

able to demonstrate knowledge of the use or operation of that equipment. Refresher training shall be conducted at least annually.

21.6.5.3 Planning of effective fire control measures shall be coordinated with local emergency response agencies and shall include, but not be limited to, the identification of all tanks by location, contents, size, and hazard identification as required in 21.7.2.1.

21.6.5.4 Procedures shall be established to provide for safe shutdown of tank storage facilities under emergency conditions and for safe return to service. These procedures shall provide requirements for periodic training of personnel and scheduled inspection and testing of associated alarms, interlocks, and controls.

21.6.5.5 Emergency procedures shall be kept available in an operating area. The procedures shall be reviewed and updated in accordance with 6.4.2.

21.6.5.6 Where tank storage facilities are unattended, a summary of the emergency plan shall be posted or located in a strategic location that is accessible to emergency responders.

21.6.6 Inspection and Maintenance of Fire Protection and Emergency Response Equipment.

21.6.6.1* All fire protection and emergency response equipment shall be maintained, inspected, and tested in accordance with regulatory requirements, standard practices, and equipment manufacturers' recommendations.

21.6.6.2 Maintenance and operating procedures and practices at tank storage facilities shall be established and implemented to control leakage and prevent spillage and release of ignitable (flammable or combustible) liquids.

21.6.6.3 Ground areas around tank storage facilities shall be kept free of weeds, trash, and other unnecessary combustible materials.

21.6.6.4 Accessways established for movement of personnel shall be maintained clear of obstructions to permit evacuation and access for manual fire fighting and emergency response in accordance with regulatory requirements and the emergency plan.

21.6.6.5 Combustible waste material and residues in operating areas shall be kept to a minimum, stored in covered metal containers, and disposed of daily.

21.6.6.6 Personnel responsible for the inspection and maintenance of fire protection and emergency response equipment shall be trained and shall be able to demonstrate knowledge of the inspection and maintenance of that equipment. Refresher training shall be conducted as needed to maintain proficiency.

21.7 Operation of Storage Tanks.

21.7.1* Prevention of Overfilling of Storage Tanks. Facilities with aboveground tanks larger than 1320 gal (5000 L) storing Class I or Class II liquids [FP < 140°F (60°C)] shall establish procedures or shall provide equipment, or both, to prevent overfilling of tanks.

21.7.1.1 Facilities with aboveground tanks that receive and transfer Class I liquids [FP < 100°F (37.8°C)] from mainline pipelines or marine vessels shall establish and follow formal

written procedures to prevent overfilling of tanks utilizing one of the following methods of protection:

- (1) Tanks shall be gauged at intervals in accordance with established procedures by personnel continuously on the premises during product receipt. Acknowledged communication shall be maintained with the supplier so flow can be shut down or diverted in accordance with established procedures.
- (2) Tanks shall be equipped with a high-level detection device that is either independent of any gauging equipment or incorporates a gauging and alarm system that provides electronic self-checking to indicate when the gauging and alarm system has failed. Alarms shall be located where personnel who are on duty throughout product transfer can arrange for flow stoppage or diversion in accordance with established procedures.
- (3) Tanks shall be equipped with an independent high-level detection system that will automatically shut down or divert flow in accordance with established procedures.

21.7.1.2 Alternatives to instrumentation described in 21.7.1.1(2) and 21.7.1.1(3) shall be allowed where approved as affording equivalent protection.

21.7.1.3 Instrumentation systems covered in 21.7.1.1(2) and 21.7.1.1(3) shall be wired fail-safe, such that valid alarm conditions or system failures create an alarm condition that will notify personnel or automatically shut down or divert flow.

21.7.1.3.1 Written instrumentation performance procedures shall be established to define valid alarm conditions and system failures in accordance with API 2350, *Overfill Protection for Storage Tanks in Petroleum Facilities*.

21.7.1.3.2 System failure shall include, but not be limited to, the following:

- (1) Loss of main electrical power
- (2) Electrical break, short circuit, or ground fault in the level detection system circuit or the alarm and signal circuit
- (3) Self-diagnostic features
- (4) Failure or malfunction of the level detection system control equipment or signaling devices

21.7.1.4 Formal written procedures required by 21.7.1.1 shall include the following:

- (1) Establishment of the maximum working, high-high, and critical-high alarm levels.
- (2) Response times required to allow operations to conduct an orderly shutdown in the event that an alarm indicates an imminent overfill.
- (3) Instructions covering methods to check for lineup and receipt of initial delivery to tank designated to receive shipment.
- (4) Provision for training and monitoring the performance of operating personnel by supervisors.
- (5) Schedules and procedures for inspection and testing of gauging equipment and high-level instrumentation and related systems. Inspection and testing intervals shall be approved but shall not exceed 1 year.

21.7.1.5 An underground tank shall be equipped with overfill prevention equipment that will either alert the transfer operator when the tank is no more than 90 percent full by triggering an audible and visual high-level alarm or automatically shut off the flow of ignitable (flammable or combustible) liquid into the tank when the tank is no more than 95 percent full.

21.7.1.5.1 Other methods of overfill protection shall be permitted as approved by the authority having jurisdiction.

21.7.1.6 Shop-fabricated aboveground atmospheric storage tanks, constructed to the recognized standards of 21.4.2.1.1, shall meet the requirements of 21.7.1.6.1 through 21.7.1.6.4 whenever the vertical length from the tank bottom to the top of the fill, normal vent, or emergency vent exceeds 12 ft (3.7 m).

21.7.1.6.1 An approved means shall be provided to notify the tank filling operator of the pending completion of the tank fill operation at the fill connection.

21.7.1.6.2 An approved means shall be provided to stop delivery of ignitable (flammable or combustible) liquid to the tank prior to the complete filling of the tank.

21.7.1.6.3 In no case shall these provisions restrict or interfere with the functioning of the normal vent or emergency vent.

21.7.1.6.4 The manufacturer of the tank shall be consulted to determine if reinforcement of the tank is required. If reinforcement is deemed necessary, it shall be done.

21.7.2 Identification and Security.

21.7.2.1 Identification for Emergency Responders. A sign or marking that meets the requirements of NFPA 704 or another approved system shall be applied to storage tanks containing ignitable (flammable or combustible) liquids. The marking shall be located where it can be seen, such as on the side of the tank, the shoulder of an accessway or walkway to the tank or tanks, or on the piping outside of the diked area. If more than one tank is involved, the markings shall be so located that each tank can be identified.

21.7.2.2* Security for Unsupervised Storage Tanks. Unsupervised, isolated aboveground storage tanks shall be secured and shall be marked to identify the fire hazards of the tank and the tank's contents to the general public. Where necessary to protect the tank from tampering or trespassing, the area where the tank is located shall be secured.

21.7.3 Storage Tanks in Areas Subject to Flooding.

21.7.3.1 Tank Loading.

21.7.3.1.1 The filling of a tank to be protected by water or product loading shall be started as soon as floodwaters are predicted to reach a dangerous flood stage.

△ **21.7.3.1.2** Where independently fueled pumps are relied on, sufficient fuel shall be available at all times to permit continuing operations until all tanks are filled.

△ **21.7.3.1.3** Tank valves shall be locked in a closed position when loading has been completed.

21.7.3.2 Operating Instructions. Operating instructions or procedures to be followed in a flood emergency shall be established and implemented by personnel identified in 21.7.3.3.

21.7.3.3 Personnel Training. Personnel responsible for activating and performing flood emergency procedures shall be trained in their implementation and shall be informed of the location and operation of valves and other controls and equipment necessary to effect the intent of these procedures. Personnel shall also be trained in the procedures required to place the facility back into service following a flood emergency.

21.7.4 Removal from Service of Storage Tanks.

21.7.4.1* Closure of Aboveground Storage Tanks. Aboveground tanks taken out of service or abandoned shall be emptied of ignitable (flammable or combustible) liquid, rendered vapor-free, and safeguarded against trespassing in accordance with NFPA 326 or in accordance with the requirements of the authority having jurisdiction.

△ **21.7.4.2 Reuse of Aboveground Storage Tanks.** Aboveground tanks shall be permitted to be reused for liquids service provided they comply with applicable sections of this code and are approved.

21.7.4.3 Removal from Service of Underground Storage Tanks.

21.7.4.3.1* General. Underground tanks taken out of service or abandoned shall be emptied of ignitable (flammable or combustible) liquid, rendered vapor-free, and safeguarded against trespassing in accordance with this section and in accordance with NFPA 326 or the requirements of the authority having jurisdiction. The procedures outlined in this section shall be followed when taking underground tanks temporarily out of service, closing them in place permanently, or removing them.

21.7.4.3.2 Temporary Closure. Underground tanks shall be rendered temporarily out of service only when it is planned that they will be returned to active service, closed in place permanently, or removed within an approved period not exceeding 1 year. The following requirements shall be met:

- (1) Corrosion protection and release detection systems shall be maintained in operation.
- (2) The vent line shall be left open and functioning.
- (3) The tank shall be secured against tampering.
- (4) All other lines shall be capped or plugged.

21.7.4.3.2.1 Tanks remaining temporarily out of service for more than 1 year shall be permanently closed in place or removed in accordance with 21.7.4.3.3 or 21.7.4.3.4, as applicable.

△ **21.7.4.3.3 Permanent Closure in Place.** Underground tanks shall be permitted to be permanently closed in place if approved by the authority having jurisdiction. All of the following requirements shall be met:

- (1) All applicable authorities having jurisdiction shall be notified.
- (2)* A safe workplace shall be maintained throughout the prescribed activities.
- (3) All liquids and residues shall be removed from the tank, appurtenances, and piping and shall be disposed of in accordance with regulatory requirements and industry practices, using a written procedure.
- (4) The tank, appurtenances, and piping shall be made safe by either purging them of flammable vapors or inerting the potential explosive atmosphere. Confirmation that the atmosphere in the tank is safe shall be by testing of the atmosphere using a combustible gas indicator if purging, or an oxygen meter if inerting, at intervals in accordance with written procedures.
- (5) Access to the tank shall be made by careful excavation to the top of the tank.
- (6) All exposed piping, gauging and tank fixtures, and other appurtenances, except the vent, shall be disconnected and removed.

- (7) The tank shall be completely filled with an inert solid material.
- (8) The tank vent and remaining underground piping shall be capped or removed.
- (9) The tank excavation shall be backfilled.

21.7.4.3.4 Removal and Disposal. Underground tanks and piping shall be removed in accordance with the following requirements:

- (1) The steps described in 21.7.4.3.3(1) through 21.7.4.3.3(5) shall be followed.
- (2) All exposed piping, gauging and tank fixtures, and other appurtenances, including the vent, shall be disconnected and removed.
- (3) All openings shall be plugged, leaving a ¼ in. (6 mm) opening to avoid buildup of pressure in the tank.
- (4) The tank shall be removed from the excavated site and shall be secured against movement.
- (5) Any corrosion holes shall be plugged.
- (6) The tank shall be labeled with its former contents, present vapor state, vapor-freeing method, and a warning against reuse.
- (7) The tank shall be removed from the site as authorized by the authority having jurisdiction, preferably the same day.

21.7.4.3.5 Temporary Storage of Removed Tanks. If it is necessary to temporarily store an underground tank that has been removed, it shall be placed in a secure area where public access is restricted. A ¼ in. (6 mm) opening shall be maintained to avoid buildup of pressure in the tank.

21.7.4.3.6 Disposal of Tanks. Disposal of underground tanks shall meet the following requirements:

- (1) Before a tank is cut up for scrap or landfill, the atmosphere in the tank shall be tested in accordance with 21.7.4.3.3(4) to ensure that it is safe.
- (2) The tank shall be made unfit for further use by cutting holes in the tank heads and shell.

21.7.4.3.7 Documentation. All necessary documentation shall be prepared and maintained in accordance with all federal, state, and local rules and regulations.

Δ 21.7.4.3.8 Reuse of Underground Storage Tanks. Underground tanks shall be permitted to be reused for underground storage of liquids provided they comply with applicable sections of this code and are approved.

21.7.5* Leak Detection and Inventory Records for Underground Storage Tanks. Accurate inventory records or a leak detection program shall be maintained on all Class I liquid [FP < 100°F (37.8°C)] storage tanks for indication of leakage from the tanks or associated piping.

21.8 Inspection and Maintenance of Storage Tanks and Storage Tank Appurtenances.

21.8.1* Each storage tank constructed of steel shall be inspected and maintained in accordance with API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*, or STI SP001, *Standard for the Inspection of Aboveground Storage Tanks*, whichever is applicable.

21.8.2 Each storage tank constructed of other materials shall be inspected and maintained in accordance with the manufacturer's instructions and applicable standards to ensure compliance with the requirements of this code.

21.8.3 Testing of storage tanks shall meet the requirements of Section 21.5.

21.8.4 Each storage tank shall be maintained liquidtight. Each storage tank that is leaking shall be emptied of ignitable (flammable or combustible) liquid or repaired in a manner acceptable to the authority having jurisdiction.

21.8.5 Each storage tank that has been structurally damaged, repaired, reconstructed, relocated, jacked, or damaged by impact, flood, or other trauma, or is suspected of leaking shall be inspected and tested in accordance with Section 21.5 or in a manner acceptable to the authority having jurisdiction.

21.8.6* Storage tanks and their appurtenances, including normal vents, emergency vents, overflow prevention devices, and related devices, shall be inspected and maintained to ensure that they function as intended in accordance with written procedures.

21.8.7 Openings for gauging on storage tanks storing Class I liquids [FP < 100°F (37.8°C)] shall be provided with a vapor-tight cap or cover. Such covers shall be closed when not gauging.

21.8.8* Facilities with aboveground storage tanks shall establish and implement a procedure to check for and remove water from the bottom of storage tanks that contain nonmiscible ignitable (flammable or combustible) liquids.

21.9 Change of Stored Liquid. Storage tanks that undergo any change of stored liquid shall be re-evaluated for compliance with Chapters 21 through 25, as applicable.

Chapter 22 Storage of Ignitable (Flammable or Combustible) Liquids in Tanks — Aboveground Storage Tanks

Δ 22.1 Scope. This chapter shall apply to the following:

- (1) The storage of liquids, as defined in 3.3.34 and Chapter 4, in fixed tanks that exceed 60 gal (230 L) capacity
- (2) The storage of liquids in portable tanks that exceed 660 gal (2500 L) capacity
- (3) The storage of liquids in intermediate bulk containers that exceed 793 gal (3000 L)
- (4) The design, installation, testing, operation, and maintenance of such tanks, portable tanks, and bulk containers

22.2 Definitions Specific to Chapter 22. For the purpose of this chapter, the terms in this section shall have the definitions given.

Δ 22.2.1 Fire-Resistant Tank. An atmospheric aboveground storage tank with thermal insulation that has been evaluated for resistance to physical damage and for limiting the heat transferred to the primary tank when exposed to a hydrocarbon fuel fire and is listed in accordance with UL 2080, *Fire Resistant Tanks for Flammable and Combustible Liquids*, or an equivalent test procedure.

22.2.2 Floating Roof Tank. An aboveground storage tank that incorporates one of the following designs:

- (1) A closed-top pontoon or double-deck metal floating roof in an open-top tank constructed in accordance with API Standard 650, *Welded Steel Tanks for Oil Storage*
- (2) A fixed metal roof with ventilation at the top and roof eaves constructed in accordance with API Standard 650 and containing a closed-top pontoon or double-deck

metal floating roof meeting the requirements of API Standard 650

- (3) A fixed metal roof with ventilation at the top and roof eaves constructed in accordance with API Standard 650 and containing a metal floating cover supported by liquidtight metal floating devices that provide buoyancy to prevent the liquid surface from being exposed when half of the flotation is lost

22.2.2.1 For the purposes of this chapter, an aboveground storage tank with an internal metal floating pan, roof, or cover that does not meet 22.2.2 or one that uses plastic foam (except for seals) for flotation, even if encapsulated in metal or fiberglass, shall meet the requirements for a fixed roof tank.

Δ 22.2.3 Protected Aboveground Tank. An atmospheric aboveground storage tank with integral secondary containment and thermal insulation that has been evaluated for resistance to physical damage and for limiting the heat transferred to the primary tank when exposed to a hydrocarbon pool fire and is listed in accordance with UL 2085, *Protected Aboveground Tanks for Flammable and Combustible Liquids*, or an equivalent test procedure.

Δ 22.3 General Requirements. Storage of Class II and Class III liquids [FP ≥ 100°F (37.8°C)] heated at or above their FP shall follow the requirements for Class I liquids [FP < 100°F (37.8°C)], unless an engineering evaluation conducted in

accordance with Chapter 6 justifies following the requirements for some other liquid class.

22.4* Location of Aboveground Storage Tanks.

22.4.1 Location with Respect to Property Lines, Public Ways, and Important Buildings.

22.4.1.1 Tanks storing Class I, Class II, or Class IIIA stable liquids [FP < 200°F (93°C)] whose internal pressure is not permitted to exceed a gauge pressure of 2.5 psi (17 kPa) shall be located in accordance with Table 22.4.1.1(a) and Table 22.4.1.1(b). Where tank spacing is based on a weak roof-to-shell seam design, the user shall present evidence certifying such construction to the authority having jurisdiction upon request.

22.4.1.2 Vertical tanks with weak roof-to-shell seams (*see* 22.7.2) that store Class IIIA liquids [140°F (60°C) ≤ FP < 200°F (93°C)] shall be permitted to be located at one-half the distances specified in Table 22.4.1.1(a), provided the tanks are not within the same diked area as, or within the drainage path of, a tank storing a Class I or Class II liquid [FP < 140°F (60°C)].

22.4.1.3 Tanks storing Class I, Class II, or Class IIIA stable liquids [FP < 200°F (93°C)] and operating at pressures that exceed a gauge pressure of 2.5 psi (17 kPa), or are equipped with emergency venting that will permit pressures to exceed a gauge pressure of 2.5 psi (17 kPa), shall be located in accordance with Table 22.4.1.3 and Table 22.4.1.1(b).

Δ Table 22.4.1.1(a) Location of Aboveground Storage Tanks Storing Stable Liquids — Internal Pressure Not to Exceed a Gauge Pressure of 2.5 psi (17 kPa)

Type of Tank	Protection	Minimum Distance (ft)	
		From Property Line That Is or Can Be Built Upon, Including the Opposite Side of a Public Way ^a	From Nearest Side of Any Public Way or from Nearest Important Building on the Same Property ^a
Floating roof	Protection for exposures ^b	$\frac{1}{2} \times$ diameter of tank	$\frac{1}{6} \times$ diameter of tank
	None	Diameter of tank but need not exceed 175 ft	$\frac{1}{6} \times$ diameter of tank
Vertical with weak roof-to-shell seam	Approved foam or inerting system ^c on tanks not exceeding 150 ft in diameter ^d	$\frac{1}{2} \times$ diameter of tank	$\frac{1}{6} \times$ diameter of tank
	Protection for exposures ^b	Diameter of tank	$\frac{1}{3} \times$ diameter of tank
	None	2 × diameter of tank but need not exceed 350 ft	$\frac{1}{3} \times$ diameter of tank
Horizontal and vertical tanks with emergency relief venting to limit pressures to 2.5 psi (gauge pressure of 17 kPa)	Approved inerting system ^c on the tank or approved foam system on vertical tanks	$\frac{1}{2} \times$ value in Table 22.4.1.1(b)	$\frac{1}{2} \times$ value in Table 22.4.1.1(b)
	Protection for exposures ^b	Value in Table 22.4.1.1(b)	Value in Table 22.4.1.1(b)
	None	2 × value in Table 22.4.1.1(b)	Value in Table 22.4.1.1(b)
Protected above ground tank	None	$\frac{1}{2} \times$ value in Table 22.4.1.1(b)	$\frac{1}{2} \times$ value in Table 22.4.1.1(b)

For SI units, 1 ft = 0.3 m.

^aThe minimum distance cannot be less than 5 ft (1.5 m).

^bSee definition 3.3.46, Protection for Exposures.

^cSee NFPA 69.

^dFor tanks over 150 ft (45 m) in diameter, use "Protection for Exposures" or "None," as applicable.

Table 22.4.1.1(b) Reference Table for Use with Tables 22.4.1.1(a), 22.4.1.3, and 22.4.1.5

Tank Capacity (gal)	Minimum Distance (ft)	
	From Property Line that Is or Can Be Built Upon, Including the Opposite Side of a Public Way	From Nearest Side of Any Public Way or from Nearest Important Building on the Same Property
275 or less	5	5
276 to 750	10	5
751 to 12,000	15	5
12,001 to 30,000	20	5
30,001 to 50,000	30	10
50,001 to 100,000	50	15
100,001 to 500,000	80	25
500,001 to 1,000,000	100	35
1,000,001 to 2,000,000	135	45
2,000,001 to 3,000,000	165	55
3,000,001 or more	175	60

For SI units, 1 ft = 0.3 m; 1 gal = 3.8 L.

Table 22.4.1.3 Location of Aboveground Storage Tanks Storing Stable Liquids — Internal Pressure Permitted to Exceed a Gauge Pressure of 2.5 psi (17 kPa)

Type of Tank	Protection	Minimum Distance (ft)	
		From Property Line that Is or Can Be Built Upon, Including the Opposite Side of a Public Way	From Nearest Side of Any Public Way or from Nearest Important Building on the Same Property
Any type	Protection for exposures*	$1\frac{1}{2} \times$ value in Table 22.4.1.1(b) but not less than 25 ft	$1\frac{1}{2} \times$ value in Table 22.4.1.1(b) but not less than 25 ft
	None	$3 \times$ value in Table 22.4.1.1(b) but not less than 50 ft	$1\frac{1}{2} \times$ value in Table 22.4.1.1(b) but not less than 25 ft

For SI units, 1 ft = 0.3 m.

*See definition 3.3.46, Protection for Exposures.

22.4.1.4 Tanks storing ignitable (flammable or combustible) liquids with boil-over characteristics shall be located in accordance with Table 22.4.1.4. Liquids with boil-over characteristics shall not be stored in fixed roof tanks larger than 150 ft (45 m) in diameter, unless an approved inerting system is provided on the tank.

22.4.1.5 Tanks storing unstable liquids shall be located in accordance with Table 22.4.1.5 and Table 22.4.1.1(b).

22.4.1.6 Tanks storing Class IIIB stable liquids [FP \geq 200°F (93°C)] shall be located in accordance with Table 22.4.1.6.

Exception: If located within the same diked area as, or within the drainage path of, a tank storing a Class I or Class II liquid [FP < 140°F (60°C)], the tank storing Class IIIB liquid [FP \geq 200°F (93°C)] shall be located in accordance with 22.4.1.1.

22.4.1.7 Where two tank properties of diverse ownership have a common boundary, the authority having jurisdiction shall be permitted, with the written consent of the owners of the two properties, to substitute the distances provided in 22.4.2 for the minimum distances set forth in 22.4.1.1.

22.4.1.8 Where end failure of a horizontal pressure tank or vessel can expose property, the tank or vessel shall be placed

with its longitudinal axis parallel to the nearest important exposure.

22.4.2 Shell-to-Shell Spacing of Adjacent Aboveground Storage Tanks.

22.4.2.1* Tanks storing Class I, Class II, or Class IIIA stable liquids [FP < 200°F (93°C) and any BP] shall be separated by the distances given in Table 22.4.2.1.

22.4.2.1.1 Tanks that store crude petroleum, have individual capacities not exceeding 3000 bbl [126,000 gal (480 m³)], and are located at production facilities in isolated locations shall not be required to be separated by more than 3 ft (0.9 m).

22.4.2.1.2 Tanks used only for storing Class IIIB liquids [FP \geq 200°F (93°C)] shall not be required to be separated by more than 3 ft (0.9 m) provided they are not within the same diked area as, or within the drainage path of, a tank storing a Class I or Class II liquid [FP < 140°F (60°C)]. If located within the same diked area as, or within the drainage path of, a tank storing a Class I or Class II liquid [FP < 140°F (60°C)], the tank storing Class IIIB liquid [FP \geq 200°F (93°C)] shall be spaced in accordance with the requirements for Class IIIA liquids [140°F (60°C) \leq FP < 200°F (93°C)] in Table 22.4.2.1.

Table 22.4.1.4 Location of Aboveground Storage Tanks Storing Boil-Over Ignitible (Flammable or Combustible) Liquids

Type of Tank	Protection	Minimum Distance (ft)	
		From Property Line that Is or Can Be Built Upon, Including the Opposite Side of a Public Way ^a	From Nearest Side of Any Public Way or from Nearest Important Building on the Same Property ^a
Floating roof	Protection for exposures ^b	$\frac{1}{2} \times$ diameter of tank	$\frac{1}{6} \times$ diameter of tank
	None	Diameter of tank	$\frac{1}{6} \times$ diameter of tank
Fixed roof	Approved foam or inerting system ^c	Diameter of tank	$\frac{1}{3} \times$ diameter of tank
	Protection for exposures ^b	$2 \times$ diameter of tank	$\frac{2}{3} \times$ diameter of tank
	None	$4 \times$ diameter of tank but need not exceed 350 ft	$\frac{2}{3} \times$ diameter of tank

For SI units, 1 ft = 0.3 m.

^aThe minimum distance cannot be less than 5 ft.^bSee definition 3.3.46, Protection for Exposures.^cSee NFPA 69.**Table 22.4.1.5 Location of Aboveground Storage Tanks Storing Unstable Liquids**

Type of Tank	Protection	Minimum Distance (ft)	
		From Property Line that Is or Can Be Built Upon, Including the Opposite Side of a Public Way	From Nearest Side of Any Public Way or from Nearest Important Building on the Same Property ^a
Horizontal and vertical tanks with emergency relief venting to permit pressure not in excess of a gauge pressure of 2.5 psi (17 kPa)	Tank protected with any one of the following: approved water spray, approved inerting, ^a approved insulation and refrigeration, approved barricade	Value in Table 22.4.1.1(b) but not less than 25 ft	Not less than 25 ft
	Protection for exposures ^b	$2\frac{1}{2} \times$ value in Table 22.4.1.1(b) but not less than 50 ft	Not less than 50 ft
	None	$5 \times$ value in Table 22.4.1.1(b) but not less than 100 ft	Not less than 100 ft
Horizontal and vertical tanks with emergency relief venting to permit pressure over a gauge pressure of 2.5 psi (17 kPa)	Tank protected with any one of the following: approved water spray, approved inerting, ^a approved insulation and refrigeration, approved barricade	$2 \times$ value in Table 22.4.1.1(b) but not less than 50 ft	Not less than 50 ft
	Protection for exposures ^b	$4 \times$ value in Table 22.4.1.1(b) but not less than 100 ft	Not less than 100 ft
	None	$8 \times$ value in Table 22.4.1.1(b) but not less than 150 ft	Not less than 150 ft

For SI units, 1 ft = 0.3 m.

^aSee NFPA 69.^bSee definition 3.3.46, Protection for Exposures.

Table 22.4.1.6 Location of Aboveground Storage Tanks Storing Class IIIB Liquids [FP ≥ 200°F (93°C)]

Tank Capacity (gal)	Minimum Distance (ft)	
	From Property Line that Is or Can Be Built Upon, Including the Opposite Side of a Public Way	From Nearest Side of Any Public Way or from Nearest Important Building on the Same Property
12,000 or less	5	5
12,001 to 30,000	10	5
30,001 to 50,000	10	10
50,001 to 100,000	15	10
100,001 or more	15	15

For SI units, 1 ft = 0.3 m; 1 gal = 3.8 L.

22.4.2.2 A tank storing unstable liquid shall be separated from any other tank containing either an unstable liquid or a Class I, Class II, or Class III liquid (any FP or BP) by a distance not less than one-half the sum of their diameters.

22.4.2.3 Where tanks are in a diked area containing Class I or Class II liquids [FP < 140°F (60°C)] or in the drainage path of Class I or Class II liquids [FP < 140°F (60°C)] and are compacted in three or more rows or in an irregular pattern, greater spacing or other means shall be permitted to be required by the authority having jurisdiction to make tanks in the interior of the pattern accessible for fire-fighting purposes.

22.4.2.4 The minimum horizontal separation between an LP-Gas container and a Class I, Class II, or Class IIIA [FP < 200°F (93°C)] liquid storage tank shall be 20 ft (6 m).

22.4.2.4.1 Means shall be provided to prevent Class I, Class II, or Class IIIA liquids [FP < 200°F (93°C)] from accumulating under adjacent LP-Gas containers by means of dikes, diversion curbs, or grading.

22.4.2.4.2 Where liquid storage tanks are within a diked area, the LP-Gas containers shall be outside the diked area and at least 10 ft (3 m) away from the centerline of the wall of the diked area.

22.4.2.5 If a tank storing a Class I, Class II, or Class IIIA liquid [FP < 200°F (93°C)] operates at pressures exceeding a gauge pressure of 2.5 psi (17 kPa) or is equipped with emergency relief venting that will permit pressures to exceed a gauge pressure of 2.5 psi (17 kPa), it shall be separated from an LP-Gas container by the appropriate distance given in Table 22.4.2.1.

22.4.2.6 The requirements of 22.4.2.4 shall not apply where LP-Gas containers of 125 gal (475 L) or less capacity are installed adjacent to fuel oil supply tanks of 660 gal (2500 L) or less capacity.

22.5 Installation of Aboveground Storage Tanks.

22.5.1 Tank Supports.

22.5.1.1 Tank supports shall be designed and constructed in accordance with recognized engineering standards.

22.5.1.2 Tanks shall be supported in a manner that prevents excessive concentration of loads on the supported portion of the shell.

22.5.1.3 In areas subject to earthquakes, tank supports and connections shall be designed to resist damage as a result of such shocks.

22.5.2 Foundations for and Anchoring of Aboveground Storage Tanks.

22.5.2.1* Tanks shall rest on the ground or on foundations made of concrete, masonry, piling, or steel.

Table 22.4.2.1 Minimum Shell-to-Shell Spacing of Aboveground Storage Tanks

Tank Diameter	Floating Roof Tanks	Fixed Roof or Horizontal Tanks	
		Class I or Class II Liquids [FP < 140°F (60°C)]	Class IIIA Liquids [140°F (60°C) ≤ FP < 200°F (93°C)]
All tanks not over 150 ft (45 m) in diameter	$\frac{1}{6} \times$ sum of adjacent tank diameters but not less than 3 ft (0.9 m)	$\frac{1}{6} \times$ sum of adjacent tank diameters but not less than 3 ft (0.9 m)	$\frac{1}{6} \times$ sum of adjacent tank diameters but not less than 3 ft (0.9 m)
Tanks larger than 150 ft (45 m) in diameter:			
If remote impounding is provided in accordance with 22.11.1	$\frac{1}{6} \times$ sum of adjacent tank diameters	$\frac{1}{4} \times$ sum of adjacent tank diameters	$\frac{1}{6} \times$ sum of adjacent tank diameters
If open diking is provided in accordance with 22.11.2	$\frac{1}{4} \times$ sum of adjacent tank diameters	$\frac{1}{3} \times$ sum of adjacent tank diameters	$\frac{1}{4} \times$ sum of adjacent tank diameters

Note: The "sum of adjacent tank diameters" means the sum of the diameters of each pair of tanks that are adjacent to each other. See also A.22.4.2.1.

22.5.2.2 Tank foundations shall be designed to minimize the possibility of uneven settling of the tank and to minimize corrosion in any part of the tank resting on the foundation.

22.5.2.3 Where tanks storing Class I, Class II, or Class IIIA liquids [FP < 200°F (93°C)] are supported above their foundations, tank supports shall be of concrete, masonry, or protected steel.

Exception: Single wood timber supports (not cribbing), laid horizontally, shall be permitted to be used for outside aboveground tanks if not more than 12 in. (300 mm) high at their lowest point.

22.5.2.4* Steel support structures or exposed piling for tanks storing Class I, Class II, or Class IIIA liquids [FP < 200°F (93°C)] shall be protected by materials having a fire resistance rating of not less than 2 hours.

Exception No. 1: Steel saddles do not need to be protected if less than 12 in. (300 mm) high at their lowest point.

Exception No. 2: At the discretion of the authority having jurisdiction, water spray protection in accordance with NFPA 15 or NFPA 13 is permitted to be used.

22.5.2.5 Where a tank is located in an area subject to flooding, provisions shall be taken to prevent tanks, either full or empty, from floating or sliding during a rise in water level up to the established maximum flood stage. (See 21.7.3.)

22.5.3 Anchoring Tanks. Flat bottom, vertical cylindrical tanks constructed in accordance with API 650, *Welded Tanks for Oil Storage*, shall be anchored to a concrete ringwall or other suitable foundation under the following conditions:

- (1) The tank internal pressure exceeds the equivalent pressure of the weight of the tank shell, roof, and roof framing.
- (2) The tank must be anchored to comply with the weak roof-to-shell criteria.
- (3) Under the design criteria for the tank, including all applicable load combinations, anchorage is required to prevent overturning due to wind or seismic loads.

22.6 Vent Piping for Aboveground Tanks. Piping for normal and emergency relief venting shall be constructed in accordance with Chapter 27.

22.7 Emergency Relief Venting for Fire Exposure for Aboveground Storage Tanks.

22.7.1 General.

22.7.1.1 Every aboveground storage tank shall have emergency relief venting in the form of construction or a device or devices that will relieve excessive internal pressure caused by an exposure fire.

22.7.1.1.1 This requirement shall apply to each compartment of a compartmented tank, the interstitial space (annulus) of a secondary containment-type tank, and the enclosed space of tanks of closed-top dike construction.

22.7.1.1.2 This requirement shall also apply to spaces or enclosed volumes, such as those intended for insulation, membranes, or weather shields, that are capable of containing liquid because of a leak from the primary vessel. The insulation, membrane, or weather shield shall not interfere with emergency venting.

22.7.1.1.3 Tanks storing Class IIIB liquids [FP ≥ 200°F (93°C)] that are larger than 12,000 gal (45,400 L) capacity and are not within the diked area or the drainage path of tanks storing Class I or Class II liquids [FP < 140°F (60°C)] shall not be required to meet the requirements of 22.7.1.1.

22.7.1.2 For vertical tanks, the emergency relief venting construction referred to in 22.7.1.1 shall be permitted to be a floating roof, a lifter roof, a weak roof-to-shell seam, or another approved pressure-relieving construction.

22.7.1.3 If unstable liquids are stored, the effects of heat or gas resulting from polymerization, decomposition, condensation, or self-reactivity shall be taken into account.

22.7.1.4 If two-phase flow is anticipated during emergency venting, an engineering evaluation shall be conducted in order to size the pressure-relieving devices.

22.7.2 Weak Roof-to-Shell Seam Construction. If used, a weak roof-to-shell seam shall be constructed to fail preferential to any other seam and shall be designed in accordance with API Standard 650, *Welded Steel Tanks for Oil Storage*.

22.7.3 Pressure-Relieving Devices.

22.7.3.1* Where entire dependence for emergency relief venting is placed upon pressure-relieving devices, the total venting capacity of both normal and emergency vents shall be sufficient to prevent rupture of the shell or bottom of a vertical tank or of the shell or heads of a horizontal tank.

22.7.3.2 Except as provided for in 22.7.3.5, 22.7.3.6, and 22.7.3.7, the total emergency relief venting capacity of both normal and emergency venting devices shall be not less than that determined in Table 22.7.3.2. (See Annex B for the square footage of typical tank sizes.)

22.7.3.2.1 Emergency relief vent devices shall be vaportight and restricted to one of the following:

- (1) Self-closing manway cover
- (2) Manway cover provided with long bolts that permit the cover to lift under internal pressure
- (3) Additional or larger relief valve or valves

22.7.3.2.2 Nonmetallic plugs installed in tank openings shall not be used as a means of emergency venting.

22.7.3.2.3 The wetted area of the tank shall be calculated as follows:

- (1) Fifty-five percent of the total exposed area of a sphere or spheroid
- (2) Seventy-five percent of the total exposed area of a horizontal tank
- (3) One hundred percent of the exposed shell and exposed floor area of a rectangular tank, but excluding the top surface of the tank
- (4) The first 30 ft (9 m) above grade of the exposed shell area of a vertical tank

22.7.3.3* The total emergency relief venting capacity for tanks and storage vessels designed to operate at pressures above a gauge pressure of 1.0 psi (6.9 kPa) shall be as follows:

- (1) For tanks whose wetted area does not exceed 2800 ft² (260 m²), not less than that determined in Table 22.7.3.2

Table 22.7.3.2 Required Emergency Relief Venting — Cubic Feet of Free Air per Hour (CFH) versus Wetted Area of Tank Shell (ft²)

ft ²	CFH	ft ²	CFH	ft ²	CFH
20	21,100	160	168,000	900	493,000
30	31,600	180	190,000	1000	524,000
40	42,100	200	211,000	1200	557,000
50	52,700	250	239,000	1400	587,000
60	63,200	300	265,000	1600	614,000
70	73,700	350	288,000	1800	639,000
80	84,200	400	312,000	2000	662,000
90	94,800	500	354,000	2400	704,000
100	105,000	600	392,000	2800	742,000
120	126,000	700	428,000	and over	
140	147,000	800	462,000		

For SI units, 10 ft² = 0.93 m²; 36 ft³ = 1.0 m³.

Notes:

- (1) Interpolate for intermediate values not specified in the table.
 (2) CFH is flow capacity at absolute pressure of 14.7 psi (101 kPa) and 60°F (15.6°C). See 22.7.3.10.2.

Table 22.7.3.3 Required Emergency Relief Venting for Tanks with Wetted Area over 2800 ft² (260 m²) and Operating at Gauge Pressure over 1 psi (6.9 kPa) — Cubic Feet of Free Air per Hour (CFH) versus Wetted Area of Tank Shell (ft²)

[22.7.3.4]

$$CFH = V \frac{1337}{L\sqrt{M}}$$

ft ²	CFH	ft ²	CFH
2,800	742,000	9,000	1,930,000
3,000	786,000	10,000	2,110,000
3,500	892,000	15,000	2,940,000
4,000	995,000	20,000	3,720,000
4,500	1,100,000	25,000	4,470,000
5,000	1,250,000	30,000	5,190,000
6,000	1,390,000	35,000	5,900,000
7,000	1,570,000	40,000	6,570,000
8,000	1,760,000		

For SI units, 10 ft² = 0.93 m²; 36 ft³ = 1.0 m³.

Notes:

- (1) Interpolate for intermediate values not specified in the table.
 (2) CFH is flow capacity at absolute pressure of 14.7 psi (101 kPa) and 60°F (15.6°C). See 22.7.3.10.2.

- (2) For tanks whose wetted area exceeds 2800 ft² (260 m²), not less than that determined in Table 22.7.3.3 or not less than that calculated by the following formula:

[22.7.3.3]

$$CFH = 1107(A)^{0.82}$$

where:

CFH = venting capacity requirement (ft³ of free air per hour)

A = wetted area (ft²)

22.7.3.4 The total emergency relief venting capacity for any specific stable liquid shall be permitted to be determined by the following formula:

where:

CFH = venting capacity requirement (ft³ of free air per hour)

V = ft³ of free air per hour (CFH) value from Table 22.7.3.2

L = latent heat of vaporization of specific liquid (Btu/lb)

M = molecular weight of specific liquids

22.7.3.5 Except as provided for in 22.7.3.6 and 22.7.3.7, for tanks containing stable liquids, the required emergency relief venting capacity determined by 22.7.3.2, 22.7.3.3, or 22.7.3.4 shall be permitted to be multiplied by one of the following reduction factors when protection is provided as indicated. Only one of the following factors shall be used for any one tank:

- (1) A reduction factor of 0.5 shall be allowed for tanks with wetted area greater than 200 ft² (19 m²) that are provided with drainage that meets the requirements of 22.11.1.
- (2) A reduction factor of 0.3 shall be allowed for tanks that are protected with a water spray system that meets the requirements of NFPA 15 and that are provided with drainage that meets the requirements of 22.11.1.
- (3) A reduction factor of 0.3 shall be allowed for tanks that are protected with an automatically actuated water spray system that meets the requirements of NFPA 15.
- (4) A reduction factor of 0.3 shall be allowed for tanks protected with insulation that meets the requirements of 22.7.3.8.
- (5) A reduction factor of 0.15 shall be allowed for tanks that are protected with a water spray system that meets the requirements of NFPA 15 and that have insulation that meets the requirements of 22.7.3.8.

22.7.3.6* Where water-miscible ignitable (flammable or combustible) liquids whose heats of combustion and rates of burning are equal to or less than those of ethyl alcohol (ethanol) are stored, processed, or handled and where there is no potential fire exposure from ignitable (flammable or combusti-

ble) liquids other than these liquids, the emergency relief venting capacity shall be permitted to be reduced by an additional 50 percent. Drainage shall not be required to obtain this reduction. In no case shall the factors in 22.7.3.5(1) through 22.7.3.5(5) be reduced to less than 0.15.

22.7.3.7* Where ignitable (flammable or combustible) liquids that are not water-miscible and whose heats of combustion and rates of burning are equal to or less than those of ethyl alcohol (ethanol) are stored, processed, or handled and where there is no potential fire exposure from ignitable (flammable or combustible) liquids other than these liquids, the emergency relief venting capacity determined by 22.7.3.5(1) or 22.7.3.5(3) shall be permitted to be reduced by an additional 50 percent. No further reduction shall be allowed for protection by means of water spray. Drainage shall not be required to obtain this reduction. In no case shall the factors in 22.7.3.5(1) through 22.7.3.5(5) be reduced to less than 0.15.

22.7.3.8 Insulation for which credit is taken in 22.7.3.5(4) and 22.7.3.5(5) shall meet the following performance criteria:

- (1) The insulation shall remain in place under fire exposure conditions.
- (2) The insulation shall withstand dislodgment when subjected to hose stream impingement during fire exposure.
- (3) The insulation shall maintain a maximum conductance value of 4.0 Btu/hr/ft²/°F (22.7 W/m²/°C) when the outer insulation jacket or cover is at a temperature of 1660°F (904°C) and when the mean temperature of the insulation is 1000°F (538°C).

Exception: The requirement of 22.7.3.8(2) need not apply where use of solid hose streams is not contemplated or would not be practical.

22.7.3.9 The outlets of all vents and vent drains on tanks equipped with emergency relief venting that permits pressures to exceed a gauge pressure of 2.5 psi (17.2 kPa) shall be arranged to discharge so that localized overheating of or flame impingement on any part of the tank will not occur if vapors from the vents are ignited.

22.7.3.10 Each commercial tank venting device shall have the following information either stamped or cast into the metal body of the device or included on a metal nameplate permanently affixed to it.

- (1) Start-to-open pressure
- (2) Pressure at which the valve reaches the full open position
- (3) Flow capacity at the pressure indicated by 22.7.3.10(2)

22.7.3.10.1 If the start-to-open pressure is less than a gauge pressure of 2.5 psi (17.2 kPa) and the pressure at the full open position is greater than a gauge pressure of 2.5 psi (17.2 kPa), the flow capacity at a gauge pressure of 2.5 psi (17.2 kPa) shall also be stamped on the venting device.

22.7.3.10.2 The flow capacity shall be expressed in cubic feet per hour of air at 60°F (15.6°C) and an absolute pressure of 14.7 psi (101 kPa).

22.7.3.10.3 The flow capacity of tank venting devices less than 8 in. (200 mm) in nominal pipe size shall be determined by actual test. These tests shall be permitted to be conducted by a qualified, impartial outside agency or by the manufacturer if certified by a qualified, impartial observer.

22.7.3.10.4* The flow capacity of tank venting devices equal to or greater than 8 in. (200 mm) nominal pipe size, including

manway covers with long bolts, shall be determined by test or by calculation. If determined by calculation, the opening pressure shall be measured by test, the calculation shall be based on a flow coefficient of 0.5 applied to the rated orifice, the rating pressure and corresponding free orifice area shall be stated, and the word *calculated* shall appear on the nameplate.

22.7.4* Extension of Emergency Vent Piping. Piping to or from approved emergency vent devices for atmospheric and low-pressure tanks shall be sized to provide emergency vent flows that limit the back pressure to less than the maximum pressure permitted by the design of the tank. Piping to or from approved emergency vent devices for pressure vessels shall be sized in accordance with the ASME *Boiler and Pressure Vessel Code*.

22.8* Fire Protection for Aboveground Storage Tanks.

22.8.1 A fire-extinguishing system in accordance with an applicable NFPA standard shall be provided or made available for a storage tank where all of the following conditions apply:

- (1) The tank is a vertical atmospheric storage tank that has a capacity of 50,000 gal (190 m³) or more.
- (2) The tank contains a Class I liquids [FP < 100°F (37.8°C)].
- (3) The tank is located in a congested area where there is an unusual exposure hazard to the tank from adjacent property or to adjacent property from the tank
- (4) The tank has a fixed-roof or a combination fixed- and floating-roof that does not meet the requirements of 22.2.2(2) or (3) to be classified as a floating roof tank.

22.9 Additional Requirements for Fire-Resistant Aboveground Storage Tanks.

22.9.1 Fire-resistant tanks shall be tested and listed in accordance with UL 2080, *Fire Resistant Tanks for Flammable and Combustible Liquids*.

22.9.2 Fire-resistant tanks shall also meet both of the following requirements:

- (1) The construction that provides the required fire-resistive protection shall reduce the heat transferred to the primary tank in order to limit the temperature of the primary tank to an average maximum rise of 800°F (430°C) and a single point maximum rise of 1000°F (540°C) and to prevent release of liquid, failure of the primary tank, failure of the supporting structure, and impairment of venting for a period of not less than 2 hours when tested using the fire exposure specified in UL 2080.
- (2) Reduction in sizing of the emergency vents in accordance with 22.7.3.5 shall not be permitted.

22.10 Additional Requirements for Protected Aboveground Storage Tanks.

22.10.1 Protected aboveground tanks shall be tested and listed in accordance with UL 2085, *Protected Aboveground Tanks for Flammable and Combustible Liquids*.

22.10.2 Protected aboveground tanks shall also meet both of the following requirements:

- (1) The construction that provides the required fire-resistive protection shall reduce the heat transferred to the primary tank in order to limit the temperature of the primary tank to an average maximum rise of 260°F (144°C) and a single point maximum rise of 400°F