Preventative Maintenance of Drainpipes in Radioisotope Facility Using Flexible Hose

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A flexible hose made of plasticized polyvinyl chloride was introduced into underground radioactive wastewater drainpipes as preventative maintenance. We completed a seamless connection spanning the longest interval between the last confluence point and the wastewater tank. Although the flexible hose is not a construction material but rather a consumable article, it is robust against the effects of temperature change and erosion by chemical substances. Moreover, it is placed in an underground steel pipe where it is protected from UV irradiation and friction. Therefore, increased hose durability is expected. In addition, the risk of damage from earthquakes or ground subsidence is negligible due to the flexibility of the hose. Compared with a full renovation of the plumbing, the economic cost is much cheaper and the construction period is much shorter. We propose the use of flexible hoses as one of the most convenient methods to prevent leakage accidents at radioisotope facilities with underground plumbing for wastewater.

Key words: flexible hose, maintenance, plumbing, wastewater, pipe fitting

1. Introduction

Problems arising from plumbing at radioisotope facilities have been cited often in recent official incident reports issued by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)1,2). Although recent guidelines recommend placing water tanks and plumbing structures in a visible space3), some older institutions still use underground plumbing and storage tanks for radioactive wastewater4,5).

Earthquakes as well as construction of new buildings near radioisotope facilities will affect the underground plumbing over time. In this context, regular inspection and review of wastewater facilities such as plumbing and reservoir tanks are necessary in order to test for leakage of wastewater. If leakage is detected, much work becomes necessary6), such as reporting, measurements, dose evaluation and data recording. Some of this work is based on legal requirements7) and thus cannot be postponed or left undone.

Therefore, we performed preventative maintenance on the underground drainpipes at our radioisotope facility. We introduced a flexible hose into the steel drainpipes. Specifically, we completed a seamless connection spanning the longest interval between the last confluence point and the wastewater tank.

2. Project description

2.1 Underground plumbing at the Institute of Radioisotope Research, St. Marianna University Graduate School of Medicine

The radiation-controlled area is located on the sixth floor of
the school building. Radioactive wastewater from the controlled area flows through five main steel pipes to a building outside. After descending from the sixth floor to the ground level, each of these pipes is connected with a drainage pit made of concrete that is buried just beneath ground level. From the five drainage pits, steel pipes lined with unplasticized polyvinyl chloride (PVC-U) follow two pathways underground (Pathway A and Pathway B) and connect to the first wastewater tank, as shown in Fig. 1.

The present renovation project consisted of three main parts:

1. Closing Pathway B (area indicated by dotted lines in Fig. 1) including drainage pits 1, 9 and 10, as well as a conventional septic reservoir (indicated by “R” in Fig. 1). Vertical pipes 1 and 2 (indicated “V1” and “V2” in Fig.1) are connected by a new PVC-U pipe at a height of 4 m above ground level.

2. Preventative maintenance of Pathway A via insertion of a flexible hose.

3. Closing drainage pits 2, 3 and 4 in Pathway A.

The first step is justified only after changing the purpose of radioisotope use at our facility, namely, abrogation of animal experiment in the radiation working room. This renovation required approval from the MEXT7), which we obtained before commencing construction for the renovation.

2.2 Flexible hose and fitting equipment

The primary task in the present maintenance is the introduction of the flexible hose, as shown in Fig. 2 by a photograph. The hose is made of plasticized polyvinyl chloride (PVC-P) with an outer diameter of 78.5 mm (Kanaline A, Kanaflex Co., Ltd., Roppongi, Japan). The soft body of the hose allows for flexibility and is surrounded by a PVC-U spiral (pitch: 14.3 mm) as shown in Fig. 3.

Although the outside of the hose has a spiral structure, the inside wall is quite smooth and does not impede the flow of water. The specifications of the hose are summarized in Table 1.

Since there is a variety in diameters of opening of the concrete drainage pits, the edge of the hose was connected with a
fitting equipment PVC-U eccentric increaser (CU INH, Aronkasei Co., Ltd., Shinagawa, Japan) as shown in Fig. 4. The pipe fitting equipment with a suitable diameter is fixed to drainage pit by using stainless steel screws and epoxy adhesive at each drainage pit.

3. Countermeasures and results of measurements

3.1 Radioactivity contamination inspections

Measurements of radioactivity were performed as part of mandated inspections for radioactivity contamination for Pathways A and B. After high-pressure washing, the surface concentration of radioactivity was measured by smear tests of the walls inside the drainage pits. The interior of the drainpipe was partly smeared except for areas that were out of reach. The radioactivity concentration was also measured in the washing drain water. Sludge was collected from the bottom of the conventional septic reservoir tank on Pathway B and was measured after drying on a small measurement plate at room temperature.

The permitted nuclides used at our institution are $^3$H, $^{14}$C, $^{32}$P, $^{35}$S, $^{45}$Ca, $^{51}$Cr and $^{125}$I. Liquid scintillation counter (LSC-3500, Aloka) was used for the detection of $\beta$-rays from $^3$H and $^{14}$C. A low-background gas-flow counter (LBC-472Q, Aloka) was used for the inspection of $\beta$-rays from $^{32}$P, $^{35}$S and $^{45}$Ca. The $\gamma$-ray spectrometry was used for the evaluation of the $\gamma$-rays from $^{51}$Cr and $^{125}$I by using a Ge(Li) detector (G7700, Seiko EG&G Ortec).

A total of 65 pieces of filter paper from smear tests, two lots of water samples and three plates of sludge specimen were subjected to radioactivity measurements. The radioisotope contamination was lower than the detection limit for all samples collected from Pathways A and B.

3.2 Water flow test

The hose between the upstream and downstream ends was inspected visually with a fiberscope. Then, a leakage test was performed by letting water flow through the hose. A total of 300 L of water was passed from drainage pit 14 (point “S” in Fig. 1) at a flow rate of 16–18 L/min. The volume of the retained water in the tank was measured by using a linear scale 5–8 min after turning off the water.

The initial time lag (ITL), that is, the time interval between turning on the water and the time when the water reaches the entrance of the waste tank, was also measured. We have performed leakage inspection for the drainpipe since 2003; thus, we compared the retention efficiency and ITL as measured in water flow tests before and after the present maintenance.

The time series of the observed retention efficiency is shown in Fig. 5. Two pathways were present before the renovation; thus, two series of results are shown. Before the renovation, the maximum and minimum values of water recovery for Pathway A were 109% and 94%, respectively. However, the retention efficiency has remained within the range of 100 ± 0.84% after the renovation.

The mean values of ITL before and after the renovation are summarized in Table 2. Before and after the renovation, the mean ± SD of ITL was 3.58 ± 0.88 min and 1.89 ± 0.18 min,

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**Table 1 Specification of hose “Kanaline A”**

<table>
<thead>
<tr>
<th>Size</th>
<th>Weight (g/m)</th>
<th>Operating temperature limit (°C)</th>
<th>Permissible pressure (MPa)</th>
<th>Elongation rate at 0.4 MPa (%)</th>
<th>Allowable bending radius (mm)</th>
<th>Decompression transformation temperature at-0.098 MPa (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>1260</td>
<td>−10~+50</td>
<td>0.490</td>
<td>15</td>
<td>270</td>
<td>60</td>
</tr>
</tbody>
</table>

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respectively. We found a statistically significant difference ($p < 0.01$) between the two means by using the $t$-test for two independent groups.

### 4. Discussion

Before the present maintenance, there were two underground pathways for the flow of wastewater, Pathways A and B, as shown in Fig. 1. The two pathways met at drainage pit 2 and then went to the wastewater tank. Since drainage pit 2 lacks a valve, it functions as a T-junction. Thus, before the closure of Pathway B, water from drainage pit 1 could flow to drainage pit 3 and water from drainage pit 3 could flow to drainage pit 1. As a result, the waiting interval after turning off the water before measuring the amount of water in the wastewater tank was subject to uncertainty in water flow tests to detect leakage from Pathway A or B. This might have resulted in the observed fluctuation of retention before the closure of Pathway B, as shown in Fig. 4. However, after closing Pathway B, the size of the fluctuation decreased. In addition, the mean of ITL showed a statistically significant decrease, as summarized in Table 2. Although these findings provide only indirect evidence of the benefits of the present maintenance, at a minimum, the results suggest that the smoothness of the present hose inside the pipes is equal to or greater than that of the steel pipe with PVC-U lining.

The flexible hose used in the present maintenance is robust against the effects of temperature change and erosion by chemical substances. Of course, its rigidity and strength are less than that of the steel drainpipe. However, the flexible hose is installed inside the steel drainpipe; thus, the risk of damage occurring due to earthquakes or ground subsidence is negligible even if a gap or a shift appeared in steel pipe junctions. Moreover, protection from UV irradiation, rain and friction beneath the ground will positively affect hose durability. Furthermore, the steel pipe is lined with a coating material, and thus there is no considerable

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**Table 2** Mean ITL (min) before and after renovation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean ± SD (n)</th>
<th>Probability</th>
</tr>
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<tbody>
<tr>
<td>Before</td>
<td>3.58 ± 0.88 (12)</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>After</td>
<td>1.89 ± 0.18 (6)</td>
<td></td>
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</tbody>
</table>

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Fig. 5  Time series of retention efficiency in water flow tests since 2003 for Pathway A (top) and Pathway B (bottom). Arrow indicates time that Pathway B was closed.
difference in the durability of the steel pipe with PVC-U lining and the present PVC-P hose with respect to acids or diluted alcohols resistance. The flexible hose, therefore, can serve as a suitable material for wastewater in a radioisotope facility if it is installed in a steel pipe.

At institutions using underground facilities for radioactive wastewater, a long period of time, possibly 25 years, has passed since the establishment of the controlled area. Moreover, ground subsidence9) and earthquakes10) frequently occur in Japan, which are necessary factors in long-term risk analysis of various facilities11). This means that the risk of accident due to aging drainpipes, drainage pits or fitting equipment likely has reached a considerable level.

A regular inspection procedure will detect leakage of wastewater from underground drainpipes. However, once a leakage is detected, it means an accident has already occurred. Although the present preventative maintenance requires approval from the MEXT, the preventative maintenance is much easier than taking action after an accident.

5. Conclusion

Renovations that include building new storage tanks and plumbing facilities will incur a large cost. In addition, such renovations may not be possible due to a lack of available space at the institution. Instead, we introduced a flexible hose into the steel drainpipes. Compared with a full renovation of the plumbing, the economic cost was lower and the construction period was much shorter. Considering its flexibility, this method will be quite advantageous for underground plumbing that will sometimes encounter ground subsidence.

References