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TECHNICAL INFORMATION Bulletin

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STATIONARY FIRE PUMPS

Introduction

Compelling reasons dictate the installation of fire protection systems driven by stationary fire pumps. Foremost among these reasons is protection – protection of lives, equipment, possessions and inventories, and major assets such as hospitals, hotels, office and residential buildings, warehouses, offshore drilling platforms, refineries and chemical plants and similar facilities. There are two additional less obvious but equally compelling reasons:

-The reduction of costs.
-The protection of income-generating operations.

Costs are reduced in a simple manner: Over the projected life of a facility, the total of construction costs plus fire protection equipment costs plus fire insurance costs is lower than the total of construction costs plus fire insurance costs without fire protection equipment.

Here is an example to describe the protection of income generating operations: Suppose that a large hotel suffers substantial fire damage, causing it to close. Even if the building is repaired and later re-opened, it earns no income while closed and, in fact, most of its employees would probably be laid off. By comparison, a fire suppression system is capable of confining the fire to one room. The hotel can continue to operate while one room or perhaps one floor is being repaired. It continues to generate income and retains its employees. Las Vegas hotel fires dramatically validate this example. Analogous situations apply to manufacturing and process plants, retail stores, etc.

Virtually every American city has fire hydrants. Each has its head flow discharge capabilities. Most cities have mobile fire fighting equipment which includes "pumpers" – trucks equipped with engine-driven boost pumps. The hydrant-pumper combination can extinguish many kinds of fires – grass fires, single family dwelling fires, fires in low rise business and manufacturing establishments, etc. But there comes a point beyond which the head-flow capabilities of the hydrant pumper combination can no longer provide adequate protection. That point might be reached when a facility becomes too high, too big, too remote, too combustible… The "rules" by which one can determine whether a stationary fire pump system is required are contained in these National Fire Protection Association publications:

NFPA Pamphlet 13 – Sprinkler Systems
NFPA Pamphlet 14 – Standpipe, Hose Systems
NFPA Pamphlet 16 – Deluge Foam – Water Systems

NFPA pamphlets are inexpensive. They are changed fairly frequently, as greater insight into the solutions to fire protection problems is gained. One should be certain that he is using the latest edition.

They are available from:

Publication Sales Division
National Fire Protection Association, Inc.
Batterymarch Park
Quincy, Massachusetts 02269

As a practical matter, the fire protection system designer must submit his plans to the "local authority having jurisdiction" for preliminary approval before ordering or installing equipment. By this means, the situation where approval can be obtained only at the expense of costly modifications can probably be avoided.

Fire Pump Criteria

Of the numerous requirements applicable to approved/listed fire pumps, the following are some of the more important.

The pumps (excluding jockey pumps), controls and accessories must all be ordered on a single purchase contract, stipulating compliance with NFPA Pamphlet 20 and satisfactory performance of the equipment when installed. The pump manufacturer must be responsible for the proper operation of the installed assembly, as demonstrated by field tests.

Each fire pump, driver, controller and some of the accessories must have the appropriate UL listing and/ or FM approval and bear the appropriate UL and/or FM nameplate. (Equipment bearing such a nameplate is said to be "labeled".) For example, the pump nameplate will indicate the approval/listing agency, pump model, serial number, design capacity, design pressure, rated speed, maximum horsepower and shutoff or churn pressure.

If an adequate, reliable supply of water is available, and if a positive pressure will always be available at the pump suction, the pump may be of the horizontal end suction (for capacities under 500 gpm) or of the horizontal split case design (for capacities of 500 gpm and above). Multi-stage split case pumps are available for high head applications. A horizontal fire pump driven by an electric motor is described in Figure 1. Figure 2 depicts a horizontal fire pump driven by a diesel engine. If the water supply is not reliable or adequate, a horizontal fire pump requires a reservoir located above the pump suction.

If the pump must "lift" the water--from a well, pond, river, etc.--a vertical turbine pump must be used. An electric motor driven vertical turbine fire pump is described in Figure 3. When driven by a diesel engine, a universal drive shaft and a right angle gear drive are included, as shown in Figure 4. The vertical pump must be installed so that the static water level is never below the minimum submergence required by the pump manufacturer.

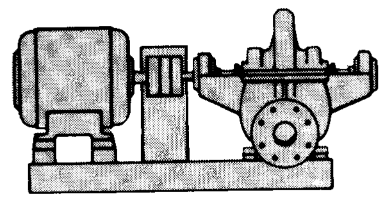

FIGURE 1. Electric motor driven stationary horizontal split case fire pump.

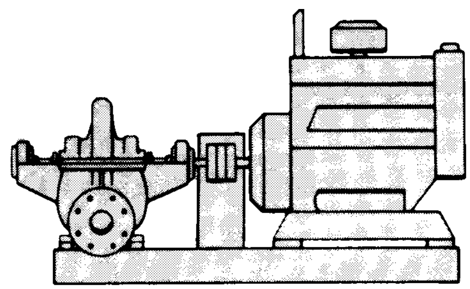

FIGURE 2. Diesel engine driven stationary horizontal split case fire pump.

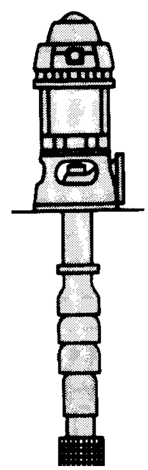

FIGURE 3. Electric motor driven stationary vertical turbine pump.

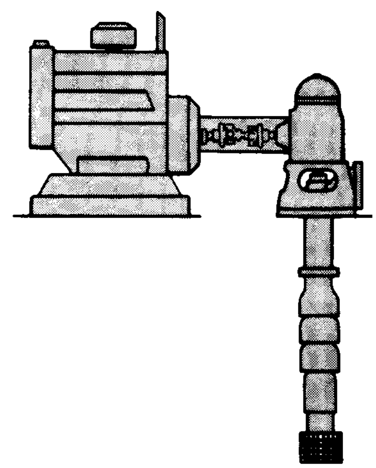

FIGURE 4. Diesel engine driven stationary vertical turbine fire pump.

The inner column (drive shafting) for vertical pumps is available in either of two configurations: OLS (open line shaft) construction, steel shafting rotating within water lubricated rubber bearings which are centered and stabilized by rigid bearing retainers, is used for static water levels which are 50 feet or less below the pump discharge flange. Over 50 feet, ELS (enclosed line shaft) construction is used. Steel shafts rotate within oil lubricated bronze sleeve bearings.

The outsides of the sleeve bearings are threaded and tubes, which enclose and support the bearings and shafts, isolating the shafting from the water being pumped.

Horizontal split case pumps are required to have shutoff (no flow) pressures no higher than 120% of their design (operating) pressures. End suction horizontal pumps and vertical turbine pumps are required to have shutoff pressures no higher than 140% of their design pressures. For all fire pumps when the pressure against the pump discharge is reduced so that the pump produces 150% of its design capacity, the discharge pressure must be no lower than 65% of the design pressure.

Certified performance test curves are required for all fire pumps. The curves show pump head, horsepower and efficiency at various pump capacities. The pump manufacturer must run the performance tests using a calibrated laboratory motor or a dynamometer.

The major determinants of pump size are the pump head and capacity required, the nature of the supply source, and the pressure (if any) at which the water is delivered to the pump suction. Labeled pumps are available for all commonly encountered head/capacity requirements. If application requirements are encountered which exceed the capabilities of labeled pumps, manufacturers can furnish unlabeled pumps made in accordance with the intent of NFPA Pamphlet 20.

Those relatively few manufacturers who specialize in stationary fire pumps, through continuously working with fire pump requirements, develop considerable knowledge and expertise in this specialized field. The fire protection system designer, particularly one who has relatively little fire pump experience, can benefit from the assistance available from manufacturers' specialists.

Materials of Construction

Since most fire pumps handle clear water, and since wear (from heavy duty use) is not usually a problem, labeled pumps are ordinarily made of commonly used industrial materials (which are named in UL/FM standards).

Horizontal pumps have casings made of cast iron. Enclosed impellers, made of bronze, and bronze case wear rings are used. Stuffing boxes are equipped with bronze or Teflon lantern rings and bronze split-type packing glands; shafts are sealed with a braided, graphited, synthetic packing. (As a reminder, all pump shaft packing must have a small amount of "leakage" when the pump is running to prevent "burning" the packing.) The impeller shaft, steel, will have a bronze shaft sleeve through the packing; the sleeve will be o-ring or gasket-sealed to the shaft. Ball bearings will be grease lubricated. In horizontal split case pumps, the inboard bearing will be of the single row radial type; the outboard bearing may be of the angular contact type or the single row type.

Vertical turbine pumps will have cast iron bowls, enclosed bronze impellers and steel or stainless steel impeller shafts. The vertical drive line will be OLS (open line shaft) construction, which includes steel shafting, rubber sleeve bearings and bronze bearing retainers, or ELS (enclosed line shaft) construction, which includes steel shafting, steel enclosing tubes and bronze sleeve bearings, all arranged for oil lubrication. Vertical turbine pumps usually have cast iron above ground discharge heads. The column pipe is furnished in 10 foot (nominal) joints, made of steel, with either threaded or flanged joints. Flanged column pipe requires accurately machined flanges with rabbet (registered) fits for accurate alignment.

Since some vertical turbine fire pumps are installed in either brackish or salt water, UL labeled pumps are available which are made of appropriate special materials.

Stationary fire pumps can be procured as packaged subsystems; they enable savings in installation time and money. Single or multiple units of horizontal or vertical pumps can be packaged. Characteristically, each packaged unit includes the pump(s), driver(s), controller(s), headers, accessories and piping mounted on a common base. To the extent possible, all wiring and piping connections are made and the unit will have been factory tested. The package arrives as a consolidated shipment. Installation consists simply of positioning and leveling the package and making external piping and electrical connections.

Figure 5 shows a packaged engine driven horizontal fire pump.

Most modern fire protection systems are designed to operate automatically (as opposed to "manual start"). The starting sequence is initiated by a pressure drop caused by activation of an automatic sprinkler or a deluge valve. In order to keep the system filled and pressurized without activating the main fire pump(s), a "jockey" or pressure maintenance pump is used.

The jockey pump is small, so that it can restore small system pressure losses but cannot fulfill the large flow/ pressure demands caused by activation of the fire protection system. Any pump which is suitable for the application may be used for jockey pump service; jockey pumps are not covered by UL listing nor FM approval requirements.

Fire Pump Drivers

Drivers include various types of electric motors and labeled diesel engines. The driver must be selected to provide the maximum horsepower required by the pump anywhere along its performance curve.

(By way of explanation, spark ignition internal combustion engines and dual drives – a motor and an engine as alternate drivers on the same pump – have not had NFPA approval since the 1974 edition of Pamphlet 20)

Most stationary fire pumps are driven by electric motors. To justify the use of an electric motor, a single power station or substation which can guarantee virtually uninterrupted power is preferred. If the source cannot guarantee continuous power, the power must be supplied by two or more stations located and equipped so that an accident or a fire at one will not cause an interruption of the power supplied by the other.

An acceptable alternative for electric motor driven pumps is to use commercially available electrical power and add a diesel engine driven emergency generator set. When alternative sources of electrical power are used, all on-site electrical switching equipment must be of the automatic transfer type.

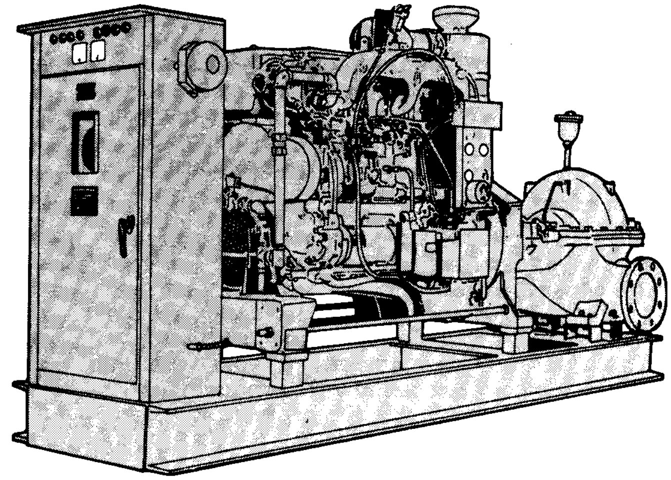

FIGURE 5. Packaged diesel engine driven horizontal split case fire pump.

Ordinarily there is no reason to avoid selecting the least expensive motor – an open drip-proof (ODP) squirrel cage induction motor with across-the-line starting. However, if required, weather protected I or II (WP1 or WP2) or totally enclosed fan cooled (TEFC) motors may be used. Depending upon city codes and the current available for starting, wound rotor, star delta, wye delta, primary resistance or part winding start motors may be used.

Labeled diesel engines are frequently used to drive stationary fire pumps. Equipped with battery packs and automatic controls, they rival electric motors for reliability and eliminate concern over the dependability of the source of electrical power. However, they do require additional considerations.

Diesel engines are rated to produce their maximum horse powers at 500 feet altitude above sea level and 85°F ambient air temperature. As these conditions change, the following deductions apply:

1. Reduce horsepower by 3% for each additional 1,000 feet of elevation.
2. Reduce horsepower by 1% for each 10°F above 85°F ambient air temperature.

If the listed engine with the required horsepower is not available, the engine chosen must produce at least 10 horsepower more than the maximum brake horsepower required by the pump anywhere along its performance curve.

If a right angle gear drive is used (as with a vertical turbine pump) the engine's horsepower requirement must be increased to compensate for the gear loss.

The minimum temperature of the room or pump house in which the engine is installed must be specified by the engine manufacturer, usually 70°F. An automatic engine water pre-heater is required to maintain the water jacket temperature at a minimum 120°F or at or near some higher operating temperature. A heat exchanger is required. Pressurized water from the fire pump passes through the heat exchanger through piping in accordance with NFPA 20 recommendations, arranged as follows:

Approved flushing type strainer indicating manual shutoff valve at entrance

Pressure regulator, which might include an integral strainer

Automatic electric solenoid valve indicating manual shutoff pressure gauge

Bypass line, also equipped with two manual shutoff valves and flushing type strainer

Each labeled engine must also be equipped with a governor capable of regulating the engine speed, through that part of the pump operating range between maximum load and shutoff, with an accuracy $\pm$ 10%.

The engine must also be equipped with a shutdown device which will limit the engine to approximately 120% of its maximum rated speed; once actuated, this device must be manually reset.

An instrument panel secured to the engine at an appropriate place must include a tachometer, an hour meter, an oil pressure gauge and a water temperature gauge.

Occasionally one encounters an application for a fire pump driven by a steam turbine. Although no labeled steam turbine is available, its use is acceptable if a dependable source of steam is available.

Fire Pump Controllers

Most modern fire pumps are started automatically. Starting is initiated by a pressure signal from the pump discharge line. Each fire pump must have its own labeled controller. Each jockey pump normally has its own non-labeled controller.

Depending upon the requirements of the application, fire pump controllers for electric motors are available in NEMA 2, 3 or 4 enclosures. Each controller must be arranged to match the starting characteristics of its motor and must include:

-Manual disconnect switch Circuit breaker
-Starter without heaters or contactors
-Pressure switch
-Minimum run timer, to prevent motor cycling

The diesel engine controller is arranged to permit either automatic or manual start. The manual start mode is required to permit periodic run tests. The power source for the controller and for starting the engine is a dual set of batteries. The controller is arranged to show the following engine conditions:

-Low lubricating oil pressure
-High water jacket temperature
-Failure to start automatically
-Shutdown due to over speed
-Battery failure. On the panel, each battery has a light to indicate battery failure.

The engine controller must also provide the means of relaying the following information to remote indicators:

-Engine is running
-Engine switch is in "off" or "manual" position
-Trouble signal. This signal is activated by one or any combination of the engine or controller signals described above.

Engine controllers are now available which include built-in battery chargers.

The jockey pump controller, non-labeled, is a combination starter with a pressure switch, a minimum run timer and either a fusible disconnect or a circuit breaker. The jockey pump's function is to keep the system pressurized so that the main fire pump(s) will not start in response to extraneous low pressure signals.

Fire Pump Fittings

Various fire pump fittings, more or less peculiar to the fire pump industry, are available from fire pump manufacturers. These include:

A. Common to both horizontal and vertical pumps:

Automatic air release valve – used with automatic systems for venting entrapped air.

Hose valve head with hose valves, caps and chains – used to permit pump flow (capacity) tests. Most modern systems use flow meters in lieu of hose valve heads.

Drain Valve – installed upstream from a hose valve which is installed outside to prevent freeze damage.

Overflow cone – shows visually whether relief valve is open.

Commercial discharge tee with (if required) 90° elbow – used when main relief valve is required.

Main relief valve – required when the pump shutoff pressure plus the suction pressure exceeds the system design pressure. Also required when an engine or other variable speed driver is used.

B. Used with horizontal pumps:

Eccentric suction reducer – required when the size of the pump suction does not match the size of the suction pipe.

Concentric discharge increaser – required when the size of the discharge pipe does not match the discharge size of the pump.

Splash partition – used for motor driven units where the hose head valves are mounted indoors near the pump.

Casing relief valve – to prevent a no flow condition when the system is running at shutoff.

C. Used with vertical pumps:

Water level testing device – to determine distance to surface of water. Required for well pump installations.

D. Required with all engine driven pumps:

Dual set of lead-acid or nickel cadmium batteries with racks and cables.

Fuel tank with gauge and fittings. Size the tank to meet the requirements of the authority exercising approval.

Muffler. Fire pump mufflers permit much of the engine noise to escape. Since engines run only during fire emergencies and during periodic tests, engine noise is not usually a problem.

Flexible connector for engine exhaust.

Summary

The fire pump system designer is encouraged to obtain and review a current copy of NFPA Pamphlet 20, enlist the aid of a fire pump manufacturer's specialist and obtain preliminary design approval from the "local authority having jurisdiction". These techniques can materially reduce the time, effort and cost associated with producing an effective and acceptable fire protection system.