, A, 1984.

[4] Welty, "Fundamentals of Momentum, Heat and Mass Transfer", John Wiley and sons Co.,PP.555-559, (1984).