First Revision No. 10-NFPA 1142-2025 [Global Input]

Delete Annexes C, D, and E and insert a new Annex C, Water Handling Apparatus and Equipment.

See attached draft of Annex C.

Supplemental Information

File Name	Description	Approved
Keller_Copyright_Release_20250120.pdf	Signed copyright release for images used in new Annex C	
1142_FR-10_Global_New_Annex_C_Photo_Source_Files.zip	Source image files for new Annex C	
1142_FR-10_Global_New_Annex_C.docx	New Annex C	
1142_FR-10_Global_New_Annex_C.docx	For prod use	
1142_Global_FR-10_Annex_C_For_Ballot.pdf		

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Committee Statement

Committee Statement: The new Annex C consolidates three existing annexes and updates the information. The new annex combines the material for various types of related equipment to allow for a holistic approach to water supply planning.

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Annex C Water Handling Apparatus and Equipment

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 General.

All fire department water supply operations can be conceptualized as moving water from a source to a destination via a means of conveyance *(see Figure C.1)*. This might be as simple as conveying water from an apparatus booster tank to the fire pump by means of internal plumbing and valves, or it might be a complex operation involving multiple mobile water supply apparatus (MWSA) running on a miles-long shuttle route. In this conceptual model, the source can be any suitable pressurized or static supply, while the destination is the incident scene.

Figure C.1 Conceptual Model of Water Supply Operations.

Water Source → Means of Conveyance → Destination

C.1.1

There are only two basic possibilities for the conveyance of water: continuous flow via a conduit and discontinuous movement in discrete unit loads. Conduits for fire department purposes include the mains and hydrants of a municipal system, as well as supply and attack hose lines. For alternative water supplies, continuous flow is achieved by means of the temporary conduits of medium- or large-diameter hose (MDH or LDH) — operations referred to as *relay pumping*. When circumstances do not permit the use of relay pumping, water is instead moved discontinuously by means of mobile water supply operations, or a water shuttle. Together, relay pumping and water shuttles comprise the playbook for fire department alternative water supply tactics. All other methods are variations on these two core operations. The remainder of this annex is an overview of the apparatus and equipment commonly used in these two tactics.

C.2 Mobile Water Supply Apparatus (MWSA).

C.2.1 General.

Mobile water supply apparatus (MWSA) are the backbone of water shuttle operations, hauling water, load-by-load, between the source and destination. MWSA are regionally referred to as water tenders, tankers, or water carriers. When designed as multirole apparatus equipped with a rated fire pump, MWSA might be referred to as pumper-tenders or pumper-tankers.

C.2.1.1

Historically, MWSA were used in rural firefighting. Given the limited financial resources in these settings, MWSA were often locally fabricated or converted from other commercial or military tank trucks. Consequently, they were often built without the safety considerations of other apparatus classes that were covered by relevant national standards. The eventual inclusion of MWSA in automotive apparatus standards, along with availability of firefighter safety grant programs, led to these older, less safe units gradually being removed from service. Although legacy MWSA still exist in the fire service fleet, they are steadily being replaced by modern, purpose-built apparatus that are designed to meet NFPA 1900 requirements.

C.2.2 MWSA Design.

C.2.2.1 General.

The first MWSA were severely limited in performance compared to modern versions. The gasoline motors prevalent at the time produced relatively limited power and struggled to carry large water loads. Fill ports were often awkwardly located and undersized, resulting in long fill times. Likewise, MWSA often needed to remain on scene while the water was slowly unloaded through small outlets that required use of a pump, preventing a rapid turnaround for refilling. With the benefit of experience and technological progression, these limitations have been largely overcome. Modern, purpose-built MWSA have diesel motors that provide ample power to carry large water loads at roadway speed and have efficient means for loading and unloading. Modern MWSA can be classified by mode of operation into two general classes: conventional (gravity) and vacuum.

C.2.2.1.1 Conventional (Gravity) Apparatus.

Conventional (gravity) apparatus are the most common type of MWSA in service. These units have tanks that are open to atmospheric pressure and are commonly constructed of polypropylene (poly), although metal construction is still encountered. Conventional MWSA are unloaded by gravity flow via large-diameter transfer valves, or *dump chutes*, with the most common size being 10-in. (25 cm) square designs. In the past, the unloading process was sometimes facilitated using jet-assist mechanisms, but the need for this additional mechanical complexity was obviated by the advent of large-bore dump chutes, beginning in the 1970s. When properly designed, even very large conventional MWSA can be unloaded rapidly using gravity alone. If equipped with a fire pump, these units can self-load by drafting, but they are generally loaded by a supporting pumper unit or hydrant pressure, if available, for efficiency. An example of a conventional (gravity) apparatus is shown in Figure C.2.2.1.1.

Figure C.2.2.1.1 Conventional (Gravity) MWSA.

C.2.2.1.2 Vacuum Apparatus.

While less common than conventional MWSA, vacuum apparatus are popular in some regions. Vacuum tanks are sealed pressure vessels and are always constructed of metal. A pneumatic pump system, which is entirely separate from any mounted fire pump, is used to raise or lower pressure within the tank above or below ambient atmospheric pressure. This allows the unit to self-load through a suction hose by creating a vacuum condition within the tank. Likewise, by pressurizing the tank, the contents can be unloaded faster than by using gravity alone. If the pneumatic pump system is out of service, the tank can be manually vented to allow loading and unloading as a conventional (gravity) MWSA, although unloading rates will generally be restricted due to smaller outlet sizes. An example of a vacuum apparatus is shown in Figure C.2.2.1.2.

Figure C.2.2.1.2 Vacuum MWSA.

C.2.2.2 Tank Design.

The core defining characteristic of an MWSA is the water tank. Table 8.1 of NFPA 1900 requires a minimum tank capacity of 1000 gal (4000 L) for MWSA. Aside from those chapters of NFPA 1900 that are applicable to all classes of apparatus (e.g., automotive, chassis, and crew safety elements), the only mandatory chapter applicable to all MWSA is Chapter 17. Section 17.5 provides specific design and performance requirements for tanks on MWSA. NFPA 1900 does not prescribe a specific tank material but does require the use of non-corrosive materials. Poly and related plastic materials have become the dominant tank material since the 1990s, although legacy apparatus with stainless steel, aluminum, or even fiberglass tanks remain in service.

C.2.2.2.1 Tank Capacity.

The specific design of an MWSA tank is determined by several factors, with desired capacity generally ranking chief among them. There is no optimal MWSA tank capacity; the answer depends on local requirements, road conditions, terrain, and weather considerations. Fire departments must decide on a capacity that strikes a balance between maximizing water brought to an emergency scene, practical weight limitations (physical and legal), truck chassis design envelopes, and additional equipment to be carried. Increasing tank capacity will require extending the tank’s height, width, length, or some combination of the three. While in many jurisdictions, fire apparatus are exempt from legal dimensional and weight limitations for highway vehicles, exceeding these is generally unwise as it might render routes within the jurisdiction untraversable due to low clearances, poor road surfaces, or other limiting factors. Because of these considerations, MWSA built on straight-truck chassis have a practical upper capacity limit of about 4000 gal (15,000 L). Larger capacity MWSA will require a tractor-trailer design. For straight-chassis MWSA with capacities exceeding 1500 gal (5700 L), tandem rear axles are generally needed to ensure adequate road performance.

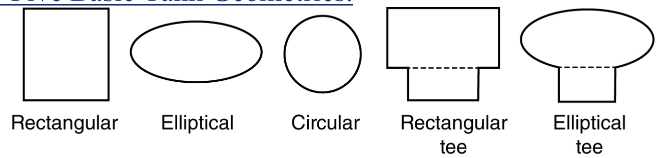
C.2.2.2.1.1

Per NFPA 1900 requirements, apparatus manufacturers must provide certification of water tank capacity for MWSA. *(See Section 17.6 of NFPA 1900.)* If the certified capacity is not available, tank capacity can be estimated by measuring the tank dimensions and using basic geometric methods. However, such methods will not be able to account for potential volume losses due to baffles or swash partitions, internal plumbing, or the notches and cutouts common in poly tank customization. In such cases, departments should use a certified commercial truck scale to obtain the weights of the apparatus with the water tank entirely full and entirely empty, and use the difference in weight to estimate capacity, given that water weighs 8.34 lb/gal (1.0 Kg/L).

C.2.2.2.2 Tank Geometry.

In terms of shape, water tanks for MWSA fall into five broad categories of extruded horizontal forms, as viewed from the rear: rectangular, elliptical, circular, and variations of rectangular and elliptical having "tee" shaped troughs at the bottom. These basic geometries are illustrated in Figure C.2.2.2.2. Tanks can have any number of custom notches, cutouts, pass-throughs, or other modifications, but these five basic shapes can be used to describe any MWSA tank. The selection of tank geometry is more than an aesthetic choice, as each one has certain advantages and limitations.

Figure C.2.2.2.2 The Five Basic Tank Geometries.



C.2.2.2.2.1

New-build circular tanks are limited to the pressure vessels of vacuum apparatus, although some older units converted from civilian purposes have this shape. Figure C.2.2.2.2.1 provides an example of this.

Figure C.2.2.2.2.1 Legacy MWSA with Circular Tank Geometry, Converted from Civilian Use.

C.2.2.2.2.2

Elliptical tanks were the dominant tank geometry until the 1990s, due in large part to the borrowing of design concepts from commercial tank trucks, as well as the conversion of commercial trucks to fire service use. All other things being equal, an elliptical tank will unload slightly faster under gravity than a rectangular tank of the same capacity, and elliptical tanks are somewhat more stable and less prone to rollovers. However, the void spaces created by elliptical tanks limit potential capacity for a given design envelope. A rectangular tank fitting the same height, width, and length profile will be capable of carrying 20 to 30 percent more water. The void spaces also make for awkward cabinetry design. Elliptical tee designs remedy these limitations somewhat but not entirely. Figure C.2.2.2.2.2 shows an example of an elliptical tank.

Figure C.2.2.2.2.2 Typical Elliptical Tank Configuration on an Older MWSA.

C.2.2.2.2.3

Rectangular tanks, and especially rectangular tee tanks, are the dominant shapes found in modern MWSA. This is due to the prevalence of poly tanks and the highly customizable nature of that material. These rectangular tank shapes meet two important requirements for many fire departments: maximization of water-carrying capacity and ease of fitting cabinetry for carrying additional equipment. An example of a rectangular tee tank is shown in Figure C.2.2.2.2.3.

Figure C.2.2.2.2.3 Rectangular Tee Tank Configuration, as Found on Most Modern MWSA.

C.2.2.3 Tank Fill Requirements.

NFPA 1900 specifies several design and performance requirements regarding the filling of MWSA water tanks. *(See 17.5.1 of NFPA 1900.)* Notable among these requirements is that the tank must be equipped with at least one external fill connection plumbed directly into the tank. This allows the tank to be filled without using the MWSA pump, if one is equipped, or routing water through it. Further, this fill connection must permit a minimum fill rate of 1000 gpm (4000 L/min), a requirement in place since the 1985 edition of the standard. This requirement is normally met by the provision of one (rarely) or two (commonly) valved fill ports of 2½ in. (65 mm) diameter, located on the rear of the apparatus. An example of a typical arrangement with dual 2½ in. (65 mm) fill connections is shown in Figure C.2.2.3. Sometimes, one or both fill ports is sized to accommodate LDH fill lines, generally of the 4 in. or 5 in. (100 mm or 130 mm) size. In other cases, adapters might be used to allow LDH connections.

Figure C.2.2.3 Typical Arrangement of Dual 2½ in. (65 mm) Fill Connections Located on the Rear of an MSWA Tank.

C.2.2.3.1 Fill Connection Accessibility.

Regardless of the number or size of fill connections provided, the connections should be located low enough on the apparatus to allow the ground crew to safely access them without climbing on the tailboard and risking slip-and-fall injuries. Older MWSA that were built with high-mounted fill ports can be retrofitted by either tapping new connections at a lower height or installing pipe extensions, as illustrated in Figure C.2.2.3.1.

Figure C.2.2.3.1 Fill Port Pipe Extensions Retrofitted to an Older Apparatus to Allow Safe Access by Ground Crew.

C.2.2.3.2 Tank Fill Restrictions.

Since the 1990s, most apparatus water tanks have been constructed of polypropylene (plastic or poly), whereas, in the past, tanks were made of steel, aluminum, or fiberglass. Poly tanks offer many advantages, including, but not limited to, lighter weight, corrosion resistance, and easy customization. Disadvantages of poly tanks include limitations on the rate and pressure at which they can be filled without damaging the tank seams. The major manufacturers of poly tanks for fire apparatus place the following two hard limits on the filling of poly tanks of 1000 gal (4000 L) capacity or greater:

(1) Maximum fill pressure of 100 psi (690 kPa)

(2) Maximum fill rate of 1000 gpm (4000 L/min)

C.2.2.3.2.1

Exceeding the limits noted in C.2.2.3.2, even with a fully vented tank and with diffusers installed, can damage tank welds and baffles and void the tank manufacturer's warranty. It should be noted that NFPA 1900 requires a minimum fill rate capability of 1000 gpm (4000 L/min). This requirement has been in place, unchanged, since the 1985 edition of the standard, a time at which steel tanks were the norm. This creates some potential confusion on the part of operators, given a design minimum and manufacturer maximum that seem to be in conflict. To avoid damage to equipment, fire departments should adhere to the safest benchmark, that of the tank manufacturers. Simply because the fill ports are theoretically capable of accepting higher flows, that does not mean that it is wise to test this proposition.

C.2.2.3.2.2

Because there is no pressure gauge or flowmeter at the MWSA fill port, these factors must be calculated hydraulically to ensure that pressure and flow rate are kept under the allowable maximums. A formula for estimating open orifice flow, such as the Freeman formula *(see Fire Service Hydraulics, 1970),* can be reconfigured for this purpose. By setting a desired flow rate at the fill port and estimating friction loss in the filling hose lay, pump discharge pressure can be calculated with Equation C.2.2.3.2.2.

$$P_d = \left(\frac{Q}{29.7 \cdot d^2 \cdot C} \right)^2 \quad \text{[C.2.2.3.2.2]}$$

where:

Pd = pressure at the point of discharge (psi; at the fill port)

Q = desired flow at the fill port (gpm)

d = diameter of the fill port opening (inches; not hose size)

C = discharge roughness coefficient (*see C.2.2.3.2.5)*

C.2.2.3.2.3

For the common fill port size of 2**1⁄2** in. (65 mm) and an assumed *C* value of 0.9 (rounded opening), Equation C.2.2.3.2.2 can be simplified as shown in Equation C.2.2.3.2.3.

$$P_d = \left(\frac{Q}{167} \right)^2 \quad \text{[C.2.2.3.2.3]}$$

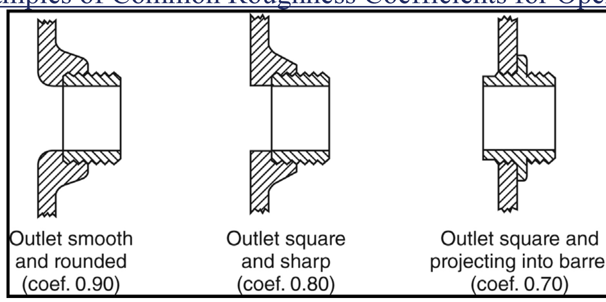
C.2.2.3.2.4

By adding friction loss in the supply hose and appliances between the pump discharge and the fill port, a pump discharge pressure can be calculated for the desired fill rate. Except in the case of very high friction loss layouts, only relatively low pump pressures are required to achieve high fill rates within safe limits. Because this is a relatively complex calculation to make, the best practice is to use standardized fill line layouts and fill rates, so that standard pump pressures can be planned in advance, easing the job of the pump operator during an actual incident. To avoid damaging a poly tank, it is best practice to resist the urge to maximize the fill rate and, instead, use a lower rate that leaves a reasonable safety margin that accounts for potential pressure fluctuations.

C.2.2.3.2.5

It should be noted that the discharge roughness coefficient (*C*) will vary depending upon the design of the MWSA. The value of 0.9 (rounded opening) is commonly used when the actual value is unknown because this will provide a conservative estimate. Similar to the process for testing fire hydrant flow, a more precise fill rate estimate can be obtained by determining a more accurate *C* value for the tank fill inlet. Figure C.2.2.3.2.5 identifies some common configurations. When in doubt, departments should use a conservative (lower) *C* value rather than overestimating performance.

Figure C.2.2.3.2.5 Examples of Common Roughness Coefficients for Openings.



C.2.2.3.2.6

Likewise, when using this method, the best results will be obtained by referring to manufacturer-provided friction loss estimates for all hose and appliances used in the fill line layout. If this documentation is not available, then general values for friction loss estimates should be obtained from reputable sources.

C.2.2.3.3 Measurement of Fill Performance in the Field.

Using the hydraulic calculation method described in C.2.2.3.2, it is possible to obtain a reasonable estimate of fill performance for an MWSA. Divide the tank capacity (gallons) by the fill rate used in Equation C.2.2.3.2.2 or Equation C.2.2.3.2.3 to estimate the fill time. However, it is sometimes desirable to directly measure actual fill rates for MWSA to confirm estimated values. At first, this might seem to be a simple matter of timing the fill process from opening the fill port valve to tank overflow. It should be clear from the preceding section, however, that there will be no single fill rate value for a given apparatus. Rather, the fill rate will vary situationally depending upon the following:

(1) Fill port opening size, taking into consideration any reduction due to attached adapters

(2) Fill port inlet hydraulic roughness

(3) Discharge pressure at the fill port

C.2.2.3.3.1

The information above assumes that the water supply source under consideration is sufficient to provide the desired flow without cavitating the supporting engine or damaging the water main system. In short, any fill rate associated with a given MWSA must also consider the conditions used to fill it, including, at a minimum, the following:

(1) Flow available from the water supply source

(2) Discharge pressure from the supporting engine or hydrant

(3) Friction loss due to supply hose and appliance layout

(4) Fill port diameter and roughness, incorporating effects of any attached adapters

C.2.2.3.3.2

It is recommended that, when attempting to characterize fill rate performance for MWSA, departments develop estimates for all potential fill site scenarios that are likely to be used, rather than attempting to assign a single blanket value. Departments should also repeat each filling evolution several times and determine an average value to account for natural variation and any unusual circumstances that could skew estimates. Generally, repeating the process three to five times for each scenario should yield satisfactory average results.

C.2.2.4 Water Transfer Requirements.

Just as with fill performance, NFPA 1900 requires that MWSA meet several design and performance requirements for water transfer, commonly referred to as offloading or dumping. *(See 17.5.2 of NFPA 1900.)* MWSA must be capable of water transfer (dumping) to the right, left, and rear of the apparatus through one or more tank connections, typically dump valves. This requirement is generally met either by installing three separate dump valves (left, right, and rear), or by fitting a single dump outlet with an articulating and telescoping dump valve that can be swiveled in the necessary direction and is high enough to clear the top of portable water tanks. Figure C.2.2.4(a) shows an example of an articulating dump valve. Older MWSA that only have rear dump valves can often be retrofitted with a simple elbow adapter to allow offloading in all three directions, as shown in Figure C.2.2.4(b).

Figure C.2.2.4(a) MWSA Equipped with Rear-Mounted Articulated Dump Chute to Allow Water Transfer to Left, Right, and Rear.

Figure C.2.2.4(b) Locally Fabricated Dump Chute Elbow Extension, Allowing Older Rear Dump-Only MWSA to Transfer Water to Left and Right.

C.2.2.4.1 Water Transfer Rate.

All transfer outlets are required to be capable of offloading 90 percent of the tank contents at an average rate of 1000 gpm (4000 L/min). Older MWSA, which might have had outlets no larger than 2½ in. (65 mm), could be challenged by this requirement. Modern MWSA, however, with large-bore outlets and adequately vented tanks, are typically able to exceed this rate, often nearly doubling it in actual practice.

C.2.2.4.2 Water Transfer Performance.

Understanding the offload performance for an MWSA is important for planning potential water shuttle operations. Although NFPA 1900 lays out specific offload rate minimums, there are no standard test procedures for testing or certifying performance. Vacuum apparatus offloading under pressure will discharge their entire load at a consistent rate, and this rate can be determined by simply timing how long is required to fully empty the tank. Gravity apparatus, however, discharge at a variable rate, with high initial discharge rates that slow as head pressure steadily decreases. The time required to empty any tank under gravity alone can be described using the Torricelli equation, found in Equation C.2.2.4.2.

$$t = \left(\frac{S}{C \cdot A}\right)\sqrt{\frac{2h}{g}} \quad \text{[C.2.2.4.2]}$$

where:

t = time to drain tank (seconds)

S = surface area of the liquid [ft^2 (m^2)]

C = discharge roughness coefficient (unitless value from 0 to 1)

A = area of discharge orifice [ft^2 (m^2)]

h = tank height [ft (m)]

g = gravitational acceleration constant [32.2 ft/s^2 (9.8 m/s^2)]

C.2.2.4.2.1

Equation C.2.2.4.2 applies only to tanks that maintain a constant water surface area throughout the draining process (i.e., a straight-sided tank without curved or slanted walls) and that are being drained under gravity alone. Modified versions of the Torricelli equation are available for tanks with variable water surface area (e.g., elliptical and circular tanks) and for tanks that are emptied under additional pressure (vacuum apparatus). The key takeaway is that the greatest reductions in offload time will come from maximizing the size of the dump orifice (increasing *A*) and minimizing turbulent flow (increasing *C*). Adding head pressure by increasing tank height (*h*) will only yield minimal performance improvements given that there is limited scope to make apparatus tanks taller by any significant amount. Note that for conventional MWSA with multiple dump chutes, such as the one shown in Figure C.2.2.4.2.1, the area for all orifices in use is cumulative, creating a larger value for *A* and allowing very high-capacity apparatus to unload at high rates.

Figure C.2.2.4.2.1 Large Capacity MWSA [4000 gal (15,000 L)] Equipped with Multiple Transfer Outlets (Dump Chutes) to Decrease Offload Time.

C.2.2.4.2.2

It is important to note that Equation C.2.2.4.2 is only valid when the water surface is at or above the midpoint of the discharge orifice when using gravity flow alone. When the water surface is below this level, the discharge rate will continue to slowly taper off toward zero and is inefficient to use under field conditions. This minor amount of deadhead volume, along with spillage through vents, means that conventional MWSA are typically credited for 90 percent of their nominal tank volume. Vacuum MWSA receive full credit when discharging under pressure because the entire tank volume is evacuated but will be subject to the same losses as conventional units if the pneumatic system is inoperative, forcing the MWSA to discharge under gravity alone.

C.2.2.4.3 Measurement of Transfer Performance in the Field.

Although it is possible to obtain reasonable estimates for offload rates using Equation C.2.2.4.2, it is sometimes beneficial to directly measure water transfer performance in the field. Notably, it is difficult to determine accurate values for the discharge roughness coefficient (*C*) without taking direct measurements. As is the case when measuring fill rates for MWSA, as described in C.2.2.3.3, offload rates must be estimated with reference to the specific scenario used during the transfer operation. The amount of turbulence in the discharge flow path will vary depending on whether the water follows a straight or angled path, so that discharge to the side through a 90-degree elbow or articulated chute will be more turbulent (lower *C* value) than flow through a straight chute (higher *C* value). Measurements should thus be made for any potential discharge scenario that a given MWSA might use, specifically, left, right, or rear discharge scenarios incorporating any elbow adapters as they would be used during incident operations. Any tank vents should be opened as they would be during incident operations to prevent constricted flow. Tank vents will likely open automatically in modern MWSA but might need to be manually opened on legacy apparatus.

C.2.2.4.3.1

Once the various operational scenarios have been accounted for, discharge rates can be determined for each case by measuring the time required to discharge the MWSA tank contents from fully loaded to some consistent, repeatable level. Attempting to measure time to completely empty a conventional (gravity) apparatus is fruitless, because discharge rates decline with decreasing head pressure and become negligible toward the bottom of the tank. The best practice is to clearly mark the discharge outlet, or dump chute opening, at a point one-half its height using an indelible marker, grease pencil, or tape. For example, for a 10 in. (25.4 cm) square chute, make clearly visible marks on the interior walls of both sides at 5 in. (12.7 cm) in height. When the water level reaches this mark, stop timing and assume any remaining volume is unusable. Repeating this process three to five times to account for natural variability will allow for a reliable average value to use as an estimate. For conventional MWSA, nominal tank volume should be discounted by 10 percent to account for deadhead load and spillage. Because performance testing will be performed in a controlled environment, normal spillage losses occurring during emergency responses will not be reflected in the tank volumes being unloaded (i.e., the tank will be all the way full, rather than partially empty due to road slosh losses). The discounted capacity serves to account for these normal losses during response. To determine offload rate (gpm or L/min), simply divide the discounted tank capacity by the average time determined for each transfer scenario.

C.2.2.4.3.2

Because vacuum apparatus can be assumed to use their full tank capacity without spillage or deadhead loss when offloaded by means of the pneumatic system, the full tank volume is generally used in determining these estimates. Measure the time needed to fully empty the tank contents under pressure for each operational scenario and apply this time to the known tank capacity to determine discharge rates. Vacuum apparatus can still function as conventional MWSA even if the pneumatic system is inoperative. Because of this, it can be beneficial to make measurements of their offload performance with and without tank pressurization. To measure performance without the pneumatic system providing pressurization, follow the same procedure as for conventional MWSA, being sure to adequately vent the tank before opening any discharge valves.

C.2.3 Nursing Operations.

C.2.3.1 General.

The concept of large-bore dump valves and other means of rapid offloading were not present in the first generations of MWSA. Instead, early MWSA delivered their cargo directly to attack apparatus via umbilical supply hose, a tactic called *nursing* or *nurse tanking*. If equipped with an adequate pump, the MWSA could provide pressurized supply to an attack apparatus. Otherwise, the attack apparatus could draft from the MWSA tank. Either way, MWSA were tied up on scene until the tank was emptied, generally by means of a single 2**1⁄2** in. (65 mm) outlet. The development of large-bore dump chutes to provide rapid water unloading and of portable folding tanks to provide on-scene reservoir storage paved the way for the mobile water supply tactics used today. However, nursing was considered the default tactic for many decades, as evidenced by the fact that predecessor documents to NFPA 1900 did not require a 1000gpm (4000 L/min) dump rate until the 1985 edition. Previous editions only required the installation of a single dump outlet of “four inches or larger” for those MWSA that were not equipped with a pump of at least 500 gpm (1900 L/min) transfer capacity, capable of nursing an attack apparatus.

C.2.3.1.1

Nursing is still used in some situations, either as a standalone tactic or as a transitional method of water supply pending establishment of a full water shuttle or relay pumping operation. It is often used during incidents where water needs are projected to be moderate, thereby saving the additional labor of setting up and breaking down a more complex water supply operation. While this can be attractive in staffing-limited environments, it can impede the rapid establishment of higher-capacity water supply operations such as water shuttles if water supply needs unexpectedly escalate.

C.2.3.2 Rural Hitch Operations.

A modern variation of nursing called the *rural hitch* is commonly used as a transitional water supply method while a full water shuttle is established. This is a hybrid tactic involving both water shuttle and relay pumping components and is used in situations where it is impractical for a water shuttle dump site to be established adjacent to attack apparatus, such as for rural residences serviced by long, narrow driveways.

C.2.3.2.1

A rural hitch is established by an attack apparatus forward laying an LDH supply line from a designated dump site – typically located at the end of a driveway – to the incident scene. At the roadway end of this LDH line is a clappered Siamese appliance (or, less commonly, a flipped gated wye). As MWSA arrive, they attach to the Siamese appliance and relay pump their water through the supply line to the attack apparatus. Additional MWSA connect to the other Siamese port and begin pumping once the first MWSA is finished. This provides water supply at a reduced level, while a full water shuttle dump site is set up. Once a dump site relay pumper is in place, it connects to the Siamese appliance and drafts from the portable tanks to provide water to attack apparatus while MWSA proceed to unload into the tanks rather than pumping off.

C.2.3.2.2

Rural hitch operations have the advantages of allowing rapid setup, keeping MWSA on better roads, and keeping the immediate incident scene uncrowded by apparatus. To use this tactic, participating MWSA must be equipped with a pump capable of producing the necessary pressure and flow, with a 500 gpm (1900 L/min) rated fire pump generally considered the minimum acceptable capability.

C.2.3.3 Nursing Performance.

Just as with fill and transfer (offload) performance, the nursing performance of a given MWSA must be described in terms of the operational scenario planned for use. Firstly, to participate in nursing operations, the MWSA must have some kind of pumping ability, either a rated fire pump or some lesser capability such as a portable pump. The performance capability of this pump will determine much of the potential performance of the MWSA in nursing operations. External operational factors and apparatus design features will constrain the pump's inherent capabilities. The pump itself will be supplied by a tank-to-pump line. This would be internal plumbing in the case of a fire pump and a suction line in the case of a portable pump. For MWSA built to NFPA 1900 standards, an internal line will provide at least 500 gpm (1900 L/min) flow to the pump, unless a larger line is specified. Friction loss in the supplied lines will further define MWSA performance. This can be negligible for a short umbilical setup, but for a long rural hitch, there can be considerable pressure loss due to friction and elevation. Consideration must also be given to the fact that, for long LDH lays, a considerable portion of the water carried by the first-arriving MWSA will be consumed simply filling the hose lay, and this volume of water will not be available for attack use.

C.2.4 Water Shuttle Performance.

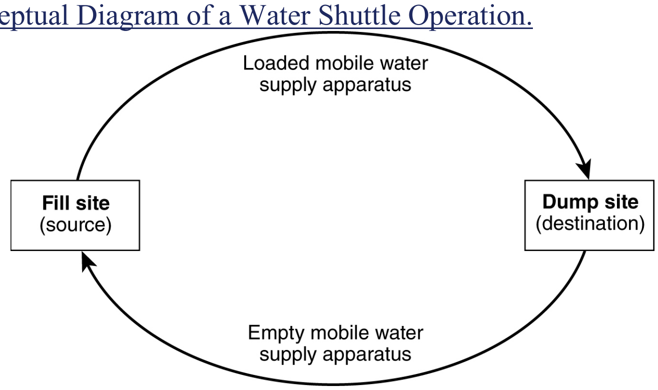
C.2.4.1 General.

To support water supply planning for incident operations, fire departments need to know how their MWSA will perform during a water shuttle. Just as with the performance characteristics described in the preceding sections, the performance of any MWSA in a water shuttle operation depends not only on the apparatus itself, but on the specifics of the planned operational environment.

C.2.4.2 Water Shuttle Operations.

Understanding the potential performance of an MWSA within a water shuttle requires some discussion of these operations and the role of MWSA within them. A water shuttle is simply the conveyance of water from a water source (fill site) to an incident scene (dump site) by means of one or more MWSA following a planned route, generally over public roadways. Once offloaded at the dump site, the MWSA return to the fill site to be reloaded, and then make another circuit. Figure C.2.4.2 illustrates the concept of a continuous water shuttle operation.

Figure C.2.4.2 Conceptual Diagram of a Water Shuttle Operation.



C.2.4.2.1 Water Shuttle Delivery Rate.

The contribution of any individual MWSA to the water shuttle operation is given in terms of water delivery rate to the dump site (gpm or L/min). This can be calculated with Equation C.2.4.2.1.

$$Q_{WT} = \frac{V_{EFF}}{T}$$ **[C.2.4.2.1]**

where:

Q_{WT} = water delivery contribution of a given MWSA

V_{EFF} = effective tank volume of the MWSA (nominal volume minus normal operating losses, typically 10% for conventional apparatus)

T = total time required for the MWSA to complete the water shuttle circuit (minutes)

C.2.4.2.1.1

The total water delivery rate of the water shuttle is the sum of the individual rates for all MWSA currently participating in the operation, as shown in Equation C.2.4.2.1.1. This number will change as MWSA are added to or leave the shuttle operation.

$$Q = Q_{WT1} + Q_{WT2} + \cdots + Q_{WTn}$$ **[C.2.4.2.1.1]**

where:

Q = total water delivery rate of the shuttle operation (gpm or L/min)

Q_{WTn} = water delivery rates for individual participating MWSA, 1 through *n* (gpm or L/min)

C.2.4.2.2 Water Shuttle Time Estimates.

The total cycle time for a given MWSA in the shuttle will be unique for that unit, given the varying performance characteristics of the various apparatus participating. The cycle time will also be influenced by the experience of the MWSA driver, the skill and training level of any supporting ground crew, and the overall staffing level of the operation. The total cycle time can be decomposed as shown in Equation C.2.4.2.2.

$$T = TR + TD + TF + TW \quad \text{[C.2.4.2.2]}$$

where:

T = total cycle time for a given MWSA (minutes)

TR = route time; time required to navigate the shuttle roadway route (minutes)

TD = dump site time; dwell time required for the MWSA to be serviced at the dump site (minutes)

TF = fill site time; dwell time required for the MWSA to be serviced at the fill site (minutes)

TW = queueing time; time spent by the MWSA waiting in line to be serviced at the fill and dump sites (minutes)

C.2.4.2.2.1

Minimizing any of the constituent time elements will reduce overall cycle time, thereby improving the throughput performance of the water shuttle. By further decomposing these time elements, water supply planners can better identify points in the process where time savings can be had and can focus training and funding to maximize benefits.

C.2.4.2.3 Route Time (TR) Estimates.

Route time (*TR*) is the time required for an MWSA to navigate the shuttle roadway route. Equation C.2.4.2.3 provides a simple method of estimating the route time from the total travel distance and an average travel speed. Traditionally, an average speed of 35 mph (56 km/h) is assumed, meaning that approximately 1.7 min is required for each mile of route length (1.1 min/km). The use of 35 mph as a standard travel speed for water shuttles has been confirmed as a reasonable figure by decades of field use and is intended to account for variations in speed due to stops, curves, intersections, and other common roadway issues.

$$TR = \frac{60 \cdot R}{v} \quad \text{[C.2.4.2.3]}$$

where:

TR = route time (minutes)

R = total route distance, round trip [miles (km)]

v = average travel speed [mph (km/h)]

C.2.4.2.3.1

For example, an MWSA traveling at an average speed, *v*, of 35 mph for a total road distance, *D*, of 5 miles (2.5 miles, each way) would require 8.6 min to navigate. It is possible to break the total time down into loaded and empty segments, but there is little to be gained in doing this when using a single average travel speed.

C.2.4.2.4 Dump Site Time (TD) Estimates.

Dump site time (*TD*) is the dwell time required for an MWSA to be serviced by the dump site ground crew or for the MWSA driver to self-service. As illustrated by Equation C.2.4.2.4, this is more than just the time needed to physically unload the water from the tank.

$$TD = TDM + TDC + TDD \quad \text{[C.2.4.2.4]}$$

where:

TD = dump site time (minutes)

TDM = dump site maneuver time (minutes)

TDC = dump site connection time (minutes)

TDD = dump site delivery time (minutes)

C.2.4.2.4.1

Estimates for dump site maneuver time (*TDM*) should include the time necessary for an MWSA to move from a full stop at some designated position outside the dump site work zone and into position to unload (e.g., at a portable tank or rural hitch hookup). Typically, a distance of 50 to 100 feet (15 to 30 m) is traversed at a walking pace for safety of ground crew. While *TDM* will likely be the same for all participating MWSA, it should be estimated realistically to account for driver experience, ground crew training, and staffing levels.

C.2.4.2.4.2

The dump site connection time (*TDC*) will vary according to the design of each participating MWSA. This factor is meant to encompass the time needed to bring transfer valves (dump chutes) into operation, as well as to stow them for travel once offloading is completed. The time required can be quite short for MWSA with cab-operated powered dump chutes but might be longer if ground crew manipulation is required, such as for MWSA requiring the attachment of 90-degree elbow adapters. Estimates of *TDC* should be adjusted to account for the skill and staffing levels of the personnel involved.

C.2.4.2.4.3

Dump site delivery time (*TDD*) will be unique to each MWSA and based on the specific characteristics of that apparatus. Refer to C.2.2.4 for a detailed discussion on determining reliable estimates for this time factor.

C.2.4.2.5 Fill Site Time (TF) Estimates.

Fill site time (*TF*) is the dwell time required for an MWSA to be serviced at the fill site. It can be estimated with Equation C.2.4.2.5, in a similar fashion to the dump site time (*TD*) estimation, with similar processes occurring.

$$TF = TFM + TFC + TFF \quad \text{[C.2.4.2.5]}$$

where:

TF = fill site time (minutes)

TFM = fill site maneuver time (minutes)

TFC = fill site connection time (minutes)

TFF = fill site fill time (minutes)

C.2.4.2.5.1

Fill site maneuver time (*TFM*) is similar to its counterpart at the dump site (*TDM*), as discussed in C.2.4.2.4.1, and represents the time required to maneuver apparatus into and out of position for filling. The impacts of driver experience, ground crew skill, and staffing levels should be accounted for when estimating *TFM*.

C.2.4.2.5.2

Fill site connection time (*TFC*) represents the time needed to make all necessary fill line connections, operate fill port valves, and disconnect the lines once filling is complete. The impacts of driver experience, ground crew skill, and staffing levels should be accounted for when estimating *TFC*.

C.2.4.2.5.3

The time required to fill the apparatus water tank *(TFF)* is a function of both the physical characteristics of the MWSA itself (e.g., tank capacity, fill outlet size) and the planned fill configuration (hose layout and pump pressure). Refer to C.2.2.3 for a detailed discussion on determining reliable estimates for this time factor.

C.2.4.2.6 Queueing Time (*TW*) Estimates.

As a water shuttle grows in size and fill site and dump site ground crews are working at capacity, it is inevitable that MWSA will spend time waiting in line (queueing) to be serviced at both locations, as shown in Figure C.2.4.2.6. This time can become a considerable drag on throughput performance but is often not well accounted for in water shuttle plans. This can result in overly optimistic projections of water delivery rates to the incident scene.

Figure C.2.4.2.6 MWSA Queueing to Be Offloaded at the Dump Site.

C.2.4.2.6.1

To estimate potential queueing time (*TW*) for a water shuttle operation, planners should think of both route time (*TR*) and dwell time (*TD* and (*TF*) as a kind of temporal buffer. Once those buffers are saturated, the average queuing time will begin to mount for all participating MWSA. Proficient and well-staffed crews at the dump site and fill site serve to reduce queuing time, as do arrangements at these sites that allow for the processing of multiple MWSA simultaneously. Reasonable estimates of queueing time can be derived with Equation C.2.4.2.6.1. Negative values should be treated as zero.

$$TW = \frac{\left[THm \cdot \left(nWT - Kf - Kd\right)\right] - TR}{nWT}$$ **[C.2.4.2.6]**

where:

TW = queueing time (minutes)

THm = mean handling time (*TF* + *TD*) for all participating MWSA (minutes)

nWT = number of participating MWSA

Kf = fill site handling capacity

Kd = dump site handling capacity

TR = route time (minutes)

C.2.4.2.6.2

Using this method, *TW* is treated as an average value and applied to the cycle time of all MWSA participating in the water shuttle. An average value is used because it is unlikely that specific arrival sequences for MWSA at the fill site and dump site can be predicted in advance. The handling capacity values for the fill site (*Kf*) and dump site (*Kd*) represent the maximum number of MWSA that can be simultaneously serviced at each site. For example, a fill site configured to fill three MWSA at the same time has *Kf* = 3, while a dump site, such as the one shown in Figure C.2.4.2.6.2, configured to allow simultaneous offloading of two MWSA has *Kd* = 2. The value of *TW* will initially be zero as the buffering capacity of *TR*, *TD*, and *TF* are not yet exceeded. Once the buffer capacity is exceeded, the value of *TW* will become non-zero and will increase with each additional MWSA added to the shuttle.

Figure C.2.4.2.6.2 Dump Site Configured to Simultaneously Service Two MWSA (*Kd* = 2).

C.2.4.2.6.3

An example of the queuing time estimation process is provided in Table C.2.4.2.6.3. In this example, a hypothetical water shuttle is used to show the increase of queuing time as the number of participating MWSA increases from one to ten (WT-01 through WT-10). Each MWSA added to the operation is assumed to have its own fill site time (*TF*) and dump site time (*TD*), and the mean handling time (*THm*) is calculated for all MWSA in operation (WT-01 through WT-n) when the new MWSA is added. For simplicity, this example uses constant values of *TR* = 10 min, *Kf* = 1, and *Kd* = 1.

Table C.2.4.2.6.3 Example of Water Shuttle Queueing Time (*TW*) Calculation

MWSA	***nWT***	***TF***	***TD***	***TF+TD***	***THm***	***TW***
WT-01	1	4	3	7	7	0
WT-02	2	3	3	6	6.5	0
WT-03	3	5	4	9	7.3	0
WT-04	4	3	4	7	7.3	1.2
WT-05	5	4	4	8	7.4	2.4
WT-06	6	3	4	7	7.3	3.2
WT-07	7	6	7	13	8.1	4.4
WT-08	8	3	3	6	7.9	4.7
WT-09	9	4	4	8	7.9	5
WT-10	10	3	4	7	7.8	5.2

C.2.4.2.6.4

As shown in Table C.2.4.2.6.3, the mean handling time (*THm*) can increase or decrease, depending on the characteristics of the MWSA participating at each step. The native buffering capacity of the shuttle operation is not reached until the arrival of the fourth MWSA (WT-04), at which point *TW* begins to grow with each additional apparatus added to the shuttle. Of note, the inefficient seventh MWSA (WT-07), which has comparatively large *TD* and *TF* values, results in a spike in *TW* for the water shuttle overall.

C.2.4.2.6.5

From an operational safety standpoint, the temporal buffer concepts underlying the queueing time concept should reinforce the pointlessness of MWSA operators attempting to improve performance by rushing between the dump site and fill site. Such recklessness will likely only trade route time for queuing time, at the risk of a potential speed-related mishap.

C.2.4.2.7 Water Shuttle Phases.

When planning for water shuttles, it should be borne in mind that these operations have two distinct phases that are sometimes conflated to ill effect. The preceding sections dealing with time factors are all predicated on the shuttle infrastructure at the fill site and dump site being established and in service. This represents the mature, steady-state phase of a water shuttle. Planners should also consider the time needed to build up this infrastructure, known as the response phase. This phase includes the time needed for apparatus – MWSA and supporting pumpers – and their crews to respond from their home stations to the incident. This phase also includes the time needed to deploy the necessary equipment and hose lines to bring the fill site and dump site into operation. Particularly in rural areas, the response phase can represent a considerable amount of time. When using the water shuttle as a supply method, the impact that extended response phase times can have on achieving desired water delivery benchmarks should be given appropriate consideration for incident response planning.

C.2.5 MWSA Safety.

For decades, MWSA have carried a reputation as an inherently unsafe class of apparatus. There were two reasons for this reputation: the apparatus themselves and the drivers.

C.2.5.1

In previous decades, purpose-built MWSA were not readily available from fire apparatus manufacturers. Many of the original MWSA were, therefore, converted from former civilian or military tank trucks, both as a cost-saving measure and out of necessity, since units built to applicable NFPA standards were simply not available. An example is shown in Figure C.2.5.1. In converting these tank trucks, inadequate thought was often given to the differences between commercial and fire service use, including, but not limited to, differing densities of liquids carried, vehicle weight rating, the need for baffled tanks, and the need for stouter suspensions and more robust braking systems. Many of these early units were thus considered somewhat ramshackle by fire service standards and were prone to mishaps stemming from mechanical shortcomings. Although a few of these legacy MWSA remain on the road, most have been retired from service due to the increased availability of purpose-built apparatus, concerted safety messaging, and targeted safety grant programs.

Figure C.2.5.1 Legacy MWSA Locally Converted from a Surplus Military Truck.

C.2.5.2

The second factor, the drivers, remains with us. While poor design is often believed to be a major contributing factor to MWSA accidents, driver error is a more important factor. In spite of the haphazard construction of many older MWSA, a 2003 US Fire Administration study of line of duty deaths due to crashes by these apparatus (USFA FA-248, *Safe Operation of Fire Tankers*) found that, of the 38 cases analyzed, apparatus design and mechanical issues were a factor in only 11 percent of accidents. Excessive speed (57 percent) and the right-front wheel leaving the paved surface (54 percent) were the dominant causes of fatal mishaps.

C.2.5.3

Factors inherent in the design of MWSA, especially their high center of gravity, exacerbated driver errors leading to fatal accidents. The poor roadway conditions prevailing in many rural areas where MWSA are used also tend to amplify the effects of driver errors. Consider, however, that in these same rural settings, thousands of civilian tank trucks with the same design characteristics as fire service MWSA successfully navigate many more road miles every day without experiencing excessive numbers of accidents.

C.2.5.4

Because fire service MWSA driver-operators have limited time behind the wheel and are likely to be driving under emergent conditions, fire departments operating these apparatus should pay special attention to training their drivers. Initial and continuing MWSA driver training based on applicable standards, such as NFPA 1010 and NFPA 1400, should be implemented by any department with MWSA in its fleet.

C.3 Pumping Apparatus in Water Supply.

C.3.1 General.

While pumps are most often associated with fire attack operations, they also have a role to play in supporting water supply operations. Two general types of pumping apparatus are commonly used in alternative water supply operations: automotive pumper apparatus (pumpers or engines) and portable pumps (packable or trailer-mounted).

C.3.2 Automotive Pumping Apparatus.

Fire department pumpers are commonly used as part of alternative water supply operations, with roles in both relay pumping and water shuttle tactics. Pumper apparatus have the advantage of a large pumping capacity on a high-mobility chassis. Additionally, fire department crews are familiar with pumper capabilities and are experienced in their use under a variety of conditions. Relay pumping evolutions involving several fire department pumpers connected by LDH, such as the one shown in Figure C.3.2, are effective and readily set up for short- or medium-distance conveyance operations. Pumpers are also used in water shuttles, supporting MWSA at both the fill site and dump site.

Figure C.3.2 Fire Department Pumper in a Relay Pumping Operation.

C.3.2.1 Pumpers Used for Water Supply Operations.

In some cases, pumpers are designed and equipped specifically for a water supply role. For example, an engine might be equipped with additional suction hose, strainers, and appliances that optimize the pumper for service at the fill site or dump site. If such units are envisioned to commonly supply water from static sources, fire departments should ensure that any external intake valves have large, unrestricted waterways. This will ensure that the external valve does not need to be removed every time the pumper attempts to operate from draft, simplifying operations for the pump operator.

C.3.2.2 Pumpers Used in Water Shuttle Operations.

Other automotive pumping apparatus are sometimes used in water shuttle operations, often to free up full-size pumpers for more critical duties. Wildland apparatus, for example, are sometimes used at the dump site where their smaller pumps are effective for running jet siphon devices for transferring water between portable tanks. This frees up the dedicated dump site pumper from running these additional lines and obviates the need for assigning an additional pumper to the role.

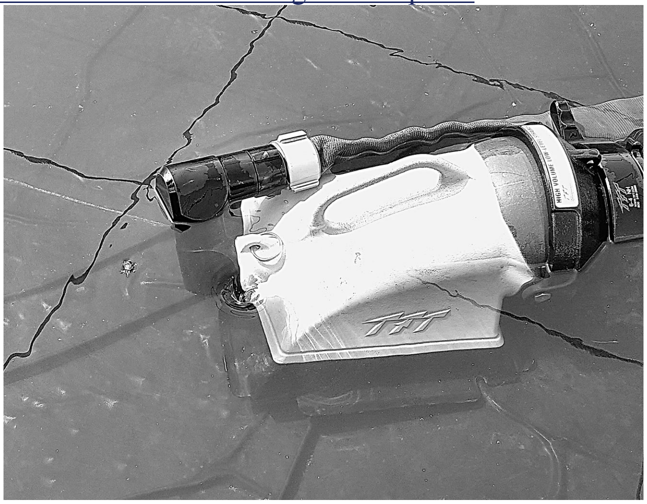
C.3.2.3 Specialized Appliances.

Pumpers assigned to water supply duties are often equipped with specialized appliances to better perform this mission.

C.3.2.3.1 Low-Level Strainer.

While any pumper is capable of operating from draft and will carry suction hose and a basket strainer for that purpose, those working from portable tanks, such as at a water shuttle dump site, should be equipped with a low-level strainer. These specialized strainers have a flat, metal footplate that allows the pumper to draft down to a few inches of water depth, maximizing use of the limited portable tank volume. These strainers can be attached to a section of suction hose that is run over the top of the tank frame or attached directly to the inside of a through-wall coupling, with the suction hose attached to the outside. Current models of low-level strainers, such as the one shown in Figure C.3.2.3.1, usually feature a built-in jet siphon so that these appliances can also be used for tank-to-tank water transfer.

Figure C.3.2.3.1 Low-Level Strainer with Integral Jet Siphon.



C.3.2.3.1.1

Although low-level strainers allow drafting to very shallow depths, a vortex will still be produced once water depth decreases sufficiently. This vortex will allow air entrainment into the pump and possible loss of prime. To prevent this, water supply pumpers should carry small objects, such as a buoyant bowling pin or small beach ball, that will float in the tank and break up any vortex that forms.

C.3.2.3.2 Suction Elbow.

Another appliance useful for the water supply pumper is a suction elbow. This is a long-sweep 90-degree elbow that attaches between the pump intake and the suction hose, as shown in Figure C.3.2.3.2. This allows the suction hose to be run close alongside the pumper, preventing the need for a large bend of hose at the pump intake. With this configuration, portable tanks can be set up fore and aft of a supporting pumper, allowing a narrower footprint and keeping a lane of travel open for MWSA.

Figure C.3.2.3.2 Dump Site Pumper Using Suction Elbow to Minimize Footprint and Keep Travel Lane Open.

C.3.3 Portable Pumps.

In addition to fire department pumpers, portable pumps are sometimes used as part of alternative water supply operations. These pumps come in a variety of sizes and capabilities and can be either packable or trailer mounted. All modern portable pumps are centrifugal models. They are predominantly powered by small gasoline or diesel motors attached directly to the pump, although some types are hydraulically or electrically powered, and battery-powered models are under development. In some settings, portable pumps are used to supplement fire department pumpers. Their smaller size permits the use of static water sources that are inaccessible to road-bound pumpers. Portable pumps of adequate capacity, working alone or in tandem at static sources during long-duration water supply operations, can also free up pumpers for other missions.

C.3.3.1 Specifications.

There is currently no national standard for portable pumps for fire department use. The former NFPA 1921 was discontinued after the 1993 edition and has not been replaced or subsumed by another standard. The United States Forest Service does publish standards for several types of portable pumps under the 5100 series of specifications. These are for small-capacity pumps intended for wildland firefighting, however, and not for units capable of providing the flows needed for structural firefighting purposes. Fire departments considering incorporating portable pumps into their water supply operations should, therefore, proceed with caution and only acquire pumps from reputable manufacturers since there will be no national standard to form the basis of purchase specifications.

C.3.3.2 Wildland Portable Pumps.

Portable pumps are used extensively for wildland firefighting, and these pumps, such as the one shown in Figure C.3.3.2, are designed specifically for that purpose. The design of these pumps places a premium on portability, ruggedness, and simplicity. They are principally used to access water sources in remote areas and are generally small enough to be carried on a backpack frame or in a pickup truck bed. These pumps generally prioritize pressure overflow. They are typically designed to provide relatively small flows at the nozzle delivered over long lays of small-diameter hose, often over significant elevation increases. In many cases, wildland fire apparatus use these same pumps in vehicle mounts to pressurize attack lines, allowing easy interchange of parts and entire pumps in remote and austere incident settings.

Figure C.3.3.2 Wildland Firefighting Portable Pump Set Up to Draft from a Static Source.

C.3.3.2.1

In most cases, it is unlikely that portable pumps intended for wildland use will be able to serve as a primary water supply pump for structural firefighting purposes. These pumps are simply not intended to provide the level of flow required to support fire department operations. While sometimes readily available, these pumps are likely to serve, at best, in an auxiliary capacity in alternative water supply operations. A common role for these pumps in water shuttle operations is at the fill site when using a static source of supply with marginal flow or depth. One or more portable pumps are set up to access the static water source, pumping water into a portable folding tank, which is, in turn, used by an assigned pumper to fill MWSA as they arrive. Although there is no way to increase the base flow or volume of the static source, the portable pumps make the most of it by continuously accessing it in the lull times between MWSA arrivals.

C.3.3.3 Commercial Portable Pumps.

Portable pumps made for construction, agricultural, and allied commercial purposes are produced with a wide range of pumping capabilities, power sources, and portability options. Large, trailer-mounted units can offer volume performance on par with that of a fire department pumper. These pumps are not built to any fire service standard and should not be used for any purpose where life safety could be an issue. Commercial pumps will likely require adapters if intended to connect to fire department fittings. Under the right circumstances, these pumps can be useful adjuncts in supporting roles, such as long-term pumping operations at a static source. For low-quality water sources, these pumps can be an option to avoid potential wear and damage to expensive fire department pumps. Commercial portable pumps might be available as surplus units at low cost or potentially under emergency rental agreements in support of incidents or disasters with long-term, high-volume water supply needs.

C.3.3.4 Floating Pumps.

Portable pumps of various sizes and configurations, such as the one shown in Figure C.3.3.4, are available in floating models. These pumps can provide advantages in accessing static water sources where working with suction hose from the shoreline is impractical. The simplest models are similar to wildland portable pumps but placed in floating plastic collars with suction appropriately oriented below the pump. These pumps have a small internal combustion motor and must be periodically recovered to replenish fuel. Such units have performance limitations similar to those of wildland pumps when used in support of structural firefighting but can be useful adjuncts under some circumstances.

Figure C.3.3.4 Floating Portable Pump Used in Support of Fill Site Operations During a Water Shuttle.

C.3.3.4.1

Much more capable floating pumps are powered via hydraulic umbilical lines connected to a hydraulic pump carried in a shore-based support vehicle. The separate hydraulic power source allows these floating submersible source pumps (FSSPs) to provide high-volume flow comparable to a fire department pumper without the need for periodic refueling. Figure C.3.3.4.1 provides an example of an FSSP and its hydraulic power source.

Figure C.3.3.4.1 FSSP Deployed in Static Source (Left) and Shore-Based Hydraulic Power Unit (Right).

C.3.4 Specialized Pump Support Equipment.

Static water sources in rural areas are often difficult to access, limiting their potential utility for fire protection water supply. Many devices have been developed to assist pump operators in overcoming access difficulties. These devices can be useful but are often limited to specific applications and will not be a solution for every fire department's challenges. There are numerous such items. Two common examples are discussed below.

C.3.4.1 Eductor Devices.

Eductor devices are designed to allow drafting from a static source located some distance from a fire department pumper (further than could be drafted via suction hose). The device is placed with its intake in the static source. A hand line is run from the pumper to the device, and a supply line is run back to the pumper. Using flow from the hand line, water is conveyed from the source to the pumper by means of Venturi effect. More water is supplied to the pump than is used to charge the hand line, although the total amount supplied is less than would be provided by operating at true draft because some flow is tied up to provide the Venturi effect. These devices are only usable by pumpers (not portable pumps) because the on-board water tank is needed to initiate the Venturi flow. These devices can be useful under certain circumstances, but flows provided will be modest and ice-free access to the static source will be required.

C.3.4.2 Portable Dams.

When using streams as a source of static supply, total flow is often adequate, but depth might be insufficient to allow drafting. Portable canvas dams have been successfully used to remedy this situation. By impounding streamflow to an adequate depth behind the dam, pump operators can successfully draft from the stream and take advantage of the existing flow. These dams are often used for flood protection and hazardous materials response and are readily available from manufacturers in a variety of heights and lengths. For example, a 25 ft (7.6 m) model, capable of impounding a stream to a depth of 28 in. (70 cm) will allow drafting with a low-level strainer and can be readily deployed by two firefighters.

C.4 Supply Hose and Related Appliances.

C.4.1 General.

Fire service supply hose is used extensively in alternative water supply operations, most obviously for relay pumping, but also in support of water shuttle operations. Supply hose can be divided into two general classes based on diameter:

(1) Medium-diameter Hose (MDH): 2**1⁄2** in. or 3 in. diameter (65 or 76 mm)

(2) Large-diameter house (LDH): 3**1⁄2** in. (90 mm) or larger diameter; commonly in 4 in. or 5 in. diameter (100 or 130 mm) size for fire department use

C.4.1.1

While supply hose is operated under lower pressures than attack hose, it is pressurized nonetheless and capable of causing injuries. Fire departments should only use supply hose manufactured in accordance with NFPA 1960 and maintained in accordance with NFPA 1930, or the appropriate predecessor standards.

C.4.2 Large Diameter Hose.

Supply hose in the MDH class, especially 2**1⁄2** in. (65 mm), was long the workhorse of the fire service, and MDH retains an important role in water supply. Due to its advantages in terms of weight and reduced friction loss, LDH has largely supplanted MDH for long-distance relay pumping. Single-jacket relay-supply hose was still considered experimental in the 1968 edition of NFPA 196, but by the 1974 edition was recognized as a standard type of fire hose. In the meantime, LDH has entered common fire service use for any water supply setting where friction loss is a major consideration.

C.4.2.1

Modern LDH is commonly carried on fire department pumpers as the principal supply line. As a single-jacket hose constructed of synthetic materials, it has the dual advantages of having a relatively light weight and being repackable without drying. Typically, lightweight, sexless couplings are used to simplify connections. The principal advantage of LDH over smaller hose, however, is its very low friction loss values due to the large hose lumen. The large lumen does lead to one potential disadvantage of LDH: a large volume of water is required to simply fill the hose to begin flow. While not an issue in hydranted municipal areas, this can be a concern when the volume of available water is constricted, such as in the initial stages of a water shuttle.

C.4.2.2

When planning water supply operations that will involve relay pumping of any complexity, it is critical to determine potential friction losses in the contemplated hose lay. It is important that accurate estimates of friction loss for hose and appliances be used to avoid overly optimistic estimates of water delivery rates. Manufacturer provided documentation for hose and appliances is the best source for friction loss estimates. If this is not available, water supply planners should use conservative generic estimates from a reputable source to ensure that good estimates are made for the planned operation.

C.4.3 Appliances.

A variety of large-capacity supply hose appliances find common use in alternative water supply operations. Just as with the supply lines they are connected to, these appliances will be operated under pressure. Misuse or mechanical failure could result in injury. Any appliances in fire service use should be compliant with the current edition of NFPA 1960 and maintained in accordance with NFPA 1930, or the relevant predecessor standards.

C.4.3.1 General.

Because these appliances are robustly built and tend to be infrequently used, they are not always a high priority for replacement. In many cases, older appliances are used to equip multiple generations of apparatus. As these vehicles are replaced, the appliances are simply transferred from the old unit to its replacement. This misguided effort at economy can result in two problems. First, although these appliances seem relatively simple, there have been technological improvements in their design over time. New materials and design innovations have resulted in lighter weight models with improved flow and friction loss characteristics. Older appliances are unlikely to have performance documentation available from the manufacturers, limiting the accuracy of hydraulic estimates. Second, safety issues with older models are not always well publicized. This can result in departments keeping appliance models in service, not knowing that the model has failed elsewhere, disrupting operations and causing injuries. Although the list of potentially available appliances is very long, information on some of the most used items is provided in the following sections.

C.4.3.2 Manifolds.

Also called a water thief, manifolds feature an LDH inlet along with two or more separately valved MDH outlets. Some also have an LDH outlet to allow pass-through flow. This allows the flow of an LDH line to be divided among multiple smaller lines. These appliances are especially useful at water shuttle fill sites, where a pumper supplies an LDH trunk line up to the appliance and multiple MDH branch lines are used to create multiple stations for filling MWSA. An example is shown in Figure C.4.3.2.

Figure C.4.3.2 Manifold Appliance in Use at a Water Shuttle Fill Site with an LDH Trunk Line Divided into Four MDH Branch Lines to Create Two Fill Stations, Each with Two Fill Lines.

C.4.3.2.1

Any manifold appliance should have an integral pressure relief device (PRD), set to accommodate the supply hose in use. A built-in pressure gauge is also useful for the manifold operator during fill site operations. Fire departments should be alert to the fact that some older versions of this appliance have failed catastrophically, seriously injuring firefighters. In each case, these were cast aluminum models without integral PRDs that were imported from Europe in the 1970s and 1980s, before LDH use became widespread in North America. Because the metallurgical flaws that caused these incidents are not easily detected, appliances fitting this description should be immediately removed from service and replaced with modern versions built to appropriate standards.

C.4.3.3 Clappered Siamese.

Clappered Siamese appliances allow the flow of two incoming supply lines to feed a single line out. Devices equipped with an internal, spring-loaded clapper prevent flow from an incoming line with a significantly lower pressure, allowing for a gradual transition between two incoming hoses. These appliances are used at the water shuttle dump site as part of a transitional rural hitch operation, as described in detail in C.2.3.2. Fire departments that commonly use the rural hitch tactic will often keep a clappered Siamese permanently attached to the LDH supply line on attack pumpers, ready to forward lay from the dump site. As with manifold appliances, some older, cast aluminum versions of this appliance have failed catastrophically under pressure. These older models should be removed from service and replaced with modern versions.

C.4.3.4 Four-Way Valves.

Sometimes called a relay valve, four-way valves allow the insertion of an additional pumper into an established supply or relay hose lay without interruption of flow. When attached directly to a pressurized hydrant, these valves allow a later-arriving pumper to add to the hydrant's pressure. When placed at intervals along a relay hose lay, a later arriving pumper can be inserted seamlessly into the relay, boosting pressure as needed.

C.4.3.5 Supply Line Elbow.

When working with a relatively weak source of water supply at a water shuttle fill site, such as a low-flow rural hydrant or portable pump, it is often beneficial to allow the source to continuously flow into a portable tank. This allows an assigned fill site pumper to draft from the tank to fill MWSA as they arrive, thus making the most of the weak water supply. While hose lines can be tied to the tank frame to allow open-butt flow, purpose-built supply line elbow appliances are available that will more securely hold the line by clamping directly to the tank frame. When combined with a small gate valve, such an arrangement can provide better control of the incoming supply line with better safety for the fill site crew.

C.5 Portable Tanks.

C.5.1 General.

The exact history of portable tanks for firefighting is not clear, but they were first mentioned in North American fire literature in the 1950s. Portable water tanks are used extensively in mobile water supply operations (water shuttles), mostly at the dump site, but occasionally at the fill site as well. At the dump site, portable tanks serve as receptacles for water delivered by MWSA. Water in portable tanks can be used to directly supply an attack apparatus operating from draft, or it can be relay pumped to distant attack apparatus by an assigned pumper that is stationed closer to the tanks. By providing onsite, temporary storage for water hauled by MWSA, these apparatus are free to return immediately to the fill site for reloading after delivering their water. This prevents MWSA from being tied up on scene providing water via umbilical supply to an attack apparatus (nurse tanking). At the fill site, portable tanks are sometimes used to allow accumulation of water from low-volume sources, such as weak hydrants or portable pumps, during intervals between MWSA filling.

C.5.2 Portable Tank Design.

There are three basic designs of portable tanks: self-supporting, packable frame, and folding frame. There is no NFPA or other national standard for portable tanks for fire department use; claims that a tank is "NFPA 1142 compliant" are meaningless.

C.5.2.1 Self-Supporting Tanks.

Sometimes called blivets, self-supporting tanks are frameless and have a circular, floating collar. As it is filled, the tank expands, creating a characteristic bubble shape. These tanks are not commonly used for structural firefighting operations because they are not easily stowed on fire apparatus and tanks of significant volume tend to be too tall for easy drafting by common structural pumper apparatus. These tanks are often used in wildland firefighting operations, however. Wildland helicopter buckets can be dipped directly into tall versions of these tanks for refilling while the aircraft hovers, eliminating the need for landing and speeding bucket fill operations.

C.5.2.2 Packable Frame Tanks.

Sometimes called snap tanks, packable frame tanks consist of a lightweight metal (steel or aluminum) frame supporting a collapsible synthetic canvas liner. The frame members are not permanently connected, and the frame is fully disassembled for stowage, generally in a large canvas bag made for the purpose. This allows for storage of the tank in a relatively smaller space, such as a pickup truck, but comes at the expense of a longer deployment time due to the need to assemble the frame components. When deployed, these tanks are similar in appearance and function to the folding frame tanks described in C.5.2.3. Packable tanks are not common for fire department MWSA applications but can be useful in specialty applications, such as wildland firefighting, where speed of deployment is less critical, and cargo space is at a premium.

C.5.2.3 Folding Frame Tanks.

By far the most common type of portable tank for fire department mobile water supply applications is the folding frame tank. Because this annex is intended principally for fire department reference, the remainder of this section will be focused on this type of portable tank. Folding frame tanks feature a lightweight metal frame of steel or aluminum, with the frame members permanently connected and hinged to allow folding, as shown in Figure C.5.2.3. An attached synthetic canvas liner forms the open-top tank when deployed. The liner is permanently attached to the folding frame, with the tank stored and deployed as a single unit. The synthetic liner material can be stowed wet without risk of damage, easing the process of breaking down equipment at the conclusion of an incident. These tanks are equipped with one or more permanently attached drain tubes to allow for rapid emptying of water. Folding frame tanks are most commonly carried on fire department MWSA, stowed in dedicated racks on the side of the apparatus water tanks. They are also occasionally found on pumper apparatus with a dedicated water supply role in the fire department. One significant limitation of folding frame tanks is that they must be deployed on flat ground. Failure to account for this fact will result in reduced usable volume, as well as potential damage to the frame if portions of it are unsupported (such as by overhanging a roadside ditch). Folding frame tanks are characterized by their volume, geometry, and specialized features.

Figure C.5.2.3 Folding Frame Portable Water Tank.

C.5.2.3.1 Tank Volume.

There is no optimal or mandatory capacity for folding frame tanks or any other portable tanks carried on MWSA. Tank capacity is a decision left up to fire departments to meet local needs and practices. NFPA 1900 only mentions portable water tanks for MWSA carriage in annex material as "additional equipment that might be considered." *[See Table A.8.4(c).]* The major portable tank manufacturers offer standard tank designs suitable for equipping MWSA in capacities ranging from 1000 to 3000 gal (3785 to 11,356 L), with custom designs available to suit department needs. Portable tank capacity carried on MWSA is an important fire department decision because apparatus racks for carrying the portable tank (or tanks) must be sized appropriately and will be difficult to modify once built. Although there is no standard for portable tank capacity to be carried on MWSA, it is advisable that sufficient capacity is readily available to hold at least the rated capacity of the MWSA itself, as well as some overage. This ensures that the MWSA can fully unload its tank without the need for additional portable tanks arriving on different apparatus, a critical consideration during the early stages of a mobile water supply operation. When designing large-capacity MWSA [larger than 2000 gal (7571 L)], departments should be alert to the fact that a single large portable tank will require significant flat ground for deployment and will be nearly impossible to reposition once deployed and filled. Therefore, for larger MWSA, the use of multiple, smaller tanks might allow for greater flexibility in positioning at the dump site.

C.5.2.3.2 Tank Geometry.

Originally, folding frame tanks came in one shape: square. Although there is no official standard for portable tank design, a frame height of 29 in. (74 cm) is common for stock models produced by the major manufacturers. This is a workable height for drafting operations by most fire department pumper apparatus. Given this common tank frame height, tank length and width when deployed are determined by nominal capacity. For square tanks, length and width are equal, yielding the dimensions shown in Table C.5.2.3.2 for common stock configurations.

Table C.5.2.3.2 Dimensions for Common Square Folding Frame Tank Capacities with 29 in. (0.74 cm) Frame Height)

Nominal Capacity	**Length and Width**
1500 gal (5678 L)	10.25 ft (3.1 m)
2100 gal (7949 L)	11.25 ft (3.4 m)
2500 gal (9464 L)	12.25 ft (3.7 m)
3000 gal (11,356 L)	13.25 ft (4.0 m)

C.5.2.3.2.1

In rural areas, where folding frame tanks are commonly used to support water supply operations, roads and driveways are often the only available flat surface for deployment of tanks. In these settings, however, lane widths can be very narrow, and the width of deployed square-profile tanks can easily occlude the trafficable road surface. To address this issue, manufacturers have developed narrow profile folding frame tanks. These tanks are available in a similar range of capacities as the standard square models but are shaped as rectangles or elongated hexagons, such as the ones shown in Figure C.5.2.3.2.1. This allows the tanks to have widths similar to fire apparatus: 8 to 10 ft (2.4 to 3.0 m), with capacity increased by increasing tank length. Deploying these narrow profile tanks in a fore-and-aft configuration with water supply pumper apparatus minimizes blocking of traffic lanes for water supply operations, especially at the dump site. Because folding frame tanks are robust and infrequently used, they tend to have a long service life, meaning that despite advances in tank design, the original square profile designs remain the most common type in actual service.

Figure C.5.2.3.2.1 Folding Frame Tanks with Narrow Profile Configuration Deployed In-Line with a Supporting Pumper Leaving a Travel Lane Open for MWSA.

C.5.2.3.3 Specialized Tank Features.

A variety of specialized features have been developed for folding frame tanks to improve efficiency of deployment, use, and breakdown. Because of the simple design of these tanks, many of these features can be easily retrofitted to older tanks by the owning fire department. Some common features include the following:

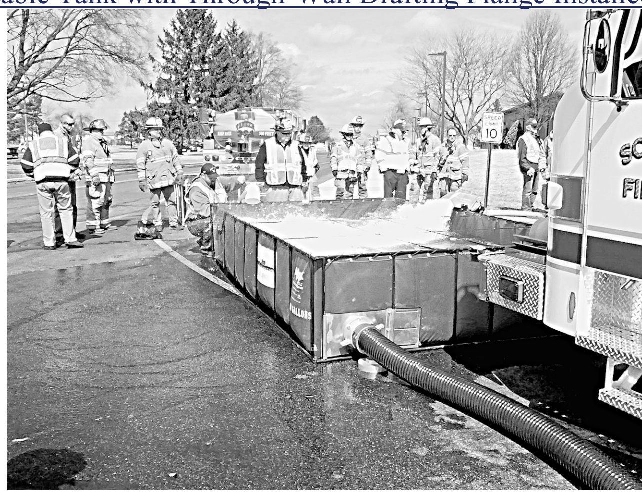
(1) *Multiple drain tubes.* Drain tubes can be installed on two or more sides of the tank (rather than just one), increasing flexibility in positioning tanks, since drain tubes are optimally positioned downhill.

(2) *Grab handles.* Simple loop handles can be affixed to the inside bottom of the tank to allow pulling up the floor material and speeding drainage.

(3) *Expansion bladders.* Attached, deployable bladders can be used to increase tank capacity when favorable terrain is available.

(4) *Drafting flanges.* A through-the-wall coupling placed in a metal flange and positioned near the bottom of the tank can be added to allow connection of suction hose and strainer, obviating the need to run suction hose over the top of the tank wall. These are used to allow fore-and-aft positioning of tanks for the water supply pumper apparatus at a dump site. An example is shown in Figure C.5.2.3.3.

Figure C.5.2.3.3 Portable Tank with Through-Wall Drafting Flange Installed.



C.5.3 Tank-to-Tank Water Transfer.

A water shuttle dump site typically requires multiple portable tanks to handle large delivery rates to the incident scene. The supporting pumper assigned to the dump site will operate at draft from one of these tanks, designated as the *draft tank*. It is important that MWSA not be offloaded into the draft tank, because the resulting turbulence can result in air entrainment and potential loss of prime for the pumper. One or more separate dump tanks positioned alongside the draft tank will be used for MWSA offloading, keeping turbulence away from the pumper intake. Water from these dump tanks must be transferred to the draft tank for use by the pumper. While it is possible to achieve this by directly linking the tanks via the drain tubes and allowing gravity flow, this will result in all tanks having the same water level. Instead, active methods of tank-to-tank water transfer are preferred, since this allows the dump site crew to keep the draft tank as full as possible to maximize volume available for drafting and the dump tanks as empty as possible to maximize available storage capacity for unloading MWSA.

C.5.3.1

Active tank-to-tank water transfer is normally accomplished by means of jet siphon appliances, powered by handlines from supporting pumpers, and conveying water via standard suction hose. Figure C.5.3.1 provides an example of this configuration. While separate jet siphon devices that screw directly into the suction hose are available, use of low-level strainers with built-in jet siphons is generally more convenient. This method has the advantage of using equipment that can be put to multiple uses, such as suction hose and low-level strainers, rather than requiring the acquisition and carrying of single-purpose appliances.

Figure C.5.3.1 Water Transfer Using Jet Siphons from Dump Tanks to Draft Tank (Center) at a Water Shuttle Dump Site.

C.5.3.2

In the past, water transfer appliances were often locally fabricated with mixed results in terms of performance and safety. These devices might still be encountered but are becoming less common, as commercial versions having better performance characteristics have become the norm, even in rural settings.

C-deleted ~~Mobile Water Supply Apparatus-DELETED~~

~~*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*~~

~~C.1 General.~~

~~The fire service has often experienced fire control difficulties in isolated areas. Although difficulties vary, one of the major problems encountered is the lack of an adequate water supply. The availability of an adequate amount of water for control and extinguishment is a major consideration for many fire officials and a factor that significantly influences their firefighting tactical decisions. Fire department training should emphasize the need to maintain an effective water supply from source to application.~~

~~A limited water supply condition during a working fire can adversely affect all phases of firefighting. This annex discusses the options and procedures for moving water where municipal-type water distribution systems are nonexistent or are substandard. When the water supply is provided from a dry hydrant, a lake, a cistern, a swimming pool, or other static source, operating procedures should include those activities required for transporting the water from the supply site to the fire. Fire departments generally commit to the draft or supply location using fire department pumper(s) with a pump capacity of 750 gpm (2850 L/min) or more, and a minimum booster tank size of 500 gal (1900 L).~~

~~In some departments, pumping apparatus assigned to water supply functions require little equipment beyond the apparatus pumps, the hose for filling mobile water supply apparatus, and some preconnected hand lines. There are many water source pumping options, and they vary widely depending on need and available resources.~~

~~Apparatus used to haul water have reflected a great deal of ingenuity, but in some instances at the risk of firefighter safety. In the interest of improving operational flexibility and safety, some rural and suburban fire departments now use standard pumpers and mobile water supply apparatus with tanks in the 1000 gal to 1500 gal (3800 L to 5700 L) range. Techniques for loading and unloading mobile water supply apparatus have also seen significant improvements. The goal~~

~~during every fire evolution is to maintain the required fire flow throughout the entire firefighting operation.~~

~~Mobile water supply apparatus serve as a necessary asset in many suburban and rural fire departments. When the necessary water-carrying capacity exceeds local capability, a sound mutual or automatic aid program can provide the necessary resources.~~

~~Such arrangements are far superior to the use of unsafe makeshift equipment that is not designed for emergency service. Departments that build apparatus that are not in compliance with NFPA 1901 should give serious consideration to the safety, reliability, and serviceability of the equipment in question. A department that depends on an assortment of mobile water supply apparatus primarily designed for other uses should seek expert assistance to check the operational safety of the equipment.~~

~~The design and construction of a mobile water supply apparatus requires those involved to determine the gross vehicle weight rating (GVWR) of a chassis necessary to safely carry the maximum load and the resulting weight distribution, the engine horsepower needed to adequately perform on the road and at the fire scene, the appropriate brake system, and gear train combination best suited for operations in that specific locale. Apparatus components, such as tank baffling, venting, loading and off-loading systems, and the center of gravity, are just as important as the engine, axles, and other driveline components.~~

~~Some fire departments that have pumpers equipped with large water tanks have retrofitted their apparatus with some form of a quick-dump system (large gravity dump, jet-assist device, etc.).~~

~~Today's commercial mobile water supply apparatus can be designed to employ one of two possible technologies (or a combination of both) for loading, and four alternatives for unloading.~~

~~Mobile water supply apparatus can be equipped with standard centrifugal fire pumps, positive displacement pressure/vacuum pump systems, or a combination of pumping equipment configurations.~~

~~C.2 Specifications for Mobile Water Supply Apparatus.~~

~~Careful attention should be paid to ensure that engine, chassis, water tank baffling, vehicle center of gravity, and brakes are adequate for mobile water supply apparatus. NFPA 1901 covers mobile water supply apparatus, and it is recommended that the standard be followed.~~

~~The tank should be properly constructed and baffled. Particular attention should be paid to flow rates to and from the tank. Consideration should be given to how the mobile water supply apparatus will discharge its water to the receiving vehicle, portable tank, or other equipment as rapidly as possible. It is essential that the mobile water supply apparatus get back on the road, reload, and bring another load of water to the fireground rapidly. Some departments install large gravity dump valves, while other departments use a jet dump arrangement to reduce the emptying time.~~

~~The terrain, weather, and bridge and road conditions expected should be considered when buying or building mobile water supply apparatus.~~

~~It is suggested that, for a mobile water supply apparatus with a capacity greater than 1500 gal (5700 L), it might be necessary to utilize tandem rear axles or a semitrailer, depending on tank size and chassis characteristics. It is further recommended that the maximum water tank capacity for mobile water supply apparatus not exceed 4800 gal (18,200 L) or 20 tons (18,200 kg) of water. The cost of two smaller mobile water supply apparatus might cost about the same as one large mobile water supply apparatus. Mobility, cost of upkeep, personnel availability and costs, state weight restrictions, and bridge weight restrictions are factors to consider in the selection of mobile water supply apparatus.~~

~~The weight of the vehicle plus the load carried should not be greater than the rated capacity of the tires. Compliance should be determined by weighing the loaded apparatus.~~

~~C.3 Regulations and Restrictions.~~

~~Regardless of rear axle configuration, specific consideration should be given to the state's legal weight-per-axle requirement. Government entities can have single-axle weight limits, which are~~

~~imposed based on road surface conditions and the longevity of highways. The need for commercial driver's license, vehicle registration, insurance coverage, and other issues should be addressed.~~

~~The load capacity of roads and bridges is a serious consideration when planning purchases of fire apparatus. Mobile water supply apparatus have to be restricted to a load capacity that will not cause overloading of roads and bridges. A good policy for every fire department is to check the bridge load restrictions before purchasing a new apparatus.~~

~~C.4 Mobile Water Supply Capacity.~~

~~Many departments find that a minimum tank capacity of 1000 gal (3800 L) facilitates meeting the minimum water requirements outlined in this standard where water supplies are readily available.~~

~~C.5 Tank Baffles.~~

~~The tank baffle or swash partition is often considered to be the weakest and most dangerous area of fire engine and mobile water supply design and construction. Careful consideration should be given to baffles by the designers and builders of tanks. *(See NFPA 1901.)*~~

~~C.6 Plumbing.~~

~~It is important to have an outlet of adequate size to empty the tank quickly. Table C.6 illustrates the emptying time for a 1600 gal (6060 L) water tank by gravity flow using different outlet sizes. Adequately sized plumbing is also important in those mobile water supply apparatus equipped with a pump with a jet dump arrangement. Many jet dump arrangements are capable of discharging at a rate of 1000 gpm (3800 L/min) or more.~~

~~Proper venting is imperative for safe and rapid filling and emptying of tanks. As a minimum, the vent opening should be four times the cross-sectional area of the inlet. Inadequate venting can cause the tank to bow outward when it is being filled rapidly or can impair the discharge flow when the tank is emptying.~~

~~If the mobile water supply apparatus is equipped with a fire pump, adequately sized pump-to-tank plumbing is also essential to provide for rapid discharge of water through the pump. In a mobile water supply operation in which the emphasis is placed on rapid, low-pressure emptying of a tank, undersized plumbing can be a major limitation to efficiency.~~

~~Mobile water supply apparatus should be designed to fill and empty completely. Applicable NFPA standards such as NFPA 1901 contain data on adequate plumbing.~~

~~Table C.6 Emptying Time for 1600 Gal (6060 L) Mobile Water Supply by Gravity Flow~~

~~Outlet Size~~		~~Discharge Time~~
~~in.~~	~~mm~~	~~(min)~~
~~21⁄2~~	~~65~~	~~20~~
~~41⁄2~~	~~115~~	~~7~~
~~6~~	~~150~~	~~5~~
~~10~~	~~250~~	~~12⁄3~~
~~12~~	~~300~~	~~11⁄2~~

~~C.6.1 Fill Line Couplings.~~

~~Often, time wasted at mobile water supply fill locations is due to difficulties in connecting and disconnecting the threaded couplings on the hose between the fill pumper and the water tank fill connection on the mobile water supply apparatus. If such difficulties exist, considerable time can be saved by using either a quarter-turn coupling (or some type of flexible hose with a quick disconnect), a specially designed large-diameter fill pipe, or a rapid-fill device that drops into the fill opening at the top of the tank, thus providing quick breakaway from the fill supply.~~

~~**C.7 Weight Distribution.**~~

~~Weight distribution is all-important in the handling of a heavy piece of fire apparatus and should be properly designed into the unit and then verified by weighing each axle. Even the slightest change in the load carried or in the distribution of the load can cause the design limits of the truck to be exceeded and turn a safe vehicle into an unsafe vehicle.~~

~~**C.8 Turning Radius and Wheelbase.**~~

~~An important consideration in mobile water supply shuttle operations is the area available for turning. Because the mobile water supply apparatus might be called on to reverse direction or to maneuver for position at the water source or the fire site, multiple single-axle straight chassis mobile water supply apparatus, each with a 12 in. (300 mm) gravity dump or a 6 in. (150 mm) jet dump, might actually move more water to the fire location than longer wheelbase tractor trailers and dual wheel, tandem-axle, mobile water supply apparatus.~~

~~**C.9 Driver Training.**~~

~~An important consideration frequently overlooked by the rural fire department is that of driver training. Few people are trained to drive a tractor-trailer combination under emergency conditions, and the fire department planning to use such a vehicle should provide specific training for drivers of this type of apparatus. Even a two- or three-axle vehicle used as a mobile water supply apparatus will probably have driving characteristics very different from other apparatus, and driver training is extremely important. Individual state operator licensing requirements should be met. NFPA 1002 and NFPA 1451 should both be used when developing programs to train and validate drivers of emergency fire apparatus.~~

~~**C.10 Calculating Water-Carrying Potential.**~~

~~The following are two primary factors to be considered in the development of tank water supplies:~~

~~(1) The amount of water carried on initial responding units~~

~~(2) The amount of water that can be continuously delivered after initial response~~

~~A number of fire departments have developed water-hauling operations where they have a maximum continuous flow capability (a sustained fire flow) of 1000 gpm to 2000 gpm (3800 L/min to 7600 L/min) at the fire scene. Such continuous flow requires several mobile water supply apparatus to haul such large quantities of water, with a developed water source near the fire scene. To improve the safety factor by reducing congestion on the highways, the departments often send the mobile water supply apparatus to the water source by one road and use another route for the mobile water supply apparatus to return to the fire scene. Therefore, the amount of time for the apparatus to travel from the fire to the water source (T_1) might be different from the travel time back to the fire (T_2). The reduction of congestion on the highway provides for a safer operation and can increase the actual amount of water hauled.~~

~~The maximum continuous flow capability at the fire scene is calculated as follows:~~

$$Q = \frac{V}{A + T_1 + T_2 + B} \times k$$

~~**DELETED**~~ ~~**[C.10a]**~~

~~where:~~

~~Q = maximum continuous flow capability [gpm (L/min)]~~

~~V = tank volume of the mobile water supply apparatus in gal (L)~~

~~A = time (min) for the mobile water supply apparatus to drive 200 ft (61 m), dump water into a drop tank, and return 200 ft (61 m) to starting point~~

~~T_1 = time (min) for the mobile water supply apparatus to travel from fire to water source~~

T_2 = time (min) for the same mobile water supply apparatus to travel from water source back to fire

B = time (min) for the mobile water supply apparatus to drive 200 ft (61 m), fill mobile water supply at water source, and return 200 ft (61 m) to starting point

k = 1.0 for vacuum/pressure mobile water supply apparatus; 0.9 for all other mobile water supply apparatus due to spillage, underfilling, and incomplete unloading

The dumping time *(A)* and filling time *(B)* for the formula should be determined by drill and by close study of water sources. Equipment does not have to be operated under emergency conditions to obtain travel time *(T)*, which is calculated using the following equation:

$T = 0.65 + XD$ **DELETED[C.10b]**

where:

T = time (min) of average one-way trip travel

X = average speed factor = 60/average speed *[see Table C.10(a)]*.

D = one-way distance (miles)

The factor 0.65 represents an acceleration/deceleration constant developed by the Rand Corporation.

Where an apparatus is equipped with an adequate engine, chassis, baffling, and brakes, a safe constant speed of 35 mph (56 km/hr) can generally be maintained on level terrain, in light traffic, and on an adequate roadway. Where conditions will not permit this speed, the average safe speed should be reduced.

Using an average safe constant speed of 35 mph (56 km/hr), the *X* factor is calculated as follows:

$$X = \frac{60}{\text{average speed}} = \frac{60}{35\text{ mph}} = 1.7$$ **DELETED[C.10c]**

Precalculated values of *X* using various speeds in miles per hour and kilometers per hour are shown in Table C.10(a). When the distance is inserted into the formula for travel time ($T = 0.65 + XD$), the results are as indicated in Table C.10(b).

Table C.10(a) Precalculated Values of X

Speed (mph)	X	Speed (km/hr)	X
15	4.0	25	2.4
20	3.0	30	2.0
25	2.4	40	1.5
30	2.0	50	1.2
35	1.7	60	1.0

Table C.10(b) Time–Distance Table Using an Average Speed of 35 mph (56 km/hr)

Distance		Time	Distance		Time
mi	km	(min)	mi	km	(min)
0.0	0.00	0.00	4.50	7.24	8.30

Distance		Time .	Distance		Time .
mi	km	(min)	mi	km	(min)
0.1	0.16	0.82	4.75	7.64	8.72
0.2	0.32	0.99	5.00	8.05	9.15
0.3	0.48	1.16	5.25	8.45	9.57
0.4	0.64	1.33	5.50	8.85	10.00
0.5	0.80	1.50	5.75	9.25	10.42
0.6	0.97	1.67	6.00	9.65	10.85
0.7	1.13	1.84	6.25	10.06	11.27
0.8	1.29	2.01	6.50	10.46	11.70
0.9	1.45	2.18	6.75	10.86	12.11
1.0	1.61	2.35	7.00	11.26	12.55
1.25	2.01	2.78	7.25	11.66	12.97
1.50	2.41	3.20	7.50	12.07	13.40
1.75	2.82	3.62	7.75	12.47	13.82
2.00	3.22	4.05	8.00	12.87	14.25
2.25	3.62	4.47	8.25	13.27	14.67
2.50	4.02	4.90	8.50	13.68	15.10
2.75	4.42	5.31	8.75	14.08	15.52
3.00	4.83	5.75	9.00	14.48	15.95
3.25	5.23	6.17	9.25	14.88	16.37
3.50	5.63	6.60	9.50	15.29	16.80
3.75	6.03	7.02	9.75	15.69	17.22
4.00	6.44	7.45	10.0	16.09	17.65
4.25	6.84	7.87			

The formulas in this annex make it possible to determine water availability at any point in an area.

As an example of how to calculate the water available from a supply where the water has to be transported to the fire scene, consider the following situation:

(1) The water tank capacity (V) is 1500 gal (5678 L).

(2) The time (A) to fill the mobile water supply apparatus with water is 3.0 minutes.

(3) The time (B) to dump the water into a portable tank is 4.0 minutes.

(4) The distance (D_1) from the fire to the water source is 2.1 mi (3.4 km).

(5) The distance (D_2) from the water source is 1.8 mi (2.9 km), as the mobile water supply apparatus returns by a different road.

First, solve for T_1, the time for the mobile water supply apparatus to travel from the fire to the water source, and then solve for T_2, the time for the mobile water supply apparatus to travel from the water source back to the fire.

Due to good weather and road conditions, the average mobile water supply apparatus speed traveling from the fire to the water source is 35 mph (56 km/hr).

Use the travel time formula as follows:

$$T = 0.65 + XD$$ **DELETED[C.10d]**

where:

$X = 1.7$

$D_1 = 2.1$

and where at an average speed of 35 mph (56 km/hr):

$T_1 = 0.65 + 1.7D_1$

$T_1 = 0.65 + 1.7 \times 2.1$

$T_1 = 0.65 + 3.57$

$T_1 = 4.22$

At an average speed of 35 mph (56 km/hr), a mobile water supply traveling 2.1 mi (3.4 km) will take 4.22 minutes. Due to traffic lights, the average mobile water supply apparatus speed between the water source and the fire is 30 mph (48 km/hr).

Use the travel time formula as follows:

$$T = 0.65 + XD$$ **DELETED[C.10e]**

where:

$X = 2.0$

$D_2 = 1.8$

and where at a constant speed of 30 mph (48 km/hr):

$T_2 = 0.65 + 2.0D_2$

$T_2 = 0.65 + 2.0 \times 1.8$

$T_2 = 0.65 + 3.60$

$T_2 = 4.25$

Use the following formula for calculating the maximum continuous flow capability:

$$Q = \frac{V}{A + T_1 + T_2 + B} \times k$$ **DELETED[C.10f]**

where:

Q = maximum continuous flow capability [gpm (L/min)]

V = 1500 gal (5678 L)

A = 3.0

T_1 = 4.22

T_2 = 4.25

B = 4.0

k = 0.9

Therefore,

$$Q = \frac{1500}{3.0 + 4.22 + 4.25 + 4.0} \times 0.9$$ **DELETED[C.10g]**

$$Q = \frac{1500}{15.47} \times 0.9$$ **DELETED[C.10h]**

$$Q = 97 \times 0.9 = 87 \text{ gpm } (330 \text{ L/min})$$ **DELETED[C.10i]**

~~The maximum continuous flow capacity available from this 1500 gal (5678 L) mobile water supply is 87 gpm (330 L/ min).~~
~~To increase the maximum continuous flow capability of a mobile water supply, any of the following changes can be made:~~

~~(1) Increase the capacity of the mobile water supply.~~

~~(2) Reduce the fill time *(see Figure C.10)*.~~

~~(3) Develop and provide additional fill points, thus reducing travel time.~~

~~(4) Reduce the dump time.~~

~~(5) Use additional mobile water supply apparatus.~~

~~The number and size of mobile water supply apparatus available to the department is of importance in calculating the probable mobile water supply volume that will be available at various fire locations. Equally important in increasing the maximum continuous flow capability of a mobile water supply is the reduction of the distance between the source of water and the fire. The distance can be reduced by increasing the number of water supply points, the number of drafting points at a given supply, or both.~~
~~Figure C.10 Example of a Quick Connect Coupling That Can Help to Reduce the Fill Time.~~

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~~**C.11 Mobile Water Supply Apparatus Filling and Off-Loading.**~~
~~During mobile water supply operations, filling and off-loading water delivery rates directly affect the fire flow capabilities established for the fire scene. Local needs usually determine mobile water supply configurations and procedures. A wide variety of off-loading and filling systems are currently in use. Some departments prefer to pump-off their water into portable tanks, while others off-load mobile water supply apparatus using gravity dump valves, jet-assisted dump devices, or air pressurization systems. Some departments still utilize a nursing operation by connecting water supply vehicles via hard suction or supply line directly to the firefighting apparatus at the scene. The use of gravity dump valves, jet-assisted dump devices, or positive displacement air-pressurization (blower)/vacuum pump systems, in concert with large portable dump tanks at the fire scene has provided additional operational flexibility and has greatly reduced the overall turnaround time associated with mobile water supply apparatus off-loading. Every fire department needs to evaluate and decide which system for filling and off-loading apparatus provides the optimal advantages in terms of water delivery rate effectiveness, efficiency, and overall compatibility with other water delivery segments. During a comprehensive water delivery evaluation, many factors must be considered. Travel distances, fill and off-loading locations, and topography greatly affect the turnaround time periods associated~~

~~with transporting water. *(See Section C.10.)* Usually, the greatest amount of time can be saved during the filling and off-loading segments of a water shuttle operation.~~

~~As with other segments of fireground operations, strategic preplanning is vital to mobile water supply evolutions. Preplanning and practice reduce unnecessary actions and minimize unsafe practices. For example, a properly established dump site should eliminate or substantially reduce the need to back up vehicles. Backing up of vehicles has caused a significant number of personal injuries associated with emergency vehicle operations and also requires extra time. The use of flexible discharge tubes or side dumps during off-loading, in conjunction with properly set up dump sites, can reduce or eliminate the necessity of backing up the vehicles.~~

~~**C.11.1 Mobile Water Supply Apparatus Equipped with Large Gravity Dumps.**~~

~~A growing trend among fire departments using mobile water supply apparatus is to increase the size of the gravity discharge dumps to reduce the time necessary to empty the water tank. Gravity dump arrangements with discharge valves of 10 in. (250 mm), 12 in. (300 mm), or larger are often used. Dump valve discharge rates will decrease as the depth of the water in a given tank decreases. Adequate air intakes and tank baffle cuts should be provided to avoid possible tank damage and inefficient operations. To check the efficiency of a dump system, weight tests should be conducted to determine discharge rates. *(See Section C.12.)*~~

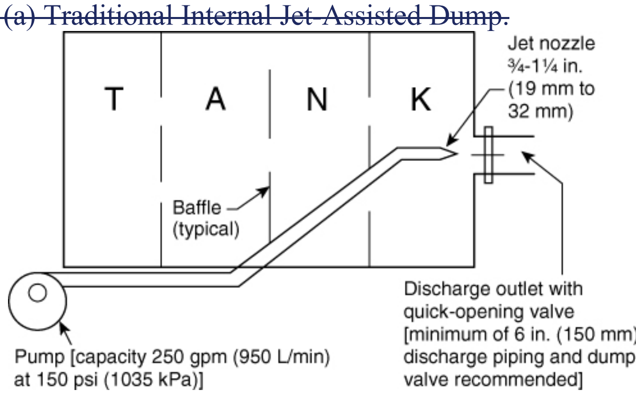
~~**C.11.2 Mobile Water Supplies Equipped with Jet-Assisted Dumps.**~~

~~A water jet is a pressurized water stream used to increase the velocity of a larger volume of water that is flowing by gravity through a given size dump valve. The jet principle used to expel water from mobile water supply apparatus has also been effectively applied to several other devices that can transfer water between portable dump tanks, fill mobile water supply apparatus from static water sources, and reduce suction losses at draft. Water jets properly installed in the discharge piping of a mobile water supply apparatus can more than double its off-loading efficiency. Effective jet-assisted arrangements have exceeded a 1000 gpm (3800 L/min) discharge rate when using 6 in. (150 mm) discharge piping and valves. Pumps supplying such jet arrangements should be capable of delivering a minimum of 250 gpm (950 L/min) at a gauge pressure of 150 psi (1035 kPa). Some departments have obtained good results with pumps that deliver flows at a gauge pressure of less than 150 psi (1035 kPa) where larger discharge openings are provided. The size and design of the nozzle and the diameter and length of the dump valve piping directly affect unit efficiency.~~

~~**C.11.2.1 Traditional In-Line Jet-Assisted Arrangement.**~~

~~Figure C.11.2.1(a) illustrates how the traditional jet is installed. A smooth-tipped nozzle is usually supplied by a pump capable of delivering at least 250 gpm (950 L/min) at a gauge pressure of 150 psi (1035 kPa). Nozzle tips range in size from **3⁄4** in. to 1**1⁄4** in. (19 mm to 32 mm). The diameter of the tip will be determined by the capacity of the pump being used and the diameter of the discharge piping and dump valve.~~

~~Figure C.11.2.1(a) Traditional Internal Jet-Assisted Dump.~~



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~~Before a jet-assisted dump is installed, questions including, but not limited to, the following should be answered:~~

(1) In what location will the dump prove to be most useful, the side or the back?

(2) Will the fixed piping need to be 11⁄2 in. (38 mm) in diameter or 2 in. (51 mm) in diameter?

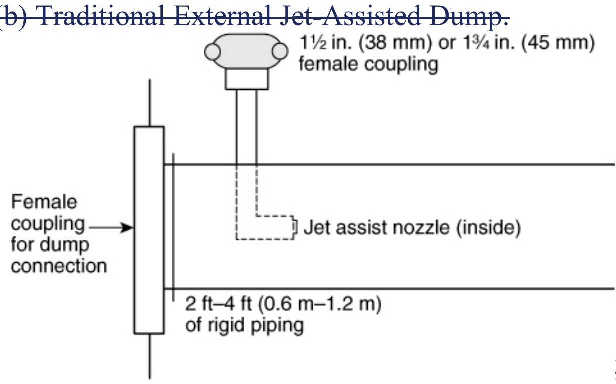
(3) What is the preferable location for the jet, in-line or at the rear of the tank?

In the interest of site versatility, many departments are utilizing lightweight flexible discharge tubes equipped with quick-lock or quarter-turn couplings. Such tubing arrangements allow rapid discharge of water to either side of the vehicle and reduce the need for hazardous backing at the dump site.

The rate of discharge will be governed by the size of the dump valve and piping, which can range from 4 in. to 12 in. (100 mm to 300 mm). Normally, a 6 in. or 8 in. (150 mm or 200 mm) diameter dump configuration permits adequate flow capacities where water jet systems are employed. Again, it is stressed that adequate air exchange and water flow passages should be provided for a jet-assisted dump arrangement to function properly. Tanks can collapse where air exchange is restricted. Lack of adequate gravity water flow to the jet area will also adversely affect the discharge efficiency of the water-hauling unit.

Although some authorities recommend that the nozzle of the in-line jet be up to 6 in. (150 mm) from the center of the discharge opening, other effective designs have included placement of the nozzle inside the discharge piping. Figure C.11.2.1(b) details how the traditional jet arrangement can be externally added to an existing dump valve. A short length of 11⁄2 in. (38 mm) hose is attached to the female coupling on the jet device. The length of the added dump piping can range from 2 ft to 4 ft (0.6 m to 1.2 m), depending on whether a flexible tube is utilized during the dump process.

Figure C.11.2.1(b) Traditional External Jet-Assisted Dump.



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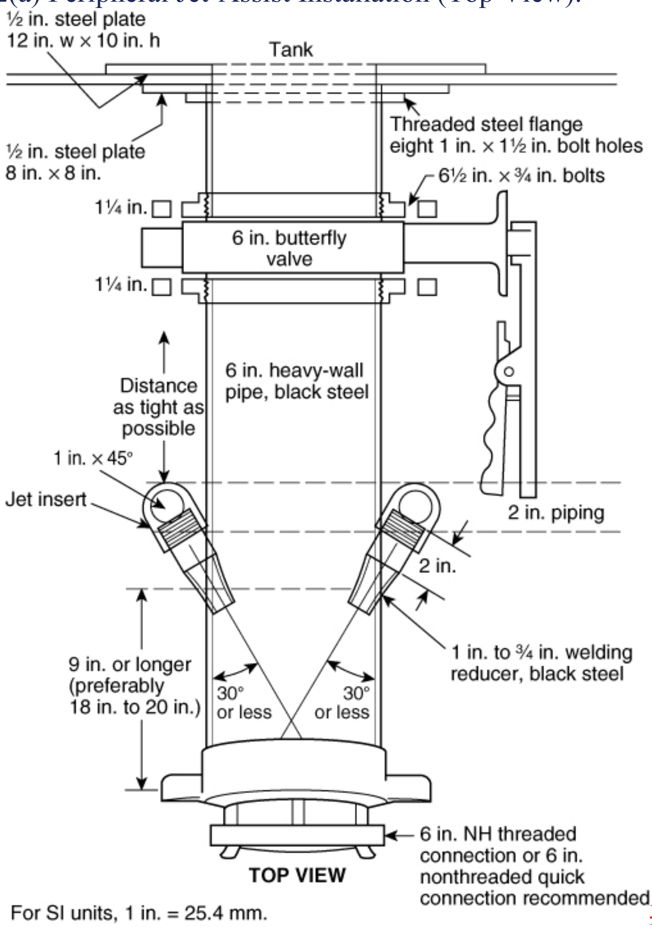
To properly operate, a jet should be able to produce a discharge gauge pressure at the nozzle between 50 psi and 150 psi (345 kPa and 1035 kPa). Higher pressures normally increase operational effectiveness. The diameter of the jet selected should be appropriate for the capabilities of the pump being utilized. Also important is the size of the piping and valves that make up the jet-assisted dump system. The major advantage of external jets is reduced maintenance. Disadvantages include the need for adequate air exchange during water flow, and the additional time for the initial setup in order to attach hose and affix appliances.

C.11.2.2 Peripheral Jet-Assist Arrangement.

The peripheral application of jet-assist nozzles has proved highly effective. This arrangement utilizes two or more jets installed in the sides of the discharge piping just outside the quick-dump valve. In addition to the reported discharge advantages of peripheral jet streams, the externally fed system is easier to plumb and has fewer maintenance problems. The jets, installed 25 degrees to 30 degrees from the piping wall, contact more surface area of the discharging water, thereby increasing water discharge efficiency. Because the water is drawn through the dump valve, less turbulence is created, and the eddy effect often present with traditional in-line jets is overcome.

~~Nozzles made of welding reducer pipe fittings work very effectively as jets. Flow rates of 2000 gpm (7600 L/min) have been obtained using a 300 gpm (1136 L/min) pump to supply two 3⁄4 in. (19 mm) nozzles in a 6 in. (150 mm) dump valve configuration. Figure C.11.2.2(a) and Figure C.11.2.2(b) represent two views of a typical installation.~~

~~Figure C.11.2.2(a) Peripheral Jet-Assist Installation (Top View).~~



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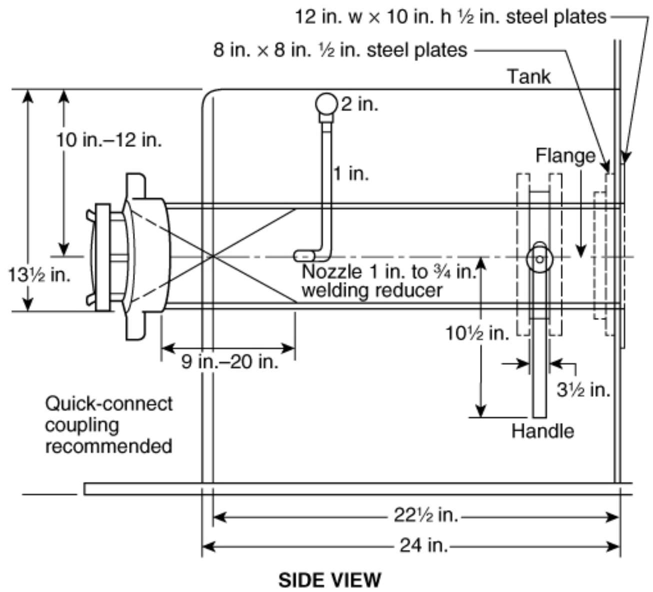
~~Figure C.11.2.2(b) Peripheral Jet-Assist Installation (Side View).~~



For SI units, 1 in. = 25.4 mm.

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C.11.2.3 Other Jet-Assist Devices.

Innovative fire organizations have put siphons and jet-related devices to good use. Some siphons use only water-level differential to transfer water from one portable tank to another. Normally constructed of PVC pipe, such siphons are placed between portable tanks to equalize water levels. Transfer is initiated by filling the U-shaped tubing with water, placing the caps on the tubing until it is put in place, and then removing the caps to allow water flow. Such an arrangement, though useful, has often proved too slow for the type of transfer operations required. A modification of the siphon transfer piping using a jet was developed and has proved useful to many departments. Although 4 in. (100 mm) PVC and aluminum piping have been used for such devices, 6 in. (150 mm) units usually are more practical. Using a **1⁄2** in. (13 mm) jet-assist nozzle supplied by a 1**1⁄2** in. (38 mm) hose makes possible transfer flows of 500 gpm (1900 L/min). *[See Figure C.11.2.3(a).]* Some departments have built a metal sleeve with a jet-assist nozzle that can be merely added to a length of suction hose. *[See Figure C.11.2.3(b).]*

Figure C.11.2.3(a) Jet-Assist Transfer Siphon.

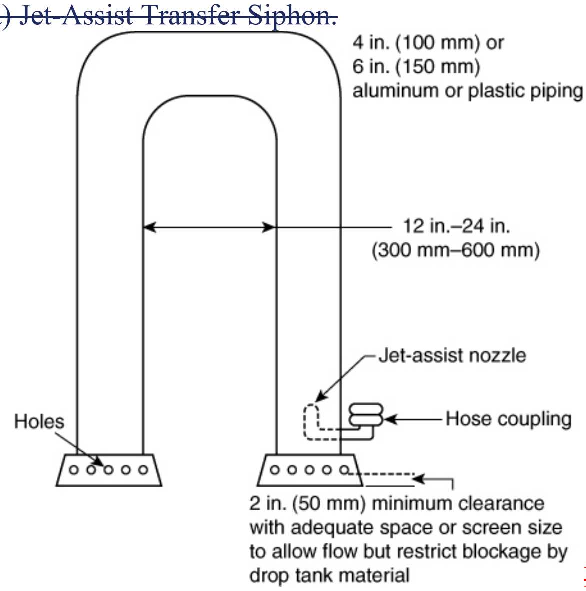

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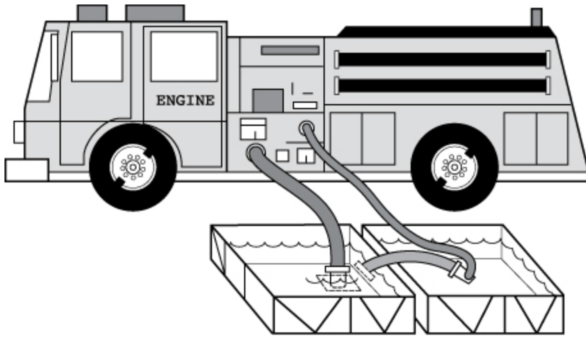
Figure C.11.2.3(b) Modified Hard Suction Jet Siphon.



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C.11.2.4 Water Eductors/Ejectors.

Water eductors (also known as water ejectors) that use the jet principle are commercially available *[see Figure C.11.2.4(a)]*. These devices can provide access to static water supply sources (lakes, ponds, streams, irrigation ditches, and swimming pools) up to 250 ft (76 m) away from a pump or as much as 100 ft (30 m) below it. They can draw water from sources only a few inches deep, and devices are available in a variety of sizes up to 2½ in. (65 mm) motive hose and a 5 in. or 6 in. (125 mm or 150 mm) supply hose.

Figure C.11.2.4(a) Water Ejector with Combination Foot/Valve Strainer Attached.

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A discharge hose referred to as the motive supply line is run from the pump discharge to feed the ejector, while a larger-diameter supply hose runs from the ejector to a valved pump intake or an open tank fill inlet, as shown in Figure C.11.2.4(b). When the ejector is set up, the motive hose line is charged with water from the water tank on the fire apparatus or other source. As the water from the motive hose passes through the eductor, water is drawn from the static water source as a result of the suction force created by the flow through the eductor's venturi *[see Figure C.11.2.4(c).]* Once the air is bled from the supply line back to the pump, the bleeder is closed and the valve on the pump intake is opened. At this point, or when the supply line into the tank fill is flowing freely, the water supply has been established.

Figure C.11.2.4(b) Ejector Use from the Street to a Back Yard Swimming Pool.

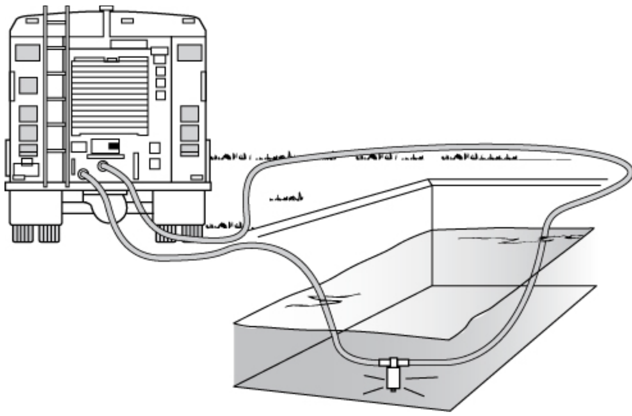

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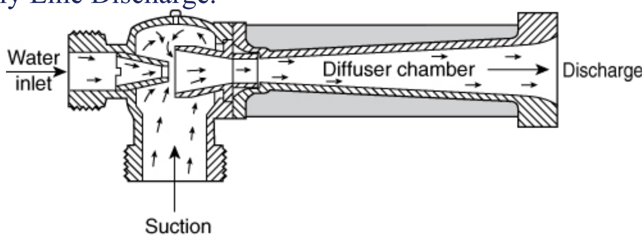
Figure C.11.2.4(c) Cross-Section of Water Ejector Showing Motive Line Water Inlet, Suction Inlet, and Supply Line Discharge.



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Ejectors are available in various sizes and capacities. Ejectors with a 1 in. (25 mm) inlet and a 1½ in. (38 mm) outlet have input capacities up to 44 gpm (167 L/min), output capacities of up to 117 gpm (443 L/min), and weigh from 1.2 lb to 3.7 lb (0.54 kg to 1.68 kg). Ejectors with a 1½ in. (38 mm) inlet and 2½ in. (63 mm) outlet have input capacities near 150 gpm (568 L/min), output capacities over 250 gpm (946 L/min), and weigh from 4.8 lb to 11.0 lb (2.18 kg to 4.99 kg). Even larger ejectors are available, with 2½ in. (63 mm) inlets and 5 in. (125 mm) outlets, with output capacities over 650 gpm (2461 L/min), and weighing over 50 lb (22.68 kg). One drawback to water eductors/ejectors is that 25 percent to 30 percent of the water delivered by the supply hose must be pumped back into the motive hose in order to maintain water flow. However, in situations where hydrants are not available and drafting is impossible, this is a small trade-off for the ability to use a static water supply.

C.11.2.5 Hard Suction Jet-Assist Devices.

In-line jets have also been developed to reduce suction losses during drafting operations. In-line and peripheral jets supplied by 1**1⁄2** in., 1**3⁄4** in., or 2**1⁄2** in. (38 mm, 44 mm, or 65 mm) hose lines can increase the output capacity of a centrifugal pump at draft up to 40 percent. The jets are placed at the intake and at every 10 ft (3.1 m) of suction in use. The design characteristics of strainers used during such application should permit adequate water flow capacity.

C.11.3 Mobile Water Supply Apparatus Equipped for Air Pressurization/Vacuum Operations.

Fire apparatus are available with a pressure/vacuum system (sometimes referred to as a blower/vacuum system) to fill and empty the water tank. When filling the water tank, the system operates by rapidly extracting air from the water tank, allowing water to be drawn into the tank from the water source through suction hose. To empty the tank, the process is reversed and air pressure is exerted on the water in the tank, forcing the water out the discharge outlet(s). The intake and discharge connections to the tank can be the same connection.

The system consists of a large positive-displacement rotary vane pump that can either pressurize the water tank with air to pressures between 5 psi and 12 psi (34 kPa and 83 kPa) or develop a negative pressure in the tank up to 26 in. Hg (88 kPa) vacuum. The water tank must be "air tight," so the vacuum is maintained while the entire capacity [generally between 2000 gal to 4000 gal (7600 L to 15,200 L)] is filled with water. Water tanks used with pressurization/vacuum

~~systems are usually round (oval) with dished heads and are specifically designed to withstand the air pressure and vacuum force placed upon them. The water tank must be properly baffled with "swash plates" and have an adequate pressure relief system.~~

~~The type of vacuum pump used for pressure/vacuum mobile water supply apparatus usually has the capability of "reversing itself," so the same pump that creates the vacuum can also be used to pressurize the tank for rapid discharge of water during off-loading. Mobile water supply apparatus with pressure/vacuum systems need to meet all applicable federal regulations and NFPA standards.~~

~~To provide handline capability and increased transfer flexibility, fire departments often install a fire pump with a 500 gpm at 150 psi (1900 L/min at 1035 kPa) or larger capacity or a large portable pump capable of supplying handline volumes and pressures on the mobile water supply apparatus.~~

~~Manufacturers indicate that pressure/vacuum-equipped units provide the same capabilities as other mobile water supply apparatus, with or without a fire pump or with or without jet-style dump valves. Apparatus equipped with pressure/vacuum systems can utilize long runs of suction hose to remote water sources and overcome a draft height (vertical lift distance) greater than apparatus with a standard fire pump and primer arrangement. Benefits that manufacturers claim are associated with the use of pressure/vacuum technology include the following:~~

~~(1) Water tanks completely fill at intake flow rates up to 2000 gpm (7600 L/min).~~

~~(2) The unit lifts water to heights of 28 ft to 30 ft (8.5 m to 9 m) and maintains effective draft capability for extended distances from the fill site. It can also be effectively filled from a hydrant or other positive pressure source.~~

~~(3) There is no water spillage during transport.~~

~~(4) The same inlets/discharges located on the right, left, and rear provide both fill and dump options.~~

~~(5) Pressurizing the water tank permits rapid off-loading using one outlet. The pressurized tank facilitates water discharge at a delivery rate in excess of normal dump valve arrangements that rely on standard atmospheric pressure and some jet-assist dump devices.~~

~~**C.12 Testing Dump Valve Capacity.**~~

~~Departments using large gravity dump valves or jet-assisted dump valve arrangements need to determine the flow rate at which they can dump each mobile water supply apparatus in use. Generally accepted procedures for determining flow capacities have been developed and should be accomplished as follows:~~

~~(1) Determine the useful water-carrying capability of the apparatus as follows:~~

~~(a) Fill the water tank and weigh the mobile water supply apparatus. This is the full weight (*FW*).~~

~~(b) Empty the water tank using the dump valve using only gravity and reweigh the apparatus. This is the empty weight (*EW*).~~

~~(c) Determine the water carrying capacity (*Q*) of the apparatus as follows:~~

$$Q \text{ in gallons} = \frac{FW(\text{lb}) - EW(\text{lb})}{8.33}$$

$$Q \text{ in liters} = FW(\text{kg}) - EW(\text{kg})$$

~~**DELETED**~~**[C.12a]**

~~where:~~

~~FW = weight of apparatus with tank full~~

~~EW = weight of apparatus with tank empty~~

~~Q = water-carrying capacity of apparatus~~

~~(2) Determine the dump rate through the dump valve when only gravity is used as follows:~~

~~(a) Fill the water tank.~~

~~(b) Off-load the water for 1 minute through the dump valve using gravity only.~~

~~(c) Weigh the apparatus to determine the gravity-only dumped weight (*GDW*).~~

~~(d) Determine the dump rate when only gravity is used (*GDR*) as follows:~~

$$GDR_{\text{gal/min}} = \frac{FW(\text{lb}) - GDW(\text{lb})}{8.33}$$

$$GDR_{\text{L/min}} = FW(\text{kg}) - GDW(\text{kg})$$

~~DELETED~~[C.12b]

~~where:~~

~~GDR = dump rate when only gravity is used~~

~~FW = weight of apparatus with tank full~~

~~GDW = weight of apparatus after 1 minute of dumping water using gravity only~~

~~(3) If the tank is equipped with a jet-assist dump, determine the dump rate through the dump valve when the jet assist is used as follows:~~

~~(a) Fill the water tank.~~

~~(b) Off-load the water for 1 minute through the dump valve with the jet assist being used.~~

~~(c) Weigh the apparatus to determine the jet assist dumped weight (*JDW*).~~

~~(d) Determine the dump rate when a jet assist is used (*JDR*) as follows:~~

$$JDR_{\text{gal/min}} = \frac{FW(\text{lb}) - JDW(\text{lb})}{8.33}$$

$$JDR_{\text{L/min}} = FW(\text{kg}) - JDW(\text{kg})$$

~~DELETED~~[C.12c]

~~where:~~

~~JDR = dump rate when jet dump assist is used~~

~~FW = weight of apparatus with tank full~~

~~JDW = weight of apparatus after 1 minute of dumping using jet dump assist~~

~~(4) If the apparatus is equipped with a pump, determine the dump rate when pumping the water off as follows:~~

(a) Fill the water tank.

(b) Off-load the water for 1 minute through the tank to pump plumbing using the pump on the apparatus and one or more 21⁄2 in. (65 mm) discharges.

(c) Weigh the apparatus to determine the pumping dumped weight (*PDW*).

(d) Determine the dump rate when a pump is used (*PDR*) as follows:

$$PDR_{\text{gal/min}} = \frac{FW(\text{lb}) - PDW(\text{lb})}{8.33}$$

$$PDR_{\text{L/min}} = FW(\text{kg}) - PDW(\text{kg})$$

DELETED[C.12d]

where:

PDR = dump rate when pump is used

FW = weight of apparatus with tank full

PDW = weight of apparatus after 1 minute of pumping water from the tank

Initially it is important to know how much water the tank is really capable of delivering. Poor tank discharge arrangements and misunderstanding of the tank's capacity often result in a tank that cannot carry as much water as thought. An effective jet-assisted dump arrangement should be capable of off-loading at least twice the volume that would be expected when off-loading by gravity for a given period of time and should exceed the volume off-loaded using the pump only. Whether using gravity dumps or jet dump arrangements, turnaround drop times and ease of operations should be the primary considerations.

C.13 Portable Drop Tanks.

Generally, the three types of portable drop tanks are the following:

(1) Self-supporting tank

(2) Fold-out frame tank

(3) High-sided fold-out tank for helicopter bucket-lift mobile water supply service

The self-supporting tank is built with the sides reinforced to support the water inside the tank. Tanks are available with an inlet or outlet, or both, built into the side of the tank. Tanks are available in a wide range of capacities with 1500 gal to 2000 gal (5678 L to 7600 L) tanks being those used most often.

Each mobile water supply apparatus should carry a portable drop tank that has a 40 percent greater capacity than the water tank of that apparatus. The strainer on suction hose used when drafting from a portable tank should be designed to minimize whirlpooling and allow the fire department to draft to a depth of 1 in. to 2 in. (25 mm to 51 mm) from the bottom.

D-deleted Large-Diameter Hose DELETED

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 General.

The use of large-diameter hose has major significance in the field of rural water supplies. This hose is viewed as an aboveground water main from a water source to the fire scene. Where delivery rates need to exceed 500 gpm (1900 L/min) and water is being moved long distances, large-diameter hose provide a most efficient means of minimizing friction losses and developing the full potential of both the water supply and the pumping capacity. NFPA defines large-diameter hose as hose with an inside diameter of 31⁄2 in. (89 mm) or larger.

D.2 Characteristics of Large-Diameter Hose.

Large-diameter hose is available in either single-jacketed or double-jacketed construction, generally in the following sizes:

(1) 31⁄2 in. (89 mm)

(2) 4 in. (100 mm)

(3) 5 in. (125 mm)

(4) 6 in. (150 mm)

Large-diameter hose is available as either supply hose or attack hose. Supply hose will have a design service test pressure of 200 psi (1380 kPa) for an expected normal highest operating pressure of 185 psi (1280 kPa). Some older large-diameter hose might only have been rated for a service test pressure of 150 psi (1035 kPa). Attack hose will have a design service test pressure of at least 300 psi (2070 kPa). At that service test pressure, the expected normal highest operating pressure would be 275 psi (1900 kPa).

The lower friction loss characteristics of such hose for a given quantity of water increases the usable distance between the water source and the fire. The department unable to use water sources more than 1000 ft (305 m) from a potential fire site using 21⁄2 in. (65 mm) hose could flow approximately twice as much water 3000 ft (914 m) or more through 4 in. (100 mm) hose with the same friction loss.

The basic reason large-diameter hose moves water more effectively is its larger size. The relationship can be explained by studying the carrying capacities and friction loss factors shown in Table D.2(a) and Table D.2(b).

Table D.2(a) Relative Water Capacity of Different Size Fire Hose per Unit Length

	Nominal Diameter of Hose (in.)						
Nominal Diameter of Hose (in.)	**21⁄2**	**3**	**31⁄2**	**4**	**41⁄2**	**5**	**6**
21⁄2	1.00	0.617	0.413	0.29	0.213	0.161	0.1
3	1.62	1.0	0.667	0.469	0.345	0.261	0.162
31⁄2	2.42	1.5	1.0	0.704	0.515	0.391	0.243
4	3.44	2.13	1.42	1.0	0.735	0.556	0.345
41⁄2	4.69	2.90	1.94	1.36	1.0	0.758	0.469
5	6.20	3.83	2.56	1.8	1.32	1.0	0.619
6	10.00	6.19	4.12	2.9	2.13	1.61	1.0

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 psi = 0.0689 bar.

Note: The values in the table are based on the Hazen–Williams equation.

Table D.2(b) Approximate Friction Losses in Fire Hose (psi/100 ft)

	Nominal Diameter of Hose (in.)					
Flow (gpm)	**21⁄2**	**3**	**31⁄2**	**4**	**5**	**6**
250	13	5	2	1	—	—

Flow (gpm)	Nominal Diameter of Hose (in.)					
	21⁄2	3	31⁄2	4	5	6
500	50	20	8.5	5	2	1
750	—	45	19	11	5	3
1000	—	80	34	20	8	5
1500	—	—	77	45	18	11
2000	—	—	—	80	32	20

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 psi = 0.0689 bar.

D.2.1 Carrying Capacity of Large-Diameter Hose.

Large-diameter hose is superior to traditional standard fire hose in its ability to carry more water per hose line. Table D.2(a) provides a comparison of the carrying capacity between different diameter hose lines.

To use Table D.2(a), find the desired hose diameter in the left-hand column and read horizontally to find the corresponding hose size equivalent. For example, the table shows that 5 in. (125 mm) diameter hose has 6.2 times the carrying capacity of 21⁄2 in. (65 mm) hose, 3.83 times the carrying capacity of 3 in. (76 mm) hose, 2.56 times the carrying capacity of 31⁄2 in. (89 mm) hose, and so on. In other words, it would require over six lines of 21⁄2 in. (65 mm) hose to equal the capacity of only one line of 5 in. (125 mm) hose.

Large-diameter hose also has less friction loss per flow rate than smaller diameter hose. Table D.2(b) shows the relative friction loss of 21⁄2 in. (65 mm) to 6 in. (152 mm) diameter hose for the various flow rates (in gpm). The values in the table are based on the Hazen–Williams equation. *(See NFPA Fire Protection Handbook, Section 13, Chapter 3 for information on Fire Streams.)*

D.2.2 Selecting Large-Diameter Hose.

The size and the amount of hose to be carried by the fire department should be selected to fit the needs of the area served and the financial resources of the department. Table D.2.2 can be used to assist in hose selection. A pumper rated 750 gpm (2850 L/min) at 150 psi (1035 kPa) operating from draft can relay 750 gpm (2850 L/min) through only 650 ft (200 m) of 31⁄2 in. (89 mm) fire hose and have a 20 psi (138 kPa) intake pressure at the receiving pump. If 6 in. (150 mm) hose is used, that same pumper could move 750 gpm (2850 L/min) through 4300 ft (1300 m) of hose. While moving water this distance is theoretically possible, another factor is how much hose a pumper or other fire apparatus can carry. Trying to carry 4300 ft (1300 m) of 6 in. (150 mm) hose is certainly not practical. The table is designed to apply primarily to situations in which a fire department is relaying water with pumps discharging at 150 psi (1035 kPa) and wants 20 psi (138 kPa) residual pressure at the point receiving the flow.

Table D.2.2 Maximum Hose Length in Feet with 130 psi (900 kPa) Loss

Internal Diameter of Hose . (in.)	Quantity of Water (gpm)					
	250	500	750	1,000	1,500	2,000
21⁄2	1,000	250	—	—	—	—
3	2,600	650	250	150	—	—
31⁄2	6,500	1,450	650	350	150	—
4	—	2,600	1,150	650	300	150
5	—	6,500	2,600	1,600	700	400

Internal Diameter of Hose . (in.)	Quantity of Water (gpm)					
	250	500	750	1,000	1,500	2,000
6	—	13,000	4,300	2,600	1,150	650

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 ft = 0.305 m; 1 psi = 0.0689 bar.

D.3 Load Capacity.

Another important advantage associated with large-diameter hose is that one engine company laying large-diameter hose instead of multiple smaller lines is much more efficient in its water-moving capacity. The use of large-diameter hose with one engine speeds up the operation, which would otherwise need multiple smaller lines with additional pumpers, personnel, and equipment to accomplish the same job.

D.4 Powered Reel Trucks for Large-Diameter Hose.

A number of trucks with powered hose reels with various hose load capacities are now in use. *(See Figure D.4.)*

Figure D.4 Apparatus with Reels for Large-Diameter Hose. ***(Courtesy of LLNL Fire Department)***

DELETED

The large-diameter hose now available is of a construction that permits field cleaning and does not require drying. The use of a reel truck permits rapid reloading using a minimum number of personnel (two), and the unit is capable of getting back into service sooner.

Such reel trucks generally require special power-driven systems to rewind the hose. The size of the reels is not conducive to fitting within most standard fire department pumper bodies. Therefore, hose reels are generally mounted on trucks specially designed for this operation.

D.5 Fittings.

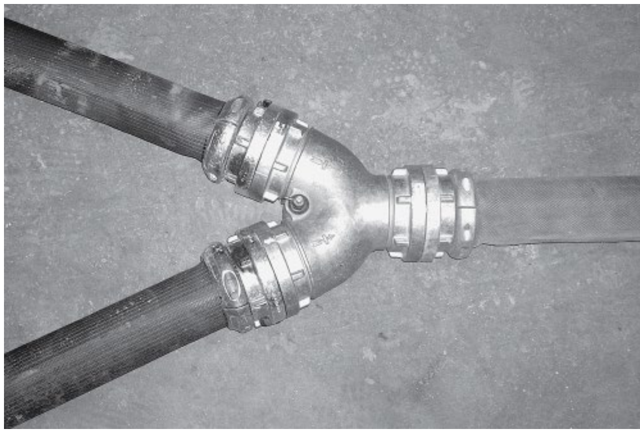
Large-diameter hose is available with either standard threaded couplings or nonthreaded couplings that eliminate the male-female feature and, consequently, many adapters.

Special fittings, as described in D.5.1 through D.5.5, have been developed to be used with large-diameter hose.

D.5.1 Clappered Siamese Connection.

During major fires, it is often desirable to supplement a water supply. If a clappered siamese is inserted into the large-diameter hose line at the source, a second pumper can provide an additional supply line at the water source. With the siamese in place, this second source can be added without interrupting the flow from the first supply. *(See Figure D.5.1.)*

Figure D.5.1 Clappered Siamese Connection. ***(Courtesy of Dan MacDonald, New Boston, NH Fire Department)***



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D.5.2 Four-Way Hydrant Valve.

A four-way hydrant valve is a versatile valve that can be utilized on a hydrant where water is available but pressure is limited. The valve is attached to the hydrant, and the normal lay of supply line is initiated. Where additional pressure is required, a pumper is attached to the valve and begins boosting pressure to the fire scene without interrupting the flow of water from hydrant to fire. In rural applications, this valve can be equipped to lie in a line during hose lay and to allow a pumper to hook into the line and boost pressure without interrupting flow to the fire scene. *[See Figure D.5.2(a) and Figure D.5.2(b)]*.

Figure D.5.2(a) Four-Way Hydrant Valve. ***(Courtesy of Kochek Co., Inc.)***

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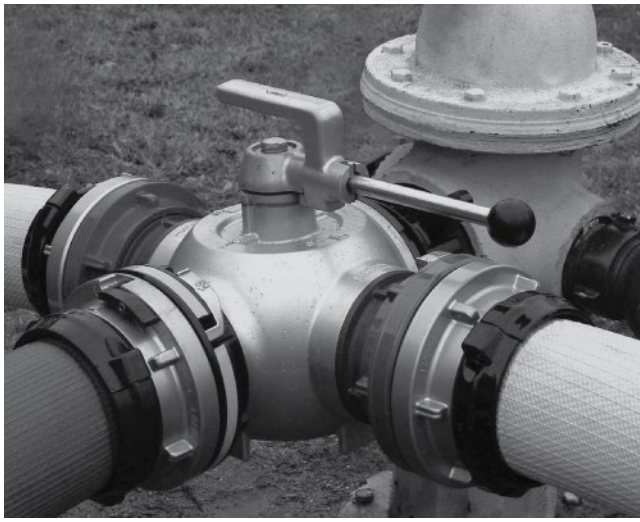
Figure D.5.2(b) Four-Way Hydrant Valve in Use. ***(Courtesy of Kochek Co., Inc.)***



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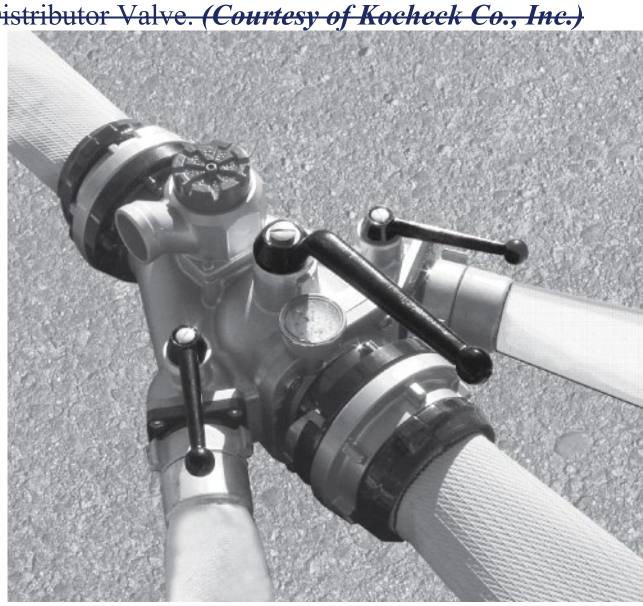
D.5.3 Distributor Valve.

A distributor valve contains a 4 in. (100 mm) or 5 in. (125 mm) opening and waterway with two 21⁄2 in. (65 mm) threaded male outlets. It is placed at the end of the supply line at the fireground, allowing distribution of water to one or more attack pumpers. The valve utilizes ball shutoffs on the discharge side plus an adjustable dump valve on the intake side. *(See Figure D.5.3.)*

Figure D.5.3 Distributor Valve. ***(Courtesy of Kochek Co., Inc.)***



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D.5.4 Intake Gated Relief Valve.

An intake gated relief valve is attached to the large suction inlet of the pumper. The supply line is connected directly to the valve. It is equipped with a slow-operating valve, an automatic air bleeder, and an adjustable dump valve. The gated valve allows the supply line to be connected while the pumper is utilizing the booster tank water. It is also used to control the volume of water from the supply line to the pump. The dump valve helps protect the pumper and supply line against pressure surges. *(See Figure D.5.4.)*

Figure D.5.4 Intake Gated Relief Valve.

DELETED

D.5.5 Air Bleeder.

An air bleeder, whether automatic or manually operated, is needed at all points where a large-diameter hose is connected to a pump inlet or at any distribution point.

D.6 Irrigation Piping.

Irrigation piping shares the same characteristics as large-diameter hose, the capability of transferring large volumes of water at relatively low friction loss. The use of irrigation in the farming community has increased throughout the country, resulting in lightweight aluminum pipe being available to the fire service. It can be carried on vehicles or used where available on the fireground.

The coupling arrangement for irrigation pipe usually will not permit its use for drafting. The pipe does provide a relatively permanent installation for long-duration firefighting. Generally, irrigation pipe is an excellent tool for major disaster situations but is less often used for conventional firefighting evolutions, since it takes longer to set up than large-diameter fire hose. Departments working in areas in which piped irrigation systems are going to be used to supply firefighting water should be aware that adapters are needed to interconnect conventional agricultural fittings with fire hose fittings. Adapters used to change the pipe coupling to fire department hose threads can be easily fabricated in local machine shops. Care must be taken in such fabrication to ensure that the resulting adapter is safe to be used at any pressure the water supply system might be subjected to, including sudden pressure surges. Such adapters are not offered by either pipe or fire hose manufacturers. At least one adapter for use at the supply end of the pipe and one adapter for use at the discharge end of the pipe should be available. An example might include an adapter with four 2**1⁄2** in. (65 mm) female inlets with National Hose (NH) thread adapting to a pipe coupling and an adapter from a pipe coupling to four 2**1⁄2** in. (65 mm) NH gated male outlets. Another example would be adapters to connect large-diameter hose to either end of the pipe.

~~Additional fittings to provide a fire hose connection at 100 ft to 300 ft (30 m to 90 m) intervals [one or more 2**1⁄2** in. (65 mm) NH per pipe section] might be desirable.~~

E-deleted ~~Portable Pumps-DELETED~~

~~*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*~~

~~E.1 General.~~

~~Both diesel-driven and gasoline-driven portable pumps are available. The use of portable pumps is a common method for moving water by rural fire departments. All rural firefighters should be able to place all portable pumps used by their department in operation, obtain draft, and perform each procedure in a minimal amount of time.~~

~~E.2 Description of a Portable Pump.~~

~~A portable pump in the fire service means a pump that can be carried to a source by firefighters, sometimes over difficult terrain. In general, two people should be able to conveniently carry the pump. It should weigh no more than 175 lb (79 kg) and be capable of supplying at least two 1**1⁄2** in. (38 mm) handlines. It should also have handles and should be constructed to be carried in a compartment in the apparatus. Heavier pumps, perhaps trailer- or truck-mounted or otherwise made mobile, are valuable but used less commonly.~~

~~Although a number of rural fire departments have used portable-type pumps that are securely mounted on their apparatus as the sole means of pumping, few fire departments consider this arrangement to be permanent, and most of those departments plan to buy a fire department pumper, in addition to the portable pump(s), when finances permit.~~

~~E.3 Evaluating Portable Pump Needs.~~

~~In order to get the maximum benefit from portable pumps, the officers of the rural fire department should carefully study the needs of the department, taking into consideration the potential fire hazard, the available water supplies, and the capabilities of the department to use portable pumps. The accessibility and the reliability of water supplies determine the need for and use of portable pumps. Many rural fire departments have found that both a low-pressure pump and a high-pressure pump are required to fill their needs.~~

~~The portable pump selected should fit the firefighting system of which it is to be a component; if direct hose streams are to be taken from a portable pump, the nozzles and hose size determine the required pump discharge versus pressure characteristics.~~

~~E.4 Classifications or Types of Portable Pumps.~~

~~Portable pumps come in a variety of pressure/volume combinations. It is important that the fire department study their needs and select a pump that will accomplish the objective.~~

~~E.4.1 Small Volume — Relatively High Pressure.~~

~~A small-volume pumping unit should be capable of pumping 20 gpm (76 L/min) at 200 psi (1380 kPa) net pressure through a 1 in. (25 mm) discharge outlet while taking suction through a 1**1⁄2** in. (38 mm) suction inlet. This class of portable pump is especially useful to fire departments for forest firefighting, which frequently requires long **3⁄4** in. to 1**1⁄2** in. (19 mm to 38 mm) hose lines and uphill pumping in rugged terrain.~~

~~E.4.2 Medium Volume — Medium Pressure.~~

~~A medium-volume pumping unit should be capable of discharging 60 gpm (227 L/min) at 90 psi (621 kPa) net pressure and 125 gpm (473 L/min) at 60 psi (414 kPa) net pressure through a 1**1⁄2** in. (38 mm) discharge outlet while taking suction through a 2**1⁄2** in. (65 mm) suction inlet.~~

~~E.4.3 Large Volume — Relatively Low Pressure.~~

~~A large-volume pumping unit should be capable of supplying 125 gpm (475 L/min) at 60 psi (414 kPa) net pressure and 300 gpm (1136 L/min) at 20 psi (138 kPa) net pressure through a 2**1⁄2** in. (65 mm) discharge outlet while taking suction through a 3 in. or 4 in. (75 mm or 100 mm) suction inlet.~~

~~E.5 Common Types of Pumps.~~

~~The common types of pumps used are described in E.5.1 through E.5.4.~~

~~E.5.1 Low-Pressure Centrifugal Portable Pumps.~~

~~Low-pressure centrifugal portable pumps (high volume) generally are rated at 200 gpm to 300 gpm (757 L/min to 1136 L/min) and are capable of discharge at pressures of 50 psi to 80 psi (345 kPa to 552 kPa). Usually these pumps will not discharge their rated capacity when they operate with a suction lift in excess of 5 ft (1.5 m).~~

~~Some low-pressure centrifugal portable pumps do not use running rings or seal rings. These types of pumps do not have close tolerances, so they can be used in dirty water where some debris or abrasives are encountered. These pumps require little maintenance.~~

~~Other types of low-pressure centrifugal portable pumps do have water or seal rings. If these pumps are pumping water containing substantial amounts of abrasive materials, the water or seal rings will not last as long as might be normally expected.~~

~~At lower discharge pressures, this type of pump can deliver larger volumes, which at times have been metered at 400 gpm to 600 gpm (1514 L/min to 2272 L/min), with adequate-size hard suction hose at very low discharge pressures and high pump rpm (e.g., relay from portable pump into fire pump on apparatus or portable drop tank; or relay from water source to drop tank where mobile water supply is filled for relay to fire site).~~

~~Operation of these pumps depends on centrifugal force to move water, and they are very effective for relay operations to pumper or for booster tank or mobile water supply filling. There are no special operating problems to watch out for, and these types of pumps will not heat up as rapidly as others if run without water.~~

~~E.5.2 High-Pressure Centrifugal Portable Pumps.~~

~~High-pressure centrifugal portable pumps (small volume) generally have a small capacity, with an average of 30 gpm to 40 gpm (114 L/min to 151 L/min) discharge and operating pressures in the 125 psi to 250 psi (862 kPa to 1724 kPa) range.~~

~~The impeller is usually geared twice as fast as the engine to achieve single-stage pressure. This type of pump uses running rings or seal rings that are the same as those used for larger fire pumpers and usually incorporates closed volutes in the impeller.~~

~~E.5.3 Floating Pumps.~~

~~A floating pump is a portable pump that primes and pumps automatically when it is placed in water. The pump is constructed to sit inside a float that resists breakage and needs no maintenance. Some entire units weigh under 50 lb (23 kg), including fuel, and provide 60 minutes to 90 minutes of operating time from the 5 qt (4.73 L) fuel tank.~~

~~The pump serves a need for a lightweight, easy-to-operate, portable fire pump that can be placed in the water and does not need suction hose or strainers. However, such pumps tend to pick up leaves and other trash that can block the nozzles and strainers downstream. *(See Figure E.5.3.)*~~

~~Figure E.5.3 Floating Pump with 1 1⁄2 in. (38 mm) Discharge Line. ***(Courtesy of LLNL Fire Department)***~~

~~**DELETED**~~

~~**E.5.4 High-Lift Pumps.**~~

~~High-lift pumps are small, portable pumps that use water to drive a water motor, which in turn drives an impeller and pumps water to high elevations and into a fire pumper for relay into hose lines for firefighting.~~

~~The high-lift pump is designed to obtain a water supply from a river, lake, stream, swimming pool, and so forth, where the source is not accessible for drafting operations using a pumper or a conventional portable pump.~~

~~The water used to power the water motor of a high-lift pump is taken from the booster tank of the pumper and discharged at high pressure through the fire pump into the hose to the high-lift pump water motor. Pressurized water, in turn, drives the water motor, which is connected to the high-lift pump impeller, thus forcing volumes of water back into the intake side of the fire pump and on into the firefighting hose lines.~~

~~High-lift pumps can be hooked into hose lines and placed into water sources at lower levels without firefighting personnel having to go down to such sources to set the pump.~~

~~**E.5.5 Floating Submersible Source Pumps.**~~

~~Floating submersible source pumps (FSSP) are hydraulically-driven centrifugal pumps that are designed for low-pressure, high-volume applications in open-water sources. These pumps differ from portable pumps in terms of their power, capacity, and their position in the water. FSSPs are partially exposed on the surface and their suction inlets are located completely below the water's surface. Typically, these pumps are for fire department use and can provide a water supply from 2000 gpm to 3000 gpm (7570 lpm to 11,350 lpm) from any open water source. These pumps do not have the restrictions associated with fire department drafting operations. The power unit can be mounted on a 4x4 or a similar type of apparatus. The pump itself can be deployed over a wide variety of terrain and infrastructure configurations over 100 ft (30.5 m) away by use of its hydraulic umbilical connection, allowing the power unit to remain on stable ground and remote from the water source. The primary benefit of FSSPs is their true access to remote water. With drafting fire pumper apparatus rated to standard 10 ft (3 m) suction heights and equipped with 20 ft (6 m) suction lines, a dry-hydrant system or near direct access to the water is required. Otherwise, fire departments must accept large flow derates on their pumps.~~

~~FSSP systems can be used in conjunction with primary response fire pumper apparatus and tanker shuttle operations. With a FSSP system in the water source, it can provide continuous filling operations to tankers (at a very fast fill rate) and portable tanks alike. When located in proximity to the fireground, they can provide high-volume water directly to supply the fire pumper apparatus at the fire scene.~~

~~**E.6 Methods of Using Portable Pumps.**~~

~~**E.6.1 General.**~~

~~Some of the many problems of supplying water in rural areas can frequently be overcome through the use of the proper portable pump. Many departments, through area pre-fire planning, locate water sources where portable pumps are the only suitable means of using the water supply for filling mobile water supply apparatus or for supplying firefighting hose lines.~~

~~Departments should, when locating a pumping site for portable pumps, determine whether the site is available year-round or whether it can be used only during certain times of the year. Further determination should be made as to the site's availability under the weather conditions anticipated. If such conditions could make use of the site difficult, a plan to prepare the site for all-weather utilization should be established.~~

~~Centrifugal pumps are usually preferred over other types because of their ability to handle dirt and abrasives with less damage and because of their desirable volume–pressure ratio. Similarly, four-cycle engines are considered more suitable for fire service use, although two-cycle or the new turbine-driven pumps can be used. However, four-cycle engines should be used with the engine in a level position or the engine will be damaged, whereas two-cycle engines can be used~~

with the engine in any position (as long as fuel is available to the engine) without damage to the engine.

A wood pallet or other firm base can be useful under soft ground conditions.

E.6.2 Uses of Portable Pumps.

Portable pumps can be used in single or multiple combinations to accomplish the following:

(1) Filling truck tanks where no fire department pumper is available

(2) Relaying water from a source in a variety of combinations or hookups

There are many factors to consider in deciding which size and type of portable pump will best fit a fire department's needs. Consideration should be given to the capabilities of the pump and its uses.

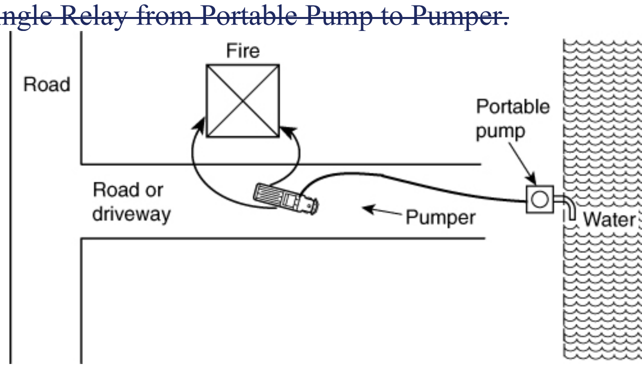
E.6.3 Relay to Mobile Water Supply Apparatus.

Under conditions where a fire department pumper cannot get to a source of water and there is considerable distance (several miles) between the source and the fire, low-pressure portable pumps of larger volume have proved to be very satisfactory where they are used to relay water to a mobile water supply apparatus that shuttles water to a portable drop tank at the fire. A fire department pumper takes suction from the portable drop tank for discharge onto a fire. *(See Section C.13.)*

E.6.4 Single Relay from Portable Pump to Pumpers.

Under conditions where a standard fire truck cannot get to a source of water, low-pressure portable pumps of larger volume have proved to be very satisfactory where they are used to relay water to pumpers. This method becomes feasible at a greater distance from water if large-diameter hose is used. *(See Figure E.6.4.)*

Figure E.6.4 Single Relay from Portable Pump to Pumper.



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A single portable pump often can supply enough water to keep a pumper supplied with effective fire streams. The portable pump can be at the water source and a line laid from the portable pump to the pumper.

One of the big advantages of the portable pump is that it can be placed close to the water supply for operation at minimum lift and minimum friction loss in the suction hose, provided adequate-size suction hose is used. Regular pumpers can accept water from portable pumps and increase water pressure for fire streams or use the water in a combination of fire streams and booster tank filling.

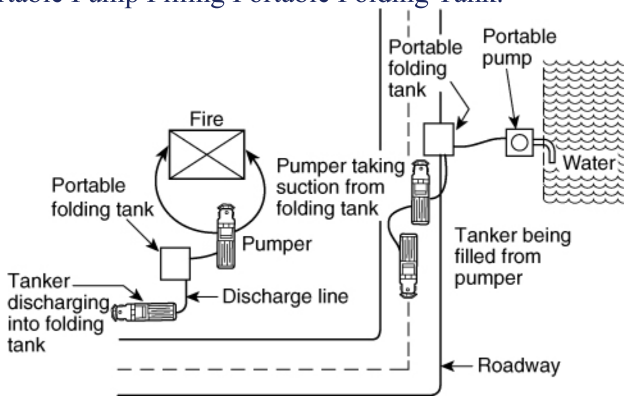
A method commonly used is for a pumper to lay hose lines from the fire to the water supply and start pumping from the booster tank into the hose line and onto the fire while the portable pump is being placed and water supply and hose lines from the portable to the regular pumper are being hooked up. *(See Figure E.6.4.)*

E.6.5 Use of Portable Pumps to Fill Mobile Water Supply Apparatus or Booster Tanks.

Many rural fire departments are overcoming problems of limited water supply by using mobile water supply apparatus to relay water to pumpers working at a fire. If the water supply is a stream with a small flow, for instance, 150 gpm (568 L/min), or if the water supply is inaccessible by

~~fire apparatus, the water can be obtained with a portable pump placed at the water supply. This pump supplies a portable folding tank that is used to stockpile water, and mobile water supply apparatus are filled from the portable folding tank for shuttle to the fire. At the fire, the mobile water supply apparatus discharges its water into another portable folding tank that is used to stockpile water from which the pumper(s) takes suction and discharges water onto the fire. *(See Section C.13 and Figure E.6.5.)*~~

~~Figure E.6.5 Portable Pump Filling Portable Folding Tank.~~



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~~It is not prudent to put the discharge line from portable pumps into the tops of booster tanks or mobile water supply apparatus unless there is no other way to fill the tank or a special filling device is provided. Placing lines into the tops of mobile water supply apparatus or booster tanks is a slow way of filling the tank and can be dangerous to those working on apparatus. Hooking the portable pump discharge line directly into intake piping of large pumpers or mobile water supply apparatus has proved to be the quickest and safest method of filling tanks.~~

~~Any of the portable pumps can be used in place of a pumper for filling mobile water supply apparatus; however, the low-pressure, high-volume-type pumps do the job more quickly than others. Where water is being pumped into tanks, strainers should be used to prevent the passage of trash and debris. Floating strainers have proved to be very effective.~~

~~Where the water supply has the capacity, multiple portable pumps for filling mobile water supply apparatus can increase filling efficiency. A 200 gpm to 300 gpm (757 L/min to 1136 L/min) rate results in a slow filling time; therefore, two or three portable pumps should be moved into the operation as mutual-aid mobile water supply apparatus arrive to achieve a 500 gpm (1900 L/min) filling rate. Multiple portable pumps also act as a backup in case of engine failure.~~

First Revision No. 8-NFPA 1142-2025 [Detail]

In Chapter 5, increase the occupancy hazard classification of "dwellings" from 7 to 6, in accordance with the following:

1) Add "Dwellings" to 5.2.4.2.

2) Delete "Dwellings" from 5.2.5.2.

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 17:49:01 EST 2025

Committee Statement

Committee Statement: The classification for dwellings is increased from 7 to 6 to account for modern fire hazards, such as batteries, solar panels, plastics, and alternative energy vehicles, in an occupancy that is typically unsprinklered and can be located in remote areas.

The committee has created a task group to further study this issue and determine if dwellings still meet the definition of a light hazard occupancy.

Response Message: FR-8-NFPA 1142-2025

First Revision No. 12-NFPA 1142-2025 [Section No. 1.1]

1.1 Scope.

This standard identifies a method of determining the minimum requirements for alternative water supplies for structural firefighting purposes in areas where the authority having jurisdiction (AHJ) determines that <u>an</u> adequate and reliable water supply ~~systems for firefighting purposes do not otherwise exist. An adequate and reliable municipal-type water supply is one~~ that is sufficient every day of the year to control and extinguish anticipated fires in the jurisdiction~~, particular building, or building group served by the water supply~~ <u>does not exist</u> .

~~**1.1.1**~~

~~This standard identifies a method of determining the minimum requirements for alternative water supplies for structural firefighting purposes in areas where the authority having jurisdiction (AHJ) determines that adequate and reliable water supply systems for firefighting purposes do not otherwise exist.~~

~~**1.1.2**~~

~~An adequate and reliable municipal-type water supply is one that is sufficient every day of the year to control and extinguish anticipated fires in the jurisdiction, particular building, or building group served by the water supply.~~

Supplemental Information

File Name	Description	Approved
1142_FR-12_Section_1.1.docx		

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Tue Jan 07 10:23:15 EST 2025

Committee Statement

Committee Statement: The current text read like a definition and could lead to confusion on how to apply the standard. The revised language is more concise.

Response Message: FR-12-NFPA 1142-2025

Public Input No. 1-NFPA 1142-2023 [Section No. 1.1.2]

First Revision No. 13-NFPA 1142-2025 [Section No. 1.2]

1.2* Purpose.

The purpose of this standard is to assist the AHJ to establish the minimum water supply necessary for structural firefighting purposes in those areas where it has been determined that there is no water or inadequate water for firefighting.

1.2.1*

A water supply is recognized by the AHJ when determined to be adequate and reliable for fire protection purposes.

A.1.2.1

Considerations can include the capacity, flow rate (gpm), duration, pressure, accessibility, and the type of fire protection system supplied.

1.2.2

The general goal is to provide sufficient water under typical firefighting conditions for the size and complexity of the building or structure being protected.

1.2.3

When an adequate and reliable water supply is not available, this standard identifies a method for determining an alernative water supply for structural firefighting purposes.

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Tue Jan 07 10:40:05 EST 2025

Committee Statement

Committee Statement: The purpose statement is expanded to provide additional guidance on evaluating how NFPA 1142 should be applied.

Response Message: FR-13-NFPA 1142-2025

First Revision No. 17-NFPA 1142-2025 [Section No. 2.4]

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code,* 2021 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* ~~2022~~ 2025 edition.

NFPA 101®, *Life Safety Code®,* 2021 edition.

NFPA 1140, *Standard for Wildland Fire Protection,* ~~2022~~ 2027 edition.

NFPA 1660, *Standard on Emergency, Continuity, and Crisis Management: Preparedness, Response, and Recovery,* 2024 edition.

~~*NFPA 1600®*, *Standard on Continuity, Emergency, and Crisis Management,* 2019 edition.~~

NFPA 1900, *Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances,* 2024 edition.

~~NFPA 1901, *Standard for Automotive Fire Apparatus,* 2016 edition.~~

NFPA 1910, *Standard for the Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels,* 2024 edition.

~~NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles,* 2017 edition.~~

~~NFPA 1925, *Standard on Marine Fire-Fighting Vessels,* 2018 edition.~~

NFPA 1960, *Standard for Fire Hose Connections, Spray Nozzles, Manufacturer's Design of Fire Department Ground Ladders, Fire Hose, and Powered Rescue Tools,* 2024 edition.

~~NFPA 1961, *Standard on Fire Hose,* 2020 edition.~~

NFPA 5000®, Building Construction and Safety Code®, 2021 edition.

Supplemental Information

File Name	Description	Approved
1142-2022_Chapter_2.docx	For staff reference only - Updates and notes on Chapter 2, including locations of references throughout the main body.	

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 00:54:31 EST 2025

Committee Statement

Committee Statement: This revision updates extracted text in accordance with the Extract Policy.

NFPA 1, NFPA 101, and NFPA 5000 extracts will be updated to 2027 editions at the Second Draft stage.

Response Message:	FR-17-NFPA 1142-2025

First Revision No. 18-NFPA 1142-2025 [Section No. 3.3.10]

3.3.10 Eductor.

A device that uses the Venturi principle to siphon a liquid in a water stream. [~~1925~~ **1910** ,~~2018~~ 2024]

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 01:00:02 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The extract is updated because NFPA 1925 has been consolidated into NFPA 1910.

Response Message: FR-18-NFPA 1142-2025

First Revision No. 23-NFPA 1142-2025 [Section No. 3.3.14]

3.3.14* Large- Diameter Hose.

A hose of 3½ in. (90 mm) or larger size. [~~1961~~ **1960** ,~~2020~~ 2024]

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 01:10:43 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The extract is updated because NFPA 1961 has been consolidated into NFPA 1960. The term was hyphenated to match the source standard and the existing usage of this term throughout this standard.

Response Message: FR-23-NFPA 1142-2025

First Revision No. 20-NFPA 1142-2025 [Section No. 3.3.15]

3.3.15 Lift.

The vertical height that water must be raised during a drafting operation, measured from the surface of a static source of water to the centerline of the pump intake.
[~~**1911**~~ **1910** ,~~2017~~ 2024]

Submitter Information Verification

Committee: WRP-AAA

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Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The extract is updated because NFPA 1911 has been consolidated into NFPA 1910.

Response Message: FR-20-NFPA 1142-2025

First Revision No. 21-NFPA 1142-2025 [Section No. 3.3.17]

3.3.17 Mobile Water Supply Apparatus (Tanker, Tender).

A vehicle designed primarily for transporting (pickup, transporting, and delivering) water to fire emergency scenes to be applied by other vehicles or pumping equipment.
[~~1901~~ **1900** ,~~2016~~ 2024]

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 01:06:56 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The extract is updated because NFPA 1901 has been consolidated into NFPA 1900.

Response Message: FR-21-NFPA 1142-2025

First Revision No. 22-NFPA 1142-2025 [Section No. 3.3.19]

3.3.19* Mutual Aid/Assistance Agreement.

A prearranged agreement between two or more entities to share resources in response to or during recovery from an incident. [~~1600~~ **1660** , ~~2019~~ 2024]

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 01:07:50 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The extract is updated because NFPA 1600 has been consolidated into NFPA 1660. This revision updates extracted text in accordance with the Extract Policy. For substantiation on any changes, see the first and second draft reports for the source document.

Response Message: FR-22-NFPA 1142-2025

First Revision No. 1-NFPA 1142-2025 [Section No. 3.3.29]

3.3.29 Water Delivery Rate.

The minimum amount of water per minute (in gpm or L/min), required by this standard or the AHJ, to be delivered ~~to~~ and applied at the fire scene ~~via mobile water supply apparatus, hose lines, or a combination of both~~ for structural firefighting .

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 11:32:41 EST 2025

Committee Statement

Committee Statement: The purpose of the standard is to assist the AHJ to establish the minimum water supply necessary for structural firefighting purposes in those areas where it has been determined that there is no water or adequate water for firefighting. Once the water supply is determined, Table 4.6.1 determines the minimum delivery rate required for manual structural firefighting. Water supply can come from a variety of sources, including, but not limited to cisterns, ponds, water tenders, and gravity fed or pressurized water tanks. Access to the water supply may be through a variety of conduits and appliances that may include pipes, valves, pumps, dry hydrants, FDCs, and hose lines. Table 4.6.1 determines the minimum GPM that needs to be available through the conduit from the water supply for firefighting purposes. Definition 3.3.29 Water Delivery Rate, establishes the requirement for the fire department to be able to deliver the minimum GPM to the fire. Therefore, the definition is amended to not exclude any conduits or appliances needed to convey the water from the water supply to the fire.

Response Message: FR-1-NFPA 1142-2025

Public Input No. 14-NFPA 1142-2024 [Section No. 3.3.29]

First Revision No. 11-NFPA 1142-2025 [Section No. 4.1.1.1]

4.1.1.1

For new construction, plans shall be submitted to the ~~fire department or the~~ AHJ for ~~determination~~ approval of the minimum water supply ~~required before~~ prior to construction ~~is started~~ .

4.1.1.1.1

A qualified person shall be responsible for determining the minimum water supply in accordance with this standard.

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 18:51:28 EST 2025

Committee Statement

Committee Statement: The existing text suggested that the fire department or AHJ is responsible for determining the minimum water supply. This revision clarifies the intent that the calculation is performed prior to the submission of plans to the AHJ.

Response Message: FR-11-NFPA 1142-2025

First Revision No. 28-NFPA 1142-2025 [Section No. 4.4]

4.4 Structures with Automatic Sprinkler Protection.

~~**A.4.4**~~

~~The following information on permitted reductions of fire flow and other fire flow provisions is based on NFPA 1 , Section 18.4.~~

~~**One- and Two-Family Dwellings.** The minimum fire flow and flow duration requirements for one- and two-family dwellings having a fire flow area that does not exceed 5000 ft ^{2} (334.5 m ^{2}) should be at 1000 gpm (3785 L/min) or 500 gpm (1900 L/min) when an approved automatic sprinkler system is installed throughout and/or separated from other buildings by a minimum of 30 ft (9.1 m). The minimum fire flow duration is 1 hour.~~

~~A reduction in required fire flow of 50 percent is permitted where the building is provided with an approved automatic sprinkler system.~~

~~A reduction in the required fire flow of 25 percent is also permitted where the building is separated from other buildings by a minimum of 30 ft (9.1 m).~~

~~The reduction for an approved automatic sprinkler system and/or separated from other buildings cannot reduce the required fire flow to less than 500 gpm (1900 L/min).~~

~~Fire flow and flow duration for dwellings having a fire flow area in excess of 5000 ft ^{2} (334.5 m ^{2}) cannot be less than that specified for buildings other than one- and two-family dwellings.~~

~~**Buildings Other Than One- and Two-Family Dwellings.** The minimum fire flow and flow duration for buildings other than one- and two-family dwellings should not be less than 1000 gpm (3785 L/min) or 600 gpm (2270 L/min) when the building is protected throughout by an approved automatic sprinkler system and quick response sprinklers are utilized throughout.~~

~~A reduction in the required fire flow of 75 percent is permitted when the building is protected throughout by an approved automatic sprinkler system.~~

~~A reduction in the required fire flow of 75 percent is permitted when the building is protected throughout by an approved automatic sprinkler system, which utilizes quick response sprinklers throughout. The resulting fire flow should not be less than 600 gpm (2270 L/min).~~

4.4.1

The AHJ shall be permitted to reduce the water supply required by this standard for manual firefighting purposes when a structure is protected by an automatic sprinkler system that fully meets the requirements of NFPA 13, NFPA 13D, or NFPA 13R. *(See Annex D.)*

4.4.2

If a sprinkler system protecting a building does not fully meet the requirements of NFPA 13, NFPA 13D, or NFPA 13R, a water supply shall be provided in accordance with this standard.

Supplemental Information

File Name	Description	Approved

1142_FR-28_Section_4.4.docx

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Tue Jan 21 15:19:12 EST 2025

Committee Statement

Committee Statement: Section A.4.4 is deleted. The text lead designers and engineers to the assumption that they should always take a reduction on an NFPA 1142 water supply when there is an automatic sprinkler system. Whether to allow a reduction and the amount of the reduction are at the discretion of the AHJ, as stated in 4.4.1.

Response Message: FR-28-NFPA 1142-2025

Public Input No. 8-NFPA 1142-2024 [Section No. A.4.4]

First Revision No. 2-NFPA 1142-2025 [Section No. 5.2]

5.2* Occupancy Hazard Classification Number.

5.2.1 Occupancy Hazard Classification Number 3.

5.2.1.1*

Occupancy hazard classification number 3 shall be used for severe hazard occupancies.

5.2.1.2

Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 3:

(1) Cereal or flour mills

(2) Combustible hydraulics

(3) Cotton picking and opening operations

(4) Die casting

(5) Explosives and pyrotechnics manufacturing and storage

(6) Feed and gristmills

(7) Flammable liquid spraying

(8) Flow coating/dipping

(9) Linseed oil mills

(10) Manufactured homes/modular building assembly

(11) Metal extruding

(12) Plastic processing

(13) Plywood and particleboard manufacturing

(14) Printing using flammable inks

(15) Rubber reclaiming

(16) Sawmills

(17) Solvent extracting

(18) Straw or hay in bales

(19) Textile picking

(20) Upholstering with plastic foams

5.2.2 Occupancy Hazard Classification Number 4.

5.2.2.1*

Occupancy hazard classification number 4 shall be used for high hazard occupancies.

5.2.2.2

Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 4:

(1) Automobile parking garages

(2) Barns and stables (commercial)

(3) Building materials supply storage

(4) Department stores

(5) Exhibition halls, auditoriums, and theaters

(6) Feed stores (without processing)

(7) Freight terminals

(8) Mercantiles

(9) Paper and pulp mills

(10) Paper processing plants

(11) Piers and wharves

(12) Repair garages

(13) Rubber products manufacturing and storage

(14) Warehouses, such as those used for furniture, general storage, paint, paper, and woodworking industries

5.2.3 Occupancy Hazard Classification Number 5.

5.2.3.1

Occupancy hazard classification number 5 shall be used for moderate hazard occupancies, in which the quantity or combustibility of contents is expected to develop moderate rates of spread and heat release. The storage of combustibles shall not exceed 12 ft (3.66 m) in height.

5.2.3.2

Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 5:

(1) Amusement occupancies
(2) Clothing manufacturing plants
(3) Cold storage warehouses
(4) Confectionery product warehouses
(5) Farm storage buildings, such as corn cribs, dairy barns, equipment sheds, and hatcheries
(6) Laundries
(7) Leather goods manufacturing plants
(8) Libraries (with large stockroom areas)
(9) Lithography shops
(10) Machine shops
(11) Metalworking shops
(12) Nurseries (plant)
(13) Pharmaceutical manufacturing plants
(14) Printing and publishing plants
(15) Restaurants
(16) Rope and twine manufacturing plants
(17) Sugar refineries
(18) Tanneries
(19) Textile manufacturing plants
(20) Tobacco barns
(21) Unoccupied buildings

5.2.4 Occupancy Hazard Classification Number 6.

5.2.4.1

Occupancy hazard classification number 6 shall be used for low hazard occupancies, in which the quantity or combustibility of contents is expected to develop relatively low rates of spread and heat release.

Detail FR-8

5.2.4.2

Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 6:

(1) Armories

~~Automobile parking garages~~

(2) Bakeries

(3) Barber or beauty shops

(4) Beverage manufacturing plants/breweries

(5) Boiler houses

(6) Brick, tile, and clay product manufacturing plants

(7) Canneries

(8) Cement plants

(9) Churches and similar religious structures

(10) Dairy products manufacturing and processing plants

(11) Doctors' offices

(12) Dwellings

(13) Electronics plants

(14) Foundries

(15) Fur processing plants

(16) Gasoline service stations

(17) Glass and glass products manufacturing plants

(18) Horse stables

(19) Mortuaries

(20) Municipal buildings

(21) Post offices

(22) Slaughterhouses

(23) Telephone exchanges

(24) Tobacco manufacturing plants

(25) Watch and jewelry manufacturing plants

(26) Wineries

5.2.5 Occupancy Hazard Classification Number 7.

5.2.5.1

Occupancy hazard classification number 7 shall be used for light hazard occupancies, in which the quantity or combustibility of contents is expected to develop relatively light rates of spread and heat release.

Detail FR-8

5.2.5.2

Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 7:

(1) Apartments

(2) Colleges and universities

(3) Clubs

(4) Dormitories

~~Dwellings~~

(5) Fire stations

(6) Fraternity or sorority houses

(7) Hospitals

(8) Hotels and motels

(9) Libraries (except large stockroom areas)

(10) Museums

(11) Nursing and convalescent homes

(12) Offices (including data processing)

(13) Police stations

(14) Prisons

(15) Schools

(16) Theaters without stages

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 12:25:25 EST 2025

Committee Statement

Committee Statement: Due to the inclusion of EV vehicles and higher plastic content in vehicles, automobile parking garages are changed from hazard classification 6 to hazard classification 4. NFPA 13 currently classifies automobile parking garages as ordinary hazard group 2, which most closely aligns with hazard classification 4 in this standard.

Response Message: FR-2-NFPA 1142-2025

Public Input No. 13-NFPA 1142-2024 [Section No. 5.2]

First Revision No. 9-NFPA 1142-2025 [Section No. 6.2.2]

~~**6.2.2**~~

~~For dwellings, the maximum construction classification number shall be 1.0.~~

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 18:27:03 EST 2025

Committee Statement

Committee Statement: The maximum construction classification for dwellings is deleted to account for modern fire hazards, such as batteries, solar panels, plastics, and alternative energy vehicles, in an occupancy that is typically unsprinklered and can be located in remote areas.

The committee has created a task group to further study this issue.

Response Message: FR-9-NFPA 1142-2025

First Revision No. 3-NFPA 1142-2025 [Section No. 7.1.3]

7.1.3

Water storage tanks used for a water supply as referenced in this chapter shall be ~~inspected, tested, and maintained in accordance with~~ ~~NFPA 25~~ designed and installed in accordance with NFPA 22 or other approved standard .

7.1.3.1

Water storage tanks shall be inspected, tested, and maintained in accordance with NFPA 25 or other approved standard.

Supplemental Information

File Name	Description	Approved
1142_FR-3_7.1.3.docx		

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 13:34:12 EST 2025

Committee Statement

Committee Statement: The revised text incorporates design requirements for water storage tanks to ensure reliability and structural integrity. NFPA 1142 did not previously include any design standards for water storage tanks. NFPA 22 is a recognized standard for such tanks. The committee included the allowance to use alternative standards as required by the AHJ.

It is difficult to comply with NFPA 25 for inspection, testing, and maintenance, as currently required, without the complementary design and installation requirements from NFPA 22.

Response Message: FR-3-NFPA 1142-2025

Public Input No. 5-NFPA 1142-2024 [New Section after 7.1.3]

Public Input No. 12-NFPA 1142-2024 [Section No. 7.1.3]

First Revision No. 4-NFPA 1142-2025 [Section No. 7.1.7.3]

7.1.7.4*

A review of the availability study shall be conducted at a maximum interval of every 5 years or when conditions that affect the water supply availability change.

A.7.1.7.4

The review should consider whether significant climatic or bathymetric changes have occurred in the water supply.

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 15:20:54 EST 2025

Committee Statement

Committee Statement: A periodic review of the water availability study at regular intervals is added to ensure the reliability of water supplies. Explanatory text is included to provide an example of conditions that might change over time.

Response Message: FR-4-NFPA 1142-2025

Public Input No. 10-NFPA 1142-2024 [Section No. 7.1.7.3]

Public Input No. 2-NFPA 1142-2023 [Section No. 8.7.2]

First Revision No. 14-NFPA 1142-2025 [Section No. 7.1.8]

7.1.8

Where required by the AHJ, a recognized water supply shall be provided in lieu of the minimum water supply, as determined in Chapter 4. *(See 3.3.23 , Recognized Water Supply.)*

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Tue Jan 07 10:48:12 EST 2025

Committee Statement

Committee Statement: A cross-reference to the definition is added to assist the reader in finding the criteria for a recognized water supply.

Response Message: FR-14-NFPA 1142-2025

First Revision No. 15-NFPA 1142-2025 [Section No. 7.4]

7.4 Fire Hose Connections.

Any fitting provided at a water source to permit a fire apparatus to connect to the water source shall be approved by the AHJ and shall conform to NFPA ~~1963~~ 1960 .

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 00:21:49 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

NFPA 1963 has been consolidated into NFPA 1960.

Response Message: FR-15-NFPA 1142-2025

First Revision No. 16-NFPA 1142-2025 [Section No. 8.3.8]

8.3.8

Suction hose connection(s) shall be compatible with the fire department's hard suction hose size ~~and shall conform to NFPA 1963 . The connection(s) shall include a protective cap. The cap and adapter shall be of materials that minimize rust and galvanic corrosion~~ .

8.3.8.1

Suction hose connection(s) shall conform to NFPA ~~1963~~ 1960 .

8.3.8.2

~~The~~ Suction hose connection(s) shall include a protective cap.

8.3.8.3

The protective cap and adapter shall be of materials that minimize rust and galvanic corrosion.

Supplemental Information

File Name	Description	Approved
1142_FR-16_8.3.8.docx		

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 00:23:36 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

NFPA 1963 has been consolidated into NFPA 1960. The section was reorganized to comply with the Manual of Style.

Response Message: FR-16-NFPA 1142-2025

First Revision No. 5-NFPA 1142-2025 [Section No. 8.3.13]

8.3.13* Strainer Placement and Design.

~~System strainers shall be constructed to permit required fire flow.~~

8.3.13.1

Dry hydrants shall be equipped with system strainers.

8.3.13.2

System strainers shall be constructed to permit required fire flow.

8.3.13.3

The suction strainer shall have a free area of at least four times the area of the suction connections.

8.3.13.4

Openings shall be sized to restrict the passage of a 0.5 in. (12.7 mm) sphere.

Supplemental Information

File Name	Description	Approved
1142_FR-5_8.3.13.docx		

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 15:50:42 EST 2025

Committee Statement

Committee Statement: Section 8.3.13 did not require a strainer. A strainer should be provided for all dry hydrants to protect the drafting operation and the fire pump. This revision also specifies the design of the strainer, which is based on NFPA 20.

Response Message: FR-5-NFPA 1142-2025

Public Input No. 6-NFPA 1142-2024 [Section No. 8.3.13]

First Revision No. 6-NFPA 1142-2025 [Section No. 8.7]

8.7 Inspection, Testing, and Maintenance of Dry Hydrants.

8.7.1*

Dry hydrants shall be inspected ~~at least~~ quarterly and ~~maintained as necessary to keep them in good operating condition~~ after each operation .

~~**8.7.2**~~

~~Thorough surveys shall be conducted, to reveal any deterioration in the water supply situation in ponds, streams, or cisterns.~~

8.7.2

Vegetation shall be cleared for a minimum 3 ft (0.9 m) radius from around hydrants.

8.7.3

The reflective material marking the hydrant and signage shall be inspected at least annually to verify that it is being maintained in accordance with 8.4.7.

8.7.4

Hydrant risers shall be protected from ultraviolet (UV) degradation by painting or other measures.

8.7.5*

The hydrants shall be flow tested ~~at least~~ annually with an approved pump to ensure that the minimum design flow is maintained.

8.7.6

Inspection, testing, and maintenance of dry hydrants shall be performed by a qualified person.

Supplemental Information

File Name	Description	Approved
1142_FR-6_8.7.docx	staff use	

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 06 16:00:54 EST 2025

Committee Statement

Committee Statement: The phrase "at least" was removed in 8.7.1 and 8.7.6 since this is a minimum standard and it is understood that the AHJ can increase the frequency as needed.

A requirement to inspect dry hydrants after each operation is added to correlate with the requirements for wet hydrants in NFPA 25.

The requirement to periodically review the water availability study has been relocated to Chapter 7. See First Revision 4.

Response Message: FR-6-NFPA 1142-2025

Public Input No. 11-NFPA 1142-2024 [Section No. 8.7]

First Revision No. 24-NFPA 1142-2025 [Section No. A.7.6]

A.7.6

The training of fire department personnel involved in mobile water supply is essential to ensure a safe and efficient operation at fire scenes involving mobile water supply operations. ~~NFPA 1001~~ NFPA 1010 , ~~NFPA 1451~~ NFPA 1400 , and Section ~~C.9~~ C.2.5 should be consulted to develop a training program focused on mobile water supply operations.

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Sat Jan 18 01:40:39 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

NFPA 1001 has been consolidated into NFPA 1010. NFPA 1451 has been consolidated into NFPA 1400.

Response Message: FR-24-NFPA 1142-2025

First Revision No. 25-NFPA 1142-2025 [Section No. A.8.1]

A.8.1

Factors to consider when determining the need and location for a dry hydrant system should include, but not be limited to, the following:

(1) Current and future population and building trends

(2) Property values protected

(3) Potential for loss

(4) Proximity to structures [e.g., not closer than 100 ft (30 m) from a structure it is designed to protect]

(5) Fire history of the area protected

(6) Current water supply systems

(7) Potential water supply sources and reliability (i.e., constructed or natural)

(8) Cost of project

(9) Other factors of local concern

The Volunteer Fire Assistance program provides grants to rural fire departments for training, organizing, and equipment serving communities with a population of 10,000 or less. The ~~U.S.~~ US Forest Service sponsors and funds this program, which is delivered by the State Forester in each state.

Grants may be available through the State Forester's office on a cost-sharing basis. It is appropriate to seek funding from the Volunteer Fire Assistance program for material for dry hydrants since rural fire departments provide much of the initial attack on wildland fires. More information about the Volunteer Fire Assistance program can be found on the USDA Forest Service website at ~~www.fs.fed.us/fire/partners/vfa/~~ fs.usda.gov . Click on VFA Desk Guide. Contact your local State Forester's office for application procedures. The name and contact information for State Foresters can be found on the National Association of State Foresters website at stateforesters.org.

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Mon Jan 20 16:53:44 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The URL for the US Department of Agriculture was updated.

Response Message: FR-25-NFPA 1142-2025

First Revision No. 29-NFPA 1142-2025 [Section No. F.2.1]

F.2.1 Residential.

A dwelling has the following characteristics: (1) a ground floor of 50 ft × 24 ft; (2) two stories of 8 ft each; (3) a pitched roof, 8 ft from attic floor to ridgepole; and (4) wood frame (Type V) construction. The calculations for minimum water supply are as follows:

Ground floor area = 50 ft × 24 ft = 1200 ft^2

Height = 8 ft + 8 ft + 4 ft = 20 ft (For pitched roofs, use half the distance from attic floor to ridgepole.)

Total volume = 1200 ft^2 × 20 ft = 24,000 ft^3

The occupancy hazard classification number is ~~7~~ 6 *(see ~~5.2.5~~ 5.2.4).* The construction classification number is 1.~~0~~ 5 , ~~maximum for a frame dwelling~~ *(see ~~6.2.2~~ 6.2.1)*~~,~~ resulting in the following calculations:

DELETED: $$\frac{24,000}{7} \times 1.0 = 3429 \text{ gal}$$

$$\frac{24,000}{6} \times 1.5 = 6000 \text{ gal}$$ [~~H.2.1~~ F.2.1]

The minimum water supply equals ~~3429~~ 6000 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Supplemental Information

File Name	Description	Approved
1142_FR-29_F.2.1.docx	Staff use	

Submitter Information Verification

Committee: WRP-AAA

Submittal Date: Fri Feb 07 17:05:52 EST 2025

Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The example was updated in accordance with changes in the main body of the standard. First Revision 9 deleted 6.2.2, which previously limited the construction classification for residences to a maximum of 1. First Revision 8 moved "dwellings" from occupancy hazard classification 7 (5.2.5.2) to occupancy hazard classification 6 (5.2.4.2).

Response Message: FR-29-NFPA 1142-2025

First Revision No. 30-NFPA 1142-2025 [Section No. F.3.2]

F.3.2 Multiple-Structure Calculations.

The following are examples of minimum water supply calculations where there are multiple structures.

Example 1. A row of five dwellings is identical to the dwelling in F.2.1, except that one dwelling has a brick barn (Type III construction) measuring 80 ft × 40 ft that is located 35 ft from the dwelling. The barn is larger than 100 ft^2 in area and is less than 50 ft from the dwelling. Therefore, the minimum water supply for this dwelling, ~~3429~~ 6000 gal, should be multiplied by 1.5 for the exposure:

~~3429~~ 6000 gal × 1.5 = ~~5144~~ 9000 gal

If the dwellings and barn are to be protected by the same water supply, as is likely, the water supply should be calculated based on the structure that requires the largest minimum water supply. If the barn has no hay storage and is 25 ft in height to the pitched ridgepole, and the ridgepole is 10 ft above the eaves, the calculations would be as follows:

Ground floor area = 80 ft × 40 ft = 3200 ft^2

Height = 15 ft + 5 ft = 20 ft (For pitched roofs, use half the distance from attic floor to ridgepole.)

Total volume = 3200 ft^2 × 20 ft = 64,000 ft^3

The occupancy hazard classification number is 4 for the barn with no hay storage *(see 5.2.2),* and the construction classification number is 1.0 *(see Table 6.2.1)*, resulting in the following calculations:

$$\frac{64,000}{4} \times 1.0 = 16,000 \text{ gal}$$

[~~H.3.2a~~ F.3.2a

16,000 × 1.5 for exposure hazard = 24,000 gal

The minimum water supply equals 24,000 gal. Since this is larger than the ~~5144~~ 9000 gal required for the dwelling, 24,000 gal would be the minimum water supply for the barn and dwelling.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Example 2. A farm equipment shed is identical to commercial occupancy in F.2.2, except that it has a one-story, pitched-roof frame dwelling (Type V Construction) measuring 50 ft × 25 ft that is located 45 ft from the equipment shed. The dwelling is an exposure because it is larger than 100 ft^2 in area and is less than 50 ft from the equipment shed. Therefore, the minimum water supply for the equipment shed is 26,250 gal × 1.5, or 39,375 gal.

The minimum water supply for the farm equipment shed equals 39,375 gal.

The total water supply for the dwelling is calculated as follows:

Ground floor area = 50 ft × 25 ft = 1250 ft^2

Height = 8 ft + 4 ft = 12 ft

Total volume = 1250 ft^2 × 12 ft = 15,000 ft^3

The occupancy hazard classification number is ~~7~~ 6 *(see ~~5.2.5~~ 5.2.4),* and the construction classification number is 1.~~0~~ 5 *(see ~~6.2.2~~ 6.2.1)*, resulting in the following calculation:

DELETED: ~~$\frac{15,000}{7} \times 1.0 = 2143 \text{ gal}$~~

$$\frac{15,000}{6} \times 1.5 = 3750 \text{ gal}$$

[~~H.3.2b~~ F.3.2b

The dwelling has an exposure from the farm equipment shed; therefore, multiply by the exposure factor of 1.5 as follows:

~~2143~~ 3750 gal × 1.5 = ~~3215~~ 5625 gal

The farm equipment shed requires the larger minimum water supply. Therefore, if these two buildings were to be protected by the same water supply, the minimum water supply would be 39,375 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Example 3. If the church and office building described in F.2.3 are less than 50 ft from each other, they would be exposures to each other. Therefore, the required water supply for the church would be 26,000 gal × 1.5 for the exposure factor, or 39,000 gal. Likewise, the water supply for the office building would be 25,000 gal × 1.5 for the exposure factor, or 37,500 gal. The larger amount would dictate the minimum water supply requirement for the site, which in this case would be 39,000 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Supplemental Information

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Submitter Information Verification

Committee: WRP-AAA

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Committee Statement

Committee Statement: This revision was developed by NFPA staff for editorial purposes, in accordance with 4.3.9.3.2 and 4.3.9.3.3 of the Regulations Governing the Development of NFPA Standards (nfpa.org/regs).

The examples were updated in accordance with changes in the main body of the standard. First Revision 9 deleted 6.2.2, which previously limited the construction classification for residences to a maximum of 1. First Revision 8 moved "dwellings" from occupancy hazard classification 7 (5.2.5.2) to occupancy hazard classification 6 (5.2.4.2).

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First Revision No. 26-NFPA 1142-2025 [Section No. K.1.2]

I.1.2 Other Publications.

I.1.2.1 ASTM Publications.

ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft-lbf/ft^3(2,700 kN-m/m^3)]*, ~~2012~~ 2021 .

I.1.2.2 ISO Publications.

~~ISO 545 Washington Boulevard, 19–5, Jersey City, NJ 07310~~ International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland .

Guide for Determination of Needed Fire Flow, 2014.

I.1.2.3 NASF Publications.

National Association of State Foresters, 444 North Capital Street NW, Suite 540, Washington, DC 20001.

~~www.~~ stateforesters.org

I.1.2.4 ~~U.S.~~ US Government Publications.

I.1.2.4.1 USDA Forest Service Publications.

United States Department of Agriculture Forest Service, 2538 Depot ~~St~~ Street , Manchester Center, VT 05255.

~~www.~~ fs.~~fed.us/fire~~ usda.gov

I.1.2.4.2 US Fire Administration Publications.

United States Fire Administration, 16825 S. Seton Ave, Emmitsburg, MD 21727.

FA-248, *Safe Operation of Fire Tankers* , 2002.

I.1.2.5 Other Publications.

Sylvia, Dick, *Fire Service Hydraulics* , 2nd edition, Edited by James F. Casey, Fire Engineering Books & Videos, Div. of PennWell Publishing Company, Saddle Brook, NJ, 1970.

Supplemental Information

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Committee Statement

Committee Statement: The references were updated in accordance with NFPA policy.

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First Revision No. 27-NFPA 1142-2025 [Section No. K.2]

I.2 Informational References.

The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

~~**K.2.1** NFPA Publications.~~

~~National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.~~

~~NFPA 1961 , *Standard on Fire Hose* , 2020 edition.~~

~~NFPA 1962 , *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances* , 2018 edition.~~

~~NFPA 1963 , *Standard for Fire Hose Connections* , 2019 edition.~~

I.2.1 Other Publications.

Handbook of PVC Pipe, Design and Construction, ~~Fifth~~ 5th ~~Edition~~ edition , 2012. The Uni-Bell PVC Pipe Association, 201 E. John Carpenter Freeway, Suite 750, Irving, TX, 75062.

I.2.2 ~~Other Resources~~ Wisconsin DNR Publications .

Wisconsin Department of Natural Resources, 101 South Webster Street, P.O. Box 7921, Madison, WI 53707-7921.

Pohlman, John, and R. White, *A Guide to Planning and Installing Dry Fire Hydrants*, PUB-FR-044, 2003.

~~**K.2.2.1** Firewise Resources.~~

~~*Using Water Effectively in the Wildland/Urban Interface* (DVD or video), 2004.~~

~~**I.2.2.1** Wisconsin DNR Publications.~~

~~Wisconsin Department of Natural Resources, 101 South Webster Street, P.O. Box 7921, Madison, WI 53707-7921.~~

~~*A Guide to Planning and Installing Dry Fire Hydrants* , 2003.~~

Supplemental Information

File Name	Description	Approved
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NFPA 1961, NFPA 1962, and NFPA 1963 have been consolidated into NFPA 1960. Since NFPA 1960 is already included in the Referenced Publications, there is no need to include it in the Informational References.

The Firewise video on using water effectively is no longer available.

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