

LINED EARTH RESERVOIRS FOR FIRE PROTECTION

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1.0 SCOPE

This document provides guidelines for the design, installation and maintenance of open reservoirs used for the storage of fire protection water.

1.1 Changes

July 2022. Interim revision. The new FM Global Worldwide Freeze Map has been developed and is available online at <https://www.fmglobal.com>. The map incorporates recent worldwide temperature data, but the key change is that the weather-related freeze hazard is now determined based on 100-year return period daily minimum temperature (100-year DMT) zones. The 100-year DMT differs from the temperature measure previously used (i.e., the lowest one-day mean temperature [LODMT]) to identify areas having a significant freeze hazard.

This data sheet is revised in parallel with Data Sheet 3-2, *Water Tanks for Fire Protection*, to adjust guidance as appropriate for use with the new 100-year DMT zones. Some editorial changes are made as well. Revisions include:

- Revised Recommendations 2.1.4 and 2.1.5

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Construction and Location

2.1.1 If the water level is to be near or above grade, a substantial earth dike is necessary. The dike should usually have a flat top at least 3 ft (1 m) wide, and sides which slope at about the angle of repose for the material. The exterior slope should be paved or loamed and grassed to prevent erosion.

On-site materials, unless silty, are usually satisfactory for the dike and the reservoir bottom. Sharp angular stones can rupture a fabric lining. This can be avoided by grading the bottom and interior slopes, and adding a layer of sand if necessary.

2.1.2 Lined earth reservoirs should be designed by a registered professional engineer. In active seismic areas he should be qualified in seismic design.

2.1.3 Reservoirs should be so located that the fire pump(s) take their suction under a head.

2.1.4 Where the 100-year return period daily minimum temperature (100-year DMT) zone is 20°F (-6.7°C) or colder, suction line(s) from the intake to the pump(s) should be located to avoid freezing, or exposed suction lines should be protected per Data Sheet 3-2, *Water Tanks for Fire Protection*, Section 2.2.6. 100-year DMT zones are shown in the FM Worldwide Freeze Map, available online at <https://www.fmglobal.com>. An overview of the worldwide map is shown in Data Sheet 3-2.

2.1.5 Where the 100-year DMT zone is -5°F (-20.6°C) or colder, an allowance should be made for loss of capacity due to ice. This allowance can be based on the maximum thickness of ice found on nearby ponds of similar size.

2.1.6 Floating covers should not be used. For information on embankment supported Fabric tanks, see Data Sheet 3-4, *Embankment-supported Fabric Tanks*.

2.1.7 A minimum 4-in. (100-mm) deep sump with drain should be provided.

2.1.8 A 12-in. (0.30-m) freeboard (above ice allowance) should be provided where the liner is supported by an embankment. A portland cement or asphalt concrete spillway should be provided at the bottom level of the freeboard.

2.1.9 A suction intake fitting should be provided, either a gooseneck or a vertical pipe with a vortex plate. Goosenecks should have a 1/8-in. (3-mm) diameter hole in the top to bleed air. Connection to the intake and drain fittings should pass through the bottom of the reservoir.

2.1.10 Fabric linings should be approximately 45 mils (1 mm) thick and reinforced. They should be anchored at the top of the interior slope of the reservoir. Intake and drain fittings should be designed to clamp the fabric against a concrete pad.

2.1.11 Asphalt plank and sheets should be installed in accordance with the manufacturer's specifications.

2.1.12 Clay additives to existing soil should be installed in accordance with specifications prepared for that site. The specifications should be written by a registered professional engineer.

2.1.13 Where the fire protection system is also supplied by a public water system see Data Sheet 3-3, *Cross Connections*.

2.2 Operation and Maintenance

2.2.1 Follow the inspection, testing and maintenance (ITM) guidance in Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance*. Some key items specific to lined earth reservoirs include:

- Remove sediment and inspect the liner at intervals not exceeding 5 years. Repair any leaks in the lining at that time.
- Reservoir slopes should be checked for erosion at least annually and repaired as required.
- The lining surface above water level should be coated to resist ultra-violet ray damage. This surface should be inspected annually and be repaired as necessary.

NFPA 22, *Water Tanks for Private Fire Protection*, does not cover open reservoirs.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General Comments

Where space is available it is sometimes economical to use an earth reservoir rather than the most conventional sprinkler tanks or concrete reservoirs.

Earth reservoirs may leak if the soil is pervious. Lining them with an impermeable material solves this problem. The material may be fabric, asphalt plank or sheet, asphalt paving, or a colloidal soil sealant.

Water may also be lost by surface evaporation, especially in dry climates. This loss can be reduced by films of fatty alcohol compounds. Floating covers of thin plastic have been used but are not advised. Removing and replacing such covers for yearly maintenance of the reservoir is difficult. Where evaporation is a problem, a tank may be the best solution.

Earth reservoirs are not normally heated, even in cold climates. Instead, an allowance is made for probable ice thickness in sizing the reservoirs.

Both asphalt plank and sheet asphalt linings may be installed without heavy equipment or skilled labor.

Earth reservoirs may also be lined with asphalt paving, or a colloidal soil sealant such as clay can be mixed with the in-place soil.

3.2 Illustrative Losses

The unreinforced rubber-like lining of a reservoir in Pennsylvania ruptured at the intake. Heavy rains had caused a void behind it.

A reservoir in Europe was abandoned after only three years because of deterioration of the lining. The 1/32-in. (0.8-mm) unreinforced lining failed at the seams and triangular ruptures developed.

4.0 REFERENCES

4.1 FM

Data Sheet 3-2, *Water Tanks for Fire Protection*

Data Sheet 3-3, *Cross Connections*

Data Sheet 3-4, *Embankment-supported Fabric Tanks*

4.2 NFPA Standards

NFPA 22, *Water Tanks for Private Fire Protection*.

APPENDIX A GLOSSARY OF TERMS

Fabric linings consist of plastic or rubber-like materials, usually with a nylon reinforcement. Thicknesses vary up to about $\frac{1}{16}$ in. (1.6 mm). They may be anchored at the top by clamping to a concrete footing, staking, or burying. Anchorage at the concrete base of the suction intake fitting may be by clamping.

Asphalt plank is a mixture of asphalt and a fibrous material, and is relatively thick (2 to 3 in.; 50 to 75 mm). It is laid with butted joints, which are then sealed with a tape embedded in hot asphalt.

Asphalt sheet is asphalt-impregnated felt. It is installed in layers, with either butted or lapped joints. Joints are sealed by taping.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

July 2022. Interim revision. The new FM Global Worldwide Freeze Map has been developed and is available online at <https://www.fmglobal.com>. The map incorporates recent worldwide temperature data, but the key change is that the weather-related freeze hazard is now determined based on 100-year return period daily minimum temperature (100-year DMT) zones. The 100-year DMT differs from the temperature measure previously used (i.e., the lowest one-day mean temperature [LODMT]) to identify areas having a significant freeze hazard.

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- Revised Recommendations 2.1.4 and 2.1.5

October 2021. Interim revision. Revised operation and maintenance recommendations in Section 2.2 to align them with the July 2021 revision of Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance*.

January 2000. This revision of the document has been reorganized to provide a consistent format.

In the September 1977 revision of this data sheet the following changes were made:

1. Reference to streams was deleted. Such practice is rare and should not be encouraged because of possible contamination of public water supplies.
2. The possibility of using colloidal soil sealants was recognized and recommendations added.
3. The recommended thickness for fabric liners has been decreased because of performance history.