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Wildland Fire Engine Component Guide

Prepared by:
NWCG Fire Equipment Working Team

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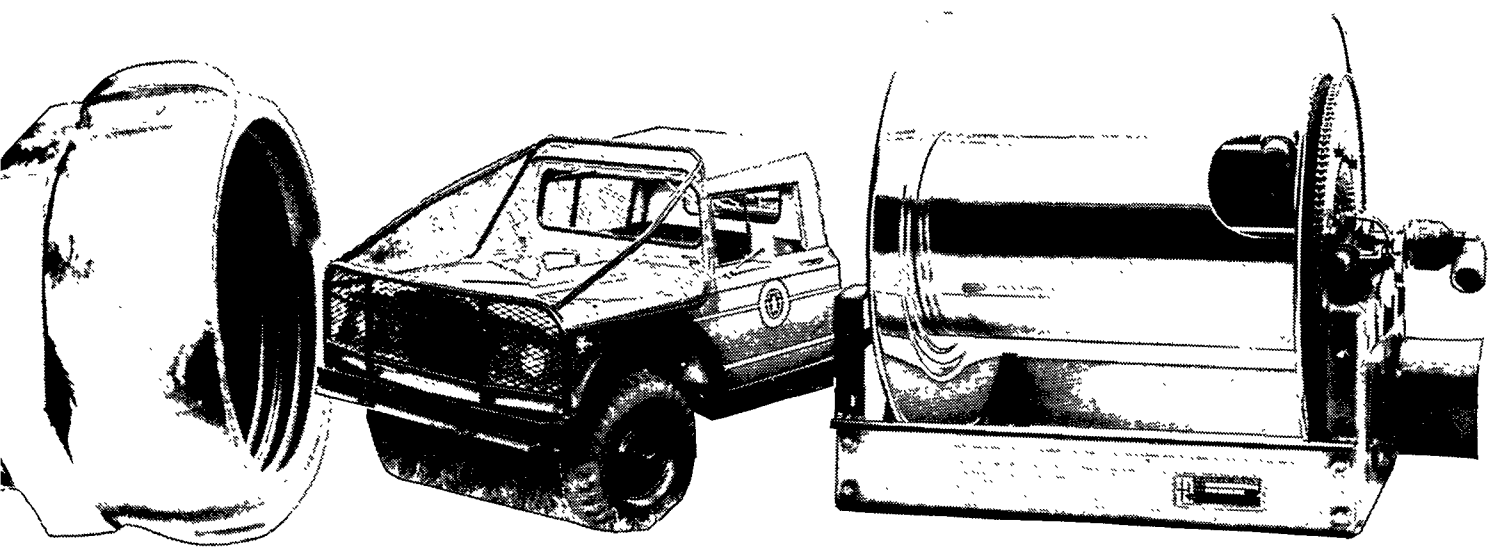

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WILDLAND FIRE ENGINE COMPONENT GUIDE

This Guide was developed by the National Wildfire Coordinating Group (NWCG), Fire Equipment Working Team (FEWT), National Engine Subcommittee. This interagency subcommittee was chartered in 1986 to define and improve the quality of wildland fire engines. The first phase of the effort was the development of performance specifications to provide improved quality truck chassis. The second phase was to develop criteria for component selection. This Guide is the product of the second phase.

The objective of this publication is to assist wildland fire agencies in the selection of quality components for assembly into fire engines. It provides information on characteristics that should be considered to meet a wide range of wildland fire engine user requirements. NWCG also publishes a companion document, the *Water Handling Equipment Guide* (NFES No. 1275). This provides additional reference information.

The National Engine Subcommittee that drafted this Guide was composed of the following personnel:

Brian Hutchins, Chairperson	State of Michigan
Dennis Davis	General Services Administration
Ted Rex	USDI Bureau of Land Management
Jim Stumpf	USDI Bureau of Land Management
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The camera-ready copy for the Guide was produced at the San Dimas Technology and Development Center (SDTDC), USDA Forest Service, San Dimas, Calif., for the National Fire Equipment System (NFES), National Interagency Fire Center (NIFC), Boise, Idaho, by the following publications personnel:

Al Seltzer	Technical Writer/Editor
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IMPORTANT USER INFORMATION

NWCG also publishes a companion document, the *Water Handling Equipment Guide* (NFES No. 1275). This provides additional reference information.

NOTE: *The mission of the engine should be determined before the vehicle is designed! The guide was developed to be used by a wide variety of experience levels. Guide users who have difficulty in choosing components may wish to consult other agencies' personnel for assistance.*

Chapter Subheadings

Each chapter in this Wildland Fire Engine Component Guide contains four sections:

A. SELECTION GUIDE

Helps users through the specification process by listing important features that should be properly specified by the buyer. Provides a step-by-step checklist for selecting appropriate elements pertaining to the chapter topic.

B. FLOW CHART

Developmental flow charts assist users in the progression of decisions that need to be made in component selection process; they show design inter-relationships. *(NOTE: The overall design variables applicable to a wildland fire engine are shown in the flow chart that follows this Preface.)*

C. SELECTION AID

Provides users with detailed information for making selection guide choices.

D. REFERENCES

Lists accepted standards and specifications that apply to wildfire components, including specifications for various components that are currently being successfully used by wildland fire agencies. *(NOTE: In some cases, sources of additional information is provided.)* The listings include pertinent standards from the Society of Automotive Engineers (SAE), the National Fire Protection Association (NFPA), the American Society for Testing and Materials (ASTM), and several governmental agencies.

Additional Considerations

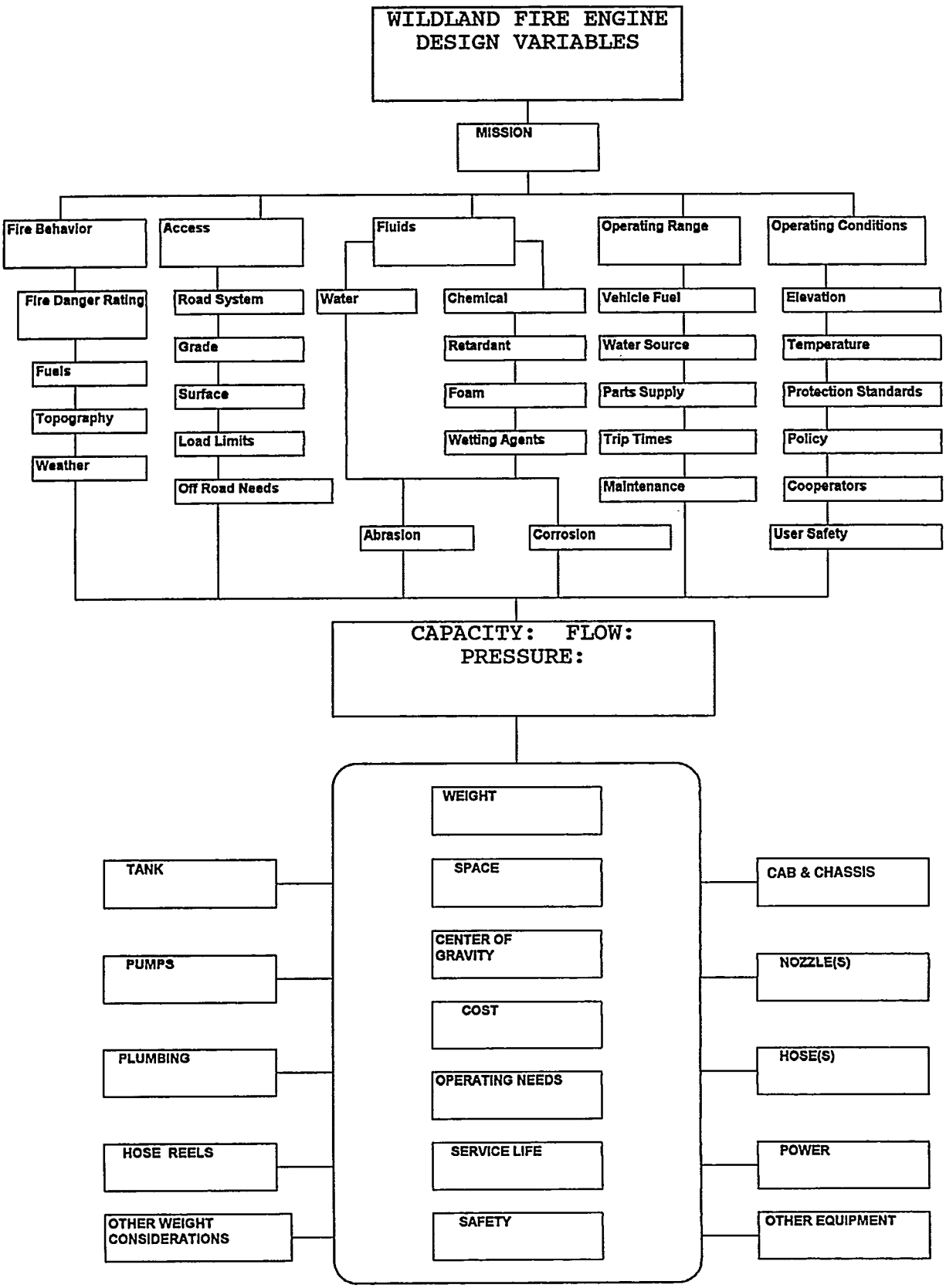
Be aware that the FEWT has not addressed within this Guide specific issues related to the following areas:

Vehicle Overloading

In wildland fire service, overloading of a vehicle reduces the service life, increases maintenance costs, and affects overall engine safety. It is important for agencies developing fire apparatus specifications to work closely with the manufacturer of the cab/chassis so that weight limitations on axles, overall unit weight distribution, and center of gravity limitations are not exceeded. Experience has shown that total weight of a wildland fire engine should not be more than 80 percent of the highway GVWR.

Safety Equipment Requirements

It is important for agencies developing engine specifications to implement their current safety equipment policies.



Wildland Fire Engine design variables flow chart.

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CHAPTER 1

CHAPTER 1. TANKS

The prime restriction to tank capacity is the GVWR of the vehicle. When determining tank capacity, consider the weight of all the other components such as pump, primer, hose reels, chemical systems, plumbing, controls, storage compartments, bumpers, brush guards, winch, emergency lights, accessories and tank itself. Important tank decisions discussed in this chapter include choosing tank material, corrosion protection, mounting requirements, inlet/outlet locations, and chemical tank needs. After selecting the other components listed in later chapters, you can adjust the tank capacity to meet GVWR restrictions. The following guide serves as a checklist of the questions to be examined, while the aid provides some explanations of those questions. The flow chart shows the relationships of the various questions to each other.

1.A TANK SELECTION GUIDE

1.A.1 Tank Capacity

1.A.1.1 Volume gallons
1.A.1.2 Type of fluid to be utilized _____
1.A.1.3 Integral concentrate tank YES ___ NO____ Volume gallons
1.A.1.4 Service life ___ years

1.A.2 Mounting Requirements

1.A.2.1 Integral tank YES_____ NO _____
1.A.2.2 Slip-on tank YES_____ NO_____
Mounts to Body YES_____ NO ____ Frame YES ____ NO ____
Skid YES ____ NO ____
1.A.2.3 Strength of construction _____

1.A.3 Material

1.A.3.1 Fiberglass_____
1.A.3.2 Stainless steel _____
1.A.3.3 Mild steel_____
1.A.3.4 Aluminum _____
1.A.3.5 Polypropylene _____
1.A.3.6 Other _____

1.A.4 Corrosion Protection

1.A.4.1 Galvanized _____
1.A.4.2 Epoxy/synthetic _____
1.A.4.3 Coal tar _____
1.A.4.4 Sacrificial anode _____
1.A.4.5 None _____

1.A.5 Tank Shape/Size

1.A.5.1 Rectangular _____ Length _____Width _____ Height_____
1.A.5.2 Cylindrical_____ Diameter _____ Length_____
1.A.5.3 Wheel well cutouts YES _____ NO ___
Location of cutouts _____
Size of cutouts _____
1.A.5.4 Sumps YES_____ NO _____
Location of sump _____
Screen size _____

1.A.5.5 Concentrate tank size _____gallons
Location _____

1.A.6 Baffles
Number/size_____
Baffle opening size _____

1.A.7 Openings
1.A.7.1 Internal access
Removable top Totally _____ Partially_____ NO _____
Access hole size _____ Location _____
1.A.7.2 Top filler locations
Shape _____
Size_____ in Number _____
Location _____
1.A.7.3 Plumbing inlets/outlets
Flanges_____
Flange material Stainless _____PVC _____ Fiberglass _____
Inlet
Size 3-in Quantity _____Locations_____
Size 2-1/2-in Quantity _____Locations_____
Size 2-in Quantity _____Locations_____
Size 1-1/2-in Quantity _____Locations_____
Size 1-in Quantity._____Locations_____
Size 3/4-in Quantity _____Locations_____

Outlet
Size 3-in Quantity _____Locations_____
Size 2-1/2-in Quantity _____Locations_____
Size 2-in Quantity _____Locations_____
Size 1-1/2-in Quantity _____Locations_____
Size 1-in Quantity _____Locations_____
Size 3/4-in Quantity _____Locations_____
1.A.7.4 Vents
Number Size_____Location_____
1.A.7.5 Quick dumps YES _____ NO _____
Size _____
Location _____
1.A.7.6 Drains YES_____ NO _____
Location _____
1.A.7.7 Level indicator YES_____ NO _____
Type Sightglass____ Float_____ Electronic _____

1.A.8 Color
Specify color requirements_____

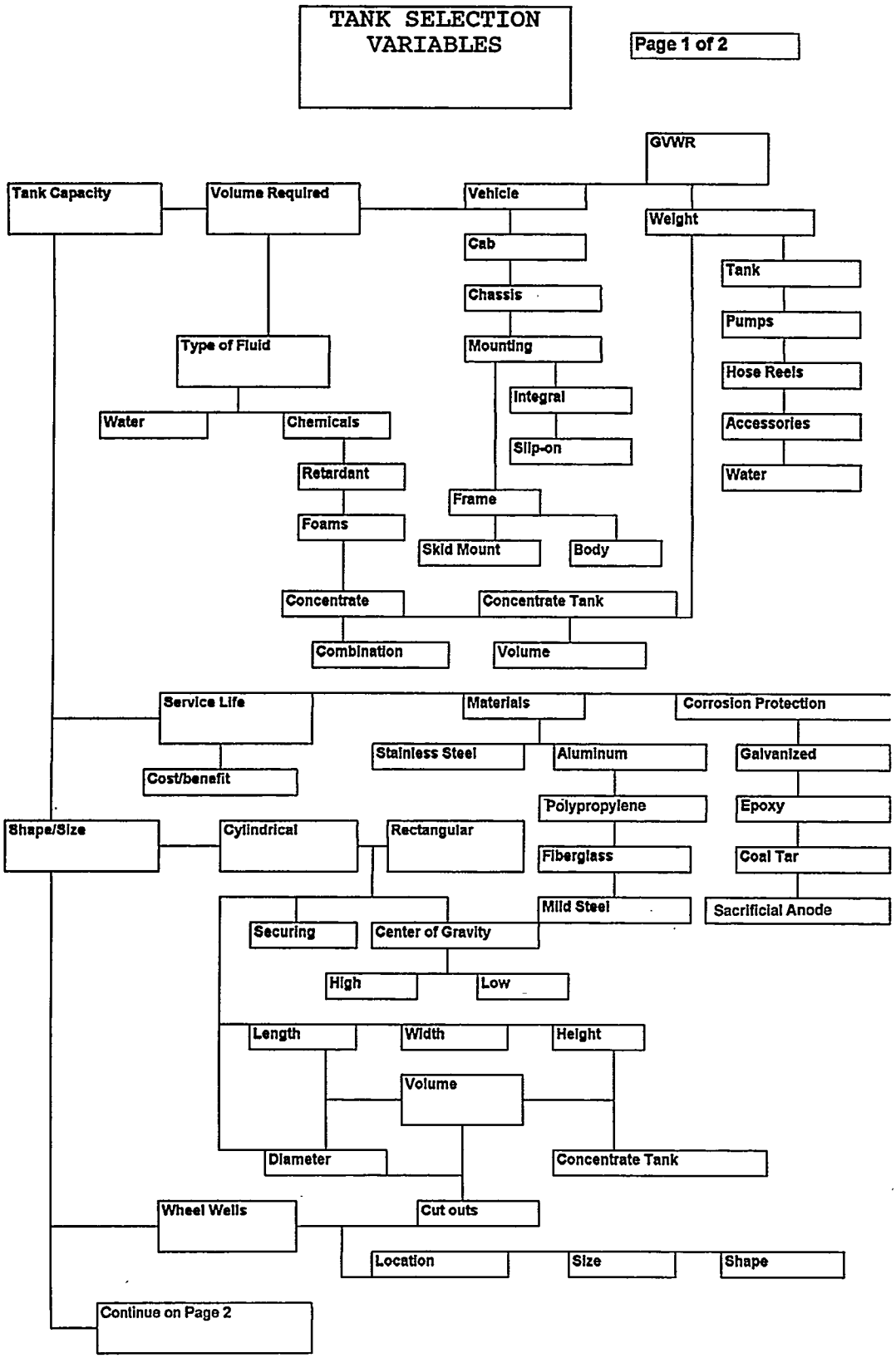
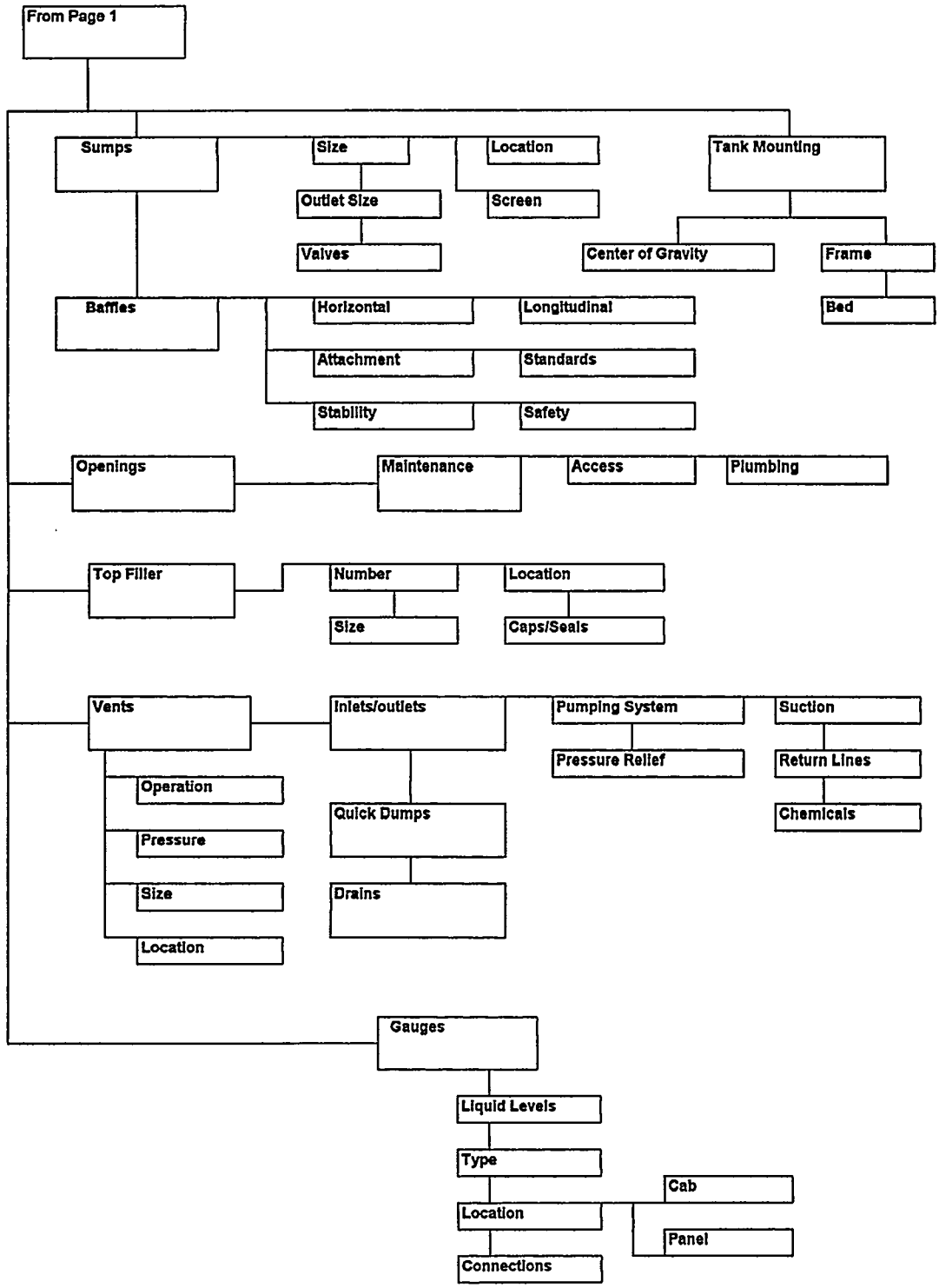


Figure 1.B. Tank selection variables flow chart.

TANK SELECTION VARIABLES (Cont.)



1.C TANK SELECTION AID

1.C.1 Tank Capacity

1.C.1.1 Volume of tank

Consider the vehicle cab and chassis on which the tank is to be mounted. GVWR is the prime restriction to the amount of water that can be carried. The weight of the tank, pump, hose reel, accessories, and water need to be considered to determine the appropriate volume of water that the chassis can carry without overloading.

1.C.1.2 Type of fluid

Will the tank only be utilized for the transport of water or will it have chemicals mixed in the primary tank; i.e., retardant, foam concentrate, or combination? Mixed retardant weighs approximately 10 lb per gal.

1.C.1.3 Concentrate tank

If there is to be a separate concentrate tank within the primary tank include that information in section 1.A.5.5. Inlet/outlet openings need to be specified in section 1.A.7.3. Determine the volume of concentrate to be carried; remembering that it will reduce the volume of water and may require adjustments to tank size in section 1.A.1.1.

1.C.1.4 Service life

The service life should be determined prior to the selection of a tank material. Material selection has definite cost benefit relationships. Corrosion protection needs to be considered in many cases, and may require future maintenance to achieve the expected service life.

1.C.2 Mounting Requirements

Mounting of tanks is a critical aspect of fire engine construction.

1.C.2.1 Integral tanks

If the tank is to be permanently mounted to the cab/chassis and enclosed by storage and other components, it is normally considered an integral tank. Mounting methods need to be designed into the original tank to ensure that the structural integrity of the tank is not compromised. Determine if the tank is to be mounted to the body or to the frame. Realize that mounting to the body may require additional structural requirements in the body construction.

1.C.2.2 Slip-on tanks

These are generally designed to be installed and removed with a minimum of effort. Mounting is temporary and can be made to the body or frame, or to skids that are mounted to the body or frame. Determine your application and ensure that accessory and mounting attachment points are designed into the original tank. Skid-mounted units usually have the tank, pumping system, and control panels all mounted to the skid. Ensure that the tank design will allow for all other components to be installed in the available space.

1.C.2.3 Construction considerations

If components are to be mounted on the top of the tank, additional structural requirements need to be considered for all the materials to be used in the construction of the tank. Bolt diagrams should be furnished for any of the components to be mounted on the tank top, along with all total weights. Remember to include the additional weight of hose, and water in the hose, if mounting a hose reel or hose basket. The same considerations must be given to the pumps and engines.

1.C.3 Material

1.C.3.1 Fiberglass

Fiberglass has many benefits: Less weight, lack of need for corrosion protection, and can be molded to meet specific needs. Fiberglass construction has to meet ANSI fiberglass standards.

1.C.3.2 Stainless steel

Stainless steel is expensive for tank construction; however, it provides the same benefits as fiberglass with relation to corrosion protection. Stainless steel requires special welding methods. Repairs are not easily obtained at all field locations. A definitive cost benefit analysis needs to be addressed with relation to other materials. There are various grades and thicknesses of stainless steel, and the appropriate material can be determined by utilizing the ASTM standards. The weight of the tank may reduce the water volume that can be carried by the vehicle.

1.C.3.3 Mild steel

Mild steel has been utilized extensively, but corrosion protection is required for just water. Types of chemicals utilized will dictate the appropriate corrosion inhibitor. Corrosion protection is addressed in section 1.C.4.

1.C.3.4 Aluminum

Aluminum does not have the total corrosion protection of fiberglass or stainless and some chemicals and retardants can create corrosion problems. It is costly and repairs can be difficult to obtain. Aluminum is lighter than stainless or mild steel, but can be heavier than fiberglass.

1.C.3.5 Polypropylene

Polypropylene is lighter than steel and provides for good corrosion protection, however, there is not enough information on chemical deterioration over time. Some manufacturers provide repair service in the field. Field repairs may be difficult to obtain due the specialty equipment required.

1.C.4 Corrosion Protection

Corrosion is a major cause of tank failures. Consider the type of fluids involved and the tank material desired, then determine if corrosion protection is required. These include retardant, foams, and hard water.

1.C.4.1 Galvanizing

Hot-dipped galvanizing is used on mild steel tanks to prevent corrosion. The tank is dipped in a galvanizing solution after all the baffles and inlet/outlet openings have been installed so that all welds can be coated. This process is not readily available in most locations, and may be difficult to repair after welding. Galvanizing can be applied by spray or brush.

1.C.4.2 Epoxy/synthetic

Epoxy/synthetic coatings are readily available and can be used on most materials to prevent corrosion. Specific compounds exist to meet specific needs. Repaired areas can be protected with additional coatings.

1.C.4.3 Coal tar

This treatment has been used for several years with mixed results. It requires annual preventive maintenance. It is the least expensive method, but maintenance costs are high. The possibility of failure exists due to incomplete coverage. The material can flake and plug screens and pumps.

1.C.4.4 Sacrificial anode

This method requires the placement of anodes in the tank to reduce the amount of corrosion resulting from electrolysis. The anode is generally a rod or plate mounted to the inside of the tank. It is utilized primarily in mild steel tanks.

1.C.4.5 None

Based on material selections and fluid types, there may not be the need for any corrosion protection.

1.C.5 Tank Shape/Size

Available space for the tank needs to be measured to ensure that tank is designed for optimum space utilization. Cylindrical tanks may produce high centers of gravity and be difficult to secure against shifting. Rectangular shapes allow for the load to be spread over a larger area and reduce the center of gravity. The length, width, and height of the tank need to be specified. The volume is determined by these measurements. If concentrate tanks are constructed within the main tank, loss of water capacity and the additional weight of the concentrate needs to be identified to keep within the GVWR of the vehicle.

1.C.5.3 Wheel well cutouts

If wheel well cutouts are required, identify their location, size, and shape.

1.C.5.4 Sumps

If cleanout sumps are required, specify their overall size, location, and outlet size. If utilizing the sump for pump suction, specify the appropriate screen size for protection of pump from the large debris. If used only as a cleanout, specify the plumbing and valve requirements.

1.C.5.5 Concentrate tank

Identify size of concentrate tank and the location within the main tank. If a separate tank is desired, provide mounting location and size. Refer to section 5.C for additional requirements on chemical tanks.

1.C.6 Baffles

Tank baffles reduce the speed at which the tank's water mass shifts when driving up or down hills, around corners, or during stops. This improves vehicle stability and handling. As an example, NFPA 1901 requires a minimum of one horizontal and one longitudinal baffle for most tanks. The minimum separation is 23 in, to a maximum of 46 in. The baffles need to be attached to the sides and bottom of the tank in a manner that will not allow them to move. Openings in each baffle must be equal in size to all inlet/outlets to allow the water and air to flow within the tank during filling, pumping, and quick dump operations.

1.C.7 Openings

Specific openings are required for tank maintenance and repair, and for appropriate plumbing to be installed in the tank.

1.C.7.1 Internal access

If the tank top is to be removable, a method for sealing is required. Gaskets designed to match the bolt patterns are the easiest and cleanest for sealing. If a manhole-type lid is used, specify exact location and diameter or dimensions. If there is an internal concentrate tank, include access to this area.

1.C.7.2 Top filler locations

Determine the number of top fill points and provide the locations for each. Remember the internal concentrate tank filler. Specify that the lids or caps must be designed to prevent the loss of water under all applications and vehicle attitudes. This can be accomplished with sealing lids or fill pipe extensions.

1.C.7.3 Plumbing inlet/outlets

Determine the number of each size and location of all plumbing inlet/outlets required in the tank to meet the operational needs of the pumping system. Include suction outlets, pressure relief return lines, and filling inlets, plus those needed for the internal concentrate tanks.

1.C.7.4 Vents

All tanks require venting to protect against collapse during pumping operations and overpressure during filling. Specify size and location for the vent. The vent should exceed the largest opening in the tank.

1.C.7.5 Quick dumps

If the application requires the need for a quick dump for filling portable tanks, or the quick release of water, specify the size and location.

1.C.7.6 Drains

Specify any drain requirements, including size and location.

1.C.7.7 Liquid level indicator

Specify the type of fluid level indicator desired. It may be a clear tube, float, or electronic level indicator. Specify location and requirements for remote gauges.

1.C.8 Color

Colors are agency specific and need to be identified with the appropriate paint manufacturers number. Fed-Std-595 is a good source of colors. Paint may not be the only method to protect the external surface of the tank. The color can be added to the final resin coat of a fiberglass tank. The tank may be totally enclosed within the cabinets and require only a good protective coating.

1.D TANK REFERENCES

ANSI D12084, Fiberglass-reinforced plastic tanks

ASTM A-123, Standard specifications for zinc (hot galvanized) coatings

NFPA 1901, Standard for Pumper Fire Apparatus

REC Project No. 11, Rustproofing treatment for steel water tanks

USDA FS 5100-341a, Tanker, slip-on, metal, end-mounted 125- & 200-gal, Model 21

USDA FS 5100-343b, Tanker, slip-on, fiberglass-reinforced resin, capacity 75-,125, 200-gal, Model 30

USDA FS 5100-346b, Tanker, slip-on, 50-gal, Model 10

USDA FS 5100-347c, Tanker, slip-on, metal, end-mounted, 75-, 125-, 200-gal, Model 20

USDA FS 5100-349b, Tanker, slip-on, 300-gal, Model 51

USDI BLM, NIFC, Tank, fiberglass, 200-gallon

USDI BLM, NIFC, Tank, fiberglass, 250-gallon

USDI BLM, NIFC, Tank, mild steel, 3,500-gallon

USDI BLM, NIFC, Tank, stainless steel, 250- to 900-gallon

CHAPTER 2

CHAPTER 2. PUMPS

The pump is literally the heart of the wildland fire engine. If its performance is not adequate to serve the needs of the user, the engine will be unsatisfactory, even if all other components are perfect. Consider flow, pressure and the types of fluids used when selecting the pump. The following guide serves as a checklist of the questions to be examined, while the aid provides some explanations of those questions. The flow chart shows the relationships of the various questions to each other.

2.A PUMP SELECTION GUIDE

2.A.1 Volume

2.A.1.1 Maximum volume to be pumped _____gpm
2.A.1.2 Typical, or most frequent, volume to be pumped_____ gpm

2.A.2 Pressure Needed

2.A.2.1 At the nozzle _____ psi
2.A.2.2 For elevation_____ psi
2.A.2.3 To overcome friction loss _____ psi
2.A.2.4 Total _____ psi

2.A.3 Type and Style

2.A.3.1 Basic type pump Positive displacement ____ Centrifugal_____
2.A.3.2 Specific style of pump _____

2.A.4 Inlet/Outlet

2.A.4.1 Size of pump inlet_____in OD
2.A.4.2 Type of connection at inlet_____
2.A.4.3 Size of pump outlet_____in OD
2.A.4.4 Type of connection at outlet _____

2.A.5 Other Openings

2.A.5.1 Drain YES_____ NO _____
2.A.5.2 Type _____ Size_____in
2.A.5.3 Primer connection YES_____ NO _____

2.A.6 Power to Drive Pump

_____ hp

2.A.7 Drive System

2.A.7.1 Auxiliary engine drive _____
2.A.7.2 Transmission power take-off_____
2.A.7.3 Split shaft power take-off_____
2.A.7.4 Hydraulic motor drive_____

2.A.8 Mounting Requirements

2.A.8.1 Does the pump need to be mounted in a specific space or location
YES_____ NO_____
If yes, describe _____
2.A.8.2 Direction of Inlet_____Outlet _____

2.A.9 Fluid(s) to be Pumped
Clean water _____ Sandy water _____ Foam solution _____ Other _____

2.A.10 Material
Pump case
Cast iron _____ Aluminum _____ Steel _____ Bronze _____
Steel _____ Cast iron _____ Aluminum _____ Bronze _____ Nylon _____
Neoprene _____ Other _____

2.A.11 Centrifugal Pump Priming Method
Manual piston ____ Manual diaphragm _____ Power _____ Self priming _____

2.A.12 Controls
2.A.12.1 Pump control type for engaging and disengaging _____
Location At the pump _____ At a remote panel ____ In the truck cab _____
2.A.12.2 Control type for changing pressure and volume _____
Location At the pump _____ At a remote panel _____ In the truck cab _____

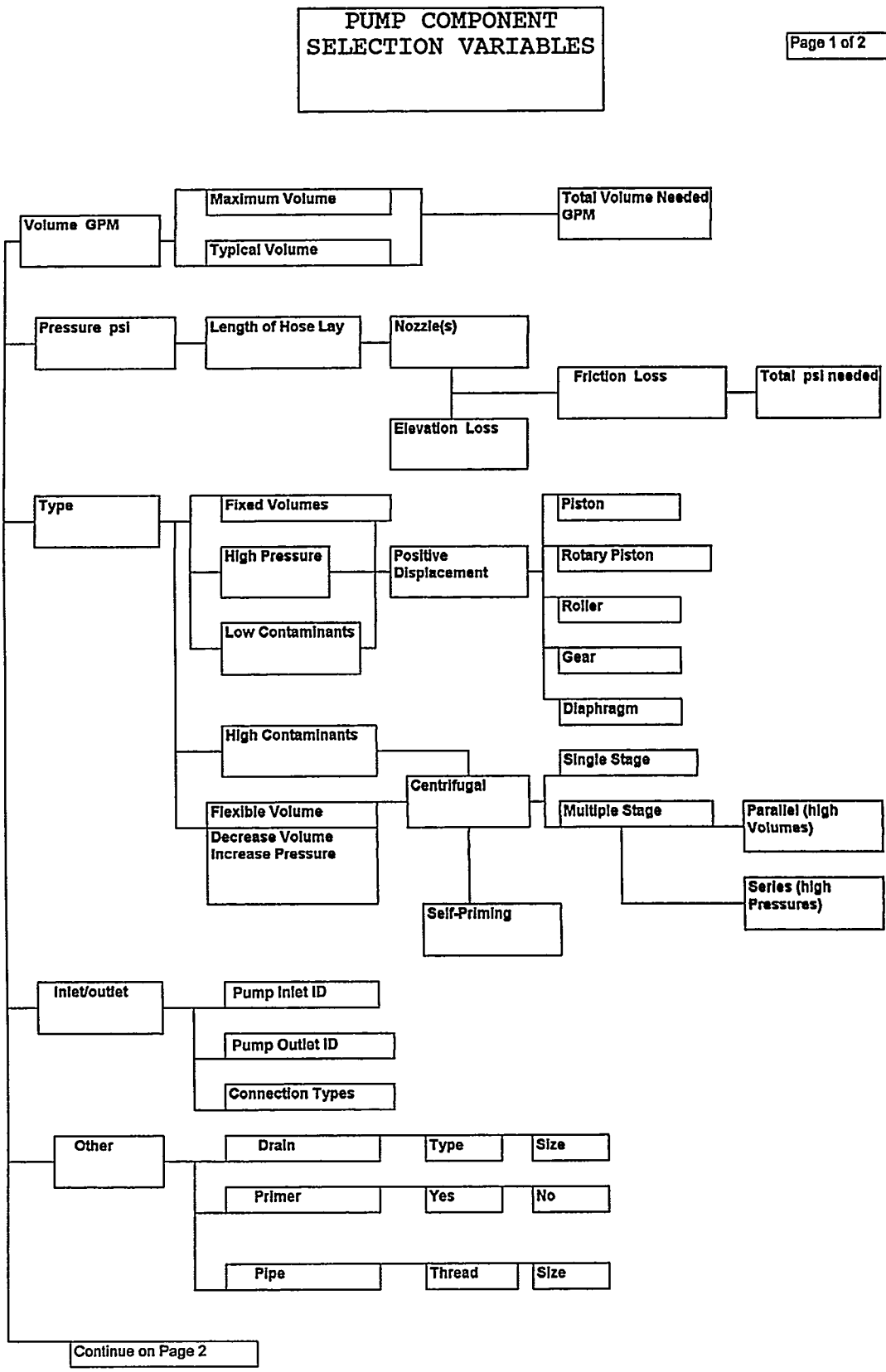
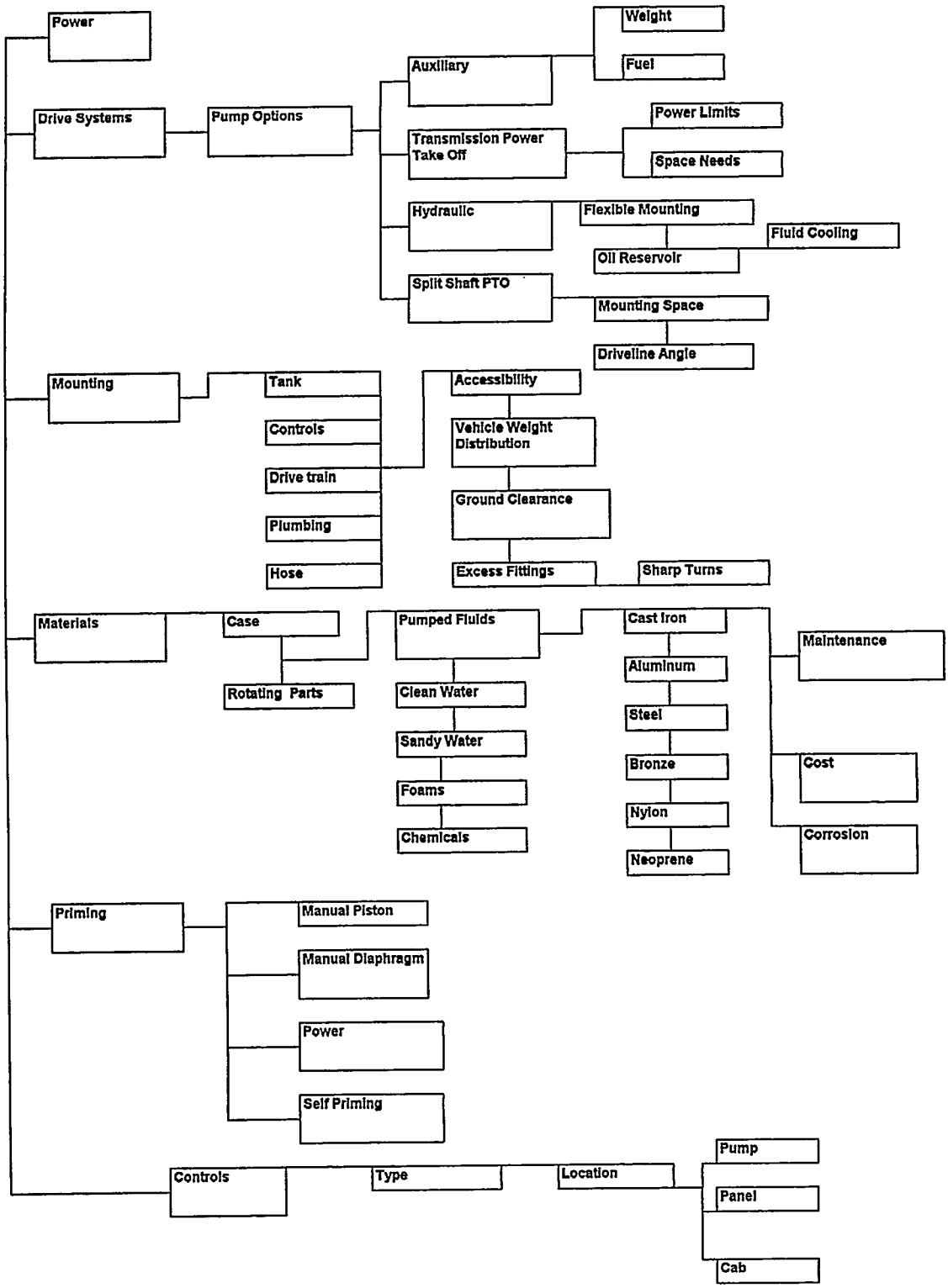


Figure 2B . Pump component selection variables flow chart (2 pgs).

PUMP COMPONENT SELECTION VARIABLES



2.C PUMP SELECTION AID

2.C.1 Volume

2.C.1.1 Maximum volume must consider the maximum number and size of nozzles that may be operated simultaneously, or the volume that may be pumped for transfer, aircraft loading, or other type operations.

2.C.1.2 Typical volume is that used for the most frequent operation, or the highest percentage of pumping time of the unit.

2.C.2 Pressure

2.C.2.1 Nozzle pressure must consider what is needed to project the stream adequately for the intended use; 50 to 100 psi is normally the adequate range.

2.C.2.2 Elevation pressure is that needed to overcome the lift from suction to pump, and from pump to nozzle under maximum operating conditions; 20 feet of suction head is considered a practical maximum. One foot of lift equals approximately 1/2 psi pressure (actually 0.43 psi).

2.C.2.3 Friction loss will increase as flow increases, hose length increases, and hose diameter decreases. It will vary with type of hose. Values are generally available from tables.

2.C.2.4 Total pressure required is the sum of all the elements mentioned above. Internal friction losses through the apparatus plumbing may be an additional factor, particularly if system pressure is measured at the pump, rather than at the outlet.

2.C.3 Type and Style

2.C.3.1 Basic types of pumps are positive displacement and centrifugal. Positive displacement pumps are generally capable of fixed volumes, regardless of pressure. They are capable of higher pressures. They are not tolerant of contaminants such as sand, scale, etc. Centrifugal pumps are generally capable of flexibility in volume with volume decreasing as pressure increases. They are more tolerant of contaminants.

2.C.3.2 There are several styles of each of the basic types. Some styles of positive displacement pumps are piston, rotary piston, roller, gear, and diaphragm. Styles of centrifugal pumps include single and multiple stage pumps, as well as multiple stages which can be arranged to pump in parallel for higher volumes, or series for higher pressures (duplex, triplex, etc.).

2.C.3.3 Self-priming centrifugal pumps are available. These incorporate a built-in primer tank, and the ability to recirculate the primer fluid to pump air bubbles out of the system. These pumps are limited to lower pressures in the 50 to 60 psi range.

2.C.3.4 Other styles of pumps include mixed-flow and turbine. These are generally designed for high-volume, low-pressure applications, and are not suitable for fire service.

2.C.4 Inlet/Outlet

2.C.4.1 Pump inlet and outlet are generally sized by the pump manufacturer to suit pump performance characteristics. Plumbing and connections from pump to hose should consider hose sizes to be employed, and plumbing needed to minimize restriction.

2.C.4.2 Type of inlet and outlet connection must consider plumbing that will be connected to the pump. Types include female threaded, male threaded, flanged, smooth nipples for clamped hose or sleeve couplings, and grooved for Victaulic couplings.

2.C.5 Other Openings

2.C.5.1 Type of drain should consider if the pump will need to be drained independent of other plumbing; to where it will drain; and how the opening will be plumbed to its ultimate outlet.

2.C.5.2 If a primer will be connected to the pump inlet, the size opening must consider the size and type of plumbing to be used between the primer and pump inlet.

2.C.6 Power

2.C.6.1 Basic horsepower requirements for the pump can be determined by use of the formula for hydraulic horsepower, which is:

$$\frac{\text{psi x gpm}}{1{,}714} = \text{hp.}$$

2.C.6.2 The product of the above calculation should be multiplied by a factor to compensate for mechanical efficiency reductions. A factor of 0.75 is a good general guideline. Engineering data for particular pumps will provide more specific information on power requirements.

2.C.7 Drive System

2.C.7.1 Auxiliary engine drives are suitable where pump and roll capability is required. Pump speed can be varied independent of vehicle speed. Added weight and space requirements may be disadvantages.

2.C.7.2 Transmission power take-off drive can provide pump and roll capability. Limitations on the amount of power that can be transmitted, and space requirements for drivelines may be disadvantages.

2.C.7.3 Split-shaft power take-off drive can transmit high horsepower. It cannot provide pump and roll capability. Mounting space requirements and driveline angle limitations may be disadvantages.

2.C.7.4 Hydraulic motor (hydrostatic) drive can provide flexibility in mounting requirements, as hydraulic drive pump and motor are connected only by hydraulic hoses or piping. Space requirements for oil reservoir, and fluid cooling requirements can be disadvantages.

2.C.8 Mounting Requirements

2.C.8.1 Pump mounting location must be planned integrally with locations of tank, controls, drive train components, plumbing, and hose connections. Practical layout of all components must consider accessibility for maintenance, vehicle weight distribution, and ground clearance.

2.C.8.2 Direction of the pump inlet and outlet must be planned integrally with the plumbing and tank locations, to minimize sharp turns, excess plumbing fittings, etc. Frequently, pump volute cases, or complete pump assemblies can be rotated to properly place inlets and outlets without disturbing gear case lubricant levels.

2.C.9 Fluid

The fluid(s) to be pumped will have some affect on the pump to be selected, and more specifically the materials in the pump. Corrosive and abrasive characteristics of water, chemicals or other fluids to be handled should be known. Most pump performance characteristics are based on water. Fluids of greater weight or viscosity change pump volume and pressure characteristics.

2.C.10 Material

Material choice should be decided based on the lightest and least expensive material required. Cast iron is generally very durable, but is heavy, and may be subject to corrosion by certain chemicals. Aluminum is light in weight, but is subject to damage from abrasion, may be subject to corrosion from some chemicals, and is generally less resistant to physical damage. Bronze is very durable and resistant to corrosion from water and minerals, but may be subject to corrosion from some chemicals. It is heavy and is expensive.

2.D PUMP REFERENCES

USDA FS 5100-273c, Pumper, engine-driven

USDA FS 5100-344a, Pumper, belt-driven, vehicle engine

NFES No. 1275, NWCG Water Handling Equipment Guide, includes data on auxiliary pumps that meet the Forest Service specifications.

CHAPTER 3

CHAPTER 3. PUMP PRIMERS

A priming pump is necessary to initially evacuate the air and fill a centrifugal pump with the liquid to be pumped. Positive displacement and self priming centrifugal pumps do not need a primer. Operator convenience, available mounting space, cost, maintenance requirements and other factors influence the type of primer selected. The following guide lists the questions to be considered and the aid provides some explanation of those questions. The flow chart shows the relationship of the various considerations to each other.

3.A PUMP PRIMER SELECTION GUIDE

3.A.1Type

Exhaust Hand _____ Electric* _____

*Voltage _____ volts Amperage _____ amps Other _____

3.A.2Size

Length _____ Width _____ Height_____

3.A.3

Capacity _____ gallons

3.A.4

Mounting _____

3.A.5

Location

3.A.6 Pump Connection

Size_____ Location _____

3.A.7

Controls for Primer _____

3.A.8

Freeze Protection

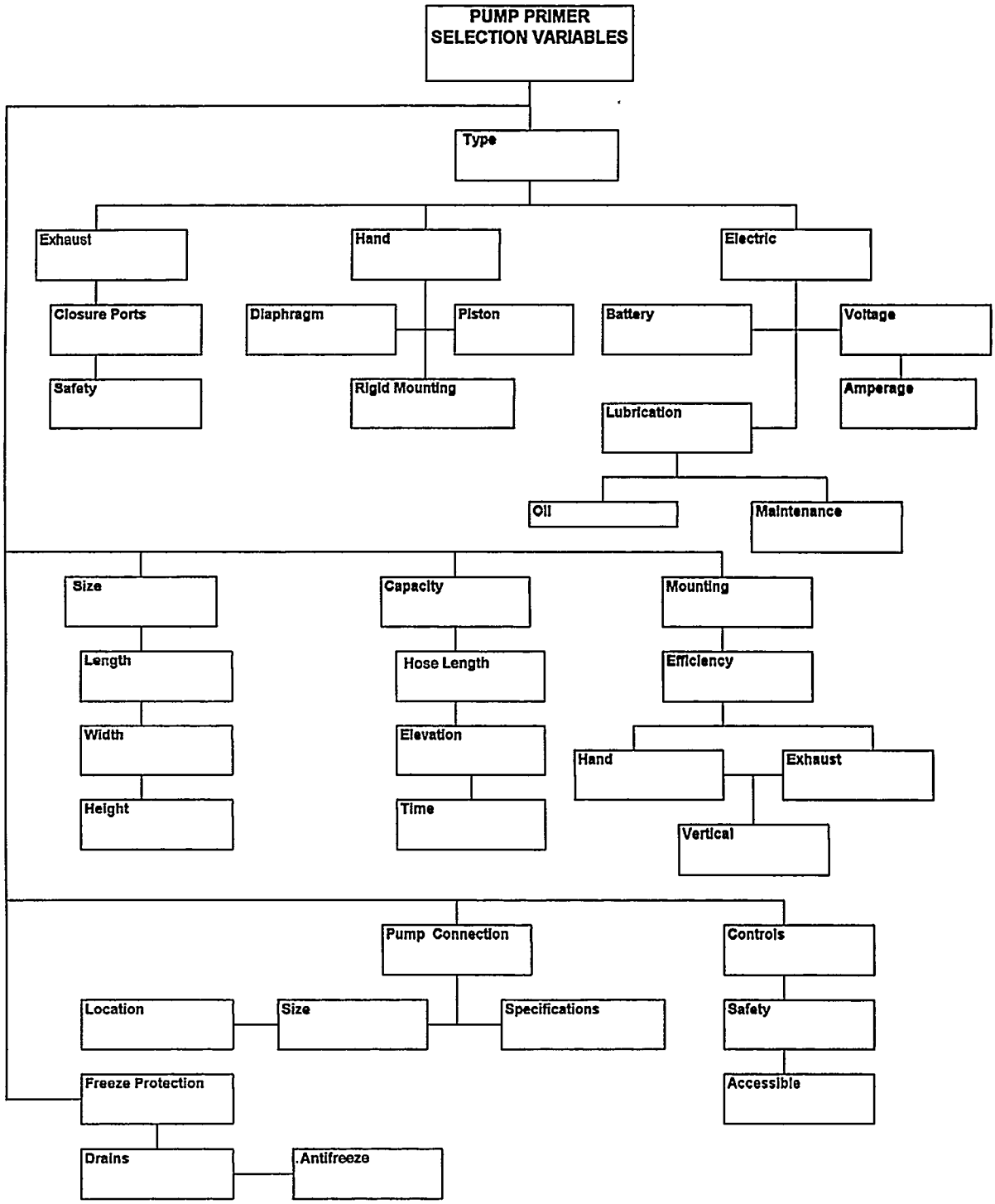


Figure 3-B. Pump primer selection variables flow chart.

3.C PUMP PRIMER SELECTION AID

3.C.1 Type

An exhaust primer needs a source of exhaust from the vehicle or pump engine to provide power for operation of the system. Hand primers work by use of a piston or diaphragm pump installed in the suction plumbing. An electric primer can run on current provided by the vehicle, or by a separate battery system (see fig. 3-1).

(Note the vertical installations in 1B and 1C.)

3.C.2 Size

Size of primer will vary based on space available and mounting location. If a hand primer is used, caution must be exercised in locating the hand level used for priming operations.

3.C.3 Capacity

Consider the amount of space that needs to be evacuated in the time specified. This is determined by hose dimensions, elevation, and time.

3.C.4 Mounting

Consider long-term maintenance needs. Hand primers must be mounted rigidly to provide continued thrust in operation. Exhaust primer closure ports must be placed in such a manner to ensure operator safety while using. The threat of burns from the primer is a consideration. Experience has shown that both exhaust and hand primers should be mounted vertically to work at maximum efficiency (fig. 3-1B and -1C). Electric primers require a pump lubricating system that must be considered in the mounting. This system requires about 6 quarts of oil and must be accessible for maintenance and addition of lubricant.

3.C.5 Location

Hand and exhaust primers must be located to provide freedom of operation. Electrical primers may be mounted where they are not seen. The controls must be easily accessible to the operator.

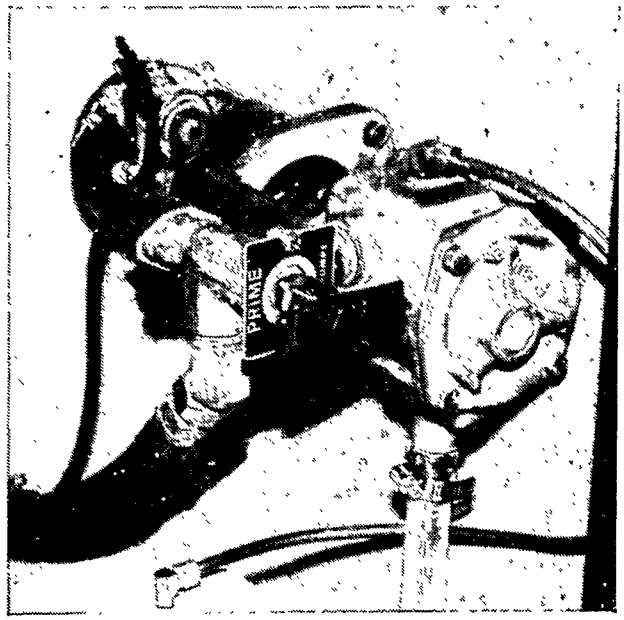


Figure 3-1A. Hale SMV electric primer.

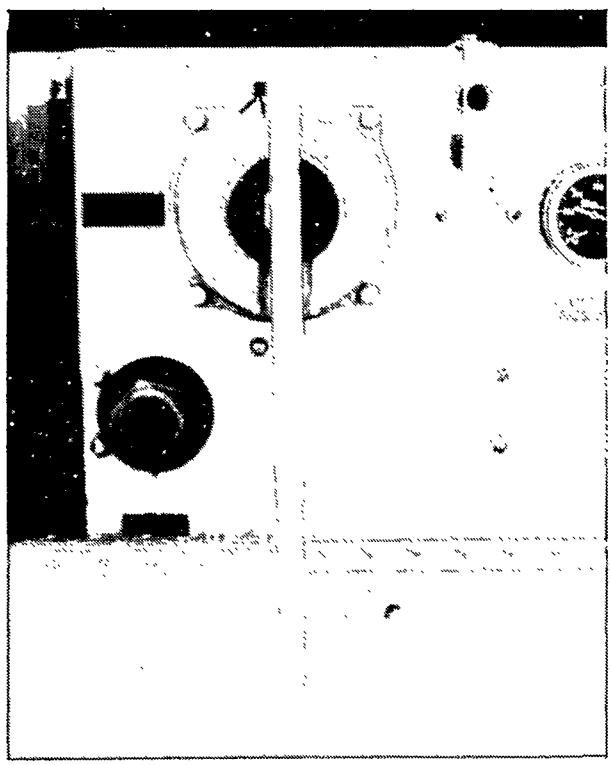


Figure 3-1B. Berkeley 6D hand primer.

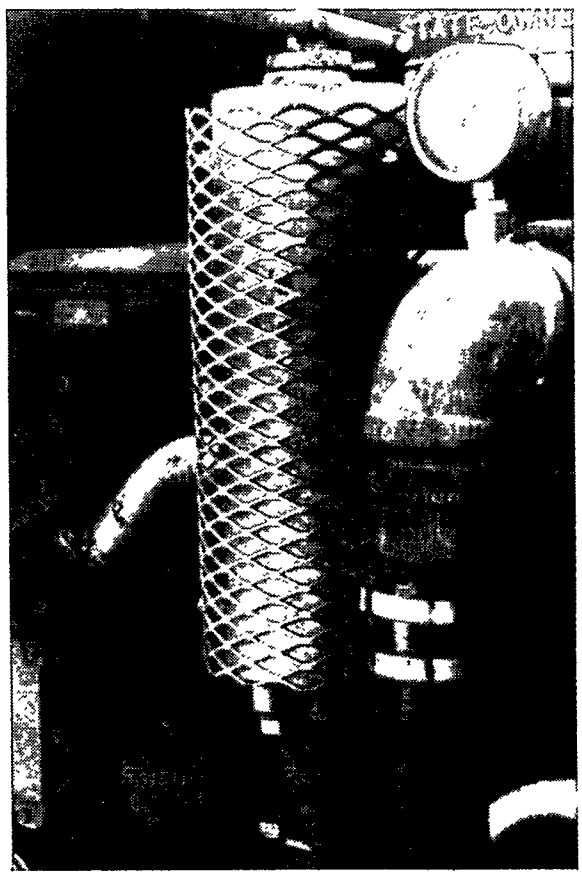


Figure 3-1C. Exhaust primer.

3.C.6 Pump Connection

Connection should be made as close to the pump impeller as possible. Consult with the pump manufacturer to ensure that the installation meets specifications.

3.C.7 Primer Controls

Controls must be located to allow operator accessibility. Provide panel space for primer operation labelling.

3.C.8 Freeze Protection

Consider a drain in the lowest point of primer system for draining during winter or freezing weather. If the system must be kept in operation it should be winterized with antifreeze.

3.D PUMP PRIMER REFERENCES

For details on these products, contact:

Hale Fire Pump Company
700 Spring Mill Avenue
Conshohocken, PA 19428

Wajax/Pacific Fire Equipment
9308 68th Avenue, South
Kent, WA 98032

Berkeley Pump Company
829 Bancroft Way
Berkeley, CA 94710

Gorman-Rupp
305 Bowman Street
Mansfield, OH 44902

Both NFES No. 1275, NWCG *Water Handling Equipment Guide* and the *Thomas Register of American Manufacturers* [Thomas Publishing Co., One Penn Plaza, New York, NY 10001; (212) 695-0500)] lists many other sources of priming pump suppliers and manufacturers.

CHAPTER 4

CHAPTER 4. HOSE REELS

Hose reel requirements are specific to the mission. Local requirements, i.e., topography, fuel type and use may dictate haose size, reel capacity, and the size of motor to rewind a fully extended hose in the required time. The flow chart shows the relationship of the various considerations to each other.

4.A HOSE REEL SELECTION GUIDE

4.A.1 Requirements (Determining Factors)

4.A.1.1
Pressure from hose reel at nozzle _____

4.A.1.2
Maximum flow at nozzle _____

4.A.2 Rewind Power Source

4.A.2.1
Electrical _____ Voltage _____volts Amperage _____ amps

4.A.2.2
Hydraulic _____

4.A.2.3.
Manual _____

4.A.2.4
Manual back-up _____

4.A.2.5
Other _____

4.A.3 Hose Type/Capacity

Length _____ ft Size _____ in ID Type _____

4.A.4 Mounting

4.A.4.1
Location of Reel(s) Passenger side _____ Driver side _____ Top _____
Front _____ Other _____

4.A.4.2
Method _____

4.A.4.3
Serviceability and access _____

4.A.4.4 Weight (fully operational) _____lb

4.A.5 Construction Material

Steel _____ Aluminum _____ Other _____

4.A.6 Connections

Rigid (solid pipe) _____ Flexible _____

4.A.7 Controls

Valves _____ Rewind control _____
Location _____

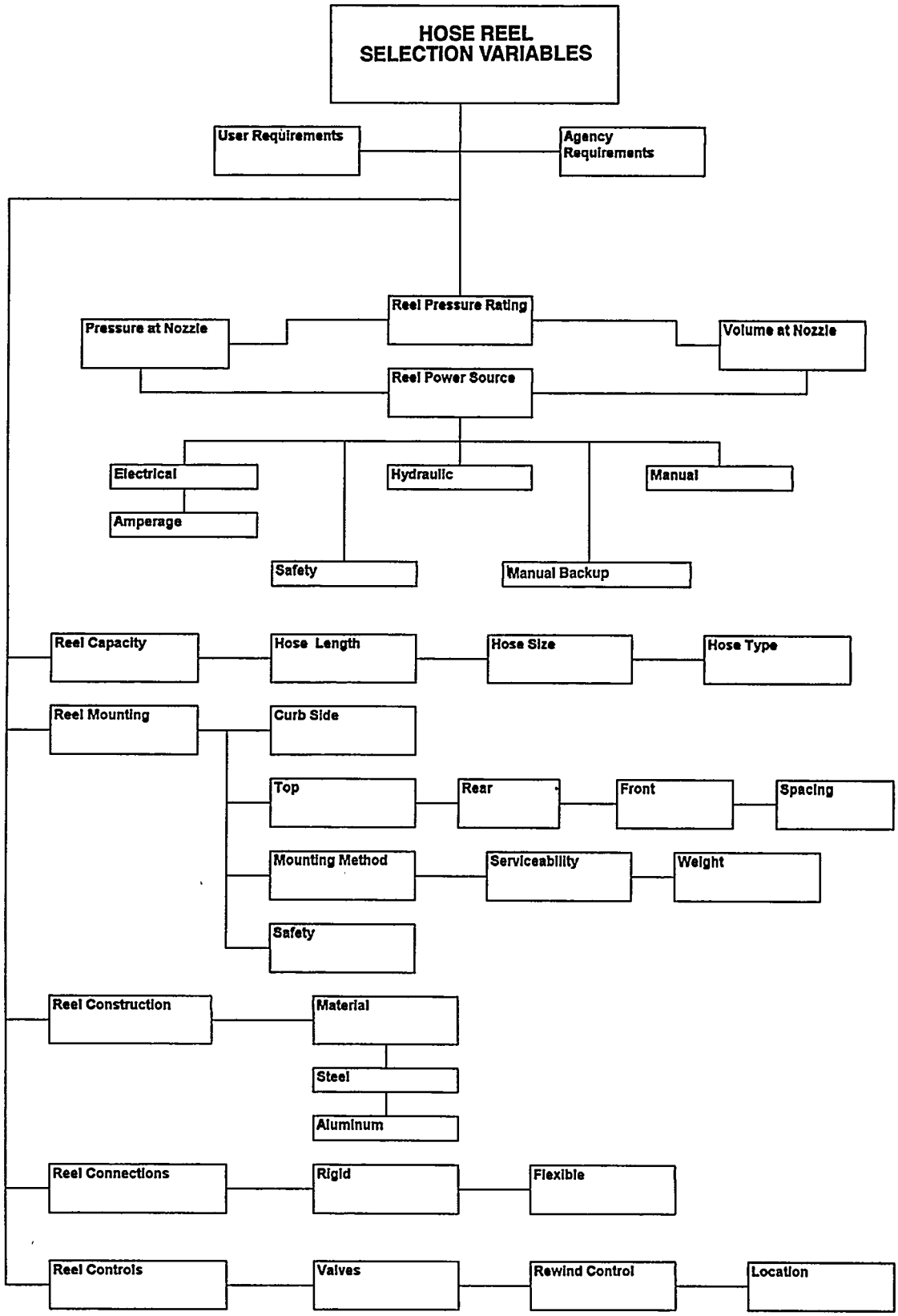


Figure 4.B. Hose reel selection variables flow chart.

4.C HOSE REEL SELECTION AID

4.C.1 Requirements

4.C.1.1 Pressure requirements are based on user preference and agency needs. The variables are the length of hose on the reel, the size (diameter) of hose on the reel, and the orifice size of the nozzle used to discharge the fluid at the nozzle. Make sure the reel purchased is rated for the pressure desired.

4.C.1.2 Volume needed at the nozzle is based on user preference and agency needs. The variables are the length of hose on the reel, the size (diameter) of hose on the reel, and the orifice size of the nozzle used to discharge the fluid.

4.C.2 Rewind Power Source

4.C.2.1 If electrical power reels are used, consideration must be given to the vehicle's electrical system. If the vehicle will operate using a regular 12-volt system, the reel electrical rewind system should conform to the same voltage. Installation of a circuit breaker will provide overload protection.

4.C.2.2 If using a hydraulic system for reel rewind, consider the source of the hydraulic drive.

4.C.2.3 If using a manual system, reel placement is critical to ensure the operator is provided safe efficient positioning to roll the hose. Hose recovery is generally slow.

4.C.2.4 A manual backup retrieval system is desirable should a failure in the primary power source occur.

4.C.3 Hose Type/Capacity

The smallest diameter hose generally used is 3/4 in garden hose on some light engines. The primary hose carried for wildland suppression use is the 3/4-in ID hard rubber hose with 1 in couplings. One in ID hose, either hard rubber or cotton or cotton synthetic, is available and may be used in some applications. The primary hose used is a hard rubber line that provides strength while wound on the reel and durability for initial attack. When choosing you must consider hose weight and fluid flow. Cotton or cotton synthetic hose may be used on booster hose reels. When using this type of hose the user must ensure that the hose is fully charged before the hose is rolled onto the reel. Hose must maintain a charge while stored on the reel. Charging the hose after rolled on the reel will result in crushing the reel.

4.C.4 Mounting

Mounting location will vary depending on space available on the engine, preference and agency requirement. Consideration must be given to the safety of the firefighter when extending hose from the booster reel.

4.C.4.1 Front mounting may have some serious considerations for limited space. If top mounted, the hose reel should be placed so hose reels off either side or to the rear of the engine.

4.C.4.2 The mounting base should be capable of supporting the overall weight of the reel (see 1.A.2.3). Mounting surfaces may require additional reinforcement.

4.C.4.3 Serviceability requires consideration of maintenance needs when selecting the mounting location.

4.C.4.4 Weight includes the reel, hose, and water.

4.C.5 Construction Material

Steel provides a great deal of durability, but rust protection is needed. Aluminum reels provide lighter weight and may eliminate the necessity for protective painting or other surface protection.

4.C.6 Connections

Reel mounting is generally permanent. Unions or flexible connections should be considered in the installation. This will ease installation and provide flexibility for maintenance.

4.C.7 Controls

Valves and rewind control placement must consider the operator position. Electrical rewind controls must be placed to minimize accidental activation. Electrical controls should be waterproof.

4.D HOSE REEL REFERENCES

USDA FS 5100-340a, Reel, hose, booster

NFPA 1901, Standard for Pumper Fire Apparatus

NFPA 1902, Standard for Initial Attack Fire Apparatus

CHAPTER 5

CHAPTER 5. CHEMICAL SYSTEMS

Chemical systems technology is a constantly evolving science. Prior to beginning this section review current publications on this subject. The Selection aid identifies source material. NWCG Foam Task Group publications provide additional information. This review should provide the information to determine specific design requirements.

5.A CHEMICAL SYSTEM SELECTION GUIDE

5.A.1 Fire Chemical Type

5.A.1.1 Wetting agent _____

5.A.1.2 Retardant _____ Short-term _____ Long-term _____

5.A.1.2.1 Retardant mixing system
Eductor _____
Proportioner _____
Bladder type _____
Pump injected _____
Electrical _____
Hydraulic _____
Gasoline/diesel engine _____
Batch mixed _____
Other _____
Metering Electronic _____ Manual/Mechanical _____

5.A.1.3 Foam Class A _____ Class B _____
5.A.1.3.1 Foam mixing system
Eductor _____
Proportioner _____
Bladder type _____
Pump injected _____
Electrical _____
Hydraulic _____
Gasoline/diesel engine _____
Batch mixed _____
Other _____
Metering Electronic _____ Manual/Mechanical _____

5.A.1.4 Foam generation system

5.A.1.4.1 Compressed air foam system (CAFS) _____
Air compressor size _____ cfm
Electrical _____
Hydraulic _____
Gasoline/diesel engine _____

5.A.1.4.2 Aspirated nozzle _____
Nozzle size _____ gpm

5.A.2 Chemical Tank(s)

Tank size _____
Integral _____ Separate _____ Openings*_____
*Filler _____ Vents_____ Outlet _____
Tank shape _____

5.A.2.1 Material
Fiberglass _____
Stainless steel _____
Mild steel _____
Aluminum _____
Polypropylene _____
Other_____

5.A.2.2 Corrosion protection YES _____ NO_____
Galvanized_____
Epoxy _____
Coal tar_____
None _____

5.A.2.3 Mounting
Mounts to Body YES _____ NO_____ Frame YES_____ NO _____
Top of tank YES _____ NO_____

5.A.3 Concentrate Plumbing/Piping

5.A.3.1 Rigid
Black iron _____
Stainless steel _____
Plastic_____
5.A.3.2 Flexible
Teflon lined _____
Plastic_____
Rubber _____
Braided stainless-steel covered_____
Other_____

5.A.4 Instrumentation/Controls

5.A.4.1 Flow meters
Water _____ Air_____
5.A.4.2 Pressure gauges
Water _____ Air_____
5.A.4.3 Control location
Panel_____ Remote_____

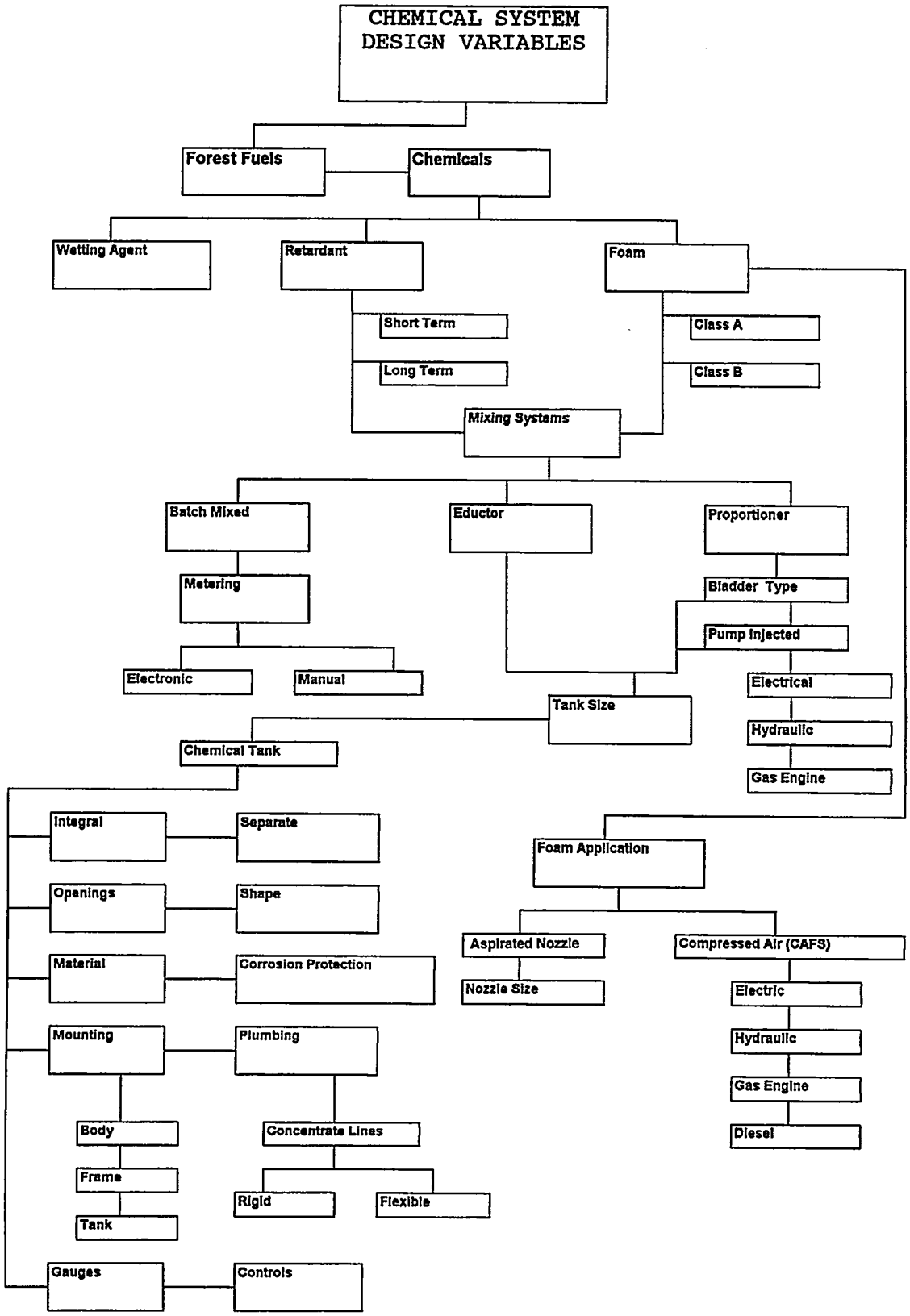


Figure 5.B. Chemical system design variables flow chart.

5.C CHEMICAL SYSTEM SELECTION AID

5.C.1 Fire Chemical Type

A variety of chemicals are available to assist fire suppression activities. Each is designed for a specific application. The chemical industry is in constant development. The user needs to research the properties and delivery systems that will meet your planned application.

5.C.1.1 A wetting agent is described as any chemical that when added to water will reduce the surface tension and penetrate exposed objects more effectively. It is generally designed not to foam.

5.C.1.2 Retardants are chemicals that inhibit flaming and glowing combustion. Short-term products work best when they remain wet. Long-term products are designed to work after the water has evaporated.

5.C.1.3 Foaming agents are chemicals that enable water to form bubbles of varying size and strength depending on their function. Masses of bubbles or foam are used for extinguishment, wetting, insulation and vapor suppression. Class A foam is intended for use on a class A (woody) fuels. It is made from hydrocarbon-based surfactants, therefore, lacking the strong filming properties of class B foam, but possessing excellent wetting properties. Class B foam is designed for use on class B (flammable liquid) fires. It is made from fluorocarbon-based surfactants, therefore, capable of strong filming action, but incapable of efficient wetting of class A foam.

5.C.2 Retardant Mixing

Retardant mixing systems range from very simple to very complex. See section 5.D for publications that describe and provide extensive details for individual operational requirements.

5.C.3 Foam Proportioning

The first step in creating foam is adding the required amount of foam concentrate to water to create a foam solution. This process, known as proportioning, can be accomplished by any of several common methods. Mixing systems range from simple to complex. See section 5.D for list of publications that provided detailed information and application methods. Figures 5-1 through 5-4 are schematic diagrams of four common proportioning systems.

5.C.4 Foam Generation

Foam is normally generated by use of an air compressor or by the use of an aerated nozzle. See section 5.D for list of publications that provide indepth detail of these methods.

5.C.5 Chemical Tank(s)

The chemical tank requires that the user research the properties of the chemicals to be utilized and based on these findings determine the material best suited for the chemical tank. Corrosion protection should be the highest priority. After determining the appropriate material, refer to section 1.C for additional information.

5.C.6 Plumbing/Piping

The plumbing and piping for chemical systems must meet the overall design and application requirements of your system. Details of the corrosion protection is a high priority consideration in material selection. The type of proportioning system or method of chemical introduction to the pumping system requires sound design criteria. See section 5.D for a list of publications to obtain detailed information.

5.C.7 Instrumentation/Controls

Instruments and controls are so diverse that it would be difficult to outline what as needed as they are system specific. Section 5.D has a list of publications that provide detailed information.

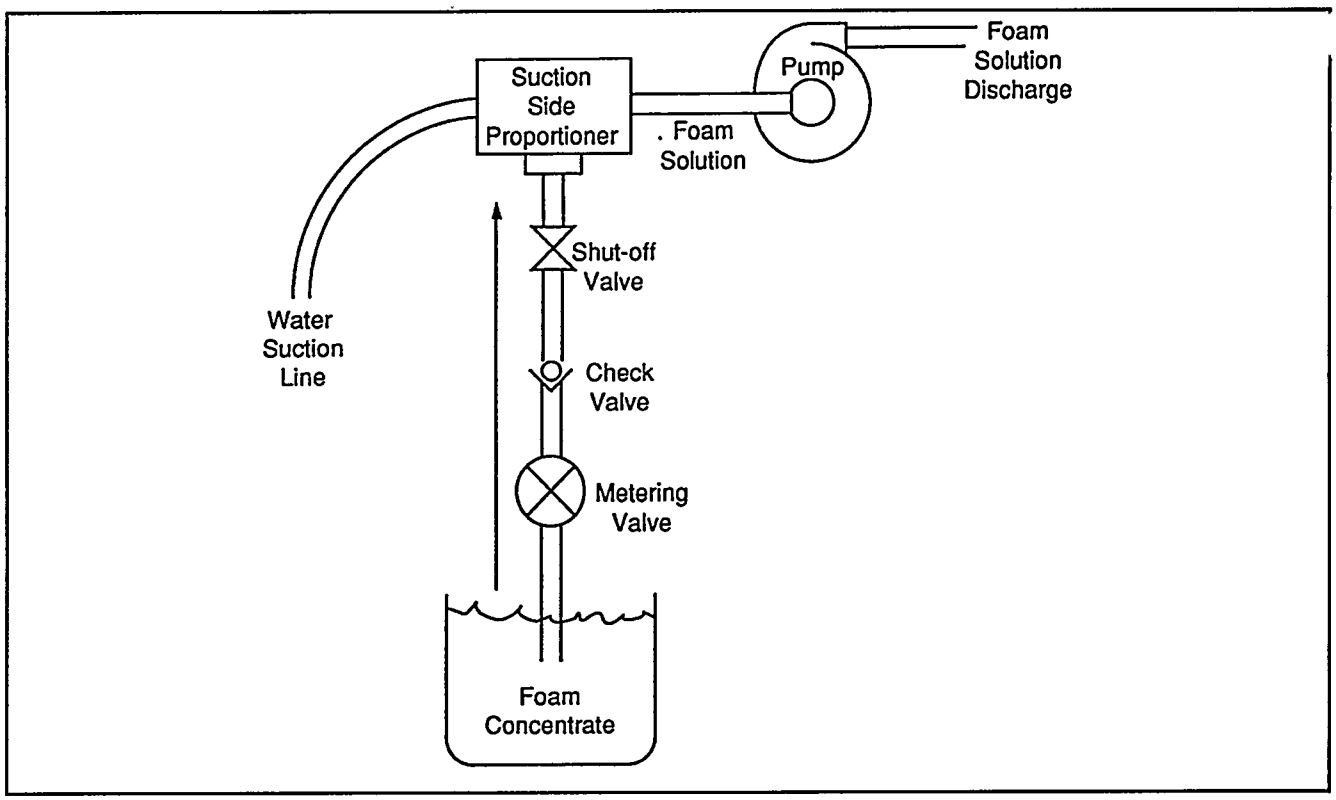


Figure 5-1. Suction-side proportioning system.

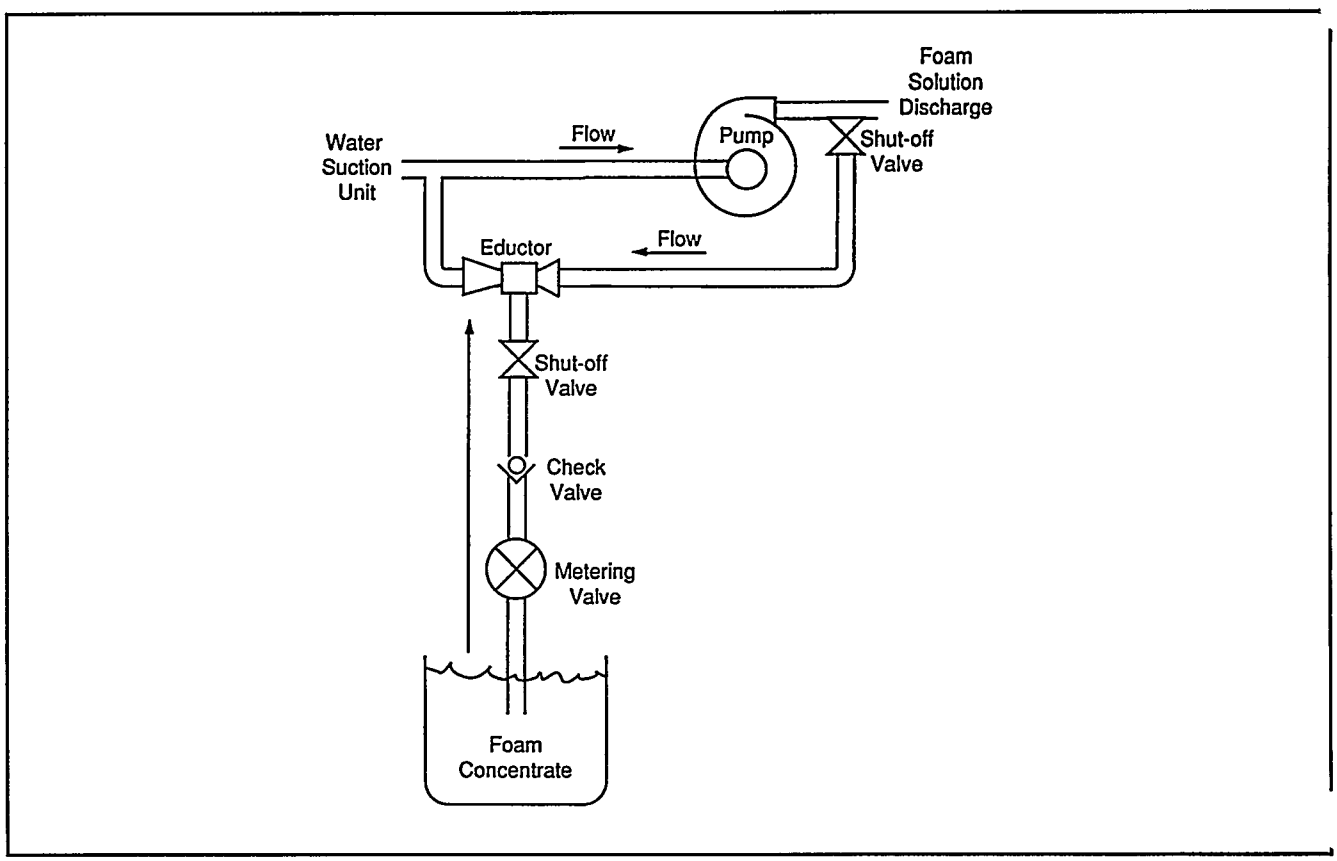


Figure 5-2. Around-the-pump proportioning system.

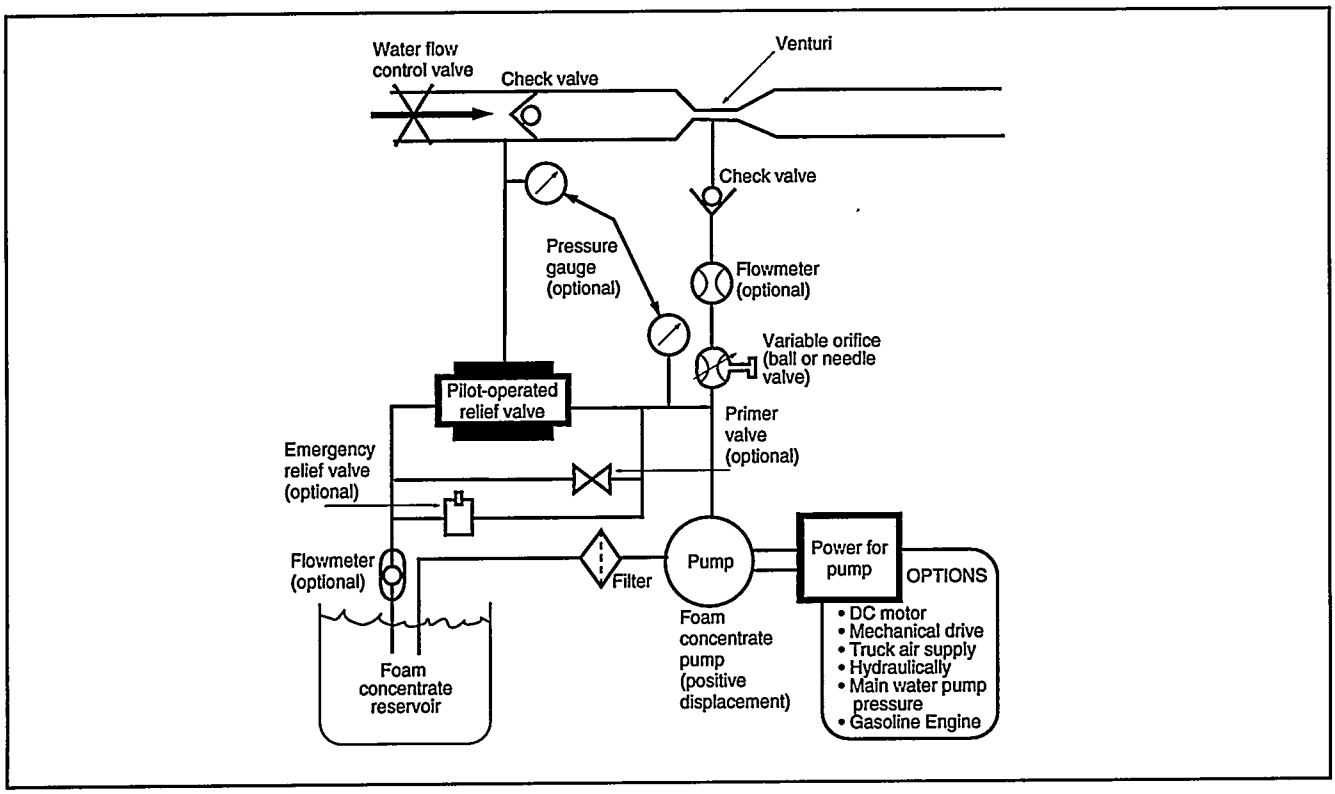


Figure 5-3. Balanced-pressure, venturi, pump proportioning system.

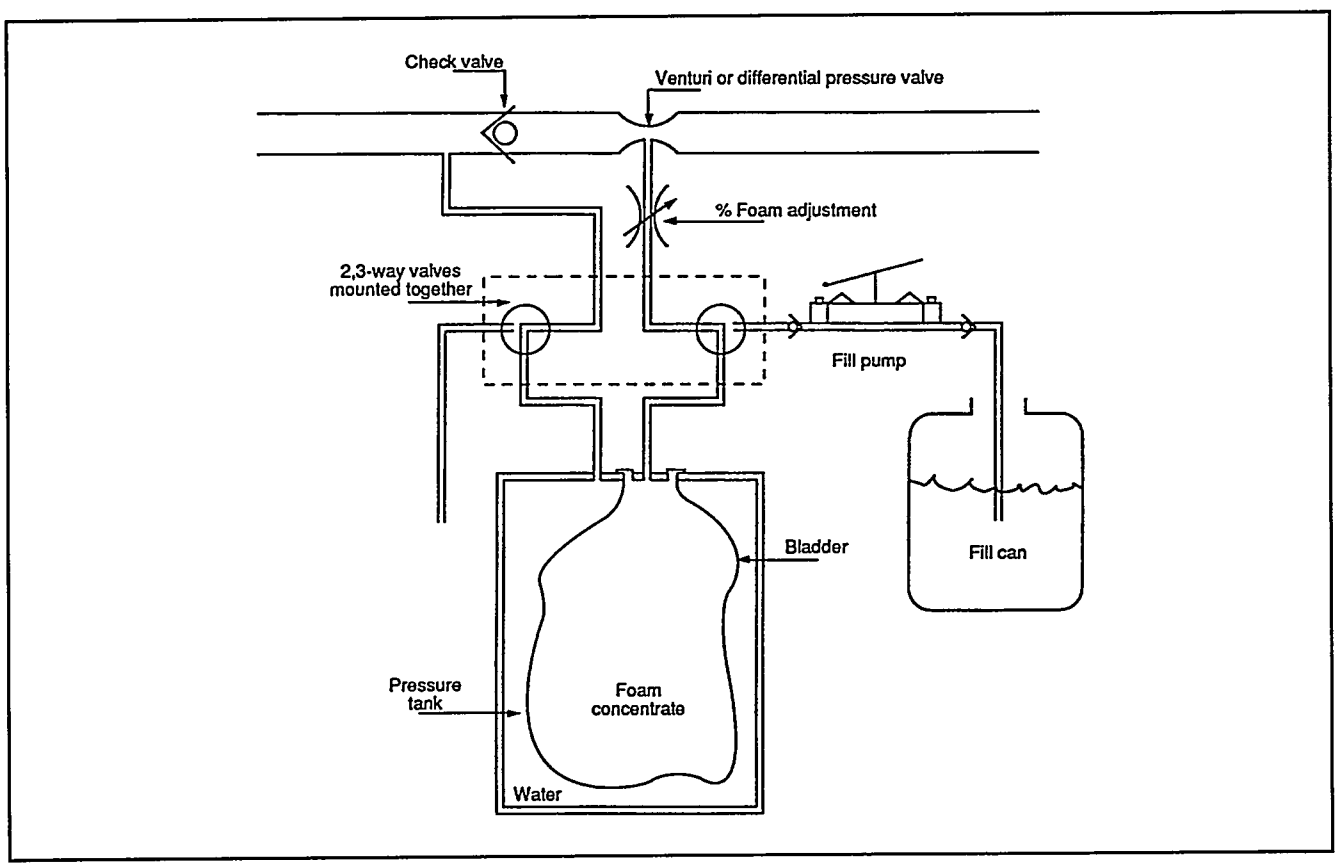


Figure 5-4. Direct injection, balanced-pressure, venturi, bladder tank proportioning system.

5.D CHEMICAL SYSTEM REFERENCES

NFPA 1902, Standard for Initial Attack Fire Apparatus

NWCG Publications: *Foam vs. Fire—Primer*, NFES No. 2270; *Foam vs. Fire—Class A Foam for Wildland Fires*, NFES No. 2246; *Lot Acceptance, Quality Assurance, and Field Quality Control for Fire Retardant Chemicals*, NFES No. 1245; and a series of publications (many issues) available from USDA FS SDTDC, *Foam Applications for Wildland and Urban Fire Management.*

USDA FS SDTDC Publications:

Report No.	Title
8957 1803	Manufacturer Submission Procedures, Qualification Testing of Wildland Fire Chemicals
8751 1202	Engineering Analysis of Threshold Compressed Air Foam Systems
9251 1203	Compressed Air Foam Systems in Wildland Fire Applications
9251 1204	Proportioners in Wildland Fire Applications

USDA FS, *Southern Guide for Using Fire Retarding Chemicals in Ground Tankers*, State and Private Forestry, Southeastern Area.

CHAPTER 6

CHAPTER 6. PLUMBING, PIPING, VALVES, AND CONNECTIONS

The plumbing of an engine ties the pump, primer, tank, chemical system, water source and hose together, and can have a profound effect on the use of an engine. The following guide serves as a checklist of the questions to be examined, while the aid provides some explanations of those questions. The flow chart shows the relationships of the various questions to each other.

6.A. PLUMBING, PIPING, VALVE, AND CONNECTION SELECTION GUIDE

6.A.1 Suction Side

6.A.1.1 Material

Black iron _____ Plastic_____ Galvanized ____ Flexible _____

Other_____

6.A.1.2 Piping size (in, ID)

1 _____ 1-1/2 _____ 2_____ 2-1/2 _____ 3 _____ Other_____

Pump inlet _____

6.A.1.3 Internal connection methods

Threaded _____ Flanged_____Welded _____ Glued_____

Other_____

6.A.1.4 Suction connections (inlets)

Locations, size (in), and threads (NH, NPSH, or other) for each

Driver's side _____

Rear _____

Passenger side _____

Front bumper _____

6.A.1.5 Valves

Locations/size _____

Types

Flow

Ball* _____ Butterfly _____ Gate _____ Other _____

*Dropout _____

Check

Size _____ Location _____

Anti-siphon

Size _____ Location _____

Pressure-relief

Size _____ Location _____

Materials

Body_____ Ball _____Seat _____

Connections

Inlet _____ Outlet _____

Control method _____

Control location_____

Position indicator _____

6.A.2 Discharge Side

Material

Black iron_____ Plastic _____ Galvanized _____ Flexible _____

Other _____

Piping size (in, ID)

1 _____ 1-1/2 _____ 2_____ 2-1/2 _____3 _____ Other_____

Pump outlet _____
Internal connection methods
Threaded _____ Flanged _____ Welded _____ Glued _____
Other _____
Working connections (outlets), locations, size (in), and threads
(NH, NPSH, or other for each
Driver's side _____
Rear _____
Passenger side _____
Front bumper _____
Preconnects or hose trays _____
Hose reel(s) _____
Spray bar _____
High volume monitor or deck gun _____
Other _____
Valves
Locations/size _____
Types
Flow
Ball ____ Butterfly _____ Gate _____ Other _____ Dropout _____
Check
Size _____ Location _____
Anti-siphon
Size _____ Location _____
Pressure-relief
Size _____ Location _____
Materials
Body _____ Ball _____ Seat _____
Connections
Inlet _____ Outlet _____
Control method _____
Control location _____
Position indicator _____

6.A.3 Drains
Location
Pump drain _____
Suction side drain _____
Discharge side drain _____
Water tank drain _____
Chemical tank drain _____
Other _____
Valves _____
Drain connection location _____
Connecting piping _____

6.A.4 Chemical Considerations
See section 5.A.

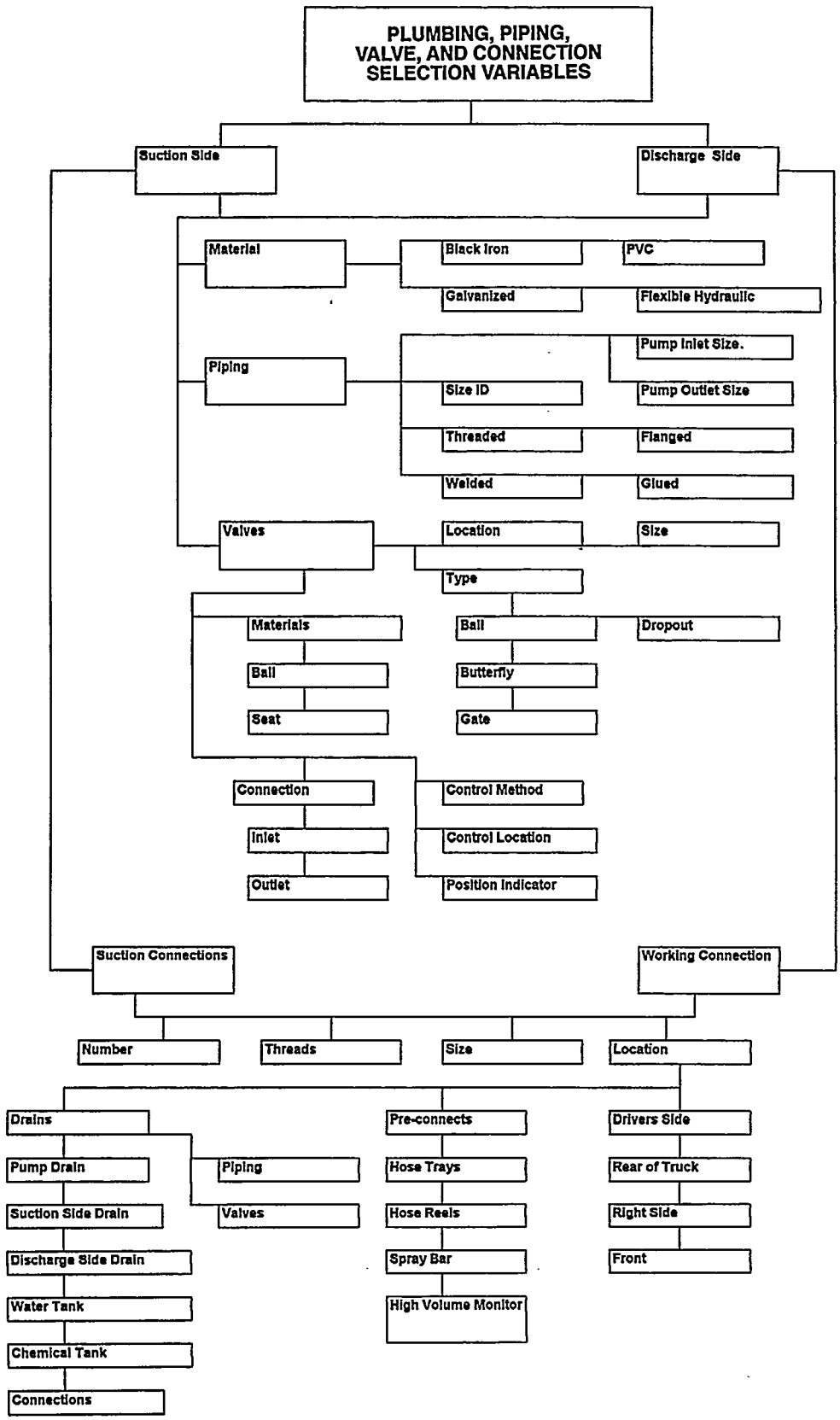


Figure 6.B. Plumbing, piping, valve, and connection selection variables flow chart.

6.C PLUMBING, PIPING, VALVE, AND CONNECTION SELECTION AID

General Information on Connections and Threads

The National Fire Protection Association (NFPA) and many wildland fire agencies have standardized with American National Fire Hose Connection Screw Threads (abbreviated NH) for fire connections of 1-1/2 in and larger. Wildland fire agencies also commonly use NH threads for 3/4-in connections, which mate with standard 3/4-in garden hose threads. For 1-in connections, in a departure from the NH standard, common use has caused the use of American National Standard Pipe Threads (normally designated NPSH) to be standard. The General Services Administration (GSA) stocks most of the common water handling accessories and hoses in these threads, plus an assortment of the most commonly used thread adaptors.

For more information refer to GSA's *Wildfire Protection Equipment and Supplies Catalog.* It is recommended that all external access connections for fire apparatus follow these guidelines to enhance their use. If your agency uses other threads, ordering the truck external connections to the standard NH convention, and attaching thread adaptors for your use will make the mutual aid use of your engine easier.

Available industry standards reviewed in the preparation of this Guide do not specify the connections to be used for internal piping. Therefore, one will not be specified or recommended here. Due to the numerous ways piping can be connected (such as threads, flanges, or even adhesive for plastic pipe), selection of connections should consider whatever material is being used and what connection types have been successfully used by other agencies in your area.

There are normally four main waterway connections in a fire engine: From an outside water source to the pump, from the pump to the tank, from the tank to the pump, and from the pump to the fire hose connections. In simpler assemblies—such as skid-mounted units—the tank may be directly connected to the pump suction inlet, and the hose connected directly to the pump discharge. In other cases, the piping can be extremely complicated and include numerous tee's, unions, valves, flexible connections, flanges, elbows, radius curves, and access connections all over the engine with color-coded labels and controls.

The plumbing at no point should restrict the flow of water more than the various inlets and outlets on the engine. For example, a 1-in discharge outlet should be connected to the pump with pipe that is no smaller than 1-in ID, and a 2-1/2-in suction inlet should be plumbed to the pump with no less than 2-1/2-in ID pipe.

Wildland apparatus must be concerned with survivability in extreme off-road conditions. Vulnerability of the plumbing must be considered, especially the portion that is underneath the chassis frame or extends out either side or either end. The plumbing should not be routed or secured in such a manner that normal frame twisting will cause damage.

Other questions to be considered: Are the minimum number of bends being used? Can the material being used be bent into a smooth corner or will elbows (which restrict flow more) be needed? Will the material withstand all the chemicals that may be used?

It is recommended that the plumbing of a engine be designed to withstand 100 psi over the pressure capabilities of the pump to be used. NFPA 1901 recommends that the entire piping of a engine be designed for a working pressure of 500 psig minimum.

6.C.1 Suction Side

This is the plumbing that supplies water to the pump, which can be from the tank or from a suction connection. The suction connection can receive water from the suction ability of the pump by suctioning out of a water source such as a fold-a-tank, pond, lake, or stream; or by being pumped to by another pump or a fire hydrant. In designing the suction plumbing, special consideration must be given if the pump will ever be fed by a high-pressure source.

6.C.1.1 Material Numerous options exist for the type of pipe material to be used. The most common are black iron, galvanized steel, plastic, and flexible reinforced suction-type hose. The choice depends on several factors: How extensive will the plumbing be? How will the engine be used? What is commonly used in your area? What do your fabricators have available or have experience in working with? Does your agency use any especially corrosive fluids? Do you foresee the periodic removal of the firefighting equipment from the vehicle? Are there any special space considerations that might affect the material choice?

6.C.1.2 Piping size

The suction side plumbing should have at least one connection capable of flowing the full rated capacity of the pump. As stated in section 6.A, the size of the suction plumbing depends primarily on the pump suction inlet size and the sizes of the various suction access connections that are connected to it.

6.C.1.3 Internal connection methods

See section 6.A.

6.C.1.4 Suction connections (inlets)

On smaller apparatus, a single suction connection is all that normally is needed. On larger engines, it depends on the type of pump and the practice of the agency. Wildland agencies that primarily draft for their water supplies, utilize male suction inlets to ease connection of suction hose. Engines used with municipal water supply systems usually have swivel female suction connections ranging from 2-1/2- to 5-in in size. All suction connections should be plainly labeled, have appropriately sized removable screens (to protect the pump and related equipment from the ingestion of damaging material such as rocks and twigs), and should be individually valved.

Suction connections that are 3 in and larger should have slow-closing valves to protect the engine and the water source from the water hammer effect created by closing large diameter valves too quickly. You may wish to have bleeder valves to allow the purging of air from the line or the bleeding off of pressure. All external connections should be equipped with

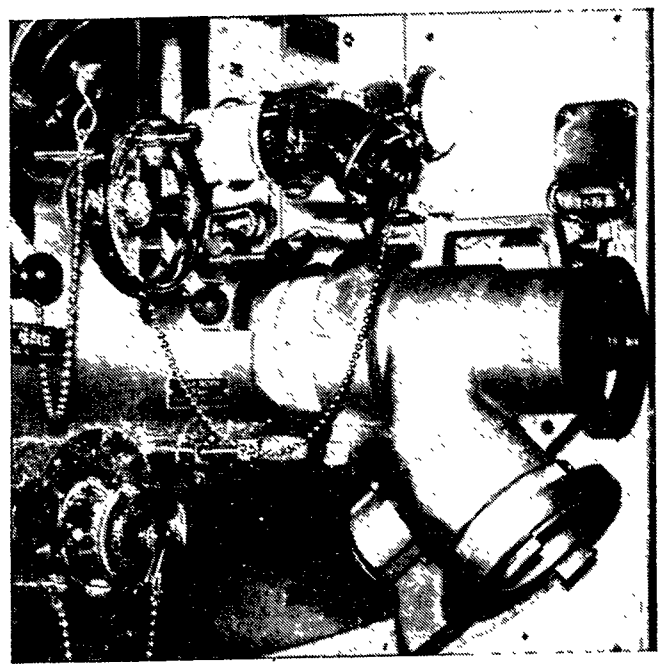


Figure 6-1. Structure-type connections: A large 5-in Storz on a surge-protection valve, and capped suction and discharge connections with caps retained by chains.

threaded plugs (or caps, as applicable) to protect the threads and seal the connection when not in use. And, all plugs and caps 3 in and smaller should be secured to the engine with a short chain (fig. 6-1).

6.C.1.5 Valves

Numerous types of valves are used in the fire service (fig. 6-2). The most common are ball valves with full diameter flow when opened. Consideration should be given to the type of fluid being pumped, as well as the maintenance history the agency has experienced with valves. Drop-out valves provide easy maintenance; especially if placed in tight or inaccessible locations, or if the plumbing connections are not easily disconnected.

When ordering valves, as much information as possible should be provided—such as size (ID); material for body, ball stem, and seat; pressure rating; method of control; handle on and off positions; whether or not it is to be a drop-out design; the connections of both the inlet and outlet; and any other special requirements—such as space limitations or resistance to certain chemicals.

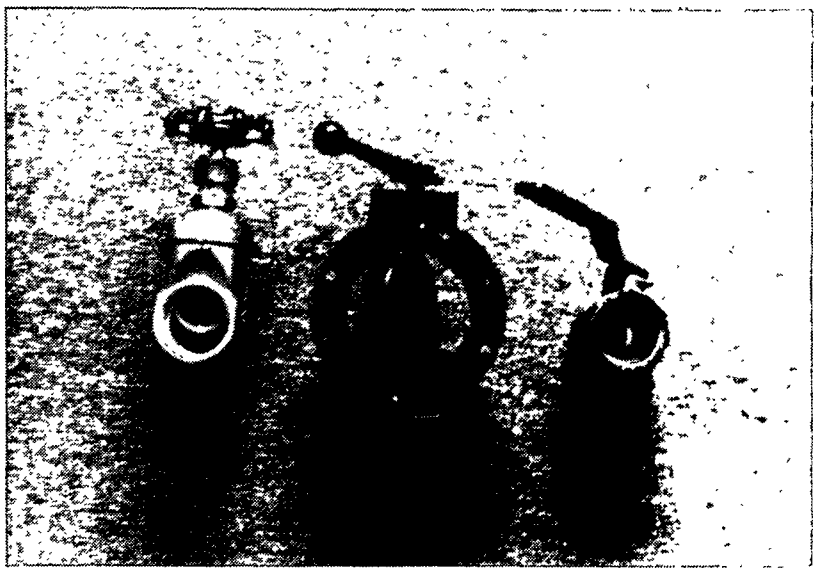


Figure 6-2. Gate valve (left); butterfly valve (center); ball valve (right).

Full control of all suction and discharge connections should be within the convenient reach of the operator's position at the pump panel. If valves are a considerable distance from the pump panel, control can be accomplished through numerous types of mechanical, electrical, hydraulic, or air-assisted controls.

6.C.2 Discharge Side

The same conventions hold true for the discharge side of the pump as for the suction side concerning material, size, and connections. Of special importance is that at no point between the pump and the discharge connection should the piping limit flow more than the outlet itself.

The plumbing for the discharge connections should be kept as simple as possible, with the minimum number of bends and elbows. The number of connections depend on use, so the cost of extra connections should be weighed against the use they will get. It might be more efficient to carry extra wye valves rather than add numerous connections that will seldom be used. It is standard for all external discharge connections to be externally threaded (male) connections. All discharge outlets, except those with preconnected hoses or appliances, should be equipped with caps. Caps 3 in and smaller should be connected to the engine with a short length of chain.

Where various pumps or other systems interconnect—such as a foam system—it is recommended that appropriate check valves be installed to prevent the flow of fluids the wrong way, or pressurizing an auxiliary system above its capabilities. Back flow prevention valves should also be placed in the system to isolate chemical systems and prevent the contamination of tank water. It is recommended that local laws be checked regarding check valves that may be necessary for the use of fire hydrant water. Pressure relief or drain valves may be necessary to allow the disconnection of a hose that cannot be otherwise purged.

6.C.3 Drains

Engines should have some means of draining the water from all spaces, including the piping, the tank, and the pump. This is especially necessary for vehicles that are stored outside, or are used in freezing weather or in areas with known corrosion problems. Environmental considerations dictate that drains be located to permit easy catching of the fluid. All drains should be capable of being operated without requiring the operator to crawl under the engine either to activate or monitor.

6.C.4 Chemical Considerations

Chemical capability should be considered, even if this means only verifying that the plan allows space for later application. See section 5.C.

6.D PLUMBING, PIPING, VALVE, AND CONNECTION REFERENCES

NFPA 1901, Standard for Pumper Fire Apparatus

NFPA 1902, Standard for Initial Attack Fire Apparatus

NFPA 1963, Standard for Screw Threads and Gaskets for Fire Hose Connections

GSA - *Wildfire Protection Equipment and Supplies Catalog*

USDA FS 5100-102, Couplings, fire and suction hose

USDA FS 5100-108, Couplings, lightweight, fire and suction hose

USDA FS 5100-238, Shut-off, valve, ball

USDA FS 5100-380, Valve, wye

USDA FS 5100-382, Valve, check and bleeder

USDA FS 5100-383, Valve, foot, with strainer

USDA FS 5100-107, Fire hose connections and fittings

USDA FS 5100-190, Threads, gaskets, and rocker lugs, connections & fittings, fire hose

CHAPTER 7

CHAPTER 7. GAUGES, INSTRUMENTS, AND CONTROLS

Gauges, instruments, and controls vary widely, depending on preference, pump types, and engine usage. Variations range from pump-mounted pressure gauges and throttle controls on some smaller units to large integrated panels similar to structural fire engines. This section attempts to cover the full range of controls, and includes sample designs to help the purchaser define needs.

7.A GAUGE, INSTRUMENT, AND CONTROL SELECTION GUIDE

7.A.1 Gauge, Pressure or Vacuum

7.A.1.1 Pressure ranges for gauge
0-200 psig (figure each 20 - subdivision 2) _____
0-300 psig (figure each 30 - subdivision 3) _____
0-400 psig (figure each 50 - subdivision 5) _____
0-600 psig (figure each 50 - subdivision 5) _____
0-30 in Hg vacuum _____
Combination gauge, 30-in Hg vacuum to _____ psig
7.A.12 Accuracy grade _____
7.A.1.3 Type of gauge display Analog _____ Digital _____
7.A.1.4 Clear viewing area diameter (analog type) _____ in
7.A.1.5 Construction
Compatible with fluids stated in section 1.A.1.2 _____
Freeze protection requirements _____
Vibration and shock dampening _____
7.A.1.6 Mounting
Front flange for panel flush mount with rear stem 1/4-in NPT connector _____
Bottom stem 1/4-in NPT _____
Wall-mount flange with bottom stem 1/4-in NPT _____

7.A.2 Control Panel

7.A.2.1 Location of operator control position
Cab ____ Left side _____ Right side _____ Rear _____
Midside _____ Other _____
7.A.2.2 Gauges, controls, and instruments required at panel
Pump discharge pressure gauge _____
Pump draft vacuum gauge _____
Pump, auxiliary engine throttle _____
Pump, auxiliary engine starter _____
Pump, auxiliary engine stop (kill) switch _____
Choke, auxiliary engine _____
Tachometer _____
Engine oil pressure _____
Engine coolant temperature _____
Tank water level _____
Hour meter _____
Chemical system controls (see section 5.A) _____
Other instruments _____
Valves (specify) _____
7.A.2.3 Control panel layout
Gauges and instruments labeled with permanent weatherproof materials
Panel illumination YES _____ NO _____
Materials and finish _____

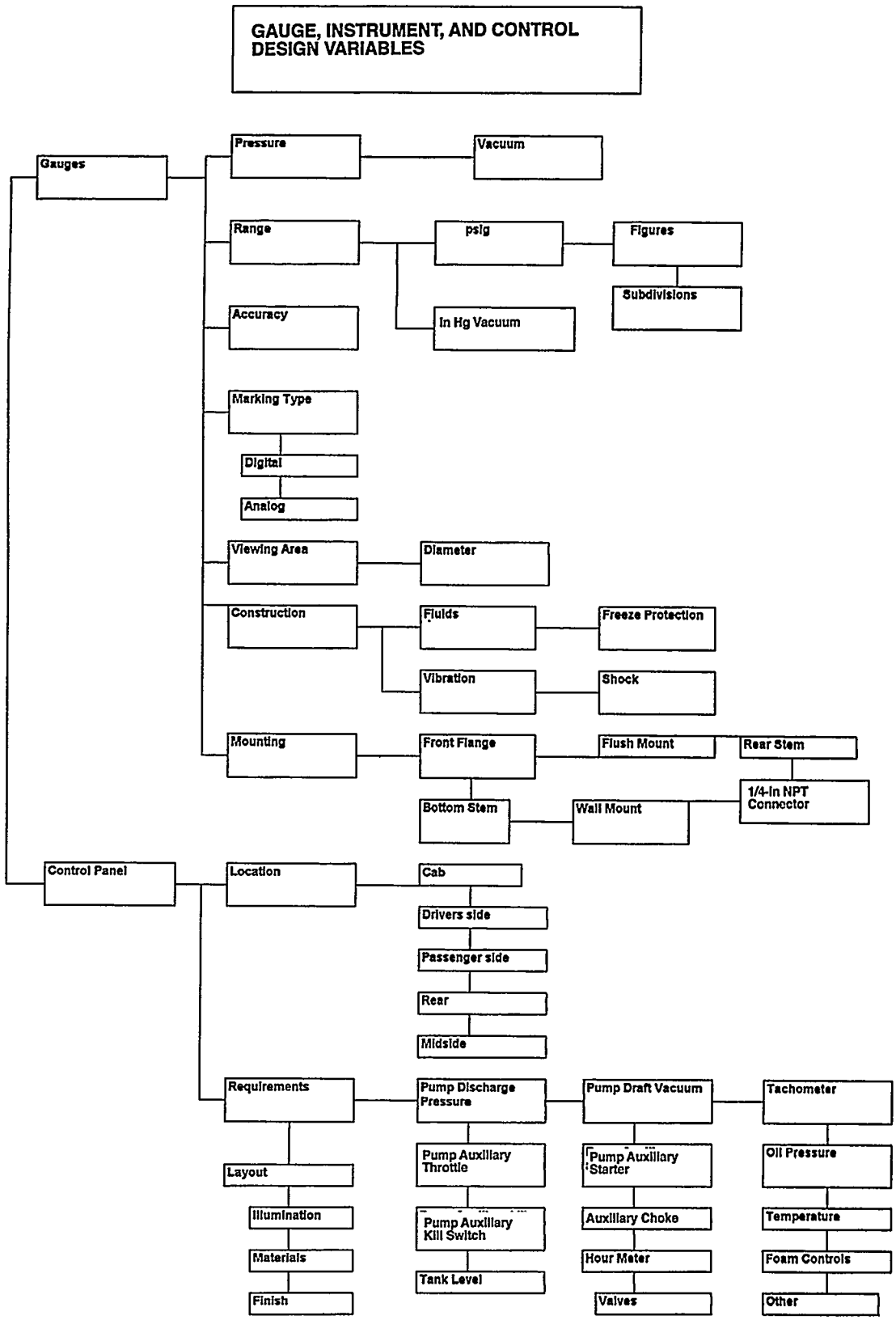


Figure 7.B. Gauge, Instrument, and Control Design Variables Flow Chart.

7.C GAUGE, INSTRUMENT, AND CONTROL SELECTION AID

7.C.1 Gauges, Pressure or Vacuum

7.C.1.1 Pressure gauges are most accurate at the midrange of the gauge, thus it is normal practice to select a gauge of 0-400 psig for systems that operate at 200 or 250 psig. The gauge's capacity should exceed the operating pressure by at least 100 psi.

7.C.1.2 The American National Standards Institute (ANSI) has set gauge standards that are universally used and accepted by manufacturers. The listing that follows shows the more common grades used in the fire service. Determine your need for accuracy and specify it by using the corresponding ANSI grade. Grade B is typical for wildland fire use. Accuracy shown in this list is for the upper 1/4 of the scale.

List of some ANSI B40.1 grades:

Grade 2A +0.5% of span
Grade 1A +1% of span
Grade A +2% of span
Grade B +3% of span

7.C.1.3 Analog gauge dial marks usually are black figures on a white background with psig shown in arabic numerals. Other preferences, such as metric measure, should be stated. Analog gauges of 2-1/2- or 3-1/2-in diameter are the most common. It is helpful to know how the gauge will be mounted so that the proper style can be obtained. If specifying a pump operators panel, refer to section 2.A.

7.C.2 Control Panel

7.C.2.1 For easy access, the pump operation control panel can be located on the driver's side behind the cab. If safety from traffic is necessary, rear or passenger side panels are better. Sometimes the plumbing and pump location may dictate where the panel is located. Standardization of the agency's fleet may be the prime consideration.

7.C.2.2 The types needed will vary, depending on the pump's drive mechanism. Auxiliary engine pumps need—at minimum—a starter, throttle, and kill switch. Drive units that are pto might require instruments for the engine oil pressure and temperature, along with a tachometer.

Chemical proportioning and delivery systems have increased on wildland engines. Considerable development of this equipment is still taking place; refer to section 5.A. Control of some or all valves may be desired from the pump operator's position. This normally requires integrating the panel with the plumbing and tank. Specify these needs carefully; refer to section 2.A.

7.C.2.3 Location of the items on the panel are normally determined by agency preference or a manufacturer's design. It is beneficial to have pump controls grouped together and engine controls grouped together. See figure 7-1 for examples of some agency instrument panels, and figure 7-2 for details of types, styles, and labels.

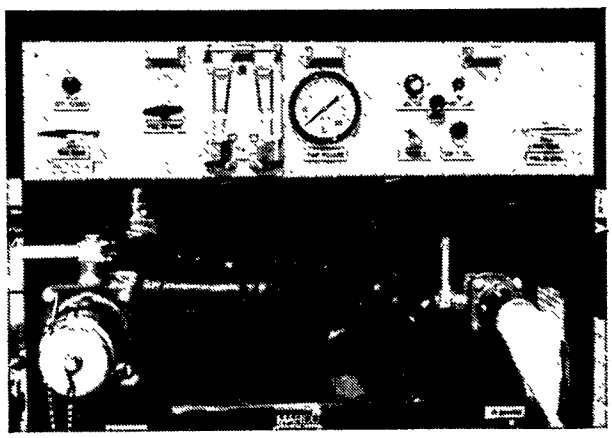


Figure 7-1.
Examples of simple start/stop controls with pressure gauge (top); a simple panel (middle); and a complex control system (bottom).

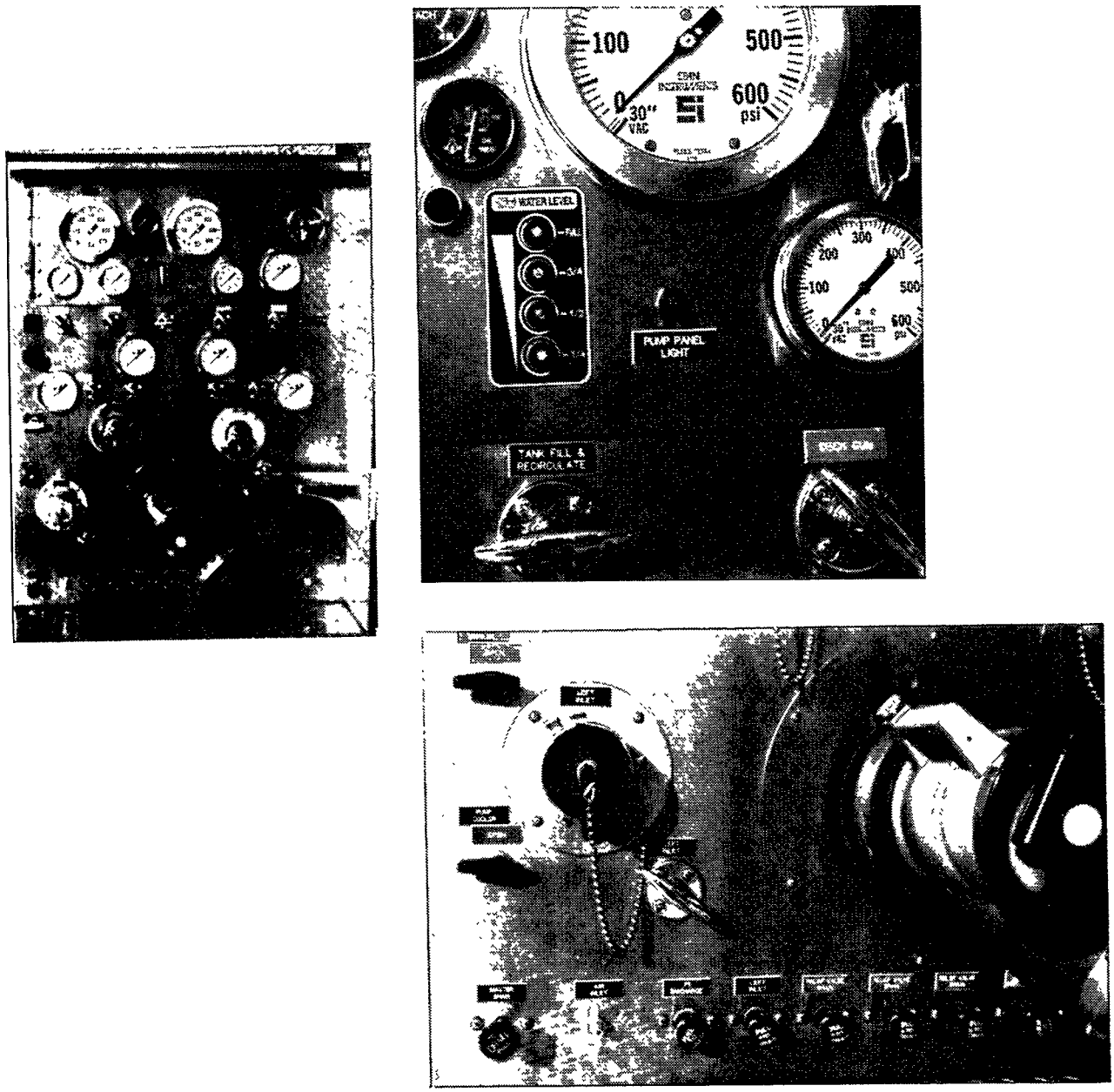


Figure 7-2.
Some popular gauge and control types and styles; combination vacuum/pressure gauge is shown at center, upper right.

Labeling of gauges and instruments should be done with permanent weatherproof materials. There are many types of label-making methods. Different manufacturers have different types. Unless a preference is clear, it may be best to use the capability of the contractor. Panels should be lit at night for ease of operation and safety. Work lights must be planned into the vehicle's electrical capacity. They should adequately illuminate all instruments and controls. State color, material, and paint finish, generally compatible with the tank. These considerations should be stated; refer to section 1.A.

7.D GAUGE, INSTRUMENT, AND CONTROL REFERENCES

ANSI B40.1, Gauges—Pressure-indicating dial type, elastic element.

NFPA 1902, Standard for Initial Attack Fire Apparatus

Thomas Register of American Manufacturers lists many gauge manufacturers.

CHAPTER 8

CHAPTER 8. STORAGE

All engines need storage space. The types and numbers of items needing storage vary widely, and depend upon policy, tactics, uses, and personal preference. This section highlights things that should be considered, but acknowledges that we cannot account for the numerous local preferences. Utility body storage cabinets are available commercially.

8.A STORAGE SELECTION GUIDE

8.A.1 Compartment Material

Aluminum _____ Fiberglass _____ Stainless steel _____
Mild steel _____ Galvanized _____ Mild Steel _____
Other _____

8.A.2 Doors

8.A.2.1 Hinge type_ Piano _____ Standard _____ Other _____
8.A.2.2 Door preference
Swing up (top hinge) _____ Swing down (bottom hinge) _____
Swing out (right or left hinge) _____ Vertical roll up _____
Roll out drawer _____
8.A.2.3 Hardware material Aluminum _____ Stainless steel _____
8.A.2.4 Latches
Slam lock _____ Turn close/open _____ T-handle _____ Electric _____
Other _____
8.A.2.5 Locks YES _____ Keyed alike _____ NO _____
8.A.2.6 Door seal YES _____ NO _____
8.A.2.7 Door travel limiters
Chains _____ Gas shocks _____ Cables (coated) _____
Spring hinges _____ None _____

8.A.3 Compartments

Number _____
Dimensions Length _____ Width _____ Height _____
Shelves Fixed _____ Adjustable _____
Drawers YES _____ NO _____
Ventilation YES _____ NO _____
Drainage holes YES _____ NO _____

8.A.4 Lights

Mounting Flush _____ Recess _____
Switch _____
Manual off/on _____ Automatic (when door closes/opens) _____
Master switch in cab _____

8.A.5 Mounting

Type
Integral with tank _____ Bolt in (removal w/fasteners) _____
Separate _____ Integrated with body _____
Rear _____ Left side _____ Right side _____ Top _____

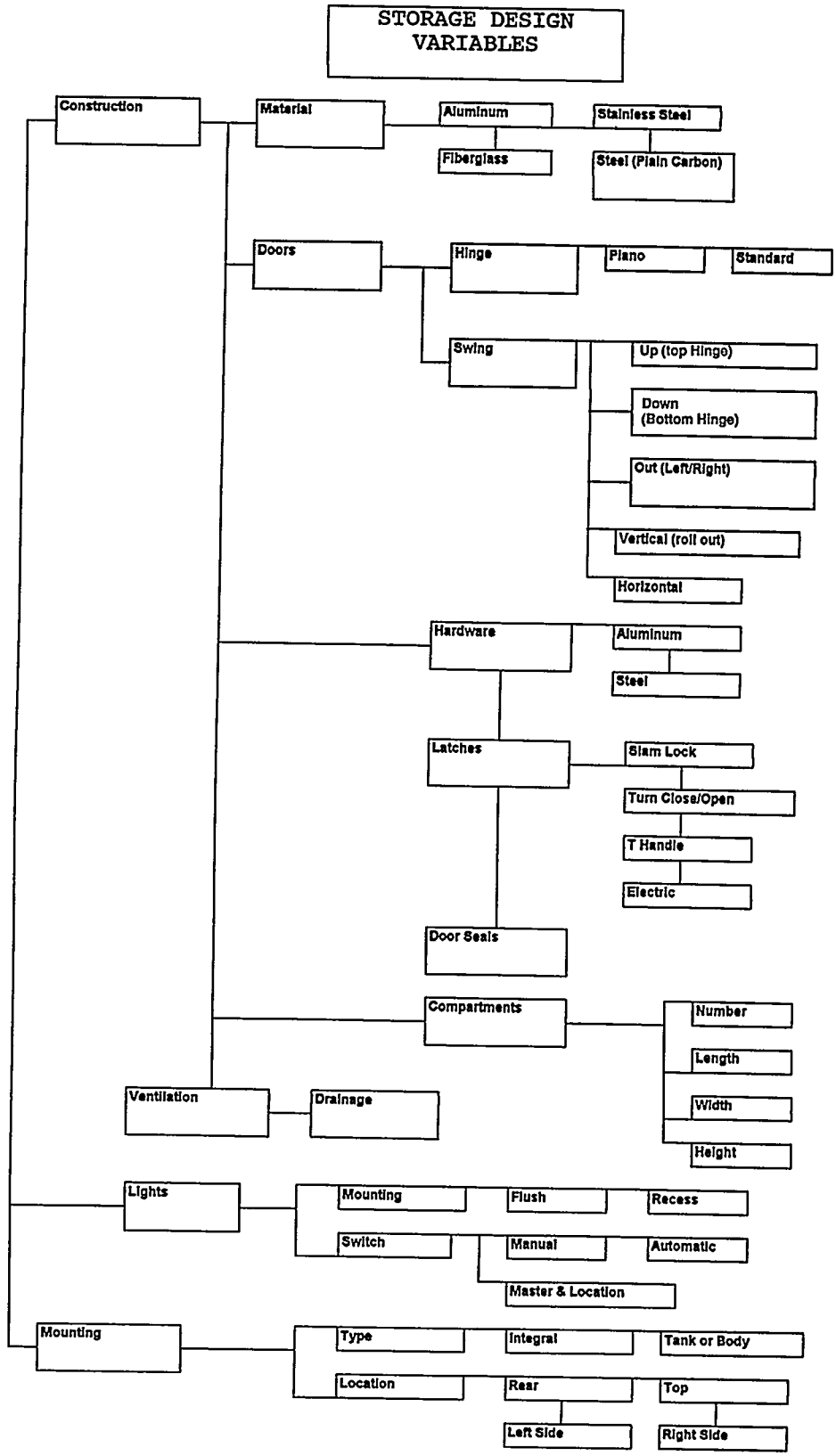


Figure 8.B. Storage design variables flow chart.

8.C STORAGE SELECTION AID

8.C.1 Compartment Material

Type of material selected depends on one or more of the following: Initial cost, durability, and weight. Aluminum and fiberglass will normally be lighter than steel. The reduced weight might allow for greater capacity of stored items or water. Both stainless and mild steel are rugged. Mild steel is easy to fabricate; stainless steel is expensive, but has the advantage of corrosion resistance compared to mild steel.

8.C.2 Doors

Piano hinges are easy to obtain. Used along the full length of the door, they normally provide adequate strength. Most piano hinges, however, do not allow for easy removal of the door for maintenance or other needs. Standard hinges provide easier door removal. Multiple hinges are needed for each door. The hinges must be sized properly to take the anticipated load for each particular door style.

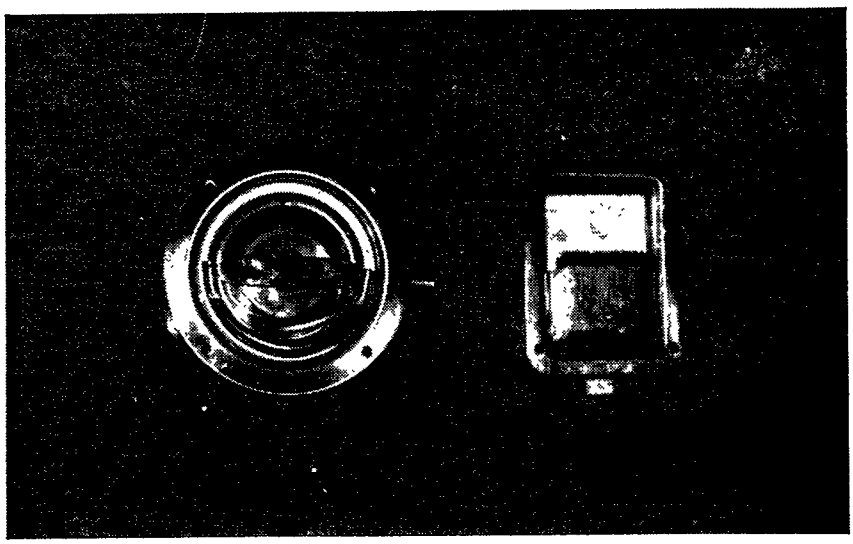
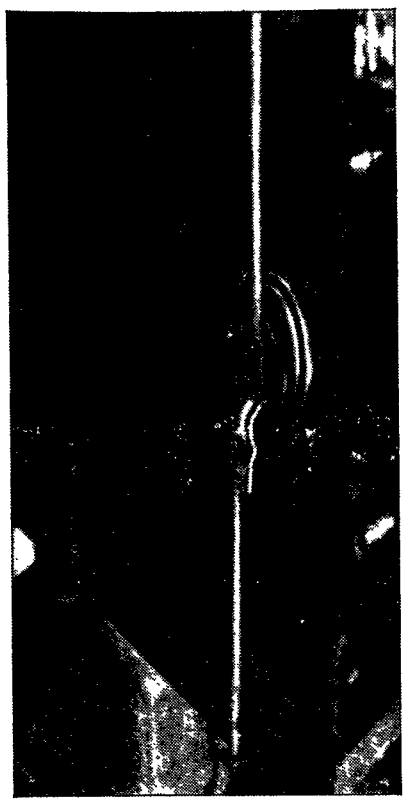


Figure 8-1. D-ring and slam lock latches are the most common storage door latch systems (above); three-point latches provide tighter fit on large storage doors.(below)

Compartment doors can swing up, down, or to the side, whereas compartment drawers can roll out with the door. The user must decide which way is the most appropriate for each compartment. Doors that swing down can be very handy to set things on, but they must be designed strong enough to take these loads. Door seals are necessary if the compartment needs to be weather-tight. Many types of latches are available; examples are seen in figure 8-1.



8.A.3 Compartments

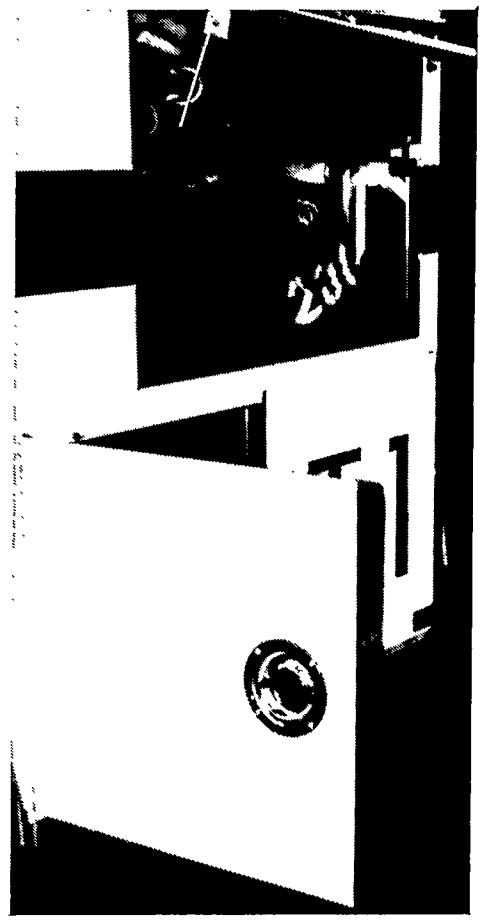
Storage is needed for a standard equipment complement for the engine. Items commonly stored on wildland engines are fuel, hose, adapters, fittings, hand tools, chain saws, portable pumps, and personal gear. Compartments that store batteries should be ventilated to avoid explosive build up of fumes. Compartments with flammable liquids must be placarded. Do not have electrical wiring or appliances in the flammable liquids storage compartment.

8.A.4 Lights

Automatic light switches help prevent accidental battery drain caused by forgetting to turn off the switch.

8.A.5 Mounting

If the storage body is mounted directly to the vehicle, it should be done in accordance with the vehicle manufacturer's instructions. Be careful that mounting of body units is done in a manner that allows the vehicle's frame to flex as designed. If mounted to the frame, use existing bolt holes. Never drill or weld to a frame without consulting the manufacturer or someone with expertise in this area. Examples of storage systems are seen in figure 8-2.



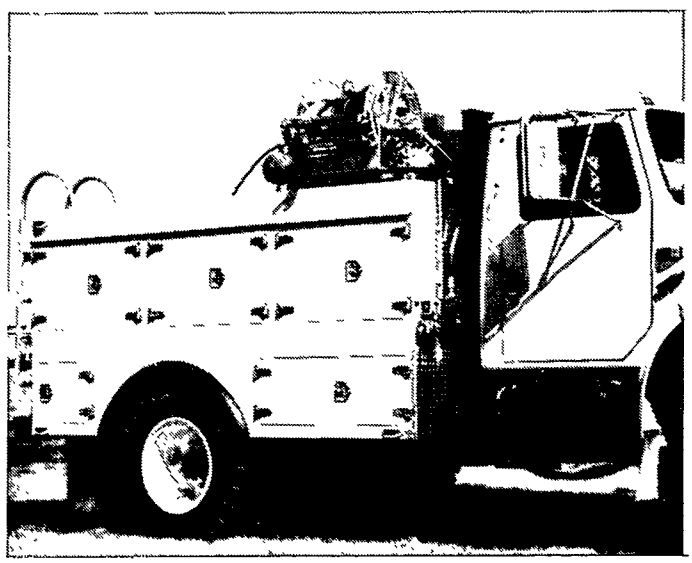


Figure 8-2. Some popular styles of storage compartments.

8.D STORAGE REFERENCES

NWCG *Water Handling Equipment Guide* (NFES No. 1275). Presents extensive collection of photos of wildland fire agencies' standard engines. Agency contacts are provided.

U. S. Department of Transportation Regulations.

Thomas Register of American Manufacturers. Lists many utility body manufacturers. Most are listed under heading of "Bodies, truck."

CHAPTER 9

CHAPTER 9. BUMPERS AND BRUSH GUARDS

All bumpers, front and rear, should conform to applicable federal and state regulations. Bumpers and brush guards should protect the vehicle from severe use conditions. These components must be strong enough and mounted correctly to perform that function. These components must not interfere with the functioning or maintenance of the vehicle. The following guide covers the questions to be considered in the selection of these components. The Aid provides some explanation of these questions. The flow chart shows the relationship of the questions to each other.

9.A BUMPER AND BRUSH GUARD SELECTION GUIDE

9.A.1 Front Bumper

Winch to be mounted (see section 10.A) YES ____ NO____
Space for
Hydraulic reservoir/pump mounting _____
Discharge outlet/hose basket _____
Equipment (nozzles, backpacks, extinguishers, etc.) _____
Other _____
Frame extensions YES_____ NO_____
Front bumper reinforcement for grill guard mounting YES_____ NO____
Non-skid step surface YES_____ NO_____
Method of attachment _____

9.A.2 Rear Bumper

Non-skid surface for step YES _____ NO _____
Provision for trailer hitch YES _____ NO _____
Ball___ Pintle____ Combination _____
Adequate bracing to frame for trailer towing YES _____ NO _____
Space for equipment (nozzles, backpacks, extinguishers, etc.)YES_____ NO _____

9.A.3 Grill Guards

Hinged for access to tilt hood YES _____ NO _____
Designed to
Avoid deflection into hood or fenders YES _____ NO _____
Minimize interference with radiator air flow YES _____ NO _____
Protect headlights/other front lights YES _____NO _____
Avoid interference with headlights/other front lights YES_____ NO _____
Bolted to front bumper for replacement without cutting/welding YES _____NO _____

9.A.4 Undercarriage Guards (Skid Plates)

Frame mounted w/enough clearance to minimize deflection into component
YES_____ NO _____
Component mounted to avoid impacts on component weak areas
YES_____ NO _____
Mounted w/adequate clearance and angles to be self-cleaning
YES_____ NO _____
No interference w/component operation, maintenance, or cooling
YES_____ NO _____

9.A.5 Body Guards (Brush Rails)

Mounted at lower perimeter of cab or body YES _____ NO _____
Mounted to vehicle frame, not body YES _____ NO_____
No interference w/access to engine, crew, or tool compartments YES_____ NO _____
Bolted for replacement without cutting/welding YES _____ NO _____

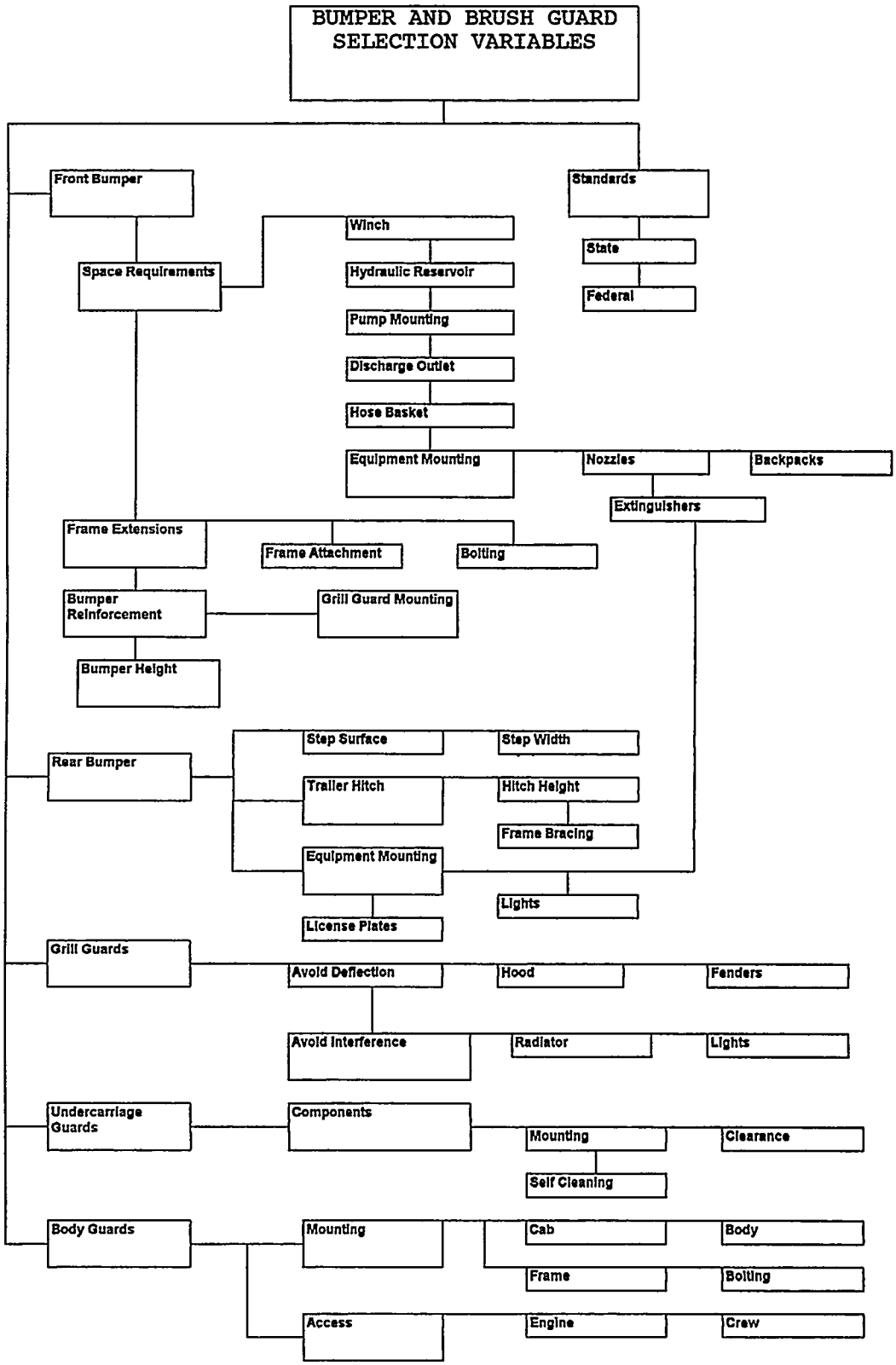


Figure 9.B. Bumper and brush guard selection variables flow chart.

9.C BUMPER AND BRUSH GUARD SELECTION AID

All bumpers, front and rear, should conform to applicable Federal and State vehicle regulations.

9.C.1 Front Bumper

Front bumpers supplied with light and medium truck chassis may need strengthening or face-bar replacement to provide strength adequate to resist impacts with vegetation and to support grill guards, pump discharge valves, hose baskets, backpack tanks, or fire extinguishers. Bumpers should be bolted to truck frames for ease of replacement when damaged. Frame rail extensions may be needed to provide space between the bumper and grill for specific applications. They should be of the same strength and size as truck frame members and be bolted to the vehicle frame.

9.C.2 Rear Bumper

Light and medium truck chassis are generally not supplied at the factory with rear bumpers. Numerous styles of aftermarket bumpers are available. Care should be exercised in selecting the type of tread surface for step-type bumpers. Smooth plate and some types of tread plate can be slippery when wet. Location of license plate mountings and lights should be considered. Extra wide surfaces may be desired for mounting backpacks, extinguishers, or other items.

If ball or pintle trailer hitch capability is desired, care must be given to proper hitch height and adequate bumper reinforcement. It is more satisfactory, particularly on medium trucks with higher frames, to mount rear bumper face bars at frame height, and mount trailer hitches independent of the bumpers.

9.C.3 Grill Guards

Grill guards may be available from vehicle manufacturers. They may not be of adequate strength if frequent contact with mature brush or small trees is anticipated. Custom-built grill guards (figs. 9-1 and 9-2) should be designed with the features listed in section 9.A.3.

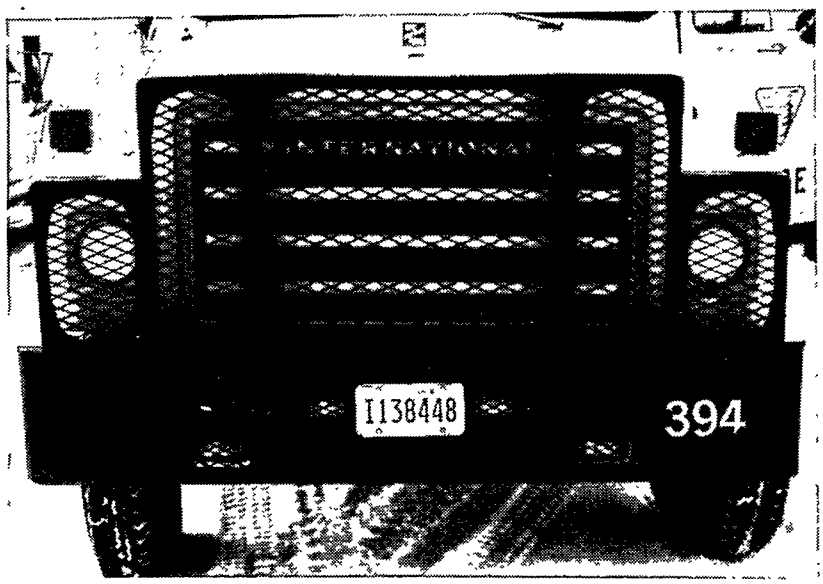


Figure 9-1. Typical grill guard with angle section frame.

9.C.4 Undercarriage Guards (Skid Plates)

Skid plates offer protection to gear cases, exhaust systems, and other sensitive vehicle components from contact with rocks and logs. They have the disadvantage of decreasing ground clearance and trapping flammable vegetation. Care must be taken in deciding if they are needed and where they should be located. Skid plates are available from vehicle chassis manufacturers for protection of various components (such as transmissions, transfer cases, and differentials). Custom skid plates should be designed to avoid transmitting impacts to the component they are protecting, either by being bent into the component or by mounting on sensitive parts of the component.

These plates should be designed to mount on the chassis frame with adequate clearance from the component, or designed with brackets to mount on and transmit impacts to component mounting bolts. They should have slight angles to the rear to be self-cleaning, or at least avoid compressing grass, weeds, etc. between the plate and other components. Care must be taken to assure that they don't interfere with access necessary for the component to operate, or be maintained (access to fluid level and drain plugs). They should be designed to not interfere with air flow around components, such as gear cases, which depend on the flow for cooling.

Figure 9-2. Typical grill guard with pipe frame.

9.C.5 Body Guards (Brush Rails)

Brush rails, sweeps, and other guards are used in many areas to protect vehicle sheet metal body parts from damage due to contact with heavy brush, trees, and rocks. These guards must be custom designed to accommodate the particular vehicle. Use of pipe generally offers the highest strength with the least weight. Designs should incorporate the features in section 9.A.5.

9.D BUMPER AND BRUSH GUARD REFERENCES

The following Roscommon, Michigan, Equipment Center publications show bumper and brush guard designs:

REC Project No.	Title
4	Jeep tanker
22	Michigan's 1,000- & Maine's 900-gal, 2-1/2-ton military 6x6 tankers
33	1-1/4-ton tanker study
34	3/4-ton tanker study
39	5-ton military 6x6 tanker study
40	Dodge W-2000 slip-on tanker (M880, 5/4-ton)
56	Evaluating the Hummer and HMMWV Series chassis for wildfire use

CHAPTER 10

CHAPTER 10. WINCHES

Determine the primary use of the winch. Carefully select a winch so that it performs correctly without interfering with other vehicle functions. The following guide covers the questions to be considered in selection of this component. The Aid provides some explanation of the questions. The flow chart shows the relationship of the questions to each other.

10.A WINCH SELECTION GUIDE

10.A.1 Use

Vehicle recovery _____ Yarding objects_____
Other equipment recovery _____

10.A.2 Pulling Capacity/Speed

Rated line pull _____ lb Rated line speed_____ fpm

10.A.3 Drum Capacity

Wire rope length _____ ft Wire rope diameter _____ in

10.A.4 Drive

Electric _____ Hydraulic_____ Mechanical_____

10.A.5 Mounting

Front mount _____ Rear mount _____
Power take-off (pto)
Shaft access YES _____ NO _____
Output speed _____ rpm Horsepower_____ hp
Direction Clockwise (CW) _____ Counter-clockwise (CCW) _____
Hydraulic hose
Access YES _____ NO _____
Diameter _____ in Pressure rating_____ psi
Pump capacity _____ gpm _____ psi
Electric cable
Access YES _____ NO _____
Cable capacity _____ amps Battery capacity _____ cold-cranking amps (CCA)
Fast idle switch YES_____ NO _____

10.A.6 Controls/Accessories

Cab controls_____ Remote control cable length_____ ft
Drag brake _____ Positive-type clutch _____
Fairlead Hawse type_____ Roller type _____

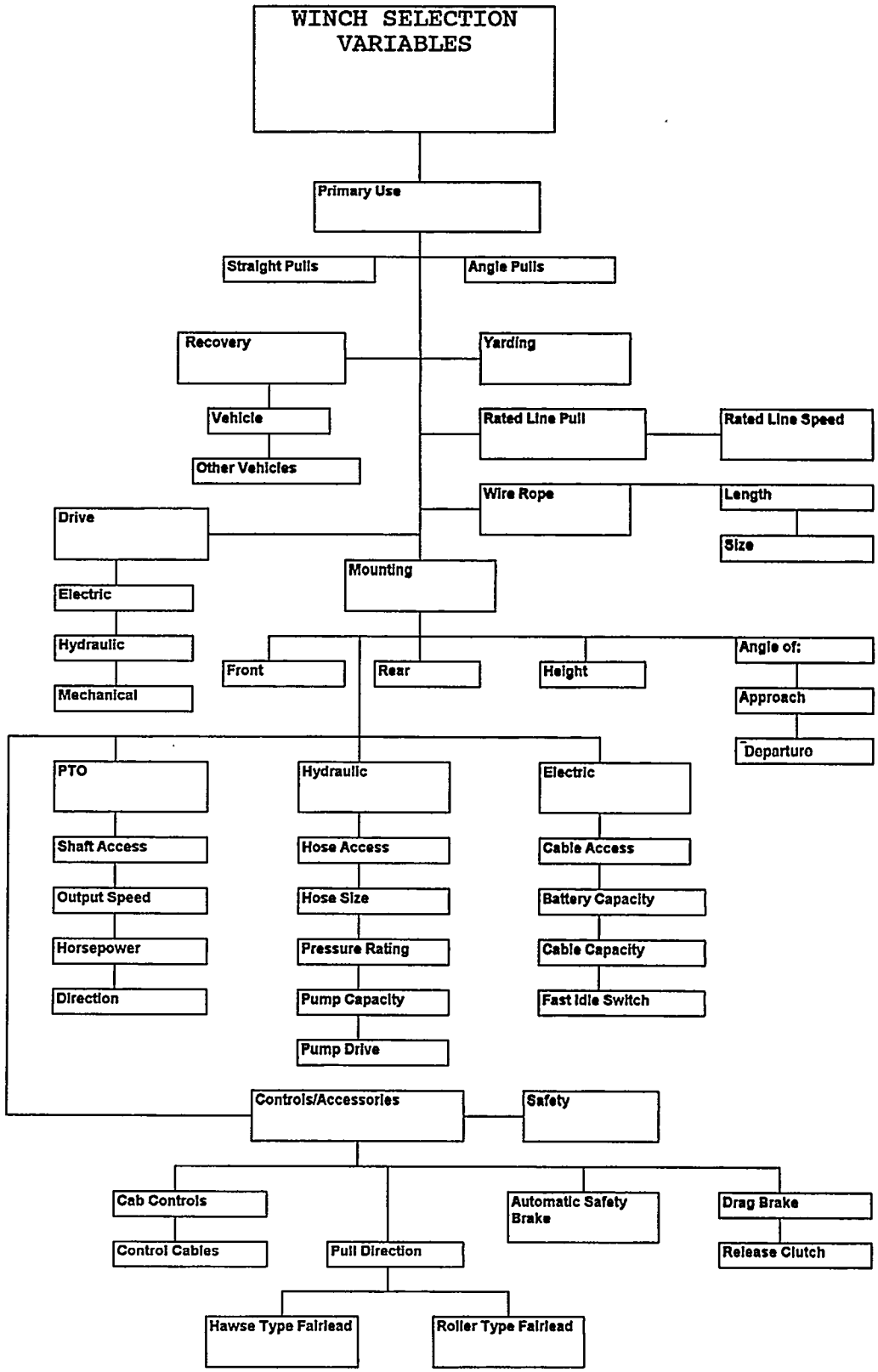


Figure 10.B. Winch selection variables flow chart.

10.C WINCH SELECTION AID

10.C.1 Use

Winch capacity, mounting, and accessories should be designed to meet the primary use. Winches should meet SAE Standard J706, which provides a method of rating winches. It applies to winches equipped with an automatic safety brake, a release clutch for "free spooling," and possibly a drag brake to control the free spooling speed.

10.C.2 Pulling Capacity/Speed

Winches have a rated line pull. Line pull ratings are generally shown for the first layer of wire rope on the winch drum. Ratings decrease with each succeeding layer of rope. A general guideline for a self-recovery winch for a light vehicle is to select a winch with a rating of 10 to 15 percent higher than the GVWR of the vehicle. Speeds vary from 1.5 to 25 feet per minute on various winches. Line speed should be slow for vehicle recovery purposes; faster speeds can be selected for yarding light objects.

10.C.3 Drum Capacity

Wire rope length will be limited by the winch drum size and diameter of the drum flanges. Length is determined by estimated distances to the winched objects or anchor points. Wire rope size and strength should be selected in accordance with winch manufacturer's recommendations. Rated strength and type of construction should be in accordance with winch manufacturer's recommendations. Rope strength should be higher than the winch rating.

10.C.4 Drive

Winches are available with a 12- or 24-volt electric motor, hydraulic motor, or mechanical drive. Mechanical drive is usually accomplished through a power take-off shaft from the vehicle transmission. Drive selection depends on individual vehicle configuration.

Electric drive is the simplest to install, but is limited to ratings of 12,000 pounds or less. Because winch operation is a heavy draw on batteries, a system of at least 1,900 CCA should be used. If the fire engine has a dual battery system, both batteries should be utilized, and any master switch should be bypassed for the winch. Extra large cables should be used to minimize any voltage drop from the batteries to the motor. It is recommended that a means be employed to increase idle speed for increased alternator output during winch operation. Examples are a fast idle solenoid or a hand throttle.

Hydraulic drive is available in higher ratings, but requires a hydraulic reservoir and a hydraulic pump driven from the vehicle engine or a transmission power take-off. It is possible to use existing vehicle hydraulic power systems to drive hydraulic winches. Mechanical, or pto, drive can provide for higher capacity winch drives without the need for an expensive hydraulic system. Winch location may be restricted by pto shaft drive angle limitations, drive shaft access routes, or ground clearance requirements.

10.C.5 Mounting

Mounting location is dependent on use. Front mounting is most common on fire engines. Mounting height should be as low as possible to minimize the vertical angle of pull on the vehicle. Mounting between truck frame rail extensions in front of the vehicle radiator is common. Such placement may reduce the approach angle of the vehicle. Compromise may be necessary to balance low winch height with adequate approach angle. Specific mounting members, bolt sizes, numbers, and placement should be in accordance with winch manufacturer's instructions.

10.C.6 Controls/Accessories

Safety is a primary consideration. Controls should be located to avoid operator injury from broken or snagged wire ropes, and sudden rope or vehicle movement. Electric winches can be equipped with remote control cables. Hydraulic and mechanical winches can be equipped with control valves or control levers located in or behind truck cabs. High-reduction (worm-gear) type winches may not need a drag brake, but planetary and direct-drive winches will require a drag, or load-holding, brake to hold the load in case of a power failure or interruption.

Most winches require a clutch to disengage the power train in order to "free spool" the rope to the load or anchor point. All clutches should be of the positive-type, such as dog or sprag, as opposed to friction-type clutches. If straight ahead pulls are anticipated, with only an occasional off-center pull, the hawse, or slider-type, rope guide or fairlead is adequate (fig. 10-1). If frequent side pulls are anticipated, a four-roller fairlead is better (fig. 10-2).

Figure 10-1. Winch installation with hawse-type fairlead.

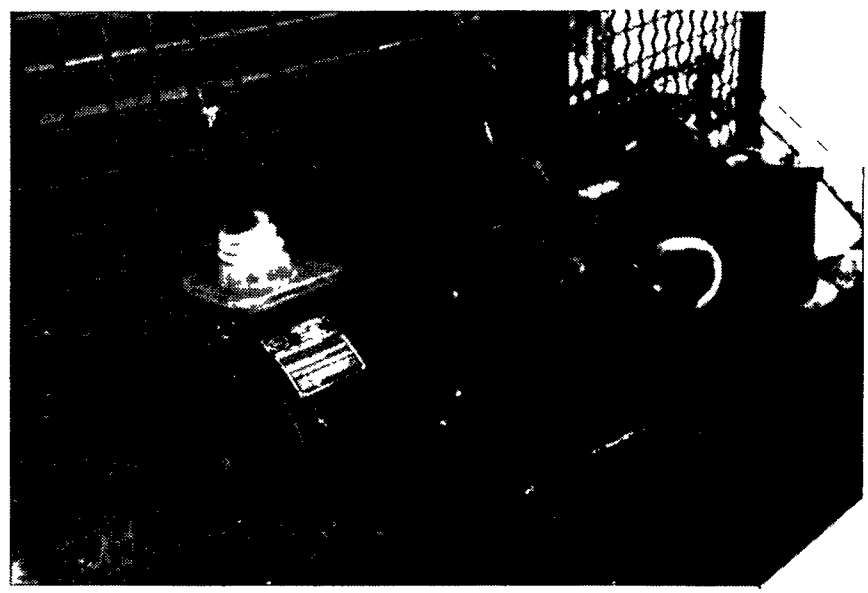


Figure 10-2. Winch installation with roller-type fairlead.

10.D WINCH REFERENCES

Society of Automotive Engineers Standard J706, Rating of Winches

CHAPTER 11

CHAPTER 11. WARNING LIGHTS AND DEVICES

11.A WARNING LIGHT AND DEVICE SELECTION GUIDE

Review applicable State laws regarding the use of warning lights and devices prior to proceeding with any warning light and devices decisions. The type, color, placement, and number of devices can be controversial. Be guided by agency policy and legal constraints.

11.A.1 Mounting

Roof _____ Under hood _____ Bumper _____

Space needed _____

11.A.2 Electrical

Voltage _____ volts Amperage _____ amps

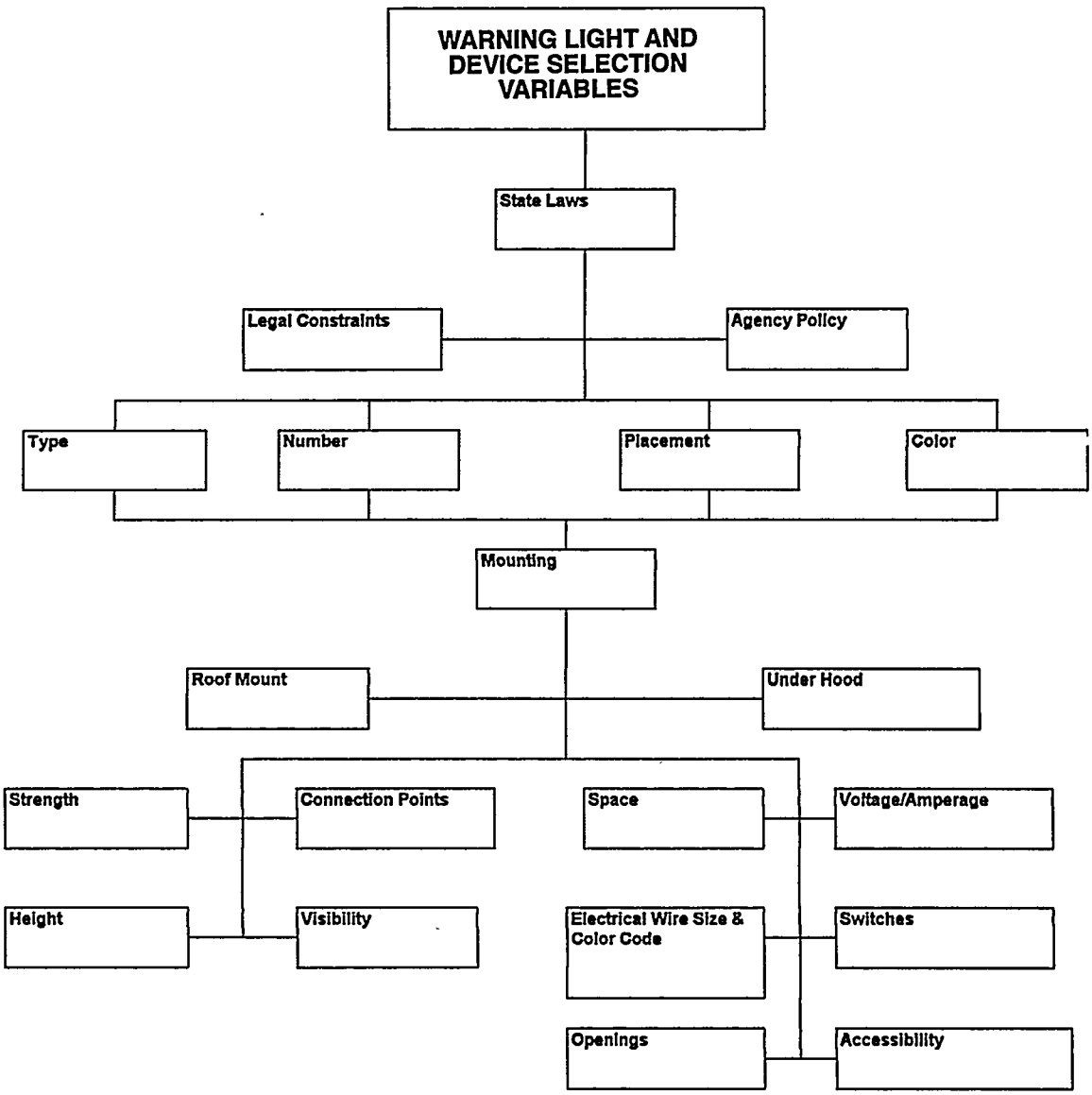


Figure 11B. Warning light and device selection variables flow chart.

11.C WARNING LIGHT AND DEVICE SELECTION AID

Any installation and use of red lights or other warning devices must comply with State law and agency policy.

11.C.1 Mounting.

Siren and air horns must be mounted forward of the vehicle cab to minimize noise impact on the cab occupants. Roof mounting must consider the strength of the mounting surface and availability of hard points for connections. Consider the height of the mounting surface to ensure visibility.

11.C.2 Electrical

Ensure appropriate voltage and amperage is available. Openings for electrical wire runs may be needed. Switches installed within the cab must be readily accessible to the operator.

11.D WARNING LIGHT AND DEVICE REFERENCES

NFPA 1901, Standard for Pumper Fire Apparatus

NFPA 1902, Standard for Initial Attack Apparatus

APPENDIXES

APPENDIX A
Acronyms

Acronyms used in this Guide are listed here, along with their meaning, to provide a ready reference for users of the Guide.

Amps	Amperage
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BLM	Bureau of Land Management, USDI
CAFS	Compressed air foam system
CCA	Cold-cranking amps
CCW	Counterclockwise
cfm	Cubic feet per minute
CW	Clockwise
DOT	United States Department of Transportation
FEWT	Fire Equipment Working Team
fpm	Feet per minute
FS	Forest Service, USDA
ft	Feet (foot)
GAWR	Gross Axle Weight Rating
GHT	Garden Hose Thread
gpm	Gallons per minute
GSA	General Services Administration
GVWR	Gross Vehicle Weight Rating
Hg	Mercury
hp	Horsepower
ID	Inside diameter
in	Inch(es)
lb	Pound(s)
min	Minute(s)
NFES	National Fire Equipment System
NFPA	National Fire Protection Association
NH	National Standard Hose Thread
NIFC	National Interagency Fire Center, Boise, Idaho [formerly BIFC]
NPSH	American National Standard Pipe Thread
NPT	National Pipe Thread
NWCG	National Wildlife Coordinating Group
OD	Outside diameter
ORV	Off-road vehicle
PMS	Publication Management System [NWCG]
psi	Pounds per square inch
psia	Pounds per square inch ambient
psig	Pounds per square inch gauge
pto	Power take-off
PVC	Polyvinylchloride
REC	Roscommon (Michigan) Equipment Center; Forest Fire Experiment Station

PVC	Polyvinylchloride
REC	Roscommon (Michigan) Equipment Center; Forest Fire Experiment Station
rpm	Revolutions per minute
SAE	Society of Automotive Engineers
SDTDC	San Dimas Technology and Development Center
UL	Underwriter's Laboratories
U.S.	United States
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
WHEG	Water Handling Equipment Guide

APPENDIX B
Definitions

Acceptance—Agreement between a purchasing authority and a contractor stating that the terms and conditions of the contract have been met.

Agency—Entity charged with the fire protection responsibility of a specific area. Can be a municipal fire department, volunteer department, fire protection district, or State or Federal entity.

Angle of approach—The smallest angle between the road surface and a line drawn from the front point of front tire ground contact to any projection of the engine in front of the front axle.

Angle of departure—The smallest angle between the road surface and a line drawn from the rear point of rear tire ground contact to any projection of the engine behind the rear axle.

Apparatus—See "Engine."

Baffles—(Also known as swash partitions.) The vertical walls within a tank structure designed to help reduce the uncontrolled movement of fluid within the tank.

Cab and chassis—The basic vehicle frame consisting of main frame rails, reinforcements, cross members, fasteners, brackets for suspension, suspension members (springs), axles, tires and wheels, cab, and power train.

Compound gauge—A gauge that reads pressure both above and below atmospheric pressure. Zero on most gauges is 1 atmosphere of pressure. Compound gauges typically measure pressure above atmospheric pressure in psi and below atmospheric pressure in inches of mercury ("in Hg").

Compressed Air Foam System (CAFS)—A system that combines air under pressure with foam solution to create foam in the hose. A system consists of an air compressor or other air source, a water pump, a nozzle or other means of applying the foam, and a source of foam solution.

Contractor—A person or company responsible for fulfilling an agreed upon contract. The contractor may not necessarily manufacture the vehicle or any portion of the vehicle, but is responsible for the completion, delivery, and acceptance of the entire unit.

Convenient reach—The ability of an engine operator to manipulate the controls from a normal driving position without excessive movement away from the seat back or without excessive loss of eye contact with the roadway.

Department—See "Agency."

Dynamic suction lift—The sum of the vertical lift and the friction and entrance loss caused by the flow through the suction strainers and hose, expressed in feet.

Electric (electro-mechanical) siren—An audible warning device that produces sound by use of an electric motor with an attached rotating slotted or perforated disc. Only one type of warning sound can be produced, but the level or pitch can be varied by the speed of the motor.

Electronic siren—An audible warning device that produces sound electronically through the use of amplifiers and electromagnetic speakers. Varied type of warning sounds can be produced—such as wail, yelp, or simulated air horn.

Enclosed compartments—Area(s) for storing items, confined on six sides with latching and closable access opening(s), designed to be weather resistant and provide protection from environmental damage.

Engine—(As used here.) A vehicle used for fire suppression by a fire department, fire brigade, or other agency responsible for fire protection.

Engine typing—Classification of wildland fire engines based on pump capacity, tank size, hose, and personnel carried. (See appendix D.)

Fire pump—Mechanical device connected to a power source and capable of sustaining an extinguishing agent fire stream at a specific rate of flow and pressure.

Foam—The collection or mass of bubbles formed by forcing air into a solution of water and foam concentrate by means of suitably designed equipment or by cascading it through the air at a high velocity.

Fully enclosed personnel area—A driving or passenger compartment on the fire apparatus providing total enclosure on all sides, and top and bottom, and having positive latching on all access doors.

Gallon—United States (U.S.) gallon.

Grade—A measurement of angle used in road design and expressed as a percentage of elevation change over distance. A 45-degree slope would be a 100-percent grade.

Gross Axle Weight Rating (GAWR)—The value specified as the load-carrying rating of a single-axle system, as measured at the tire/ground interface.

Gross Vehicle Weight Rating (GVWR)—The value specified by the chassis manufacturer as the loaded weight rating of a single vehicle.

Ground clearance—The clearance under a vehicle at all locations except the axles.

Intersection lights—Emergency flashing warning lights designed to give early warning that the emergency vehicle is entering an intersection.

Intake relief valve—A relief valve piped to the intake manifold of the pump that is designed to automatically relief excess pressure from the incoming flow of water by discharging water to the environment.

Manufacturer—The person or persons, company, firm, corporation, partnership, or other organization responsible for taking raw materials or components and constructing a finished product.

National Standard Hose Thread (NH)—A standard thread that has dimensions for the inside and outside fire hose connection screw threads as defined by NFPA 1963, "Standard for Screw Threads and Gaskets for Fire Hose Connections."

Net pump pressure—The sum of the discharge pressure and the dynamic suction lift converted to psi when pumping at draft, or the difference between the discharge pressure and the suction pressure when pumping from a hydrant or other source of water under positive pressure.

Nozzle pressure—Pressure required by the nozzle for proper operation. Most nozzles, unless otherwise specified, produce their rated output at 100 psig.

Off-road Vehicle (ORV)—A vehicle designed to be used in areas where there is need to traverse steep terrain, or to cross natural hazards on or protruding from the ground.

Preconnected line—(Also called the bucket line, cross lay, or mattydale.) A hose line that is always connected to an outlet on the pump and that can be charged by the activation of one discharge valve.

Power Take-off (pto)—A method of taking mechanical power directly from the vehicle engine without involving the axles and wheels.

Proportioner—A device that adds a predetermined amount of liquid foam concentrate to water to form a foam solution.

Pump—See "Fire Pump."

Pump operator's panel—The area on a fire apparatus that contains the gauges, controls, and other instruments designed for primary control of the pump.

Pump operator's position—The location where the pump operator stands to operate the pump.

Purchaser—The authority having responsibility for the specification and acceptance of the apparatus.

Readily accessible. Able to be seen, reached, and serviced or removed without removing other components or parts of the apparatus, and without the need to use special tools to open any enclosure.

Shall—Indicates a mandatory requirement.

Should—Indicates a recommendation, or that which is advised but not required. Split-shaft pto. A pto drive system that directs the chassis power either to the pump or to the chassis drive axle. This is accomplished by splitting the chassis driveline, which connects the chassis transmission to the drive axle, and inserting the split-shaft pto that has the shift mechanism necessary to direct the engine power as described above.

Sump—A area of a tank assembly designed primarily to entrap sludge and debris for easy removal and as a central water collection point.

APPENDIX C

Metric System Equivalents/Conversion Factors

The purpose for including the following metric system equivalents and approximate conversion factors is to meet the requirements of Public Law 100-418. This law requires each Federal agency to use the metric system of measurementby Fiscal Year 1992, in procurements, grants, and other business related activities.

THE METRIC SYSTEM AND EQUIVALENTS

Linear Measure

1 centimeter=	10 millimeters=	0.39 inch
1 decimeters=	10 centimeters=	3.94 inches
1 meter=	10 decimeters=	39.37 inches
1 dekameter=	meters=	32.8 feet
1 hectometer=	10 dekameters=	328.08 feet
1 kilometer=	10 hectometers=	3,280.8 feet

Liquid Measure

1 centiliter=	10 milliliters=	0.34 fl ounce
1 deciliter=	10 centiliters=	3.38 fl ounces
1 liter=	10 deciliters=	38.82 fl ounces
1 dekaliter=	10 liters=	2.64 gallons
1 hectoliter=	10 dekaliters=	26.42 gallons
1 kiloliter=	10 hectoliters=	264.18 gallons

Weights

1 centigram=	10 milligrams=	0.15 grain
1 decigram=	10 centigrams=	1.54 grains
1 gram=	10 decigrams=	0.035 ounce
1 dekagram=	10 grams=	0.35 ounces
1 hectogram=	10 dekagrams=	3.52 ounces
1 kilogram=	10 hectograms=	2.2 pounds
1 quintal=	100 kilograms=	220.46 pounds
1 metric ton=	10 quintals=	1.1 short tons

Square Measure

1 sq centimeter=	100 sq millimeters=	0.155 sq in
1 sq decimeter=	100 sq centimeters=	15.5 sq in
1 sq meter (centare)=	100 sq decimeters=	10.76 sq ft
1 sq dekameter (are)=	100 sq meters=	1,076.4 sq ft
1 sq hectometer (hectare)=	100 sq dekameters=	2.47 acres
1 sq kilometer=	100 sq hectometers=	0.386 sq mi

Cubic Measure

1 cu centimeter=	1000 cu millimeters=	0.06 cu inch
1 cu meter=	1000 cu decimeters=	35.31 cu feet
1 cu decimeter=	1000 cu centimeters=	61.02 cu inches

WATER HANDLING UNITS

		U.S. Measure		Metric Equivalent
		Volume (Capacity)		
One hose length				
1-1/2-in ID x 100	=	9 gal (approx)	=	34.07 liters
1-in ID x 100	=	4 gal (approx)	=	15.14 liters
Tank size (gal)				
Rectangle	=	Length x width x height (inches) x 0.0043		
Cylinder	=	3.14 x diameter squared x height (or length) (inches) divided by 4 x 0.0043		
		Weight		
1 ft of water head (column of water)	=	0.434 psi (1/2 psi)	=	2.99 kPa
		Pressure		
1 psi	=	2 ft of water head (2.304 ft)	=	6.89 kPa
Atmospheric pressure	=	14.696 psi @ sea level (or 29.92 in of Hg @ 32o F)	=	101 kPa @ sea level
1,000 ft increase in elevation	=	1/2 lb decrease in atmospheric pressure		
		Draft		
1 in of mercury	=	1 ft lift (1.134 ft)	=	0.3048 m lift
Drafting guidelines:				
Theoretical lift (max)	=	33.9 ft lift	=	10.33 m lift
Attainable	=	29.4 ft lift	=	8.96 m lift
Excellent pump	=	28 ft lift	=	8.53 m lift
Good pump	=	26 ft lift	=	7.93 m lift

APPROXIMATE CONVERSION FACTORS

To Change	To	Multiply By
inches	centimeters	2.54
feet	meters	0.305
yards	meters	0.914
miles	kilometers	1.609
square inches	square centimeters	6.451
square feet	square meters	0.093
square yards	square meters	0.836
square miles	square kilometers	2.590
acres	square hectometers	0.405
cubic feet	cubic meters	0.028
cubic yards	cubic meters	0.765
fluid ounces	milliliters	29,573
pints	liters	0.473
quarts	liters	0.946
gallons	liters	3.785
ounces	grams	28.349
pounds	kilograms	0.454
short tons	metric tons	0.907
pound-feet	newton-meters	1.365
pound-inches	newton-meters	0.11375

To Change	To	Multiply By
ounce-inches	newton-meters	0.007062
centimeters	inches	0.394
meters	feet	3.280
meters	yards	1.094
kilometers	miles	0.621
square centimeters	square inches	0.155
square meters	square feet	10.764
square meters	square yards	1.196
square kilometers	square miles	0.386
square hectometer	acres	2.471
cubic meters	cubic feet	35.315
cubic meters	cubic yards	1.308
milliliters	fluid ounces	0.034
liters	pints	0.2113
liters	quarts	1.057
liters	gallons	0.264
grams	ounces	0.035
kilograms	pounds	2.205
metric tons	short tons	1.102

Temperature (Exact)

°F=Fahrenheit °C=Celsius

°F=(°Cx9/5)+32 °C=5/9x(°F-32)

APPENDIX D
Engine Typing

The table below presents the minimum standards for the seven engine types.

Engine Type No.		1	2	3	4	5	6	7
Category	**Units**	**Minimum Standards**						
Pump capacity	(gpm)	1,000	500	120	70	50	50	20
Tank capacity	(gal)	400	400	300	750	500	200	125
Hose, 2-1/2-in	(ft)	1,200	1,000	-	-	-	-	-
Hose, 1-1/2-in	(ft)	400	500	1,000	300	300	300	200
Hose, 1-in	(ft)	200	300	800	300	300	300	200
Ladder	(ft)	20	20	-	-	-	-	-
Heavy stream	(gpm)	500	-	-	-	-	-	-
Personnel	(No.)	4	3	3	3	3	3	3

NOTES: 1. An X after the type designation for an engine would denote an all-wheel drive vehicle.
2. Foam or water expansion units must be designated as such.

[This appendix from NWCG (Handbook 3, p. A-28), NFES No. 0065, November 1989.]

APPENDIX E

Sources—Referenced Publications And Standards

The following sources issue documents and videos of interest to users of this Guide. Full information as to what is available, and the current charge (if any) for items, can be determined by writing or phoning the sources.

ANSI, an umbrella organization supported by most American technical professional societies and organizations, currently has approximately 11,000 approved American National Standards covering a broad spectrum of fields.

American National Standards Institute (ANSI)
11 West 42nd Street
New York City, NY 10036
(212) 642-4900

ASTM is the technical society that develops and publishes standard specifications, tests, practices, and definitions for materials, products, and systems. They currently have almost 2,000 standards issued in a series of over 65 volumes.

American Society Testing and Materials (ASTM)
1916 Race Street
Philadelphia, PA 19103-1187
(215) 299-5585

GSA is the Federal agency that issues catalogs of goods available through a central supply system. Of interest to wildland firefighting agencies are the GSA *Supply Catalog* and the *Wildfire Protection Equipment and Supplies Catalog.*

U.S. General Service Administration (GSA) Catalogs
GSA Centralized Mailing List Service
P.O. Box 6477
Fort Worth, TX 76115
(817) 334-5215

NIFC is an interagency organization that supports the National Fire Equipment System (NFES), which issues many documents and videos of interest—including the following publications: *Fireline Handbook*, NFES No. 0065; *Foam vs. Fire—Primer*, NFES No. 2270; *Foam vs. Fire—Class A Foam for Wildland Fires*, NFES No. 2246; *Fire Equipment Storage and Refurbishing Standards*, NFES No. 2249; and *Water Handling Equipment Guide*, NFES No. 1275. In the latter Guide there is extensive information for obtaining fire engine related drawings and specifications on water pumping, foam generating, and water delivery equipment that are in use by Federal and State agencies nationwide.

National Interagency Fire Center (NIFC)
[formerly, Boise Interagency Fire Center (BIFC)]
Publication Management System (PMS)
3905 Vista Avenue
Boise, ID 83705
(208) 389-2542

NFPA issues the *Fire Protection Handbook*, which compiles the state-of-the-art in fire protection and fire prevention practices. An appendix of the Handbook provides a listing of the complete titles of all NFPA documents.

National Fire Protection Association (NFPA)
One Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
(617) 770-3000

REC is a cooperative engineering program sponsored by the Northeast Forest Fire Supervisors and the Michigan Department of Natural Resources.

Roscommon Equipment Center (REC)
c/o Forest Fire Experiment Station
P.O. Box 68
Roscommon, MI 48653-0068
(517)275-5211

SAE is the technical society that deals with mobility on the land, sea, air, and space. It issues a multivolume Handbook containing standards, recommended practices, and information reports—including those covering trucks and equipment pertinent to wildland firefighting.

Society of Automotive Engineers, Inc. (SAE)
400 Commonwealth Drive
Warrendale, PA 15096
(412) 776-4841

UL is an organization that tests and certifies appliances, etc. as to their fire safety, etc. aspects.

Underwriters Laboratories, Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062
(708) 272-8800

SDTDC, a detached unit of the Forest Service's Washington Office Engineering Staff, has an assigned mission to systematically apply scientific knowledge to create new or substantially improved equipment, systems, materials, processes, techniques, and procedures to meet the objectives of advanced forest management and utilization. In the area of fire management, the Center has several available documents that are of interest to users of wildland fire engines; among these are the following:

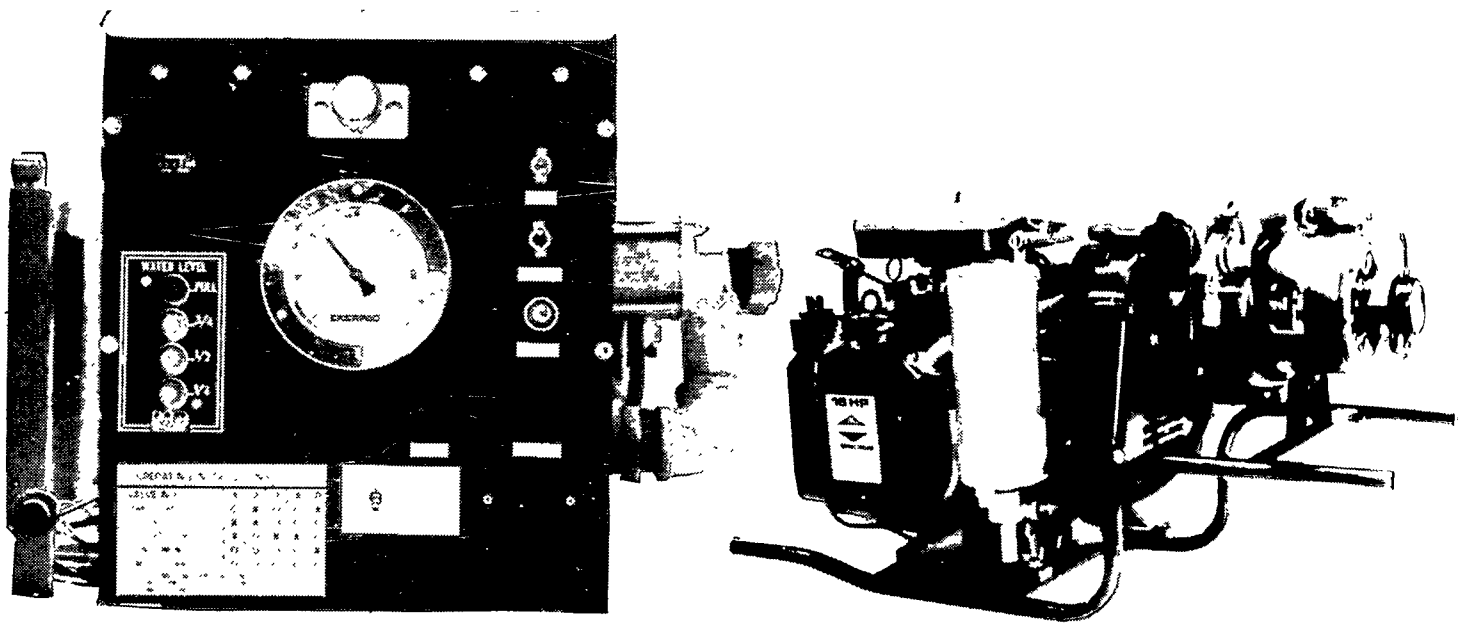
Report No.	Title
8751 1202	Engineering Analysis of Threshold Compressed Air Foam Systems
9251 1203	Compressed Air Foam Systems in Wildland Fire Applications
9251 1204	Proportioners in Wildland Fire Applications
9271 1205	Demonstration of Fire Engine w/Central Tire Inflation System
9351 1801	SDTDC Fire & Aviation Program Summary
FS-415	Central Tire Inflation. . . What's In It for Me? (Rev. 7/91)

San Dimas Technology and Development Center (SDTDC)
USDA Forest Service
444 East Bonita Avenue
San Dimas, CA 91773-3198
(909) 599-1267

* U.S. GOVERNMENT PRINTING OFFICE: 1994-589-270/00092

Comments on the
Wildland Fire Engine Component Guide
should be directed to:

National Wildfire Equipment Working Team
c/o Director, Cooperative Fire Protection
USDA Forest Service
P.O. Box 96090
Washington, DC 20013-6090


WATER LEVEL
PRE
S1
S2
S3
GND
10 HP