4

Room Requirements

4 Room Requirements

4.1 Overview

The SF902 Test system should be installed in a facility with proper lighting, cooling water, ventilation, exhaust and fire control system. The plans on the following pages are our suggestions for this room. These plans are suggestions only. SuperFlow does not certify that they are suitable for your application. Before beginning construction, have your construction plans checked for compliance with local building codes and zoning requirements.

4.2 Room Recommendations

A dynamometer engine test cell is not required for use with SuperFlow dynamometers. The dynamometer may be operated temporarily in any open area or outside of a building if desired. The test cell is primarily for controlling the test conditions around the engine, sound isolation, and for operator convenience.

When deciding to build a test cell, there are many things to consider. The plans provided by SuperFlow are only one of many possible solutions. Even though these plans are designed for a water brake dynamometer, they may also apply to Eddy Current systems.

4.2.1 Construction

The test cell must be large enough to make it easy to install and remove the engine, and to work on the engine while it is in place on the dynamometer. Having the dynamometer test cell larger than the minimum required may make it difficult to control the air flow through the cell, and the cost will go up with increased wall and floor area.

A recommended minimum length for the test cell is 12ft (3.6m) and a maximum length is 15ft(4.9m). The width should be a minimum of 10ft (3m) and a maximum of 12ft (3.6m). Minimum ceiling height is 10ft (3m).

The operator console should be located outside the test cell and it should never be located to the side of the engine. If the engine or dynamometer should fail, parts could fly out radially from the engine and injure the operator. It is recommended the operator sit in-line with the crankshaft for maximum safety.

The viewing window should extend from the top of the operator console to a point high enough that a standing operator can see all of the engine and dynamometer. At a minimum, the window should be as wide as the console. The sound isolation provided by the window is much less than provided by the walls of the dynamometer test cell. If the window is unduly large, it may rattle or transmit excessive noise into the operator area.

It is best to use either two or three panes of glass in the window. The inner pane should be at least 1/4" (6mm) thick with polished wire reinforcement in the center of the pane. The wire reinforcement prevents the glass from cracking in the event of fire, allowing air to enter the room. The second pane should be 1/2" to 1/4" thick (6 to 12mm). If a third pane is added, it is desirable to place the pane at an angle so that it is not parallel to the other two panes. The angle helps reduce transmitted sound vibrations. The area directly opposite the window should be a dark or unlighted area so strong reflections will not be seen by the operator when viewing the engine.

The lowest cost wall construction is to use staggered wood studs with gypsum board wall surfaces. For best sound attenuation, use two layers of 1/2" (12mm) gypsum on the inside wall, and one layer on the external wall. The wall studs should be narrower than the base plate so that they contact only the inner or the outer wall at each point. Two-by-four inch (2" x 4") wall studs on 24-inch centers on a two-by-six inch (2" x 6") base plate work well. By preventing contact between the inner and the outer wall studs, low frequency sound transmission is reduced. The empty space between the inner walls should be filled with fiberglass or rock-wool insulation.

A second alternative is to use a concrete block wall. When constructing the wall, fill the empty spaces in the concrete block with concrete, sand, or vermiculite. A third alternative is to use a poured concrete wall 6" to 8" (15 to 20 cm) thick.

Steel door frames and steel sheet metal doors are recommended for fire protection and longer life. If a wood door is used, make sure it is a solid core exterior door at least 1 3/4" (5cm) thick. For additional sound attenuation, place the door further from the operator position. It is also possible to use a double door or an intermediate air space between two exit doors.

Use two overhead fluorescent lights of at least 80 watts. Paint the room light colors to reflect additional light around the engine. We recommend fluorescent lights with protective covers designed for outside use. In a cold climate, obtain fluorescent light ballasts that will operate at the lowest temperatures expected in the room.

The fuel supply should be located outside of the test area. There should be a shut off valve at the supply tank and one inside the test cell for safety purposes.

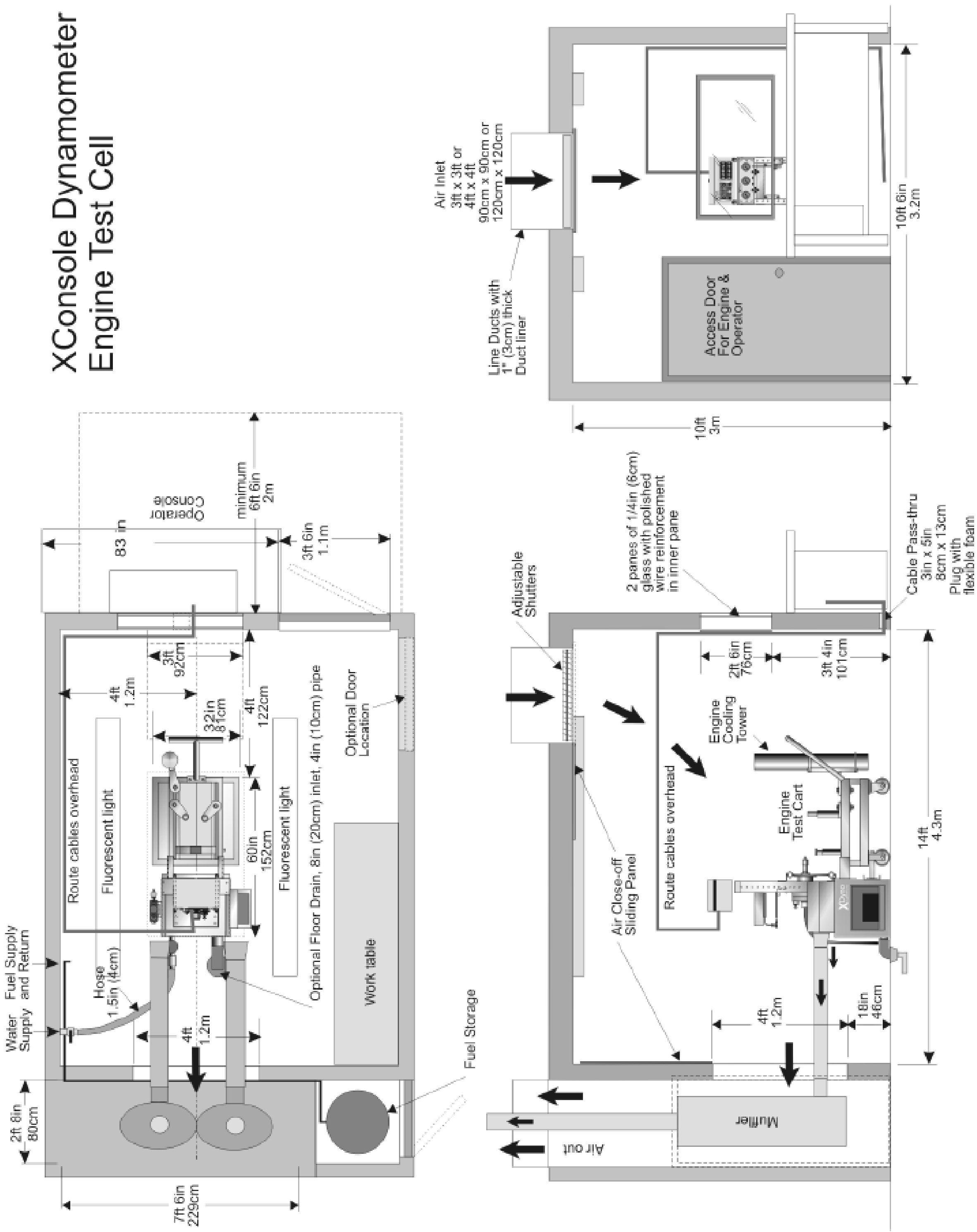

Figure 4-1 Engine Test Cell

4.2.2 Water System

The SF902 dynamometer test system requires water for the absorber and also for the engine cooling tower, if the engine is water cooled. The water flow requirement is 1 gpm for each 10 hp produced by the engine at a pressure of 35 psi minimum, (5 lpm per 10 kW at 240 kpa). For air cooled engines, the above flow rates may be reduced by one-half.

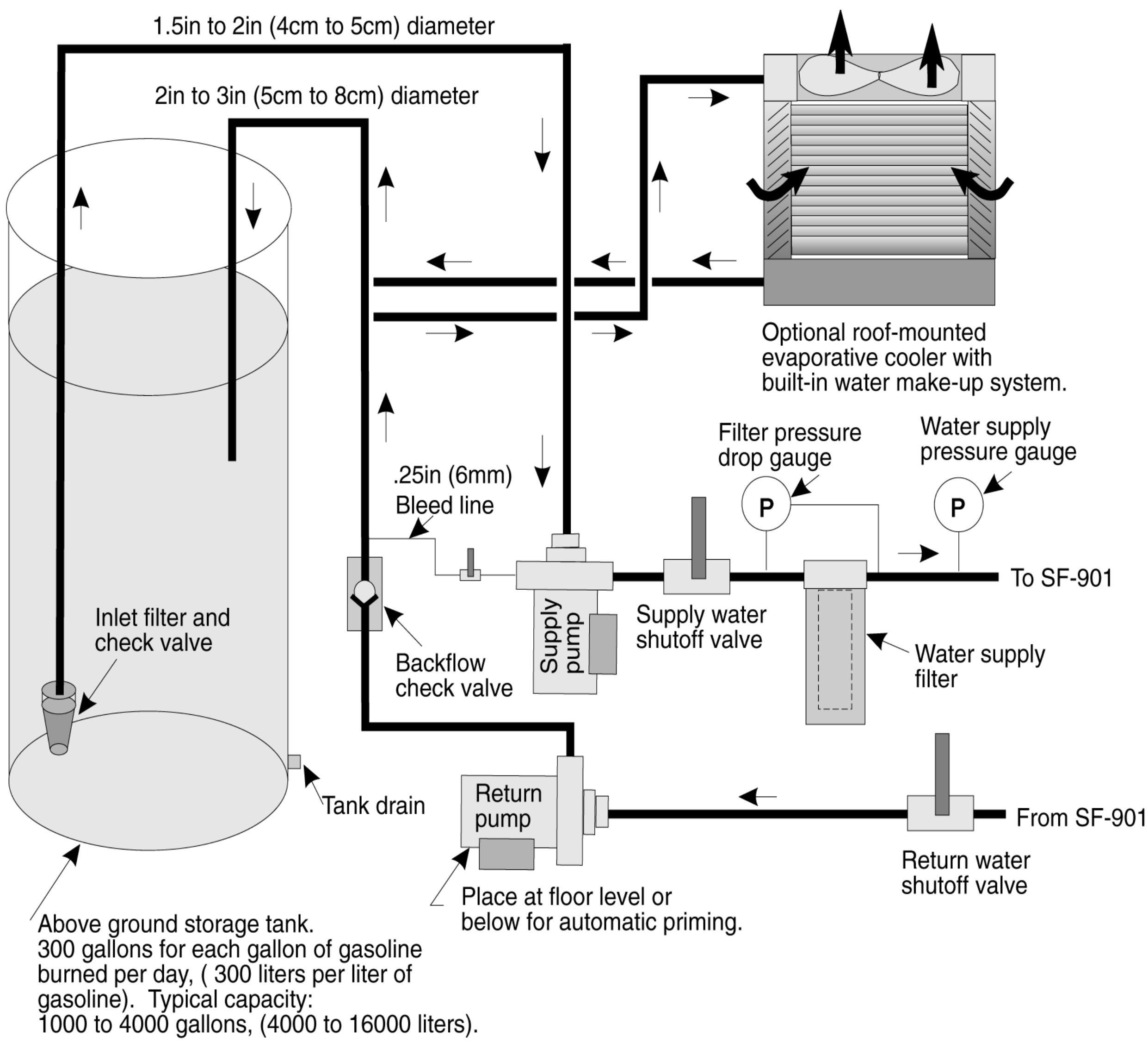

Figure 4-2 Engine Test Cell Water Recirculating Supply System

4.2.2.1 Supply

The water supply system may be an open system with water supplied from the city water supply, or a closed system which recirculates the water through a tank, and possibly a cooling tower. Typical city water systems for homes will only deliver an adequate water supply for engines up to 100 horsepower (75 kW). If the test cell will be located in a commercial establishment, a water meter at least 1 1/4" (3 cm) in diameter will be required for the average 600 horsepower (450 kW) engine.

The standard SF902 is supplied with a 1.5" (40 mm) diameter inlet on the sump tank. This valve is designed to operate with water supply pressure up to 110 psi (700 kPa). Whether a city water supply or a recirculating system is used, capacity of the water supply can be tested by placing a control valve and a pressure gauge at the end of the supply line. The pressure gauge should be on the supply-side of the control valve. To determine the maximum flow rate, fill a container of known size with water and time how long it takes to fill. When performing the test, open the control valve until the pressure gauge reading is 35 psi (240 kpa). This allows for measuring the flow at the required supply pressure. If the flow capacity is measured with no back pressure (free flow), the test conclusions may be incorrect.

If a closed water supply system is used which recirculates the water during the test, the diagram shown in Figure 4-2 may be followed. The storage tank should have a minimum capacity of 300 gallons for each gallon of gasoline burned per day (300 liters of water for each liter of gasoline). Typical capacities are 1000 to 4000 gallons (4000 to 16000 liters). We recommend a metal or plastic tank located above ground level. Tanks located below ground level cool much more slowly. In areas which are cold in the winter, be sure to provide adequate protection from freezing for the tank, pumps, and supply lines.

The supply pump should be located well below the water level in the tank so it will prime automatically. For below grade tanks, or when the pickup inlet is installed through the top of the tank, a foot valve or check valve will be required to maintain prime. Tanks with a tap in side of the tank near the bottom would not require a foot valve. Locate the return pump at floor-level or below so it will be primed automatically by the dynamometer sump tank. If that cannot be done, it will be necessary to install a float switch in the dynamometer sump tank to turn the pump off and on during operation and a foot-valve to maintain prime.

Suggested models for the pumps are shown in Section 4.3.

4.2.2.2 Cooling

For the SF902 system to operate properly, the outlet temperature of the dynamometer water should be kept below 160 Degrees F (70°C). If the outlet temperature exceeds this value, the dynamometer control may become erratic and the engine may runaway. To prevent this from happening, the inlet water temperature should be kept below 100°F (38°C). For tests above 4000 rpm, the inlet water temperature should be below 80°F (27°C). **The temperature rise of the dynamometer increases with engine speed.** A typical tank will cool down within 24 hours to its initial temperature if the above capacity guidelines are followed.

As a rule for open water systems, the typical mean temperature for commercially provided water will stay within a few degrees of the average yearly ambient temperature for the area.

If continuous testing is planned, or if a large capacity tank cannot be supplied, or if the dyno located in a very hot area where the water will not cool properly, additional cooling will be required. The least expensive cooling system is generally an evaporative cooling tower mounted on the roof of the building. The size depends on the local temperature and humidity. The higher the temperature and the higher the humidity, the larger and more expensive is the evaporative cooling tower. If a roof mounted evaporative cooling tower is used, a larger line from the cooling tower to the storage tank will be required than for a simple closed system. The cooling tower could be mounted above the storage tank so that an additional return pump will not be required.

4.2.2.3 Filters and drains

For both city water and recirculating systems, a filter should be located in the test cell to clean all the water before entering the sump tank and engine cooling tower. Install a pressure gauge on either side of the inlet supply filter so it can be determined when the filter is clogged, and to insure adequate pressure is available for the dynamometer during testing. The water should be filtered to remove 0.004 inches (.1mm) diameter particles. SuperFlow Filter Part Number SF-WF-1 is available. A filter on the return side in recirculating systems back to the supply tank can help prevent particles from the engine and dynamometer sump tank from getting into the supply water system.

If a city water supply is used, and the water will be exited from the dynamometer into the sewage system, install a floor drain at the rear of the dynamometer as shown in the drawing. Place a right angle elbow on the water outlet from the dynamometer to exit directly into the drain. If a floor drain cannot be installed, it is essential the line connecting the dynamometer and the drain be at least 3" (8 cm) in diameter so there will be very low flow losses. Use 4" (10cm) for continuous operation above 750hp, (560kW) if there is only a gravity drain, or use a sump pump with a float switching the sump outlet tank. If the drain it is not large enough, the water will backup in the dynamometer sump tank and back-flow into the dynamometer inlet water side, causing rapid overheating.

Some local codes restrict use of city water in test systems of this type without backflow prevention, or of depositing engine waste water into an open sewage system. Always consult the local authorities before installing an open water system for a dynamometer.

4.2.2.4 Quality

Contaminated, salt, or hard water can reduce the life of the absorber and pumps, and increase the maintenance costs. The quality of the water can effect the life of the control valve and water seals by as much as a factor of ten. For optimum results, we recommend water with the chemical composition and purity levels listed in Table 1.

Table 1: ***Suggested average properties for dyno inlet water***

Property	Units	Open System	Closed System
pH		7-9	7-9
Total Hardness	Deg.dH*	<30	<35
Total Salinity	mg/1	<2500	<2500
Nitrates	mg/1	-	<50
Chlorides	mg/1	<150	<150
Sulfate (SO3)	mg/1	-	<150
Manganese	mg/1	<0.15	<0.015
Organic Substances	mg/1	<5	<2
Coarse Solids	mg/1	none	none
Solids in Suspension	mg/1	<5	<2
Free Oxygen	mg/1	<0.05	<0.05
Iron	mg/1	<1	<1
Free Carbon Dioxide	mg/1	<20	<3
Iron	mg/1	<1	<1
Oils	-	none	none
Algae Growth	-	none	none
Silicates	-	none	none

For closed water systems, water treatment is available from various suppliers which are listed in the phone book yellow pages under “water treatment”.

4.2.3 Room Ventilation System

Room ventilation is one of the most commonly over-looked aspects of engine test cell design. If the temperature of the room goes up and down during a test, or if any exhaust gas recirculates within the room, the test results will vary in an unpredictable manner. Both the direction of the air flow and its quantity are critical for repeatable test results. Figure 4-3 illustrates some of the principals to be utilized in designing the test cell.

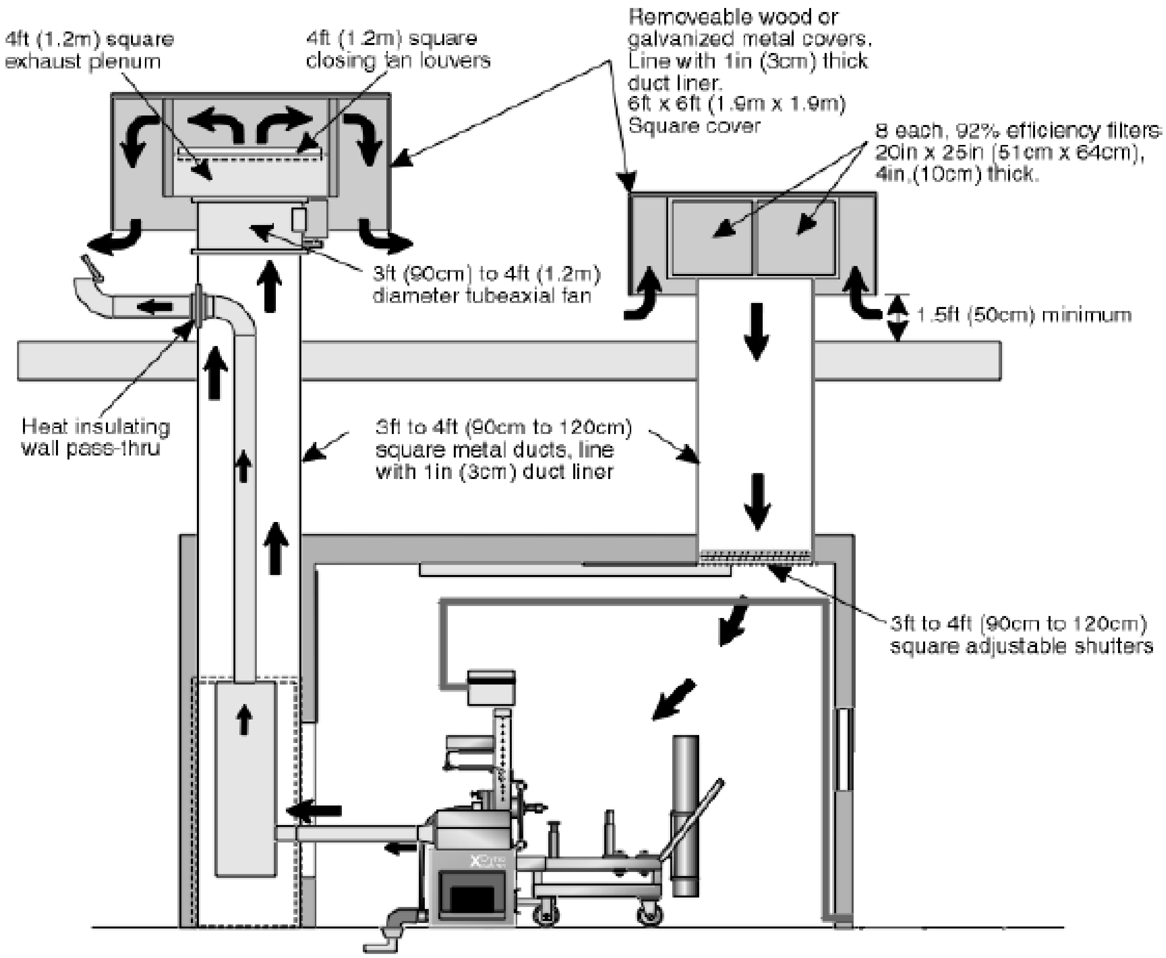

Figure 4-3 Engine Test Cell Ventilation Exhaust Systems

The air should enter at the front or top of the cell and flow across the engine to the rear of the cell. The exhaust pipes should be directly in the air flow so any leaking exhaust gases will be carried out with the main stream of air and not recirculate back to the intake of the engine. The air flow should be directed so any smoke or oil vapor will not obstruct the operator's view nor coat the operator window. The flow should be one-directional to reduce the likelihood of eddies and return flow.

We recommend adjustable shutters on the inlets so the flow direction can be adjusted as required. We also recommend close-off shutters on the intake and exhaust so the room may be sealed-off to prevent freezing in cold climates.

We recommend filtering the inlet air to engine-air-cleaner-quality so engine air cleaners will not be required on the test engines. This may be accomplished with air filters known as "92% Efficiency Filters". These are made of engine air cleaner type material and are much more efficient than typical furnace filters. Furnace filters are only effective on air that is recirculated again and again through the filter. In a test cell, the air passes through the filter only once.

When the engine runs, it radiates heat from all of its external surfaces and also from its exhaust pipes. The larger the engine, the greater the heat load on the room. Most heating and ventilation system designers will probably underestimate the amount of air flow required for your room. We recommend an air exchange rate of 8 to 10 times per minute

To overcome the flow losses caused by the filters and ducts, a tube axial propeller blade type fan is required. Most squirrel-cage type blowers will not operate against the higher pressure drop caused by this design. Suggested fans are shown in Section 4.3.4. When selecting a fan, choose one with adequate flow against a pressure of 1- to 1.5-inches of H2O (2 to 3 cm of water) pressure. It is also desirable to add an inclined manometer so the pressure drop across the filters can be measured when the fan is on. When the pressure drop doubles from the initial point, it is time to replace the filters.

Once the room is completed, check the air flow. Attach a piece of cloth or tissue onto a long stick and explore the direction of air flow through the room. Make sure the engine intake and engine surfaces are in the area of high flow. Check to make sure the air is not recirculating back into the engine intake after it passes over the exhaust pipes.

The fan should be located on the outlet to the room so all exhaust and oil smoke will be removed from the room even if the operator door is open. If the fan is on the inlet side, it will blow the smoke out into the operator area when the door is open. Some systems use fans on both the inlet and outlet and balance them to obtain approximately zero pressure difference in the room with the door closed, so pressure will not effect the test results. In most cases, the pressure is only one inch (2.5 cm) of water or less, and has no significant effect on the engine power. This pressure is also the same from test to test, further reducing that effect.

If noise is not a problem at all and you are running air cooled engines, a simpler approach is to mount the fan in the back wall of the dynamometer test cell.

For very sophisticated systems, it is possible to heat or cool the incoming air to maintain a constant temperature and humidity in the test cell. For high powered engines, the flow rates and the energy required are very high, and the cost of the equipment can be much greater than the cost of the rest of the test cell. For most cells, this is not a cost effective solution.

The repeatability of the test results can be improved by using a special duct to lead air from the operator area into the engine. Drawing air for the engine from inside the building reduces the temperature variations throughout the year. The engine air flow rate will be approximately 1.6 cfm per hp (60 l/m per kW). The area of the ducts should be a minimum of 5 to 10 times the area of the engine air inlet. If a separate engine supply duct is used, The engine air flow sensor and air temperature/humidity sensor can be permanently installed in the duct.

4.2.4 Engine Exhaust System

An engine exhaust system is almost always required in a dynamometer test cell to prevent exhaust gas recirculation and to control the sound level in the cell. If the diameter of the test cell exhaust system pipes is at least twice the diameter of the engine exhaust pipes, the effect on the power will generally be negligible. The chart below shows the recommended minimum pipe diameters for the power level of the engine connected to each exhaust pipe. For larger high powered engines, it generally best to use two exhaust pipes and two mufflers.

An exhaust back pressure of approximately 1-inch of Hg (3 kpa) will cause a power loss of approximately 1%. The pipe diameters proposed here will usually cause a much lower pressure loss, but the back pressure of the installed exhaust system should be measured at full power to be sure.

The mufflers shown on Figure 4-3 are manufactured by Donaldson and are available in five-inch (SF-ES-500), six-inch (SF-ES- 600), and eight-inch (SF-ES-800) inlet sizes. We recommend these industrial style mufflers instead of normal vehicle type mufflers to reduce the power loss without increasing the back pressure on the system. If the engine is tested with the standard vehicle exhaust installed, we recommend the standard system be placed between the engine and the larger industrial mufflers, because the losses caused by the larger mufflers will be insignificant compared to the losses caused by the typical street system.

Table 2: Exhaust Pipe Diameters

kW/Exhaust	Pipe Diameter	hp/Exhaust	Pipe Diameter
7.5	7 cm	10	3"
75	10 cm	200	4"
150	13 cm	300	5"
250	16 cm	450	6"
350	20 cm	800	8"
500	23 cm	1000	9"

By placing the exhaust system inside the exit ventilation duct, all heat and exhaust gas losses are carried away with the room ventilation air. Use a heat insulating bulkhead connector where the exhaust pipe exits the air duct. These are standard items designed for furnace exhaust stack roof penetrations.

4.2.5 The Engine Fuel System

The fuel supply should always be located outside the test room in a separate enclosure for fire protection. Provide a means to shut off the fuel at the fuel container, in the test cell, and from the operator console. If the system uses the SuperFlow pump with a bypass fuel return, the fuel return must be routed from the dynamometer stand back to the fuel supply container. If no fuel return path is provided, the pump will overheat and be damaged. The fuel supply and return lines should have a minimum inside diameter of 0.5 inches (13 mm).

Local zoning codes may prohibit storage of large quantities of fuel above ground or inside the building. At some facilities, most testing is done with five-gallon cans with only one can in the building and connected at a time. For zoning purposes, most districts accept that this is a temporary engine installation and is not required to meet the codes for permanently installed stationary engines. The total fuel required for most test cycles is less than that found in the tanks of most automobiles in repair garages. Check with local authorities to determine the requirements.

If more than one type of fuel will be used in the test cell, we recommend completely separate fuel systems. It is very time consuming, and sometimes very confusing, to mix the fuel delivery through the same lines.

4.2.6 Sound Control

For most test cell installations, sound control is very important if tests are to be run frequently. A properly designed test cell can reduce the sound level by 40 to 50 db between the inside of the cell and the operator position. The first requirement is that the exhaust system be tightly sealed to the muffler system so that no sound leaks occur. For temporary installations, this is surprisingly difficult to achieve. With the engine running in the room, listen for any obvious exhaust leaks and watch for escaping exhaust gas. If exhaust gas is detected in the room, it is leaking and the engine power may be affected.

If the walls of the room are constructed as described in the Section 4.2.1, the room should provide good sound attenuation. Most of the sound will exit the room through the door, the window, and any leaks through the walls. Be sure all electrical boxes are caulked all the way around their penetration through the wall, and even caulk all of the small screw holes in the electrical box. Caulk around the wires where they enter the conduit. Sound travels very well down long tubes.

Use special sound control insulation on the door and a lowering threshold at the bottom of the door. These special devices push down against the floor when the door is closed. They are available from building supplies. One of the manufacturers is Sonitrol. Also caulk all around the window panes during installation. Make sure all joints are filled in the gypsum board surrounding the room.

Most rooms are finished with semi-gloss painted walls so that they will be easy to clean and reflective for better lighting. It is possible to further reduce the sound level in the room by putting absorptive pads on the walls. These are typically one to two inches (2 to 5 cm) thick and covered with perforated metal. They are available from various sound control companies. It is not necessary to cover all the walls in order to substantially deaden the room. Sound absorptive pads on 25% of the total surface area will make a significant difference.

Plug the cable pass-through hole between the engine console and the dynamometer with large blocks of compressible foam. Also caulk all around the external switch plates and holes in the test cell wall. The inlet and outlet ventilation ducts should be lined with a minimum of one inch thick (2.5 cm) duct liner to prevent transmission of sound out the ducts. The removable covers on the roof should also be lined with duct liner. The sound now has to bounce back and forth across duct liner through several direction changes before exiting at the roof of the building. Make sure the duct liner is well adhered to the wall of the duct so it will not be blown loose by the high-velocity air. Never use duct liner in an area where you will be exiting exhaust gases that are not enclosed in a pipe. The duct liner will pick up oil and unburned fuel and become a fire hazard.

The pumps recommended for closed circuit water systems are also very noisy. They should be enclosed outside of the room to reduce noise transmission.

4.3 Equipment Sources[1]

Below are listed some of the common equipment sources for items used in a engine test cell. These are all U.S. Companies, but equivalent products may be available in other parts of the world.

W. W. Grainger	Pumps, Fans, Ventilation, Foot Valves
Donaldsons	Mufflers
Riker	Exhaust Pipe Components
Sonitrol	Door gaskets

These are recommendations and suggestions only. There may be other brands and models that will be suitable for the applications as long as the minimum specifications are met.

4.3.1 Water Supply Pumps

These are for supplying water from a storage tank to the dynamometer. Minimum specifications for the SF902 is 1gpm per 10hp produced by the engine at 35psi (5 l/m per 10 kW at 240 kpa).

Part No.	Flow @26psi	Dyno Power	Motor	Inlet/Outlet
3P605	90 gpm	600 hp 450 kW	3 hp, 3Ø 240VAC	2" / 1.5" Flange

1. Part numbers are from W.W. Graingers 2001-2002 Catalog
Phone 1-800-473-3473, or on the web at: www.grainger.com.

4.3.2 Water Return Pumps

These are for returning the water from the absorber sump to the storage tank possibly through a cooling system. The important consideration here is to ensure the pump keeps the sump near empty.

Part No.	Flow @15psi	Dyno Power	Motor	Inlet/Outlet
1P897	100 gpm	1000 hp 750kW	2 hp, 1Ø 240VAC	2" NPT
1P955	100 gpm	1000 hp 750kW	2 hp, 3Ø 240VAC	2" NPT
3P706	230 gpm	1500 hp 2200kW	5 hp, 3Ø 240VAC	3" NPT

4.3.3 Foot Valve and Inlet Strainer

These ensure the supply pump maintains prime and filters the water before the absorber. SuperFlow offers two types of inlet water filters. These listed are from

Part No.	Dyno Power	Inlet/Outlet
5YM45	600 hp	1.5" NPT
5YM46	1500 hp	2" NPT

4.3.4 Ventilation Tube Axial Fans

Part No.	CFM @ 1"H2O	Dyno Power	Size	Motor
7F853	14,400	500 hp	34" 86 cm	5 hp, 3Ø 240 VAC
7F872	21,700	750 hp	42" 107 cm	7.5hp, 3Ø 240VAC
7F883	28,500	1000hp	48" 122 cm	10 Hp, 3Ø 240VAC

4.3.5 Ventilation Air Shutters

Part No.	Inlet Size
3C242	42" x 42", (107cm x 107cm)
3C243	48" x 48", (122cm x 122cm)

4.3.6 Ventilation Air Filters, (8 or more required)

Part No.	Size	Arrestance Rating Capacity, Each
2W237	20" x 25" x 4"	92% 1740cfm @ 0.22" H2O
2W239	24" x 24" x 4"	92% 2000cfm @ 0.22" H2O

4.4 Water Additives

A water brake dynamometer works best with clean, cold water at the inlet. This applies for the engine cooling system as well as the absorber. For closed water systems, additional water treatment and lubrication may be required to maintain the quality of the water and extend the life of the system.

Test methods and supply water conditions both affect the performance and life expectancy of a SuperFlow dynamometer system. Since these methods and conditions vary from place to place, specific recommendations cannot be made. The following section gives only general observations on additives and their use.

The only way to determine what additives may be required is to have the water tested and analyzed for content. Expert advice is available from various suppliers which are listed in the phone book yellow pages under “water treatment”. **At no time should additives be put into a water system without first knowing why they are required or if they are needed at all.**

4.4.1 Anti-Freeze

Depending on the winter climate, antifreeze may be required to protect against dyno water supply freeze-up. Some antifreeze formulas will foam inside the absorber. Foaming will cause loss of water stability and subsequent loss of dyno control. This spells disaster for a test. Only use antifreeze that has ingredients to reduce foaming in the absorber. Always follow the manufacturer's guidelines on the container. If control issues appear, then cease using the anti-freeze.

There are alternatives for freeze prevention. The best way of course is frequent dyno testing. That will keep the water circulating and warm. Heat tape should always be put on pipes that are running outside and the larger the mass of water the longer it takes to freeze. Depending on the climate, most large tanks can typically outlast the temperature change.

Other alternatives to antifreeze are:

- Blowing warm air into the bottom of the tank during cold spells.
- Adding a small pump to circulate water from the bottom of the tank through a heater and back to the top of the tank.

Both of these methods can use thermostatic control for unattended maintenance. All that is required is to keep the water moving and the temperature above or near freezing.

4.4.2 Anti-Corrosives

When considering protection from corrosion, it is best to first have the water analyzed. Then have a treatment company advise as to what would be appropriate considering the materials that are to be protected. In some cases the use of sacrificial anodes of magnesium for control of galvanic corrosion would be indicated or possibly other types of safeguards.

The absorber, sump tank, and engine cooling tower on a SuperFlow SF902 is built of Aluminum or Bronzed Aluminum where water is contacted. Copper lines are used along with brass and nickel-plated steel fittings on the stand. Other types of materials are used where they do not interact with water.

Water filters should be used on both the supply and return to reduce particles in the water supply. The filters must be cleaned or changed regularly.

4.4.3 Anti-Fungus

Algae will sometimes grow in a large body of water such as a dyno supply tank. Although it is unnecessary to maintain the PH quality of a swimming pool, some control of algae should be administered. As with any additive, the water should first be tested to determine if there is an algae problem and a local authority contacted for advice. Sometimes, simple algae can be control by adding one gallon of chlorine bleach per 1000 gallons of water.

4.4.4 Lubricants

The real benefit from water lubricants is in it's surfactant properties. Basically, a lubricant reduces the surface tension of the water allowing it to make better surface contact with the absorber and therefore improve its ability to conduct heat from the metal surface into the liquid. This help reduce the overall outlet water temperature.