Revision

3

TAYLOR DYNAMOMETER INC.

Engine Facilities Planning Guide Manual

Table of Contents

This manual was originally produced in 1984 through the joint efforts of a major Engine OEM's Service Tool Group and Taylor Dynamometer, Inc. It has been republished several times. Its intended use is as a guide during the planning phases of test cell construction. The information contained within this book is deemed to be reliable and accurate. Specifications and regulations vary from location to location and are always subject to change. Consulting Taylor Dynamometer, Inc. for the latest specifications as well as an approved room layout drawing is always recommended.

Please consult local regulatory parties, manufacturers of construction materials and engine manufacturers for actual specifications and recommendations.

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Introduction

The Taylor dynamometer is a specialized tool that provides the final level of quality assurance when testing an out of frame engine assembly. For proper operation and safety, a dedicated dynamometer test room or "Test Cell" should be constructed. The room and equipment must have the capacity to handle your present needs with enough reserve capacity for the future.

This guide has been created to provide facilities information for distinct arrangements of engine dynamometers:

- Single dynamometers from 375-7355kW (500-10,000hp)
- Tandem dynamometer arrangements from 750-5150kW (1000-7000hp)

Note: When testing an engine that is rated at 5-10% of dynamometer capacity, one may experience stability issues because the inertia of the dynamometer is far greater than that of the engine.

When choosing a dynamometer, consider the smallest and largest engines to be tested (see "Room Arrangements – Dynamometer Sizing").

The ranges of the engines to be tested as well as the projected production quantities dictate the room design.

The major differences between these installations are:

- Size of dynamometer
- Engine and dynamometer cooling system capacity
- Ventilation/exhaust system capacity
- Main fuel tank capacity
- Room design and size

Most of the information presented in the first three sections of this bulletin (Room Location, Room Arrangements and Room Sound Control) is required for the preliminary drawing phase. The information contained in the remaining sections covers construction details.

In all cases, local building construction and zoning ordinances must be followed. The requirements of all regulatory agencies must take precedence over these instructions.

Room Location

Relationship of Dynamometer to Engine Flow Path

The dynamometer room should be in, or near, the engine shop along the flow path between engine assembly and shipping/receiving to avoid unnecessary engine handling problems (see Illustration 1). It should be easily accessible to engine assembly, dynamometer preparation, cleaning and paint room, and shipping/receiving.

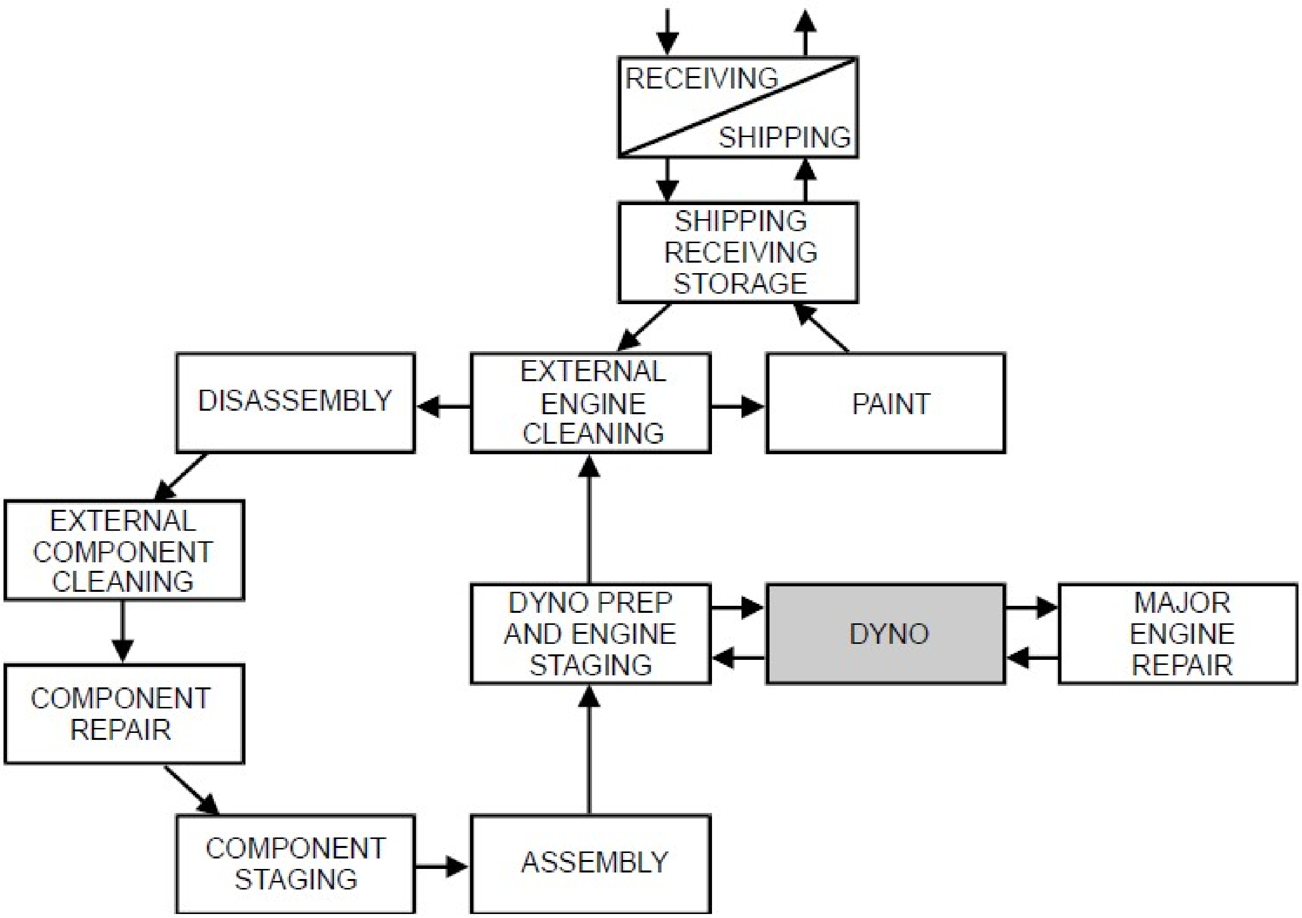


Illustration 1 – Engine Flow Path Diagram

Relationship of Dynamometer to Overhead Cranes

Engine carts are typically employed to transport and position engines for testing in the dynamometer room. It may be necessary for overhead cranes to pass over the dynamometer room. To prevent overhead crane interference with the dynamometer ventilation/exhaust system, the following restrictions apply:

1. At least one wall of the dynamometer room should be along one of the following:

    a. The exterior of the building (preferred to increase building sound control).
    b. An interior column line.

2. When the room location is not along an outside wall, but is along an interior column line, the following two conditions must be available:

    a. The shop overhead crane travels above only a portion of the dynamometer room ceiling.
    b. The adjacent bay does not have an overhead crane or other ceiling obstructions. This allows the ventilation/exhaust system to be diverted to the other side of the column line before extending to the roof.

3. You cannot use an exhaust hood if the shop overhead crane that travels over the dynamometer room has a hook height of less than 6.0 meters (20 feet).

Location of Dynamometer in Main Building

When the shop is in the main building, the preferred dynamometer room location is along an exterior wall (see Illustration 2). The ideal location places the dynamometer room on the parts warehouse side of the building. It should be away from the main office area and the center complex shop office for sound control. Effort should also be made to locate the dynamometer room away from the direction of expansion. If designed properly, as expansion occurs in disassembly, assembly and components, the dynamometer room will remain in the engine flow path between assembly and shipping/receiving.

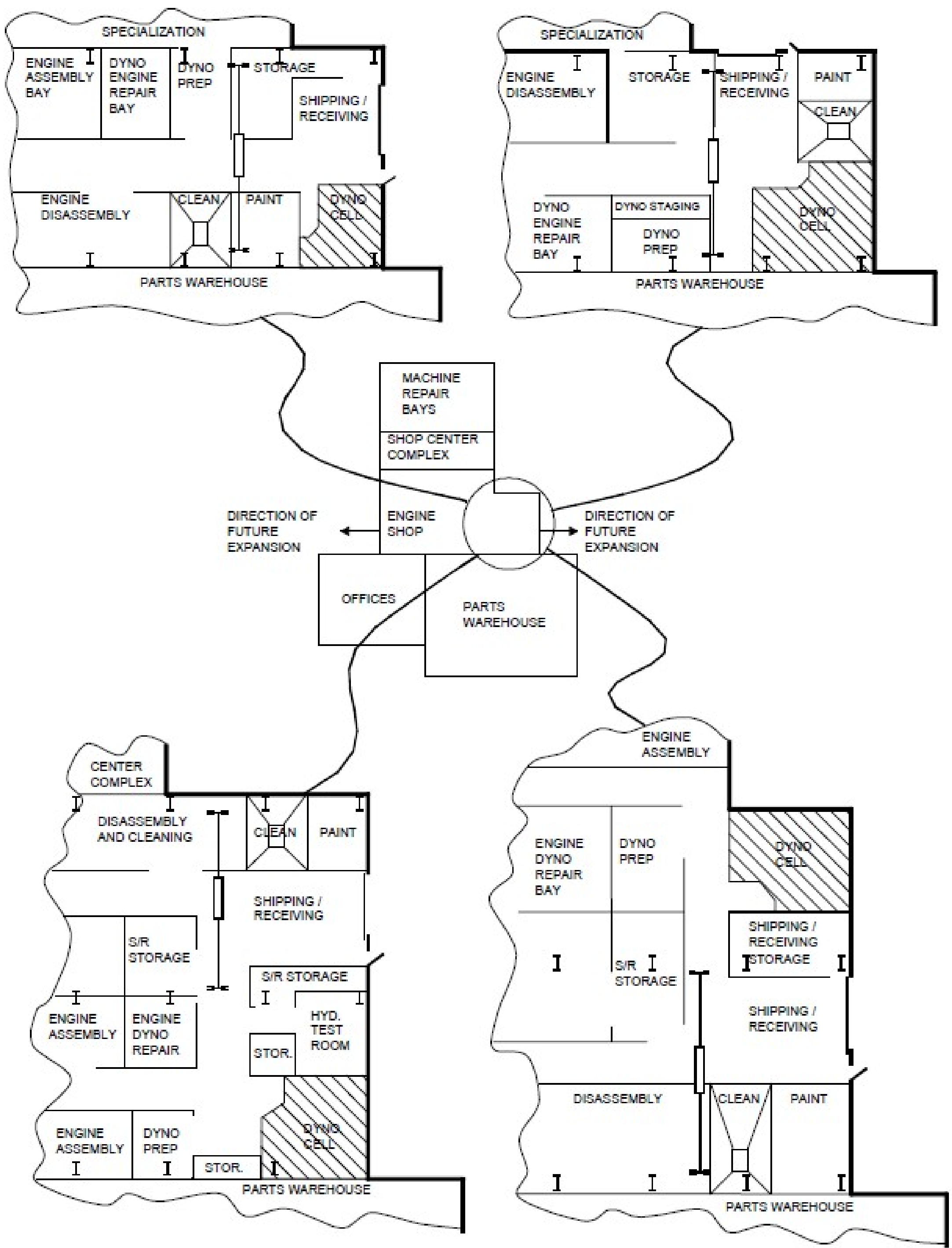


Illustration 2 – Dynamometer Test Cell Placement in Engine Shop

Location of Dynamometer when in Separate Facility

If engine assembly and testing is in a separate facility, the best location for the dynamometer room is along an exterior wall that is not in the direction of expansion (see Illustration 3) If building expansion occurs for enlargement of disassembly, assembly and the component areas, the dynamometer room should remain in the engine flow path between assembly and shipping/receiving Avoid locations near office areas to increase sound control.

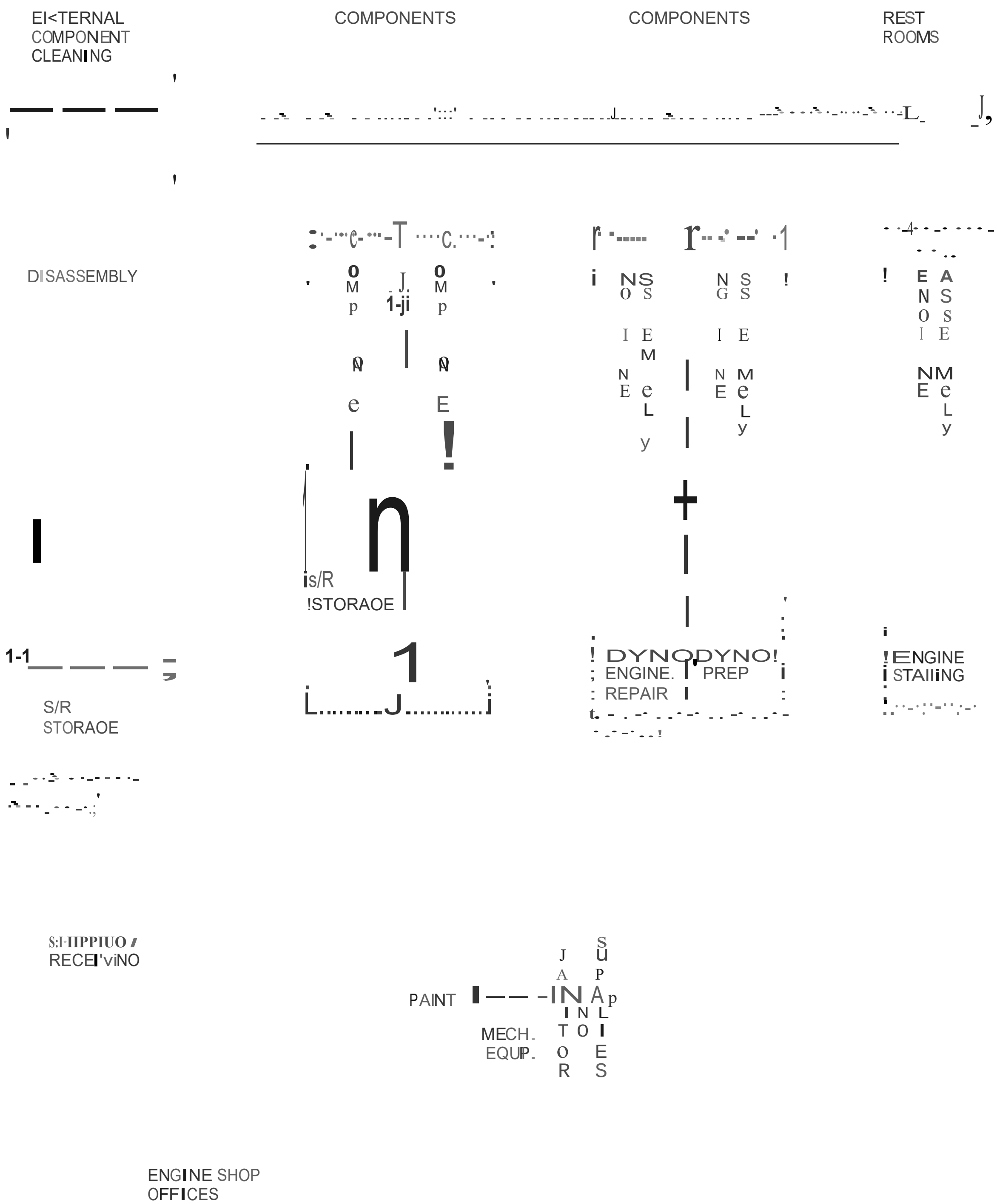


Illustration 3 -Overhead View of Engine Shop

General Room Design Criteria – Single Dynamometer Installation

The general dynamometer room and equipment nomenclature in this bulletin is shown in Illustration 4. The following information explains the layout of a dynamometer room and the major pieces of equipment for a single dynamometer installation.

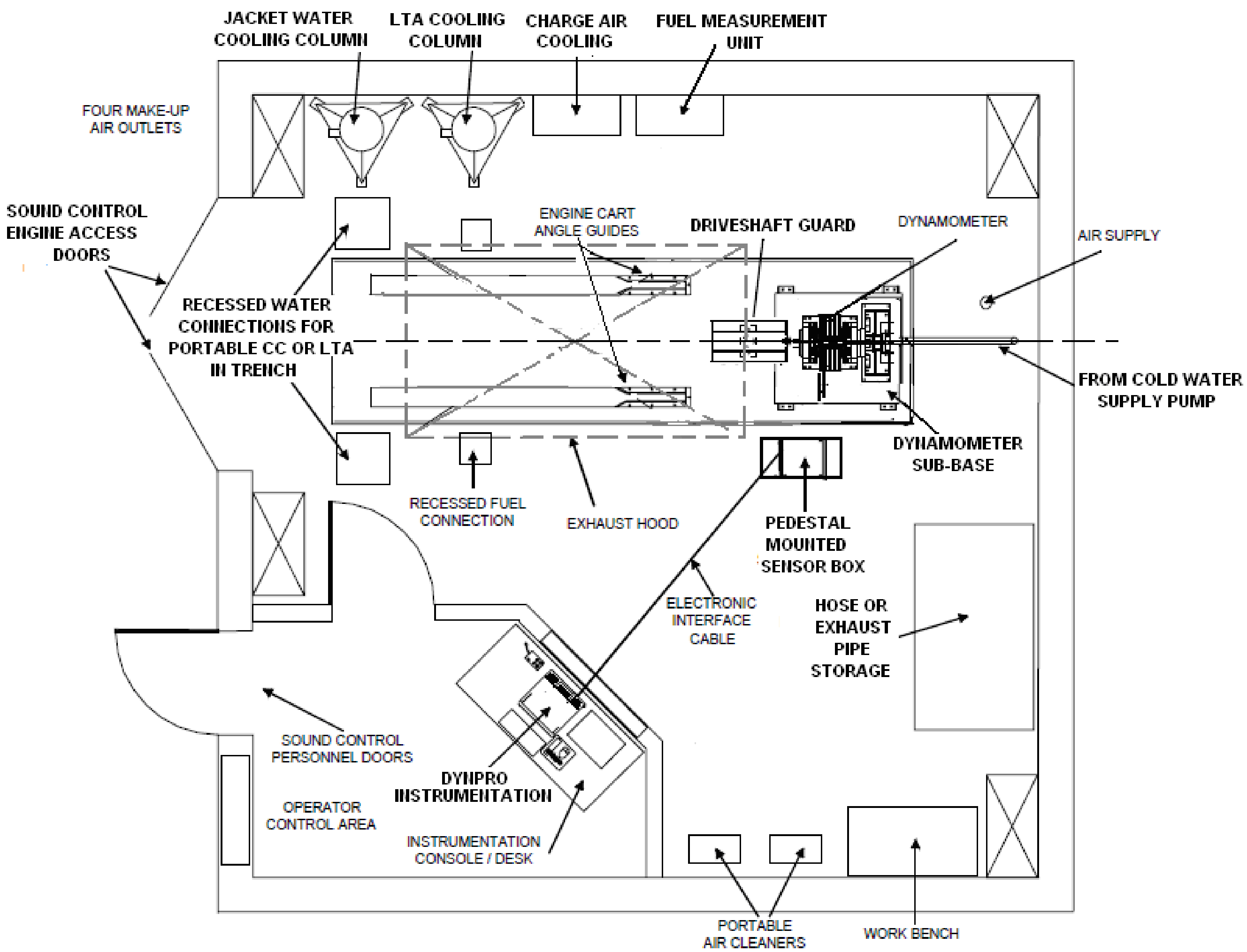


Illustration 4 – Identification of Test Cell Components

General Room Design Criteria – Tandem Dynamometer Installation

The following illustration (see Illustration 5) identifies the layout of a dynamometer room and the major pieces of equipment for a tandem dynamometer installation operated from one end. A tandem dynamometer system may be utilized to increase the power absorption capabilities when necessary while maintaining the ability to operate engines of comparatively small outputs at higher speeds by uncoupling one dynamometer. If the engine volume and space available justify it, a tandem dynamometer installation may be configured to test two engines at the same time when uncoupled. When coupled together, one engine of the combined capacity of the system may be tested on one end.

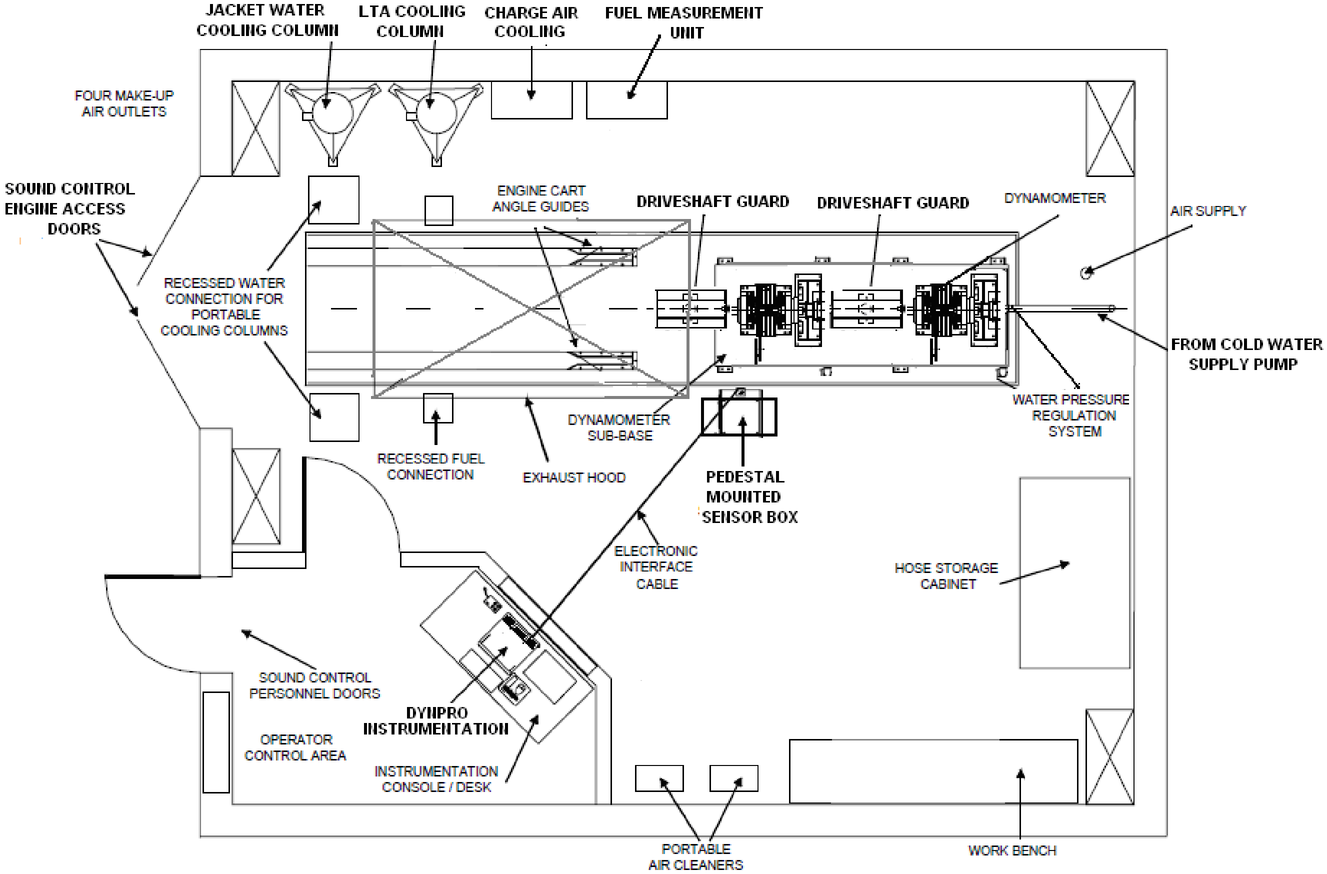


Illustration 5 – Identification of Test Cell Components, Dual Dynamometer, Single Ended Operation

Location of Instrumentation and Controls

The dynamometer controls and instrumentation should be outside the dynamometer room. A control room should be constructed to protect the operator from high sound levels and safety hazards. A control room also minimizes the effects of contamination of computerized instrumentation. Heating, A/C and humidity control may be necessary. The operator control area (see Illustration 4) should be positioned in consideration of the following:

1. Provide direct access between the shop and the operator's area without entering the dynamometer room. This feature allows promotes safety and convenience.

2. Allow efficient utilization of space by reducing the number of aisles. The same aisle used for moving engines into the room may also be used to enter the operator control area.

3. Facilitate good sales promotion because of access and visibility of the instrumentation.

4. The operator's booth observation window must be not directly across from the universal shaft or in line with the engine crankshaft pulley.

Design of the Operator Control Area

The operator's control area is typically enclosed to prevent unauthorized access to the instrumentation and to isolate the operator from distractions. For computerized instrumentation and controls, heating, A/C and humidity controls may be necessary. Construction of this area must provide safety. Consideration must be made for fire, noise and large projectiles.

A personnel door should be in the control area for direct access to the dynamometer room. A protective observation window(s) is required for the operator to see both the engine and the dynamometer. It is also helpful to see the portable cooling column at the front of the engine to observe a hose or connection break. This may require to windows.

There are two control area designs for the placement of the observation window. The preferred design has an angular corner (see Illustration 6 – Option 1). This puts an observation window at an angle for better visibility of the engine and dynamometer. The other design uses a square corner design (see Illustration 6 – Option 2) for placement of the observation window.

NOTE: For detailed description of windows and doors, refer to the "Room Sound Control" section.

Illustration 6 also shows additional arrangements of the control area. In some areas, local fire code regulations may dictate special construction. In situations where space availability is a problem and climatic conditions permit, Options 2 and 3 (see Illustration 6) may be used to reduce the width of the room. Option 4 depicts the preferred location for a tandem dynamometer installation.

Cameras may also be used for test cell viewing of engines and dynamometers.

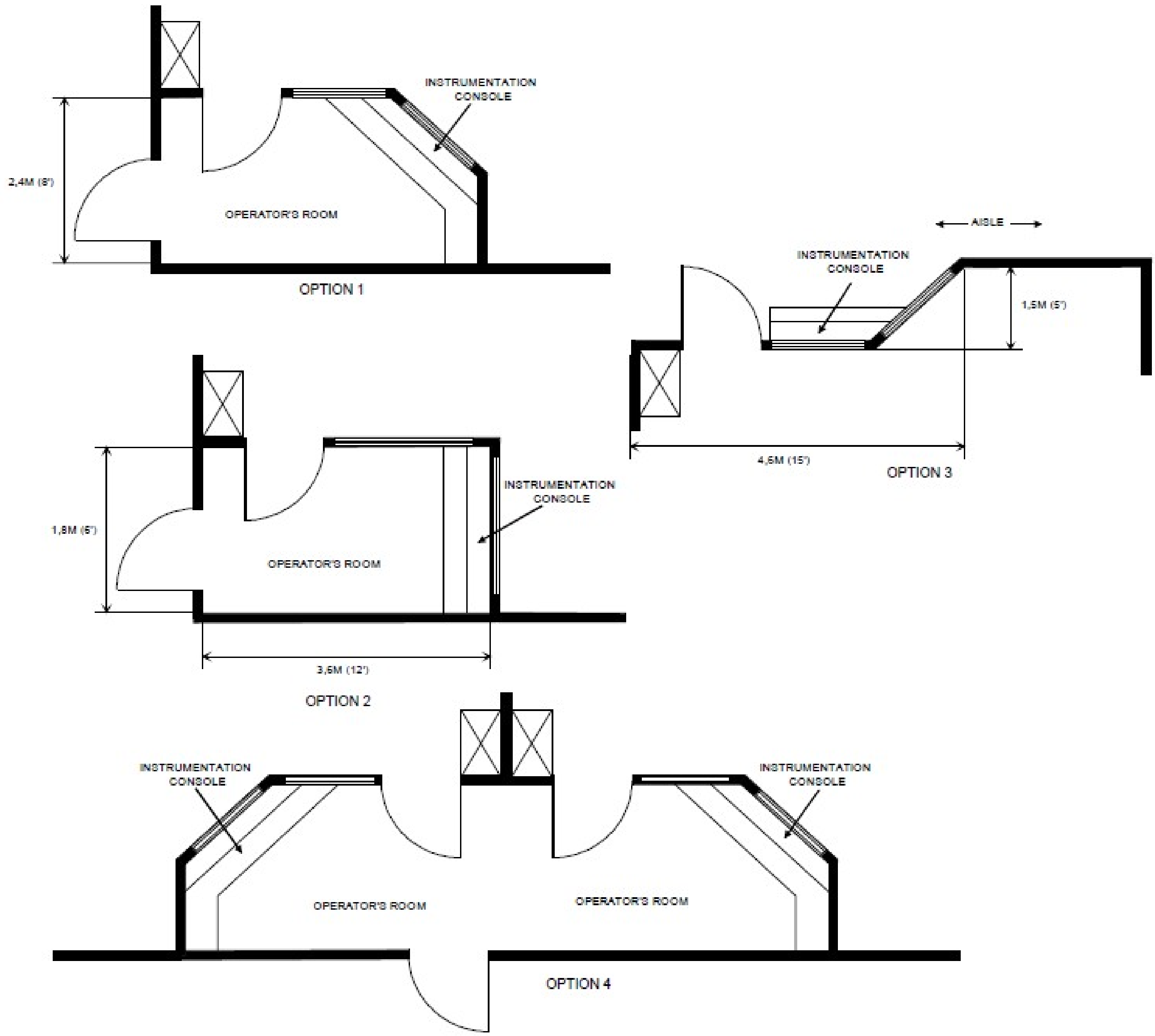


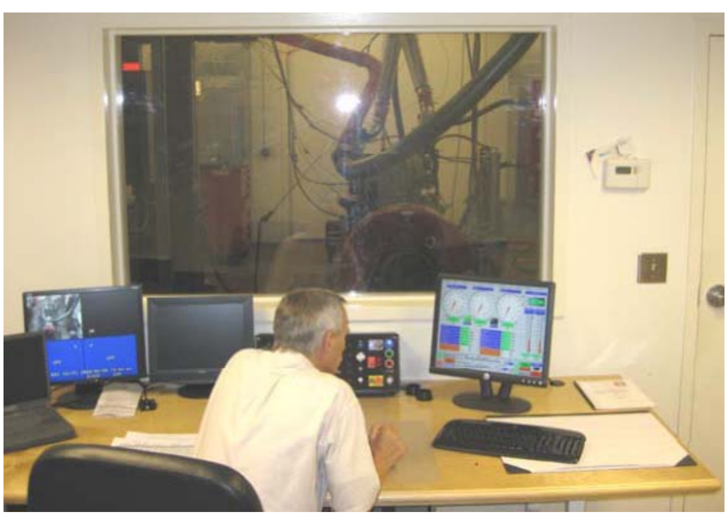
Illustration 6 – Options for Operator Control Room

Control and Instrument Console

The control and instrument consoles can be fabricated or purchased from Taylor Dynamometer. Illustration 7 (see Options 1 and 2) shows typical console designs.

Illustration 7 – Console Designs

Option 1 – Custom designed console for computerized systems.



Option 2 – DynPro Instrumentation on conventional counter top

Option 3 – Standard Work Station with PC

Cranes in Dynamometer Room

Engine carts are the primary means for moving engines into the test cell. The same cart is then used for locating the engine during the dynamometer test. Overhead crane coverage in dynamometer rooms should only be provided when it is necessary for moving engines in and out of the dynamometer room. The dynamometer room should be fully utilized for engine testing. Engine repairs should be kept to a minimum within the test cell. If an engine fails the dynamometer test, remove it from the room for repairs so another engine can be tested. The adapters and instrument connections can remain on the engine during repairs. The time required to reconnect the engine to the dynamometer should be approximately thirty minutes. If an overhead crane is desired for moving engines, refer to the "Room Arrangements" section. A jib crane may be installed to facilitate small repairs; however, the jib crane may interfere with the exhaust hood if used.

Major Room Equipment

Floor space for major pieces of equipment should be considered when designing a dynamometer room. There must be space along the walls for storing adaptors and hoses, portable equipment, benches and fixed equipment. The following list shows major pieces of equipment, which require space.

Isolated Engine/Dynamometer Inertia Block (includes engine cart area and the dynamometer mounting base) – Refer to the "Miscellaneous Equipment and Mechanical Requirements" section for construction details.

Portable Cooling Columns – You will need either one or two portable cooling columns depending on the types of cooling systems used on the engine models to be tested.

Customer with separate circuit aftercooled (LTA) engines will need two portable cooling columns: one cooling column for the jacket water circuit and one aftercooler column for the separate aftercooler. Separate circuit aftercooler systems are used on most large engines.

Engines that require only jacket water cooling and engines with an air-to-air aftercooler require only one portable cooling column (for the jacket water circuit).

Charge Air Cooler (see Illustration 8) – Air-to-air aftercooled engines will need an air-to-air aftercooler simulator.

Portable Air Cleaners – Most engines have air cleaners that are not engine mounted. So, portable air cleaners are necessary for dynamometer testing. The portable air cleaners can be fabricated using the largest air cleaner(s) of the engines to be tested mounted to a roll-around stand. Adapters for connection to the different engines must be fabricated and adapter storage provided.

Hose and Adapter Storage Rack or Cabinet (see Illustration 9) – An assortment of cooling column to engine hoses, quick connects and exhaust adapters should be built on convenient location. Taylor can provide engine flywheel adapters complete with wall mounted rack for storage. A storage cabinet also provides space for parts, test cell accessories, fuel fittings and air cleaner adapters.

Work Bench – Test Cell should allow space for a work bench and should include space for permanent or roll around tool boxes.

Make-up Air Outlet Ducts – These should be near the four corners of the room. Ductwork should be constructed in such a way to insure "balanced" air flow within the test cell therefore ensuring room heat and engine extraction.

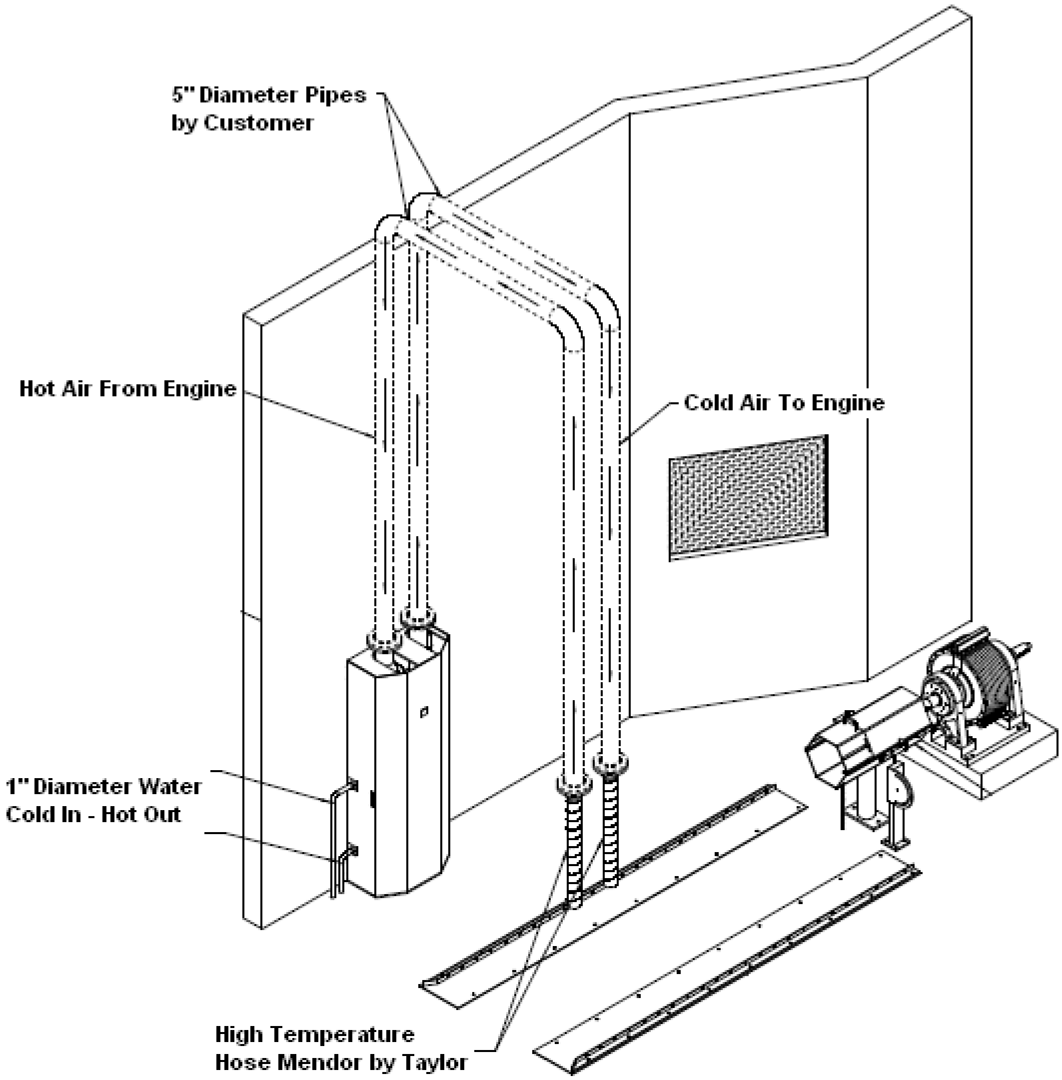


Illustration 8 – Charge Air Cooler

Illustration 9 – Tube and Hose Storage Rack

Sizing the Room

There are three major factors that determine the size of a dynamometer room. They are:

1. ***Size of the Dynamometer/Cart Assembly*** – The size of the inertia block varies in length depending on the kilowatt (horsepower) capacity of the dynamometer installation and the arrangement (single or tandem).

2. ***Clearance around the Dynamometer/Cart Assembly*** – The same amount of clearance is needed regardless of the horsepower size of the installation. Ample clearance of 1.8 to 2.7m (6' to 9') in front of the engine and 1.8 to 2.4m (6' to 8') on each side is desired for connection of portable cooling columns and a portable air-to-air aftercooler simulator. These dimensions include space for the support of equipment and proper passage of personnel. The dynamometer end of the inertia block should begin a minimum of 0.9m (3') from the wall to allow space for the dynamometer and pneumatic starter connections. If possible, there should be an additional clearance around the rear of the dynamometer for personnel passage.

3. ***Design of the Operator's Control Area*** – When there is minimal space for a dynamometer room, optional designs of the operator control area can be used (see Illustration 6). These optional designs can reduce the width by an additional 0.6m to 1.2m (2' to 4').

Room Arrangements

Recommended room dimensions and arrangements for single and tandem dynamometer installations are given in this section. Some of the recommended room dimensions are variable, ranging from minimum to optimum. These variable dimensions may be adjusted to provide flexibility to fit a dynamometer room within a building arrangement. The room arrangements must accommodate the largest engine to be tested.

Room Arrangements – Dynamometer Sizing

Dynamometer capability must be selected to match the power output range of the engines to be tested. Selecting too large a dynamometer makes the testing of comparatively small engines difficult or impossible. The Taylor dynamometer is capable of producing minimum controllable loads to within 5-10% of the full dynamometer capacity. The minimum recommended engine size is approximately 10% of the maximum dynamometer size. Dynamometer selection should be based on your territorial engine models and the anticipated volume of each. When it is desirable to test both small and large engines, or when testing engines greater than the capacity of one single dynamometer, two dynamometers may be necessary. See the “Single Dynamometer Room Arrangement” information for other requirements.

When multiple dynamometers are required, the room may be arranged as follows:

- ***Option 1*** **–** Single End Operation requires two dynamometers of similar capacity installed in one dynamometer room. These dynamometers are installed on a common base. When an engine of lesser capability is tested, only the forward dynamometer is connected to the engine. For testing engines with power outputs up to the total system capability, the two dynamometers may be coupled in tandem and the forward dynamometer connected to the engine. Examples of the tandem dynamometer – single ended operation room arrangements are given in the “Single Test Cell Installations” section.

- ***Option 2*** **–** Dual End Operation requires two dynamometer rooms situated end to end with one dynamometer in each room. Each dynamometer is of similar capacity. These dynamometers are installed end to end on a common base as above, with a partition wall separating the two rooms. Engines of lesser capability may be tested on each dynamometer independently. The two dynamometers may be coupled in tandem and one dynamometer connected to the engine for testing engines rated up to the system capacity. Examples of the tandem dynamometer – dual ended operation arrangements are given in the “Multiple Test Cell Installations” section.

- ***Option 3*** **-** Requires two dynamometer rooms. One is a 3675kW (5000hp) installation with 1800 rpm stationary dynamometer. The second is a 750kW (1000hp) installation with 4000 rpm stationary dynamometer. This type of arrangement allows full usage of each dynamometer independently. Examples of two dynamometer room arrangements are given in the “Multiple Test Cell Installations” section.

Single Test Cell Arrangements

Single Dynamometer Room Arrangement up to 2240kW (3000hp)

The room arrangement for a single dynamometer installation is determined by the size of the dynamometer desired. Illustration 10 shows a typical room arrangement. Differences in size are due primarily to engine length and to a lesser amount, dynamometer model. A 2240kW (3000hp) dynamometer is only 0.5m (21") longer than a 560kW (750hp) dynamometer. Space dedicated to the engines ranges from 2m (78") for a 2727kg (6000lb) engine cart to a 3m (120") for a 9075kg (20,000lb) engine cart.

The dynamometer water supply and recovery systems, ventilation, exhaust, instrumentation, fuel system and sound control requirements are proportional for corresponding capacities of dynamometers. The 3.0m (10') wide door opening should be centered with the dynamometer inertia block. In special cases, engines may be required to test in tandem. This creates special room requirements. Please consult Taylor for additional recommendations.

Illustration 10 shows the operator's room with an angular corner design. In situations where the depth of the room is reduced to the 5.8m (19') minimum dimension, you should consider using Option 2 or 3 shown in Illustration 6 for reducing the amount of space required for the control area.

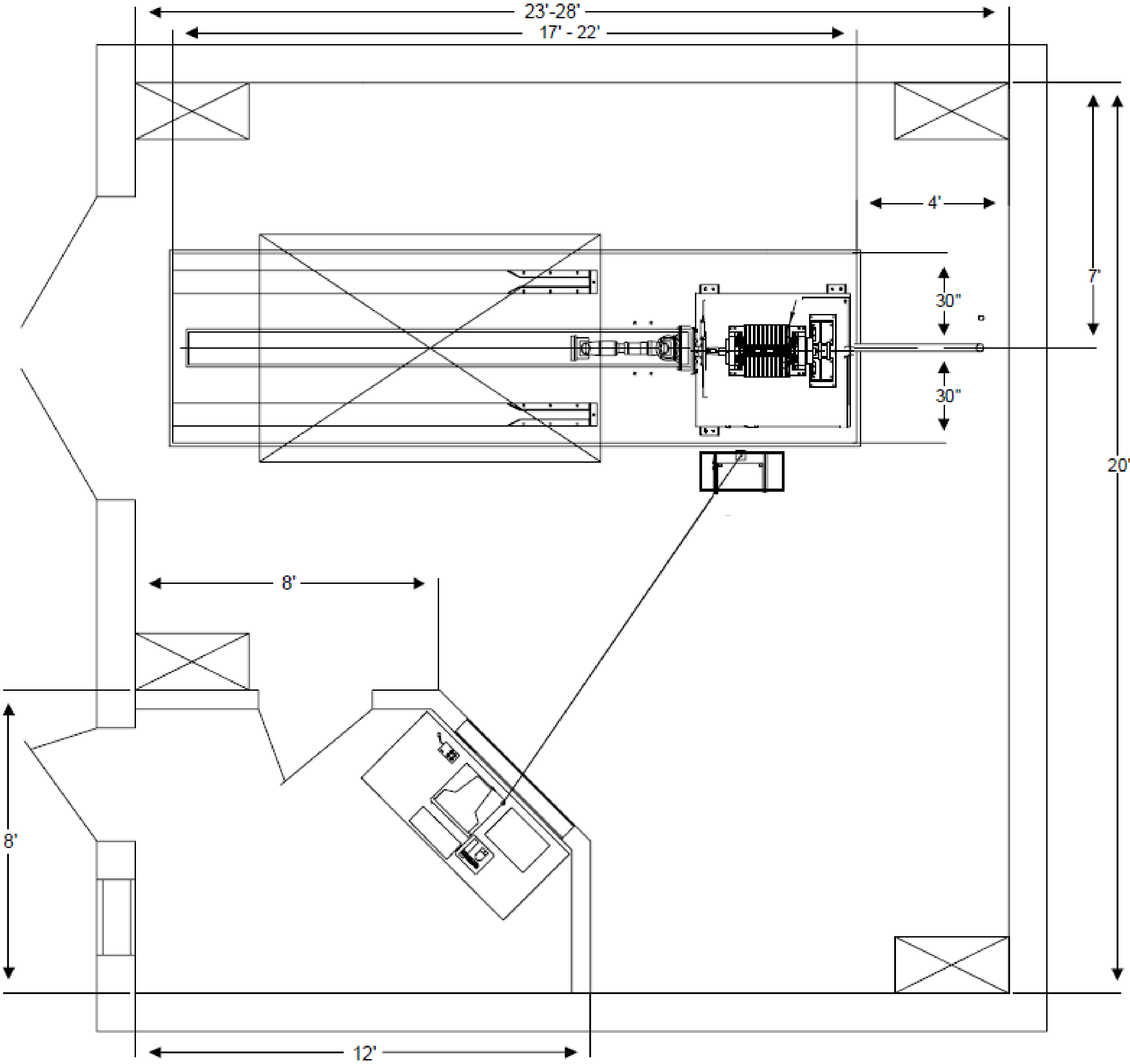


Illustration 10 – Room Layout, Single Dynamometer, End Load, Angular Corner

Single Dynamometer Room Arrangements up to 7355 kW (10,000hp)

The room configuration and access for all dynamometer installations is determined by the method you choose for moving engines in and out of the room. The volume of large engines is a key factor in selecting the method of engine transportation. The most commonly used methods are lift truck, electric tug or an overhead crane. In most cases the engines are positioned on the engine cart (see Illustration 11) prior to positioning in the test cell.

Illustration 11 – Engine Cart

The following are various room design arrangements:

End Load/Overhead Crane Arrangement – For optimum productivity when moving engines in and out of the dynamometer room, use the end load room design shown in Illustration 12 in conjunction with an engine cart. The 3.0m (10’) wide door opening should be centered with the dynamometer inertia block. If necessary, crane access to the room may be provided by placing a slot in the wall above the engine access doors and the dynamometer room ceiling. The slot must be in line with the centerline of the dynamometer. The shop overhead crane may then travel above the dynamometer room ceiling. The crane slots provide a passageway for the crane’s hoist cable and controls. Slot closures should be used to control sound. The ceiling slot should extend directly above the dynamometer’s universal shaft flange as shown in Illustration 13.

A small winch with cable can be used to move and place engine/cart into test cell. The same winch with cable can be used to remove engine/cart from the test cell.

NOTE: The crane slot is not mandatory for the end load arrangement in Illustration 12. Many dealers position the engines to be tested on the cart and move the assembly into the test cell either by man-power or with a powered device (forklift, electric pusher).

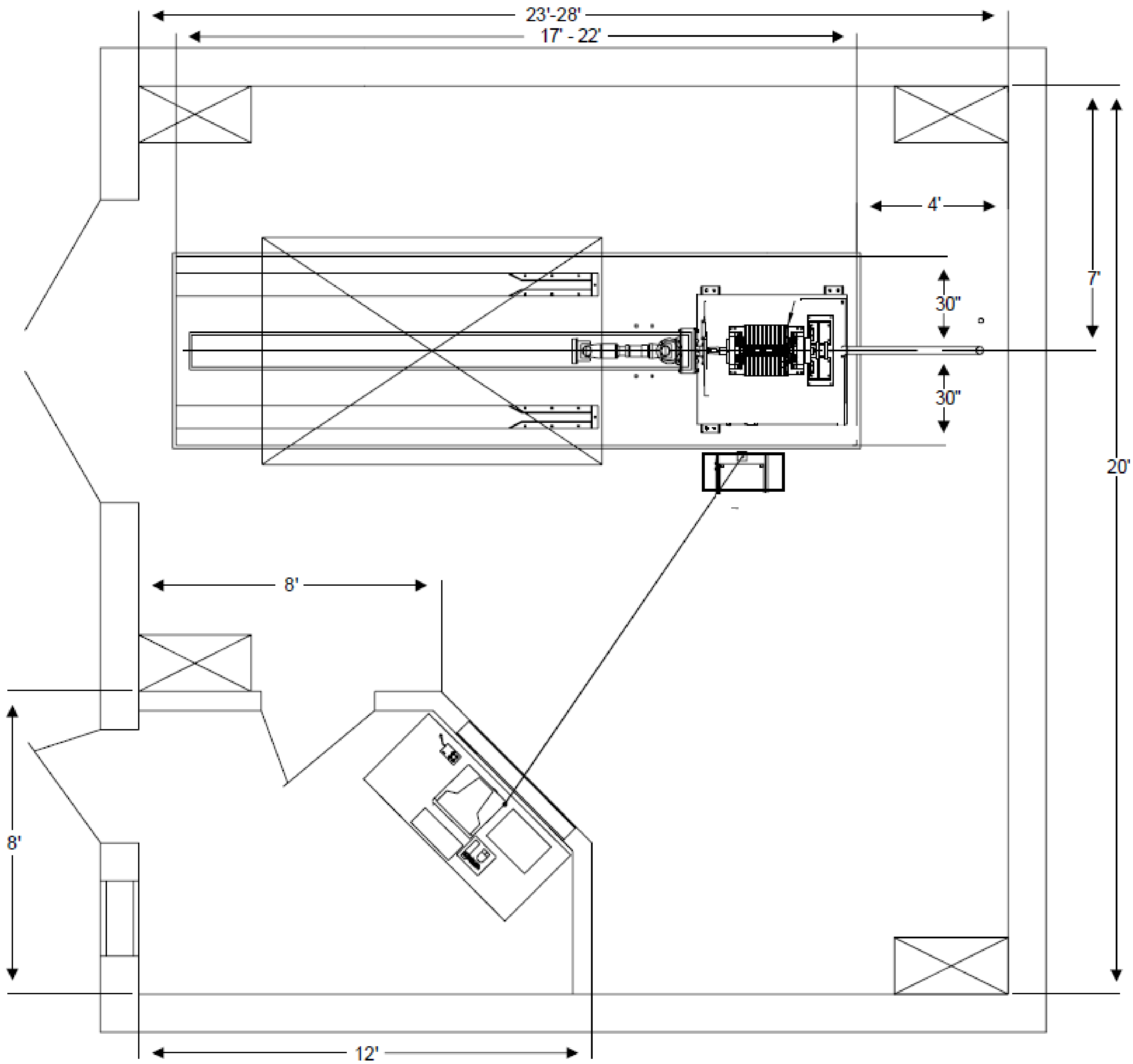


Illustration 12 – Room Layout, Single Dynamometer, End Load

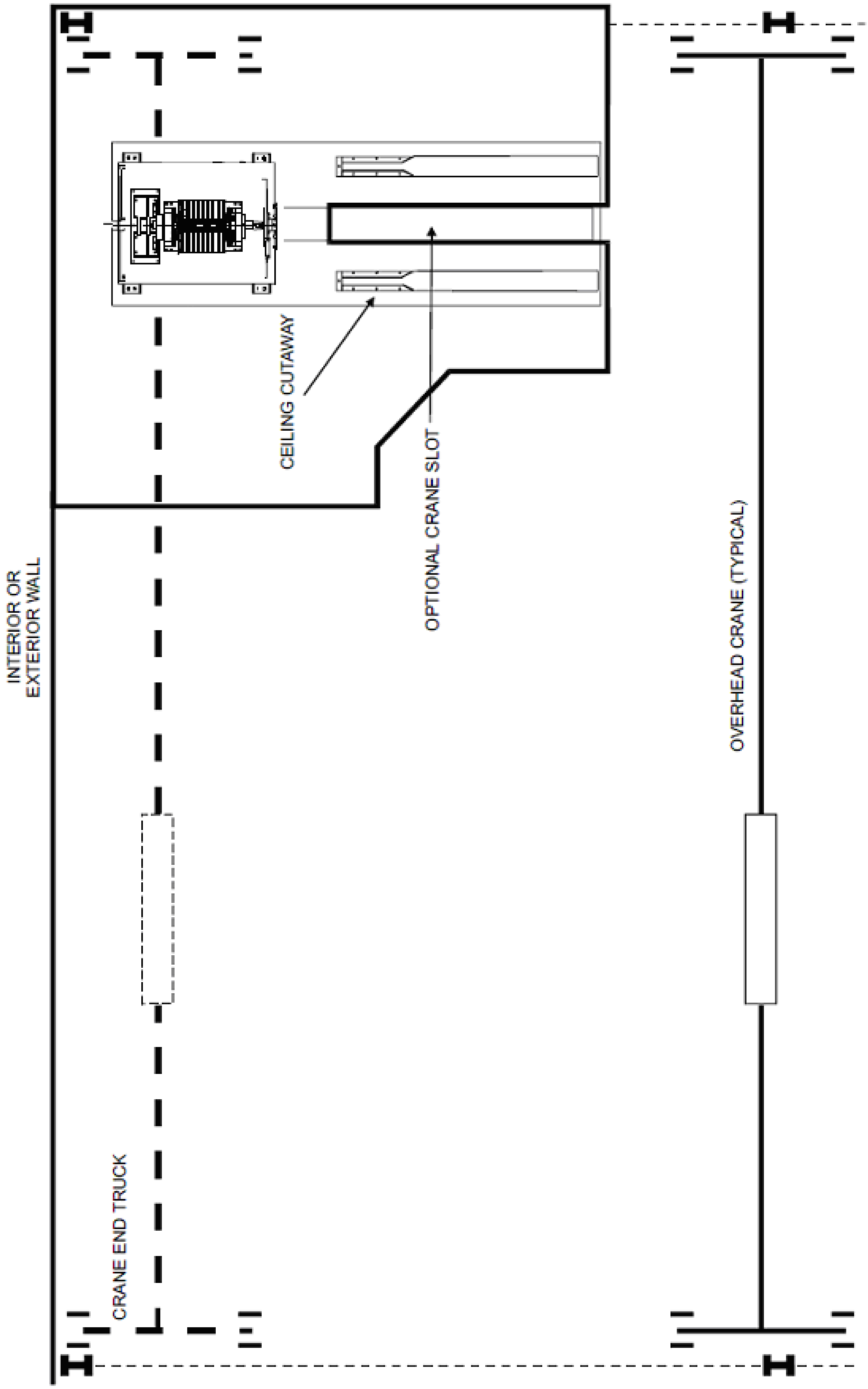


Illustration 13 – Placement of Overhead Crane Slot

Side Load/Lift Truck Arrangement – When a lift truck is used to move engines, the engine/cart assembly is placed on the dynamometer inertia block from the side to minimize maneuvering requirements. The lift truck should have an adequate capacity to accommodate the largest engine to be tested in a ready-to-run condition plus the weight of the engine cart assembly. A carriage side-shift attachment on the lift truck helps align the engine to the dynamometer.

NOTE: Side loading is recommended only when building construction does not allow end loading.

Illustration 14 shows a side load room arrangement. The operator control area must be at the dynamometer end to allow room for the engine access doors on the side. Design the room to prevent the operator from being directly across from the universal shaft. The engine access doors should be centered with the engine mounting area. A larger door opening for side loading will increase the cost of the sound controlled doors.

An overhead crane that covers other areas of the engine rebuild shop can serve the dynamometer room as well.

The make-up air and exhaust ducts must be positioned to avoid interference with crane travel. An exhaust hood can be used with a crane slot design if it also has a slot in it. For additional information, refer to the "Ventilation/Exhaust Systems" section.

End Load/Side Load Combination Arrangement – Illustration 15 shows a combination of end load and side load capabilities within one room. This option is only recommended when these conditions exist:

1. When one side of the dynamometer is an exterior wall.

2. When local sound control regulations permit.

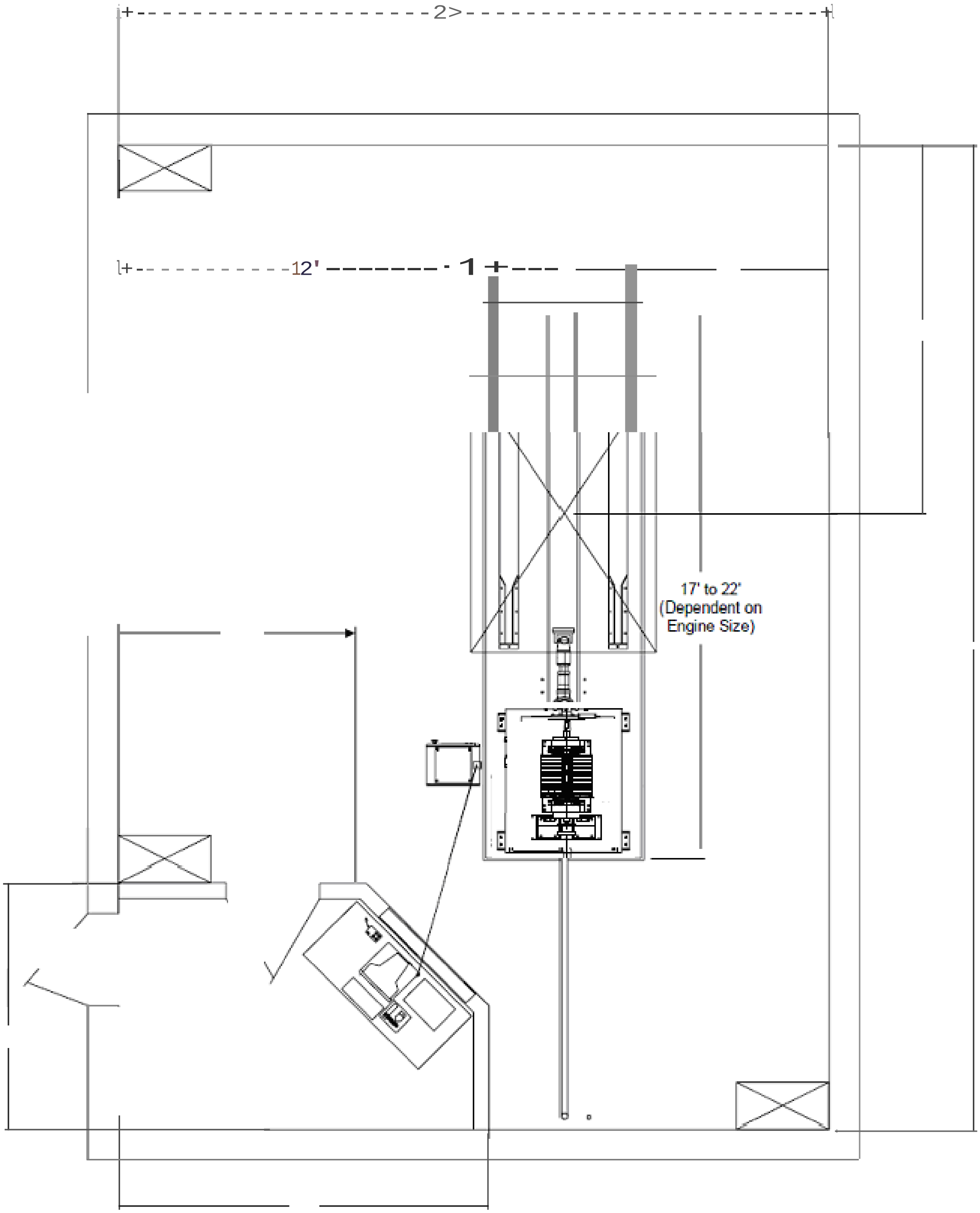
NOTE: For information about overhead and vertical lift telescoping sound controlled doors, refer to the "Room Sound Control" section.

3. If it is necessary to transport engines outside for side loading, shelter from inclement weather should be provided. It is recommended that a canopy is installed along the outside of the building between the dynamometer room side door and an outside access door (generally the shipping/receiving door).

With this option, engines may be moved outside the building with a lift truck, entering the dynamometer room through the side access door for side loading. Engines that can be accommodated on the engine cart enter the room through the end door for end loading.

For the various dimensions of a side load/end load room design, refer to Illustration 12, since they are identical to an end load room design. The outside access door must be centered with the engine mounting area.

NOTE: All doors should be specified with consideration made for local regulations including fire, noise and potential projectile hazards from failed assemblies.



Illustratioo 14-R=m LfD out, Sine Dyna>oometer, Side Load

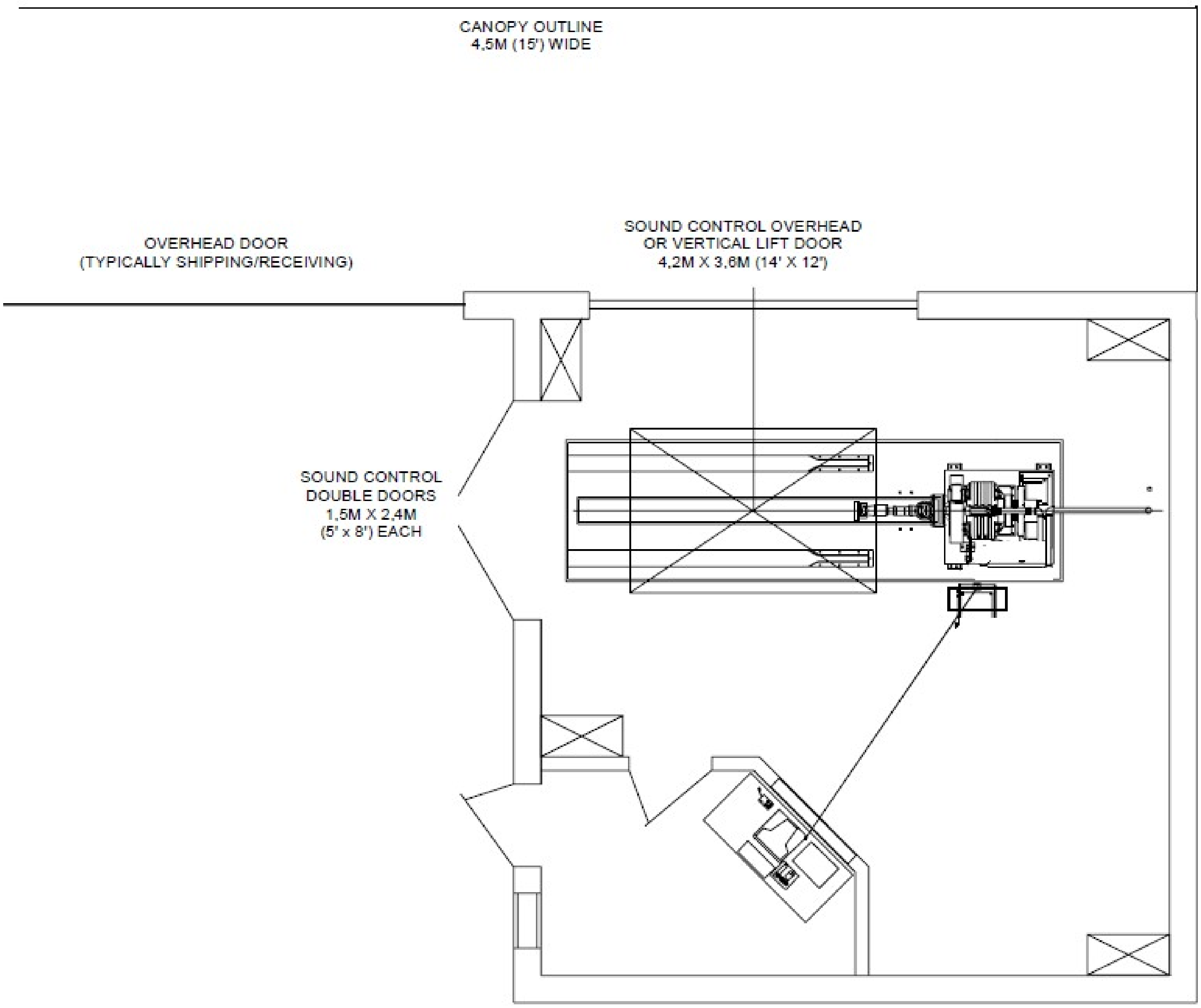


Illustration 15 – Room Layout, Single Dynamometer, End and Side Load

Tandem Dynamometer Single End Testing Arrangements

For facilities that require the ability to test small through large engines and can only devote the space to one test cell, a tandem dynamometer installation may be required. Essentially the dynamometer room is the same as a single dynamometer installation, with the exception of two dynamometers being located end-to-end at the rear of the test cell. In operation, the front dynamometer is used for testing engines through its power absorption range. When it becomes necessary to test engines of power outputs greater than the front dynamometer's capacity, the second dynamometer may be coupled to the first. An example of a single room-tandem dynamometer arrangement is shown in Illustration 16.

With tandem dynamometer installations, the following utility requirements must be met:

1. The main fuel line must be sized to equal the requirements of the largest engine to be tested.

2. The main fuel tank must be of adequate capacity.

3. With a fresh water/waste system, the main lines for water supply and wastewater must be sized to equal the combined volume of both dynamometers and the largest engine that will be tested.

4. With a water recovery system, refer to the "Water Recovery Systems" section.

5. The dynamometer room must have adequate ventilation and an exhaust system capable of supporting the largest engine to be tested.

When only one dynamometer is installed at first and a second dynamometer is going to be added later, provisions should be made to initially size the main water lines, the main fuel line and the main fuel tank for two dynamometers. The water and fuel lines for the future dynamometer should be run to their planned locations and capped.

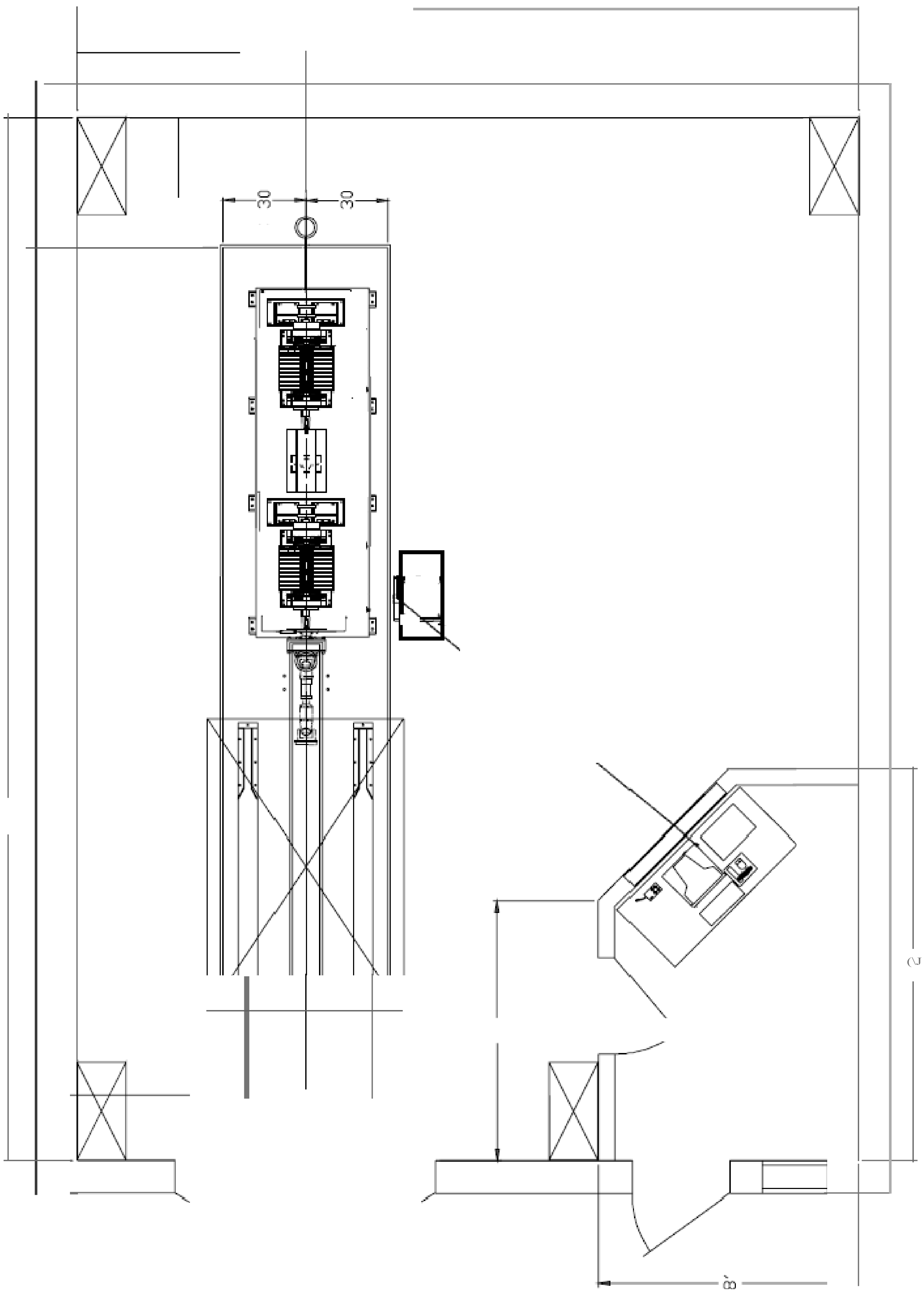


Illustration 16–Room Layout, Dual Dynamometer, Single End, End Load

Multiple Test Cell Installations

Double Room Arrangements

More than one dynamometer may be necessary if testing a high volume of engines or if engine output capacity exceeds the capacity of one dynamometer. For increased engine volume operations, or if engine outputs exceeding the capacity of one dynamometer are expected, you may need more than one dynamometer room. Examples of double room arrangements are shown in Illustrations 17, 18, 19, 20 and 21. Dynamometer rooms may be placed end to end to allow the connection of two specially designed dynamometers for increased absorption capabilities.

The following utility requirements must be met in a multiple test cell installation:

1. The main fuel line must be sized equal to the combined requirement of all rooms.

2. The main fuel tank must be of adequate capacity.

3. With a fresh water/waste system, the main lines for water supply and wastewater must be sized equal to the combined volume of all rooms.

4. With a water recovery system, refer to the "Water Recovery Systems" section for multiple test cell water recovery requirements.

5. Each test cell must have its own ventilation and exhaust system that is totally independent of the others.

   If two dynamometers are to be connected in tandem, the ventilation and exhaust system must be sized to accommodate the largest engine to be tested.

When only one dynamometer room is installed at first and additional test cells will be added later, provisions should be made to initially size the main water lines, the main fuel line and the main fuel tank for the future needs. The water and fuel lines for the future dynamometer rooms should be run to their planned locations and capped.

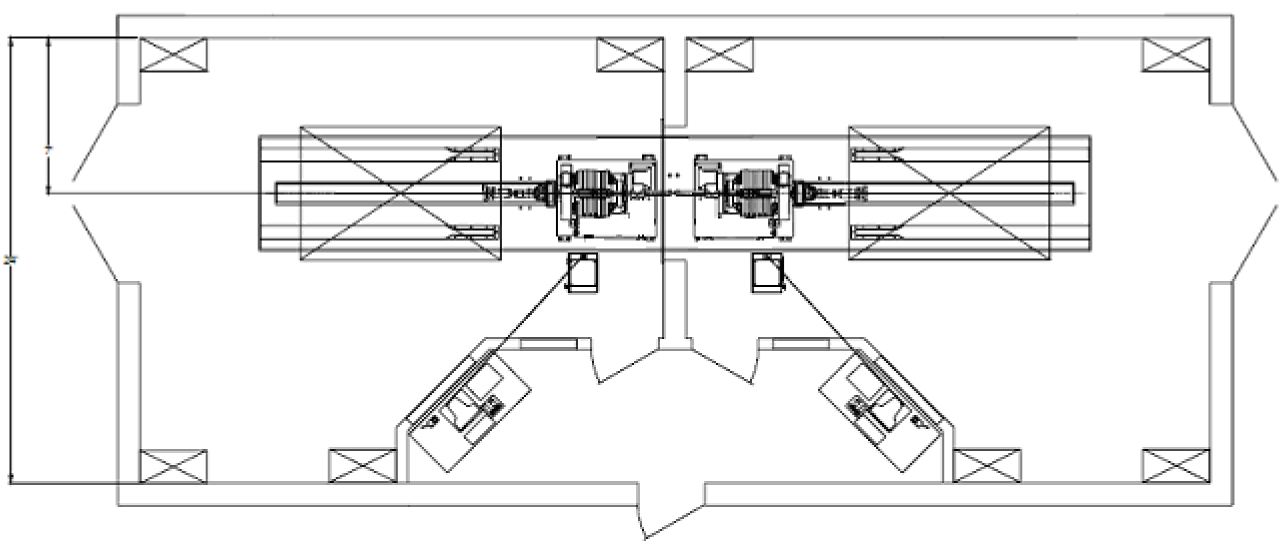


Illustration 17 – Room Layout, Dual Dynamometer, Dual End, End Load

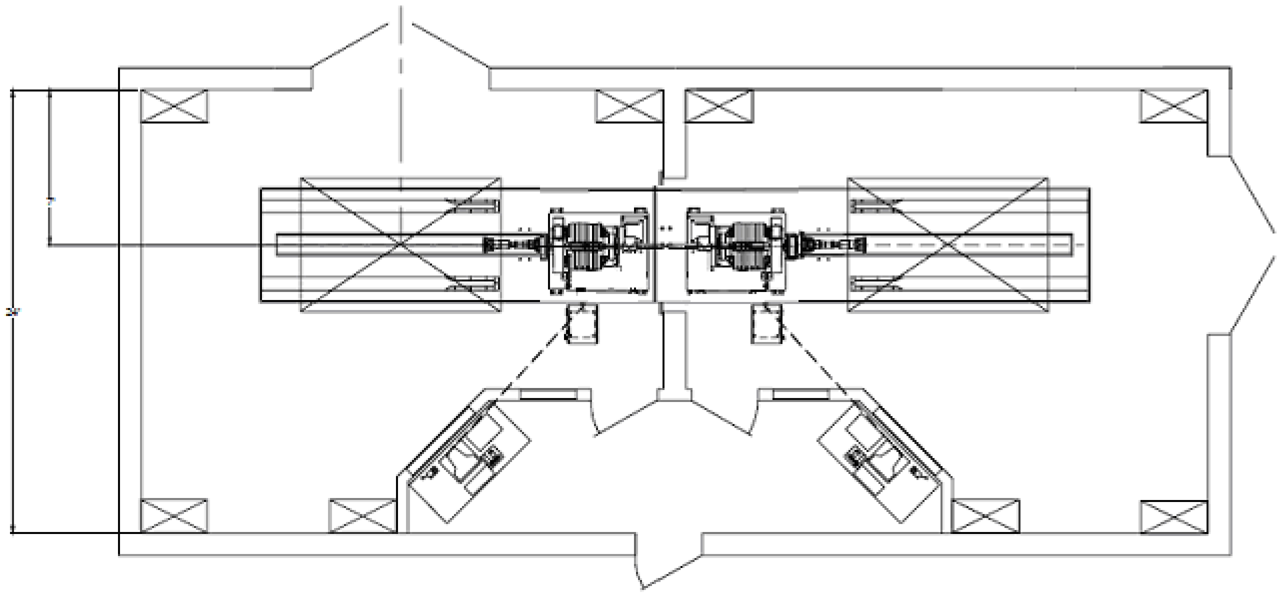


Illustration 18 – Room Layout, Dual Dynamometer, Dual End, end and Side Load

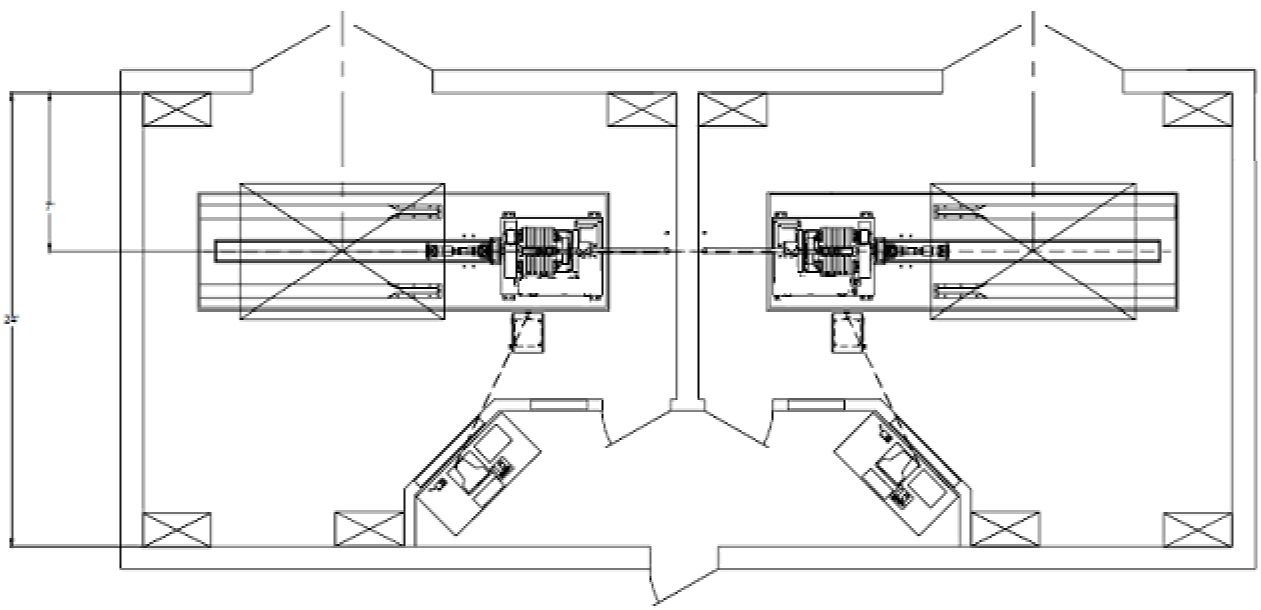


Illustration 19 – Room Layout, Dual Dynamometer (Not Connected), Dual End, Side Load

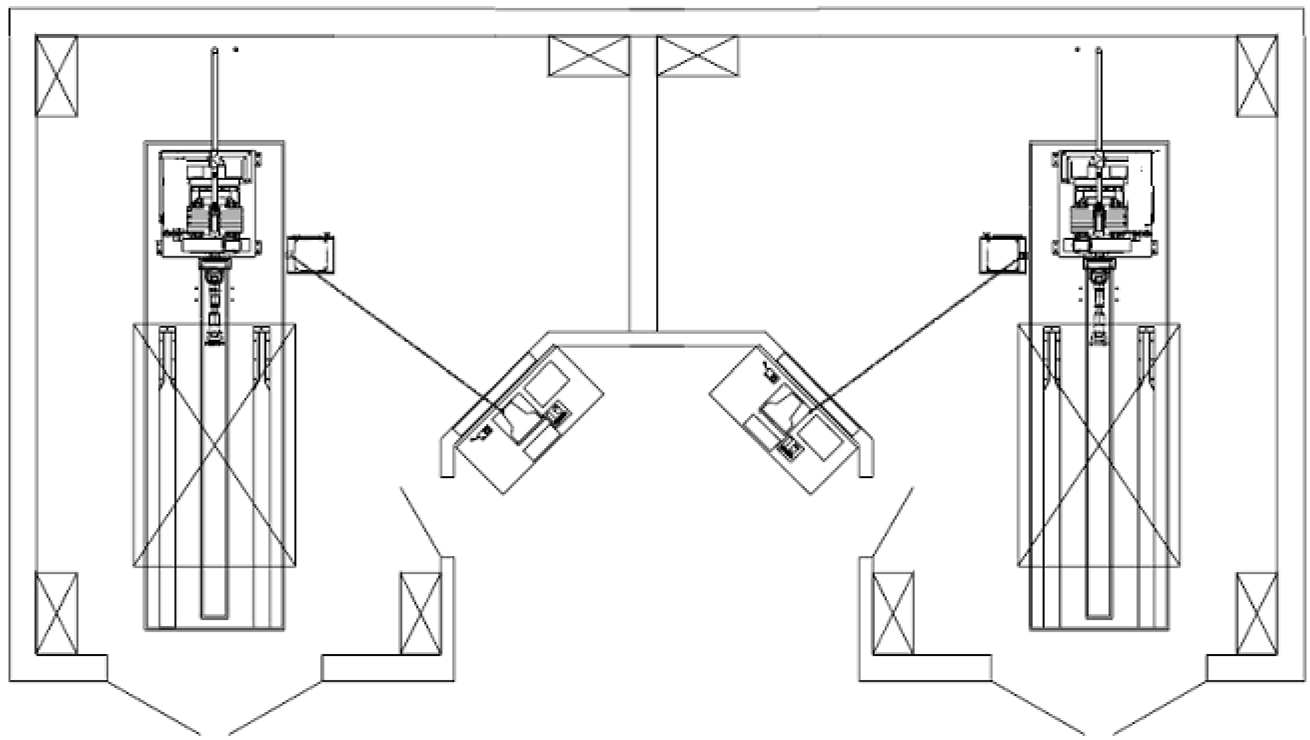


Illustration 20 – Room Layout, Dual Dynamometer, End Load, Shared Control Room

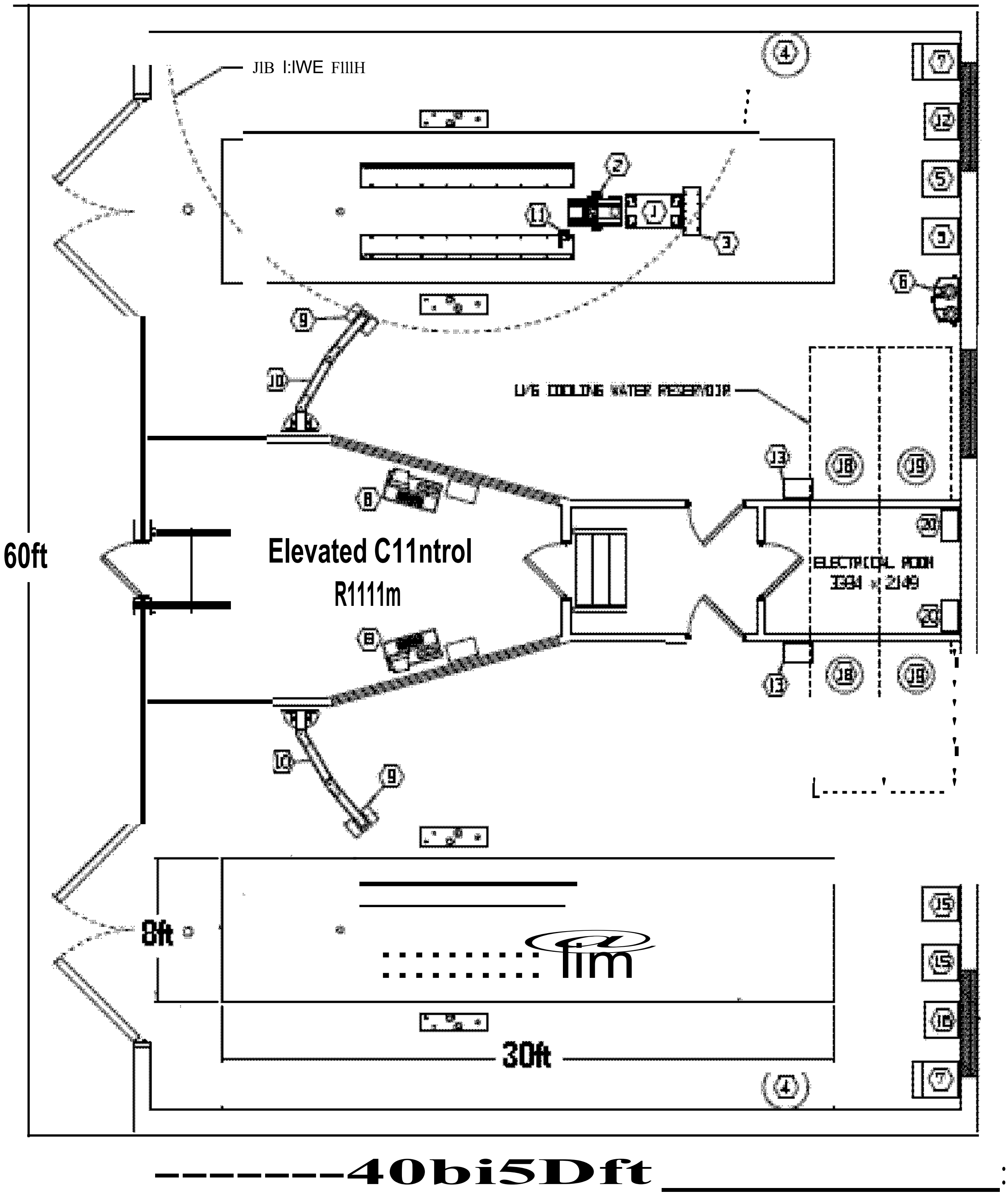


Illustration 21- Room Layout, Dual Dynamometer, End Load, Shared Control Room, Elevated

Room Sound Control

When considering sound control for the dynamometer room, two terms are frequently used to describe the amount of sound control. These are dBA (decibel "A" scale) sound level ratings and STC (sound transmission class) rating. They are independent of each other and cannot be compared. The following is a brief description of each:

HOURS	SOUND LEVEL (dBA)
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

OSHA Regulation 29 CFR 1910.95 Occupational Noise Exposure

DBA Sound Level Readings – These are sound level meter readings in decibels (dB), which define the loudness of sound based on its intensity and frequency (pitch). Sound level meters have three scales (A, B and C). The "A" scale (dBA) is the scale used by most architects and engineers because the "A" scale ignores most of the very low frequencies that the average human ear cannot hear. The lower the dBA reading, the lower the loudness of the sound.

Most local codes require compliance with a standard dBA sound level reading outside the dynamometer room. Since the allowable dBA sound level varies around the world, you should consult your local code requirements. Where local codes do not require a limit on sound control, the maximum noise level along the outside perimeter of the dynamometer room should be 85 dBA.

NOTE: Engine horsepower does not determine the loudness of an engine; the sound frequency does. It is not related to engine size. For example, an eight-cylinder, small-bore engine can produce higher noise levels than an eight-cylinder, large-bore engine.

STC Rating – When comparing different kinds of assemblies (including kinds of materials, construction and thickness) for walls, ceiling, windows and doors, and STC rating is given. STC stands for Sound Transmission Class. It is a numeric rating system that compares the ability of various assemblies to reduce sound transmission. The STC rating indicates which assemblies are better sound insulators. The larger the STC number, the greater the sound control capabilities.

Comparable STC Ratings for Walls, Ceiling, Windows and Doors

The walls, ceiling, windows and doors should have comparable STC ratings. The STC rating of each should not vary more than approximately five STC points. For example, do not choose an engine access door with an STC-50 rating and an observation window with an STC-26 rating. The higher cost of purchasing the STC-50 door is wasted, since the sound level outside the room will still be high because of high sound transmission through the window.

In the United States, the typical STC rating for a dynamometer room is STC-50 to 52 to meet sound level requirements. The STC rating required in other countries varies. Some countries have more stringent sound level requirements than the United States.

Prevent Sound Leaks

All pipes, conduit and ducts that penetrate the ceiling, floor and walls should be insulated and sealed to prevent sound leakage. Doors and windows must be gasketed on all four edges. The jambs of windows and doors must be sealed where they contact the wall. If air can get through an opening so can sound. In some areas, local codes may require internal insulation of the exhaust and ventilation system.

Walls

The following are the typical types of wall construction for controlling sound level outside the dynamometer room. The STC ratings given are nominal and can deviate +/- 2 points.

Examples of Wall Consrtruction	Material Width	Weight kg/m2 (lb/ft2)	Single Wall STC Rating	Double Wall w/ 10cm Dead Air Space STC Rating
Hollow Core Concrete Block (Std. Weight) with Sand-Filled Core	20cm (8")	270kg (55lbs.)	48	63
	30cm (12")	390kg (80lbs.)	53	68
Solid Dense Concrete Block	20cm (8")	390kg (80lbs.)	49	64
	30cm (12")	610kg (125lbs.)	54	69
Poured Dense Concrete Block or Tilt-Up Panels	20cm (8")	465kg (95lbs.)	51	66
	30cm (12")	710kg (145lbs.)	56	71
Brick	20cm (8")	390kg (80lbs.)	49	64
	30cm (12")	440kg (90lbs.)	54	69

All walls must be constructed using proper construction techniques.

NOTE: The above STC ratings assume proper construction, including airtight joints and two coats of sealer paint on both sides of the wall.

Double wall construction refers to two walls separated by a 10cm (4") dead air space. To prevent sound transfer between the two walls, there should be no physical connection between the two walls. In most areas, double wall construction is not required unless there are very stringent sound level regulations.

Wall materials are inherently porous. The porosity of the wall material acts as a natural sound leak. Therefore it is highly recommended that wall interior and exterior be painted with a high quality sealer/paint. For example, the STC rating of porous block can be improved from five to eight points by sealing both sides with paint.

When the dynamometer room is along the outside wall, most sound level regulations require that the room outside wall also be of sound controlled construction. Normally, the sound level reading applies to the area outside of the dynamometer room, whether it is inside or outside the building.

Ceiling

The following are the typical types of ceiling construction for controlling the sound level outside the dynamometer room:

- Two layers of 1.6cm (5/8") thick gypsum board with insulation above, suspended by metal hangers. The perimeter of the ceiling should be sealed along the wall.
- Solid poured concrete or pre-cast concrete panels. This is one of the best types of sound control ceilings. The thickness of the panels is determined by the structural design required to span the room. This type of construction is an excellent method to use when a crane slot is installed.

Ceilings should be painted with an epoxy type paint to seal the pores and for easier cleaning in case of an oil spray. The ceiling height should be a minimum of 4.8m (16').

NOTE: Avoid having an exposed metal roof for the dynamometer room ceiling. An exposed metal roof in the dynamometer room can cause excessive vibration throughout the building.

Controlling Noise inside the Room

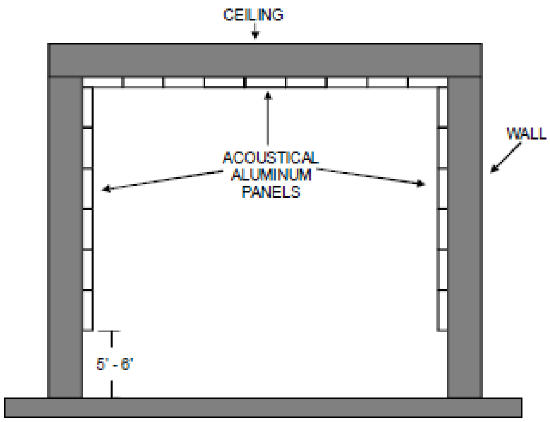


Illustration 22 – Acoustic Wall and Ceiling Panels

The types of wall and ceiling construction discussed so far are for reducing the noise level outside the dynamometer room. You may want to control the noise level inside the room as well. A typical method for controlling the noise level inside the room is to install acoustical perforated aluminum panels on the wall and ceiling (see Illustration 22). The acoustical panels should start approximately 1.5 to 1.8m (5' to 6') above the floor and extend to the ceiling (see Illustration 22). This reduces the chance for panel damage (dents and scrapes) that can occur at floor level. The panels should be aluminum to prevent rust from clean up.

Personnel Door

The personnel door should be sound controlled with an STC rating comparable to the rating of the walls. An emergency door release must be provided on the inside with the door swinging to the outside of the room. It should be 4.5 to 5cm (1 ¾" to 2") thick gasketed metal door with sound deadening material sandwiched in the middle.

Typically the dynamometer room is maintained at a slight negative pressure differential (vacuum) from the surrounding outside area. This pressure differential must be considered when specifying doors.

Hinged Double Doors (Engine Access)

Illustration 23 – Large Sound Control Door

Hinged double doors should be used for all interior engine access doors because they have a high STC rating (see Illustration 23). The doors should be gasketed on all four sides with a flush threshhold. An emergency release lever should be on the inside of the door. The door should swing to the outside of the room. These metal doors should be constructed with sound deadening material sandwiched in the middle.

Because of the heavy weight of these doors, it is important that the hinge hardware and doorframe be designed to support the weight for ease of operation.

Taylor Dynamometer can supply Engine Access doors, Personnel doors, and Windows with various sound suppression values and/or fire ratings. All doors are custom made for the end user and require a “rough opening” and finished dimensions.

In addition to doors and winows Taylor can supply complete Modular Sound Attenuating Engine Test Cell Enclosures.

Taylor Dynamometer offers Sound Controlling Test Cell doors, Personnel doors, Windows and Modular Test Cell Enclosures with various sound suppression and/or fire ratings. All doors, windows and modular enclosures are custom designed and manufactured to meet the end-users requirements.

Contact a Taylor Dynamometer Service Representative for further details and pricing.

It may be difficult to order the recommended doors outside of North America. If so, the following are recommended specifications for door and frame construction.

STC-48 Metal Door and Frame Construction Specifications – Doors shall be 4.5 or 6.4cm (1 ¾” or 2 ½”) thick, of flush design, 16 gauge cold rolled stretcher leveled sheet steel, of non-combustible construction and free of visible joints at seams of door faces. Doors shall have interior formed stiffening reinforcement shop welded full height so that faces are not connected except at edges. Non-combustible filler or insulation shall be installed throughout door interior.

For vision panels, provide for 6.4mm (1/4”) minimum double-glazing with safety glass and resilient, self-sealing and locking, mechanically unconnected glazing frames.

Doorframes shall be constructed of 1.9mm (14 gauge) steel. Head and jamb intersections shall be fitted to hairline joints, reinforced, welded and ground smooth.

Doors and frames shall be factory mortised, reinforced and fitted for heavy-duty locksets, strikes and template hinges.

Clearance between door and frame shall be sealed by adjusting neoprene gasketed sound stops. Concealed position locking screws shall provide a minimum of 9.5mm (3/8”) of closed cell neoprene gasket assemblies installed in formed metal housing attached to the frame. Sill operating clearance of flush thresholds shall not exceed 6.4mm (1/4”) with the space sealed by means of an automatic threshold closer providing instantaneous 6.4mm (1/4”) retraction of the neoprene gasket when the door is open.

STC-50 and 58 Metal Door and Frame Construction – Doors must be 10cm (4") thick and STC-58 doors shall be 15cm (6") thick.

Doors shall be of flush design for 6.4mm (14 gauge) cold rolled steel backed with vertical and horizontal reinforcing steel members. Separate face panels, except at door leaf perimeter with sound insulated materials.

For vision panels, provide for 6.4mm (1/4") minimum double-glazing with safety glass and with resilient, self-sealing and locking, mechanically unconnected glazing frames or single glazing with minimum 1.9cm (3/4") thick sound-retarding safety glass.

Door frames shall be of structural or 3.4mm (10 gauge) minimum-formed steel as detailed. Doors shall be factory drilled and fitted for hinges, closures, stops, and holders and latching hardware. Frames shall be factory template fitted, drilled and tapped for all hinge pintles, latching hardware and adjustable sealing devices. Masonry cover boxes shall be welded to backside of frame to protect all tapped holes.

Clearance between door and frame shall be sealed by adjustable neoprene gasketed sound stops with position locking washers. Sill operating clearance of flush thresholds shall be sealed by an automatic threshold closer, providing instantaneous retraction of the neoprene gasket when the door is opened.

Additional Door Specifications for All (STC-48, 50 and 58) – Hinges shall be six-way adjustable with concealed adjustment in or out, up or down, right or left. For 10cm (4") doors, hinge leaf shall be concealed mortised type, but for 15cm (6") doors, hinge leaf shall be surface applied and pintle brackets and hinge leaves shall be cast and machined high strength steel.

Multi-point latching hardware for active door leaf shall be fully concealed heavy duty positive acting, pressure exerting, vibration-free latch units with slam-type machined bolts engaging adjustable strikes for complete compression against acoustic seals. Lever handles and/or panic bar shall operate latch bolts.

Vertical two-point hardware for inactive leaves shall be fully concealed, heavy duty latch units. Latching shall be achieved with a tapered steel top bolt engaging a strike at the head of the frame only. No strike cutouts will be permitted at the sill. The bottom of the inactive leaf shall be stabilized by a pressure exerting rubber tipped spring loaded plunger holder concealed in the bottom of the door actuated by the vertical latch handle simultaneously with the top bolt. When the active leaf is in the open position, the handle-actuated foot bolt shall serve as a hold open device.

When two swinging doors are used in the same opening, provide sound seals at jambs, heads and flush threshold as specified above. The sill seal can be operated by actions of the latching device.

Vertical Lift and Overhead Doors (Engine Access)

Sound controlled doors are available in both vertical lift (telescoping) and overhead type doors. The STC rating for these doors is low because it is difficult to have good seals at the section joints and doorframe. In addition, the weight of the door must be low so it can be lifted. Most vertical lift and overhead sound controlled doors never exceed an STC-30 rating. For this reason, these doors should only be used in dynamometer applications where the door is along an exterior wall and local sound regulations permit higher noise levels to the outside of the building. These doors should have spring-loaded sound seals around the perimeter and be power operated.

Observation Window

The STC rating of the observation glass should be comparable to the rating of the walls and doors. Also, the observation windows must be resistant to high impact because of potential engine and universal shaft failures. This usually requires bullet-resistant glass.

Bullet resistant glass is multi-ply laminated glass consisting of layers of float glass 3.2 to 9.5mm (1/8” to 3/8”) thick, bound together by transparent polyvinyl butyral plastic sheet 0.38 to 1.52mm (.015” to .060”) thick between each layer. Typically, bullet-resistant glass is available in thicknesses ranging from 3.0 to 5.7cm (1 3/16” to 2 ¼”) thick. A 7.6cm (3”) thick glass is also available but not common. The 3.0cm (1 3/16”) thick glass is more than adequate to protect the operator from the more common failure of broken or loose drive shaft bolts. If a total drive shaft failure occurs, the 5.7cm (2 ¼”) thick bullet-resistant glass offers greater protection for the operator. It cannot guarantee prevention of injury, since it is impossible to predict a sheared shaft’s size, velocity and angle of protection. For additional protection, the observation window should not be located in a direct line with the drive shaft area.

NOTE: The various thicknesses of bullet-resistant glass are designed to withstand a specific amount of N*M (ft-lb.) energy. When an object with less energy than the glass rating strikes the glass, damage can occur to the glass itself; however, the operator should not be injured.

The STC ratings of bullet-resistant glass are comparable to the same thickness of multi-plate glass in 6.4mm (1/4”) layers, since both are laminated. A sound controlled window requires either bullet-resistant or multi-plate glass and ranges from 2.5 to 7.6cm (1” to 3”) in thickness for a single pane installation. Additional sound control can be attained using double-pane construction with a pressurized dry air space between the two panels. The second pane (operator side) is usually 6.4mm to 2.5cm (1/4” to 1”) thick in solid or multi-plate safety glass. Its thickness varies depending on the thickness of the first pane. Typically, the thicker the first pane, the thinner the second pane. The following chart has the typical STC ratings of laminated glass (either bullet-resistant or multi-plate) for various thicknesses of single and double pane installations. They may vary according to the size of the glass, the design of the window unit, its installation and the glass manufacturer.

Glass Thickness (Single Pane or 1st Pane of Double Glass)	STC Rating Single Pane	STC Rating of Double Pane (Second Pane 6,4mm to 2,5cm (1/4" to 1") Thick			
		w/ 2,5cm (1") Air Space	w/ 5,0cm (2") Air Space	w/ 10cm (4") Air Space	w/ 15cm (6") Air Space
2,5cm (1")	44	50	54	57	59
*3,0cm (1-3/16")	43	49	53	56	58
*3,8cm (1-1/2")	44	50	54	57	59
*4,8cm (1-7/8")	46	52	56	59	61
*5,0cm (2")	49	55	59	62	64
*5,7cm (2-1/4")	47	53	57	60	62
*7,6cm (3")	52	58	62	65	67

*Indicates sizes available in bullet-resistant glass

In order to achieve the STC ratings, the observation glass must be installed in an elastomer zipper-type mounting with a 1.6cm (5/8”) grip on the glass to prevent sound leaks. The glass is normally tilted out at the top about 7 degrees to reduce reflections and glares. In a double pane installation, the glass closest to the dynamometer is tilted. Tilting the glass in double pane installations also helps sound control. The recommended frame size of the observation windows should be 90cm (36”) high by 1.0 to 1.5m (3’ to 5’) wide.

The need for a second glass pane can be eliminated by having a thicker single glass pane. This simplifies construction of the window unit and reduces the cost. Thus, a single pane window until with 5.7cm (2 ¼”) thick bullet-resistant glass is typically the least expensive, while providing a high degree of operator safety. Assembled observation window units, specifically designed for high impact resistance and sound control, are available from most sound door manufacturers.

Engine/Dynamometer Basic Water System

The dynamometer water system supplies water for the dynamometer and engine coolant system. The proper supply of water is essential to the operation of the system. Failure to provide an adequate water supply will cause dynamometer loading difficulties and possible overheating of engines.

This section deals with the basic water system required for all dynamometer installations. Additions to the basic water system are required if water recovery is needed.

Basic Plumbing Layout

Illustration 24 shows the basic plumbing layout required for the engine/dynamometer water system. It will work for fresh or cooled recycled water.

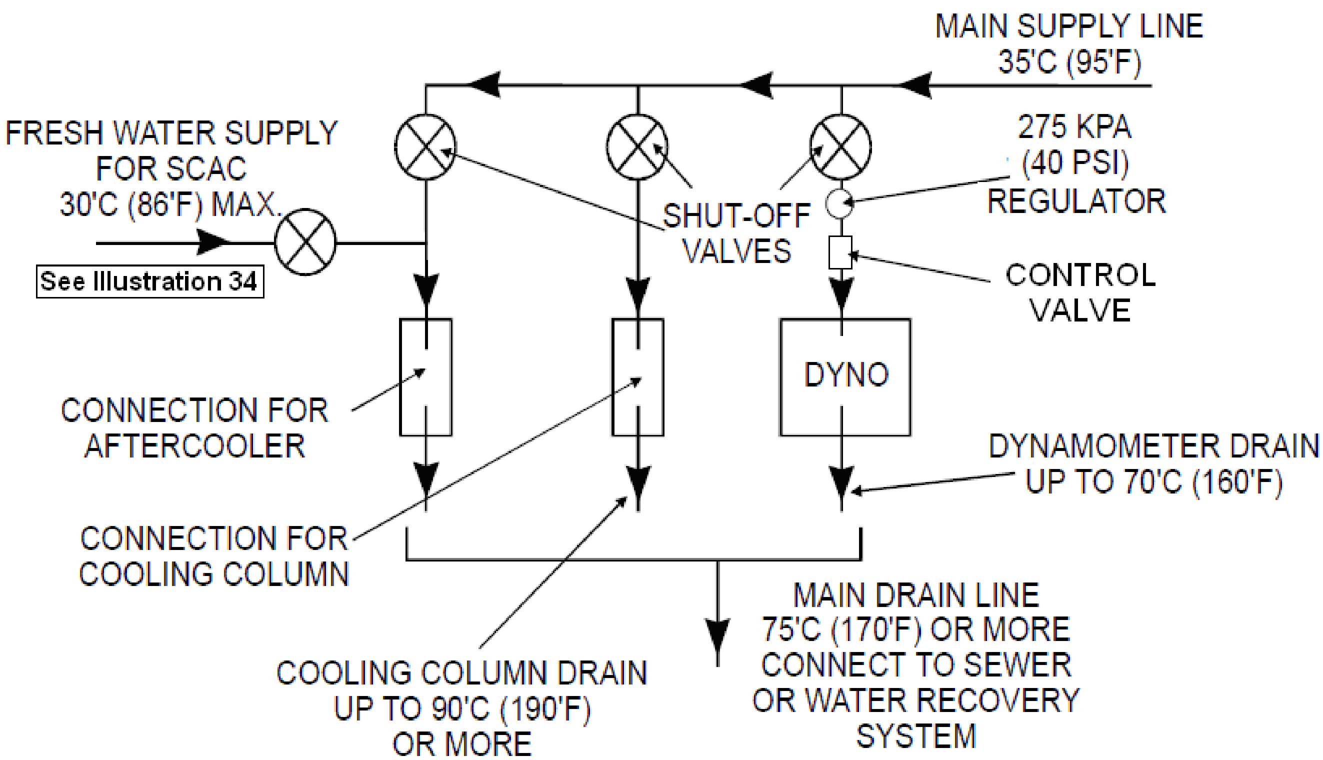


Illustration 24 – Basic Water System Layout

Supply Line Sizing

Main Supply Line

Metric	Flow (in liters per minute @ 450kPa) = kW X 0.86 Pipe Diameter (in centimeters) = √Flow(LPM) X 0.070
English	Flow (in gallons per minute @ 65PSI) = HP X 0.17 Pipe Diameter (in inches) = √Flow(GPM) X 0.041

Dynamometer Supply Line

Metric	Flow (in liters per minute @ 450kPa) = kW X 0.4:?. Pipe Diameter (in centimeters) = √Flow(LPM) X 0.070
English	Flow (in gallons per minute @ 65PSI) = HP X 0.085 Pipe Diameter (in inches) = √Flow(GPM) X 0.041

Cooling Column / Aftercooler Supply Line

Metric	Same as Dynamometer Supply Line
English	Same as Dynamometer Supply Line

Drain Line Sizing

Main Drain Line

Metric	Flow (in liters per minute @ Free Fall) = kW X 0.86 Pipe Diameter (in centimeters) = √Flow(LPM) X 0.36
English	Flow (in gallons per minute @ Free Fall) = HP X 0.17 Pipe Diameter (in inches) = √Flow(GPM) X 0.21

Dynamometer Drain Line

Metric	Flow (in liters per minute @ Free Fall) = kW X 0.43 Pipe Diameter (in centimeters) = √Flow(LPM) X 0.36
English	Flow (in gallons per minute @ Free Fall) = HP X 0.085 Pipe Diameter (in inches) = √Flow(GPM) X 0.21

Cooling Column / Aftercooler Drain Line

Metric	Same as Dynamometer Drain Line
English	Same as Dynamometer Drain Line

NOTE Preceding formulas are listed as a guideline The preceding formulas were developed with considerations made for standard plumbing lengths and warm fresh water temperatures In regions where water flow consultants are available, they should be contacted for sizing.

Determination of Water Supply Source

A fresh water supply and a waste system return is typically the least costly water system to install, maintain and operate. A fresh water/waste system means that the supply water is fresh water (city or privately owned) and the system's drain water goes into the sewer or approved disposal (is wasted). To use this system, the following local conditions must be available:

1. There must be enough water volume from either city water or the privately owned water supply system.

2. The local sewer system must be able to handle the maximum volume of discharge water.

3. The local sewer system must allow discharge temperatures of 80°C (180°F) or more.

It is important to remember that the discharge water's volume is determined by the engine power to be tested. The amount of water used by the dynamometer and for engine cooling is approximately .86 liters per minute X engine load in kW (*0.17 gallons per minute X engine load in HP*). The actual flow rate can be calculated using the formula LPM = 14.3(kW) / (Outlet Temperature in °C – Inlet Temperature in °C)(GPM = 5.1 (HP) / (T_{out}in °F - T_{in}in °F)) for the dynamometer and providing a similar amount of water for liquid cooled engines. These flow rate requirements represent the flow at a given load. As the load on the engine changes, so do the flow requirements. Remember that the dynamometer does not operate continuously. To determine if the fresh water supply and sewer system can handle the water volume you should list the various engine models to be tested and the number of each for a given period of time. The water volumes required for each of these engines will be added to determine the average water volume for the time period.

NOTE: Steps must be taken to prevent contamination of lake water, i.e. the use of heat exchangers may be required. See Illustration 34.

If there is an ample fresh water supply and the drain water can be discharged into the sewer, a fresh water/waste system can be installed as show in Illustration 24. The temperature of the incoming fresh water supply should not exceed a maximum of 35°C (95°F). The water should not exceed 30°C (85°F) when testing SCAC engines.

If there isn't an adequate fresh water supply and/or engine/dynamometer water cannot be discharged into the local sewer system, a water recovery system must be installed. With this system, water is recycled by cooling the discharge water for use as supply water. Only a small amount of fresh water is then required for make-up water. The water recovery system is an addition to the basic engine/dynamometer water system shown in Illustration 24. Refer to "Water Recovery Systems" for additional information.

In cold weather climates, it may be feasible to install a heat recovery system. This system uses a portion of the heat from the engine/dynamometer water to supplement the building heat system. Refer to "Heat Recovery Systems" for additional information.

Portable Cooling Columns and Air-to-Air Aftercooler Simulator

Due to engine model mix, two portable cooling columns may be required and an air-to-air aftercooler simulator may also be necessary. Only two of these three items will ever be connected at the same time. Depending on the type of engine, the following water connections may be required:

- One portable cooling column for engine jacket water cooling

- Two portable cooling columns, one for jacket water and one for separate circuit aftercooled engines
- One portable cooling column for jacket water and the air-to-air aftercooler simulator for charge air cooled engines.

Only two water supply and return connections are needed for the engine. These connections should be on each side of the engine mounting area at the front end. This location is ideal because the engine connections to the cooling columns and air-to-air aftercooler simulator are at the front of the engine.

Any one of the three portable cooling units (jacket water cooling column, aftercooler column or air-to-air aftercooler simulator) can be connected to either water location. The only exception is when water recovery is added to the basic water system and the water supply system is too warm for usage. A separate fresh water line for SCAC aftercooler columns may be required. For additional information concerning a SCAC connection with water recovery, refer to “Water Recovery Systems”.

Two water connections must be provided at each location. One connection is used for water supply and the other is a vented connection for the discharge or drain. Each of these water connections should terminate with a quick disconnect coupling. These couplings may be purchased from Taylor Dynamometer, Inc.

The connections between the portable cooling columns and the water connections are made with flexible coolant hose. The hose must be able to withstand water temperatures of approximately 120°C (250°F) and be resistant to abrasion, oil, antifreeze and diesel fuel. These hoses may be purchased from Taylor Dynamometer, Inc.

Since the water connections are centrally located, they should be recessed below floor level to avoid damage and provide an unobstructed floor surface. You have two options for recessing water connections:

Option 1 – Recessed Compartment Design – The connections for three portable water cooling units may be recessed compartments in the floor (see Illustration 25). The size of each compartment should be approximately 60 x 60cm (24 x 24”) x 30cm (12”) deep. Illustration 26 shows a typical water compartment. For a detailed description of the compartment construction, refer to “Miscellaneous Equipment and Mechanical Requirements”.

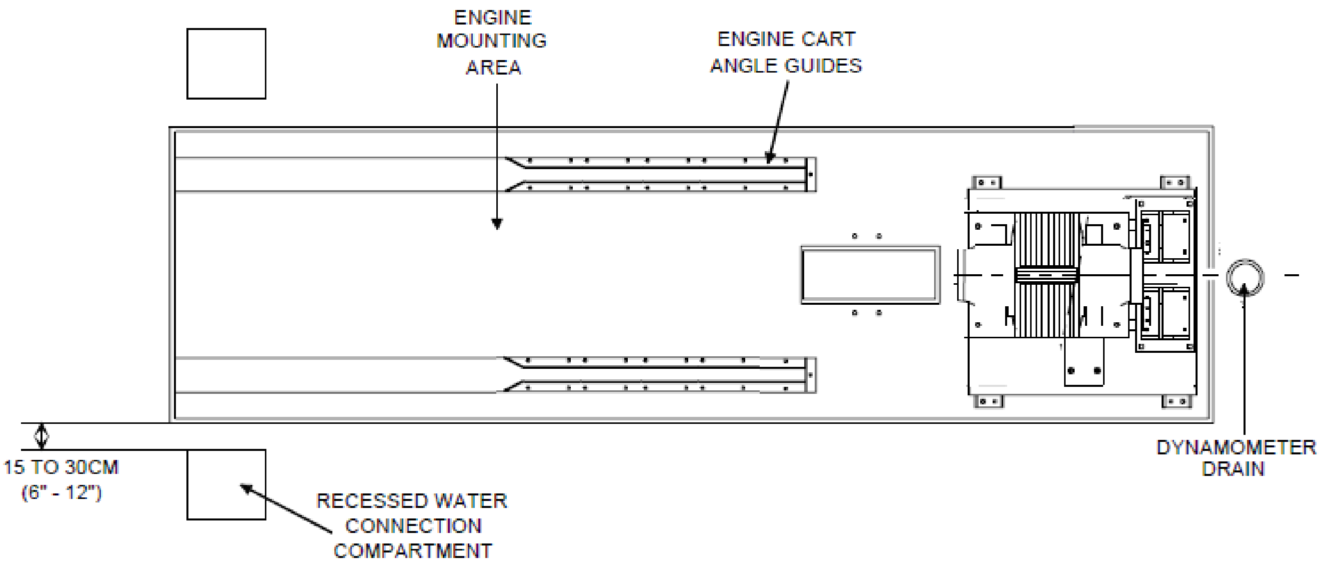


Illustration 25 – Inertia Block and Water Connection Compartment

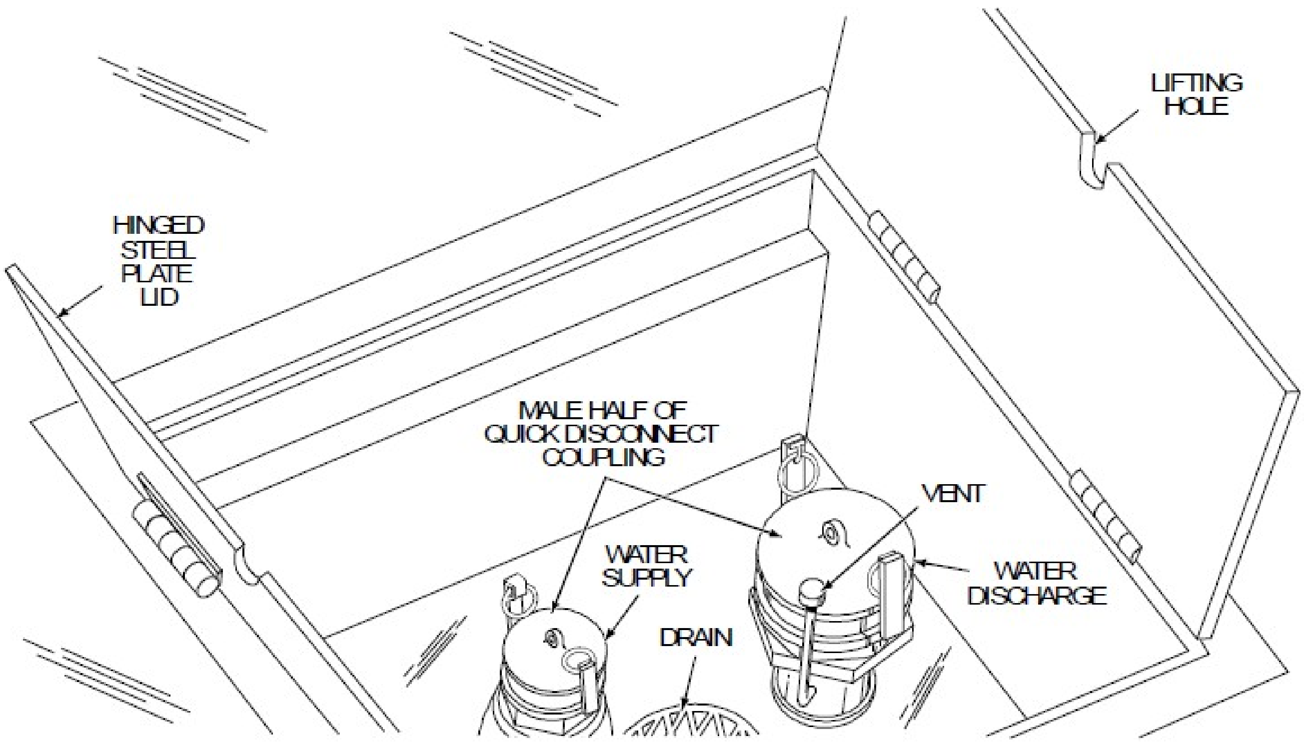


Illustration 26 – Recessed Water Connection Compartment

Option 2 – Recessed Trench Design – If local codes do not permit water lines buried below concrete, they may approve installation in a covered, recessed trench. The trench should be constructed in a U-shape around the isolated engine/dynamometer inertia block (see Illustration 27).

NOTE: With either option, the recessed are should be close to the isolated pad to minimize the length of the connection hoses and to prevent cluttering the floor.

In addition to water lines, the trench is also used for installation of fuel lines. The lift-off covers provide easy access to the pipe installation. Hinged lids are provided over the connections. The pipes enter the trench by vertically extending down the end wall to the trench. For a detailed description of the pipe installation and trench construction, refer to the “Miscellaneous Equipment and Mechanical Requirements” section.

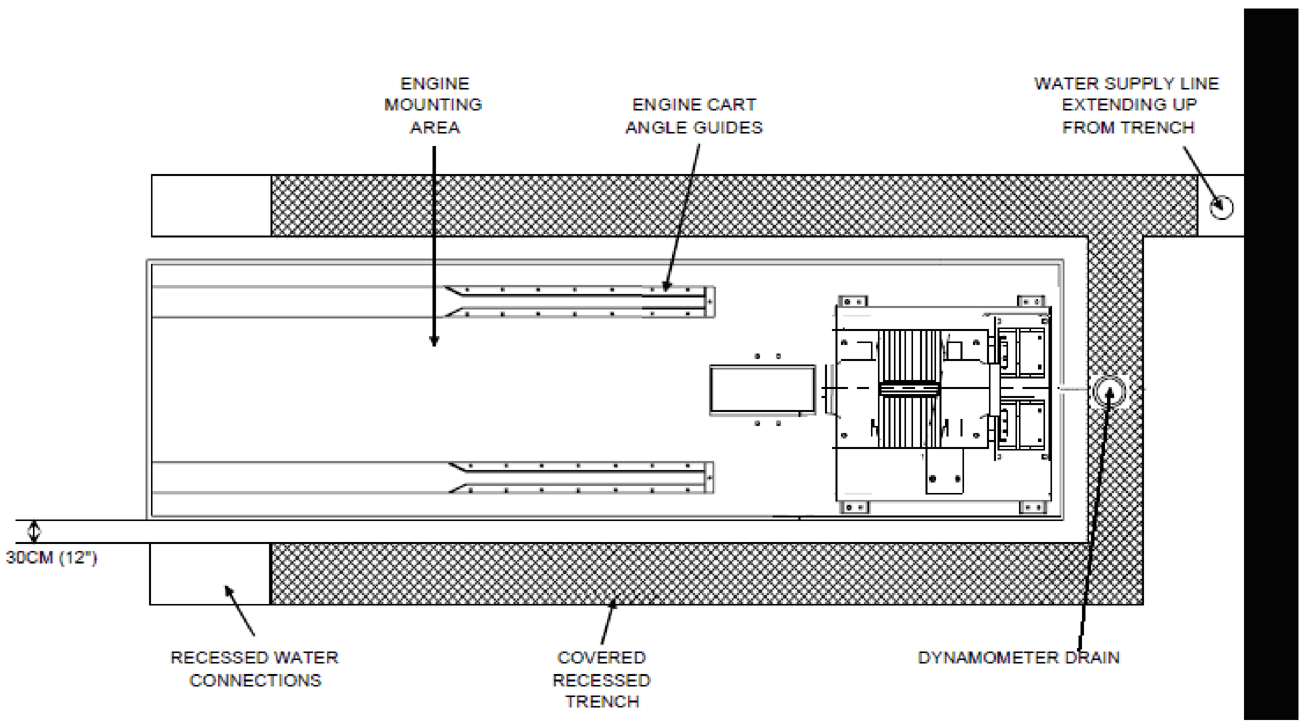


Illustration 27 – Inertia Block and Covered Recessed Trench Design

Portable Cooling Columns

Illustration 28 – Cooling Column

Illustration 28 shows a portable cooling column. Portable cooling columns regulate the flow of fresh water to maintain the desired engine water temperature. Jacket water and separate circuit aftercooler (SCAC) cooling columns are nearly identical except for the temperature regulator setting. The jacket water cooling column has adjustable temperature settings of 71 to 110°C (160° to 230°F). The aftercooler column has adjustable temperature settings of 34° to 57°C (75° to 135°F).

For jacket water cooling systems that require shunt lines, the cooling columns have plugs that can be removed to add a shunt line. Jacket water cooling columns are also equipped to allow visual indication of combustion gas leaks into the engine water cooling system.

Closed Loop Cooling Center

The closed loop cooling center (CLCC) is most commonly used for a closed loop glycol cooling system. The CLCC is designed to control engine primary or secondary water circuit temperature and pressure.

The CLCC also includes a coolant pump within the enclosure. This coolant pump is used to fill and empty the engine jacket water loop before and after testing.

A coolant tank of suitable capacity is required to complete the system.

Illustration 29 – Closed Loop Cooling Center

Water System Pressure

To supply the volume of water needed for the dynamometer and engine, it is required that the system maintain a pressure in excess of 447kPa (65psi) when the maximum flow rate is required. If the pressure fluctuates or drops below the minimum, the test might falsely indicate an engine or dynamometer problem. A system with the ability to maintain 447kPa (65psi) at full flow will ensure a valid test. A minimum setting of 207kPa (30psi) using a pressure regulator located close to the dynamometer is necessary to maintain even water pressure to the dynamometer (see Illustration 24). The other components in the water system will function at 447kPa (65psi).

Dynamometer Water Supply Line

The water supply line to the dynamometer must be connected with a flexible rubber hose to reduce vibration and allow for slight rotational movement of the dynamometer (see Illustration 30).

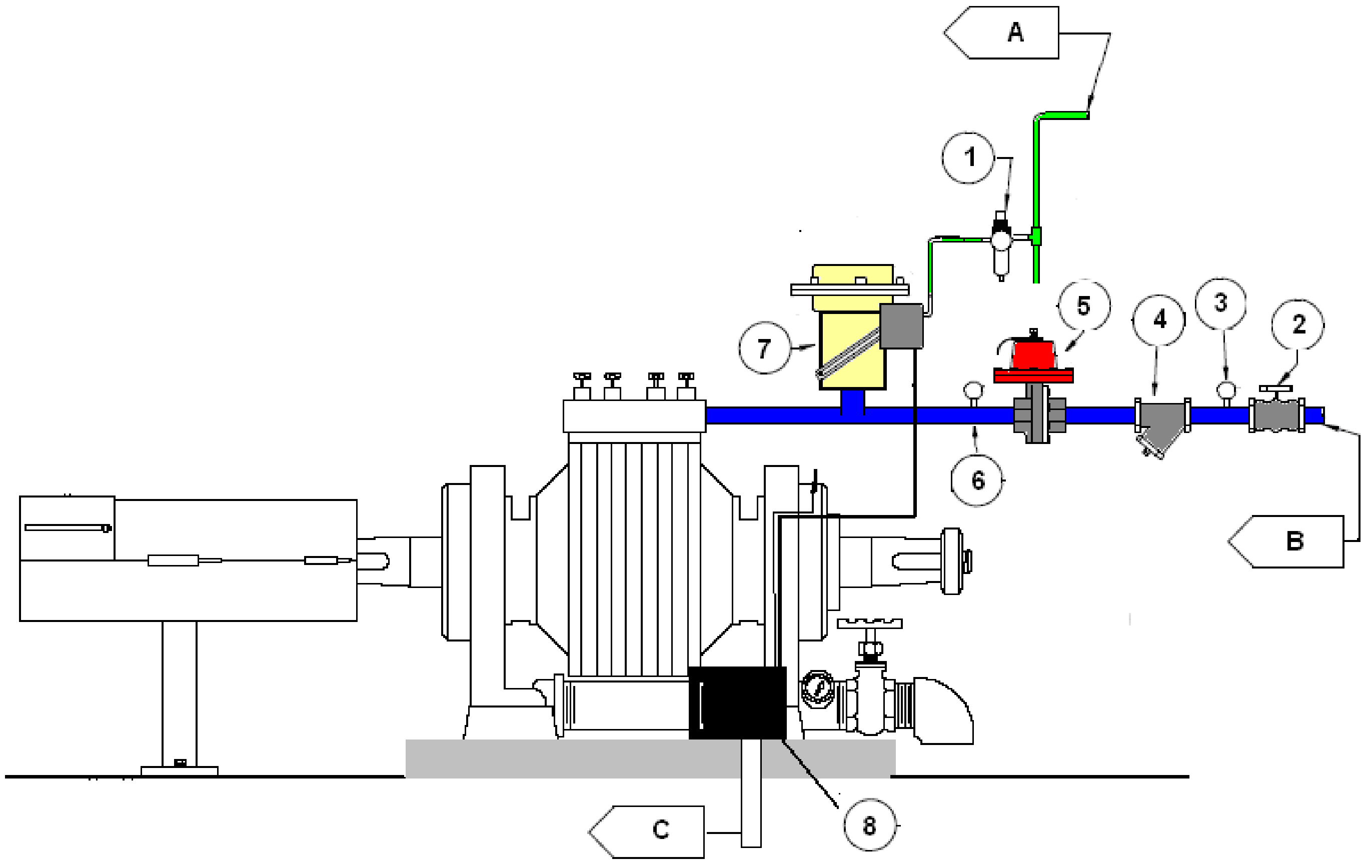


Illustration 30 – Dynamometer Water System

A. Shop air, 150psig
B. Cold water supply from WRS pump
C. 3" conduit from location of Instrumentation System

1. New air regulator(s) supplied by Taylor; set at 30psig.
2. Shut off valve can be anywhere downstream from pump.
3. 0-100psig gauge supplied by Taylor.
4. Strainer.
5. Pressure regulator valve supplied by Taylor.
6. Control valve(s) supplied by Taylor.
7. Junction box already mounted to the dynamometer frame at the factory.

A manual shutoff valve should always be installed before the pressure regulator, even if a remote control valve is used. In the event of malfunction, the manual shutoff valve may be used to control the load to the dynamometer.

Dynamometer Control Valve

A remote operated control valve for varying the dynamometer load is required. This eliminates unnecessary walking between the dynamometer and the operator control area.

The remote control valve(s) for controlling dynamometer load should be purchased as part of the dynamometer package from Taylor Dynamometer, Inc. The control valve should be located between the pressure regulator and the dynamometer. Some models incorporate the load valve in the dynamometer design. If distance between the regulator and the control valve is 1.5m (5') or less, the line between them can be reduced to the fitting size on the control valve. If the distance between regulator and control valve exceeds 1.5m (5'), the line between them should be the same size at the inlet to the regulator.

Dynamometer Water Discharge

Water discharge from the dynamometer must be to a free-fall drain.

Stationary dynamometers cannot have a pipe connection to the drain because of vibration and the rotational movement of the dynamometer. To allow for this, the dynamometer discharge water spills into a gravity drain (see Illustration 31).

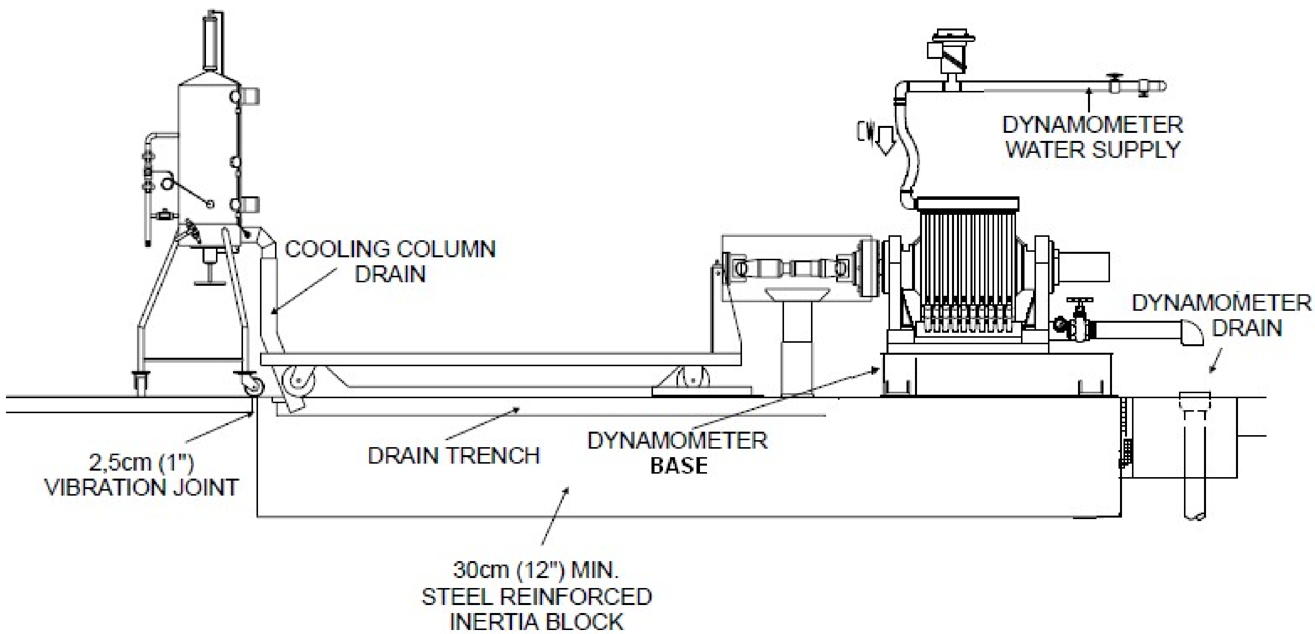


Illustration 31 – Inertia Block, Drain Trench, and Water Supply Location

NOTE: In some cases, the dynamometer exhaust manifold must be rotated to accommodate drain locations. Taylor dynamometers are designed to permit the discharge water to leave the dynamometer from either end without affecting performance. This will not interfere with the optional air starter installation.

The discharge temperature is controlled with a valve at the dynamometer outlet (see Illustration 32). It is adjusted to allow the discharge temperature to be 71°C (160°F) at maximum load and maximum pressure.

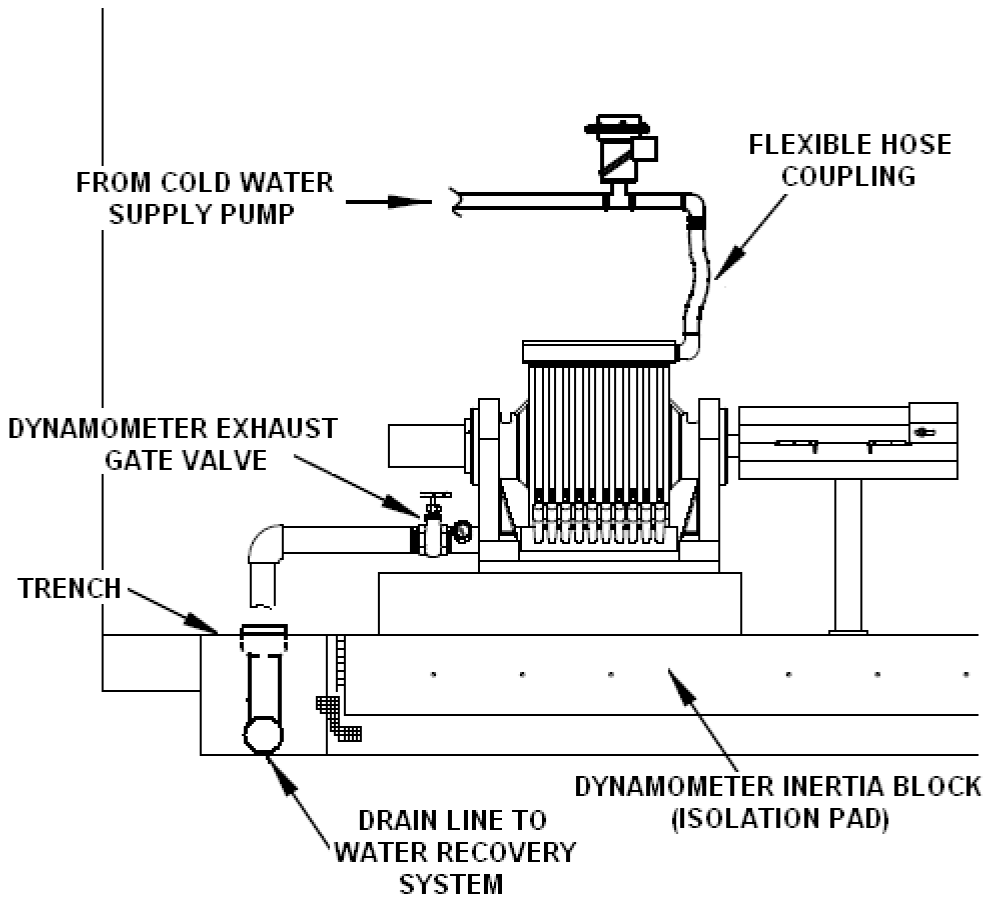


Illustration 32 – Dynamometer Exhaust Valve

Water Recovery Systems

A water recovery system should be considered if one or more of the following local conditions exist:

1. Limited capacity or excessive cost of the local water system (city or privately owned).
2. Limited capacity of the local sewer system to handle the volume of discharge water.
3. The local sewer system does not permit water temperature of 77°C (170°F) or more.

A water recovery system is an addition to the basic water system as covered in the previous section.

Principle of Operation

The typical water recovery system has two major additions to the basic water system – a water recovery storage tank and a heat exchanger. Additional items such as pumps, controls, valves and piping are also used. Illustration 33 shows a typical water recovery system. Hot wastewater from the dynamometer and test engine drains into the hot water compartment of the recovery storage tank. Cold water from the heat exchanger return sump may be required to blend with the hot water to maintain an operating temperature acceptable for the heat exchanger. The hot water is pumped through a heat exchanger, is cooled and then returned to the cool water compartment of the recover storage tank. Cool water is then pumped back to the dynamometer and test engine to be reused as supply water.

The temperature of the dynamometer system return water can reach 77°C (170°F) or more. When possible, the fresh water supply temperature should be maintained at no more than 35°C (95ºF). If the testing of the Separate Circuit Aftercooled engines is not expected or if a separate provision for the supply of 30°C (85°F) water for SCAC engines is made, then a maximum of 45°C (110°F) may be allowed. These temperatures will vary with local ambient conditions. Please consult Taylor for information specific to your application.

Depending on the cooling system design and the applied loads, water may not always be pumped through the heat exchanger or the cooling fan may not be in operation. If the temperature of the hot sump is less than the required cool water supply temperature, the hot water pump or cooling fan does not need to be operated. Instead, the return water can blend with the water in the cool sump through an equalizer pipe or perforated baffle near the bottom of the two compartments. The hot water pump to the heat exchanger or cooling fan can be designed on ambient conditions and applied load. A temperature sensor may activate the hot water pump or fan. The cool water pump operates continuously during the test cycle.

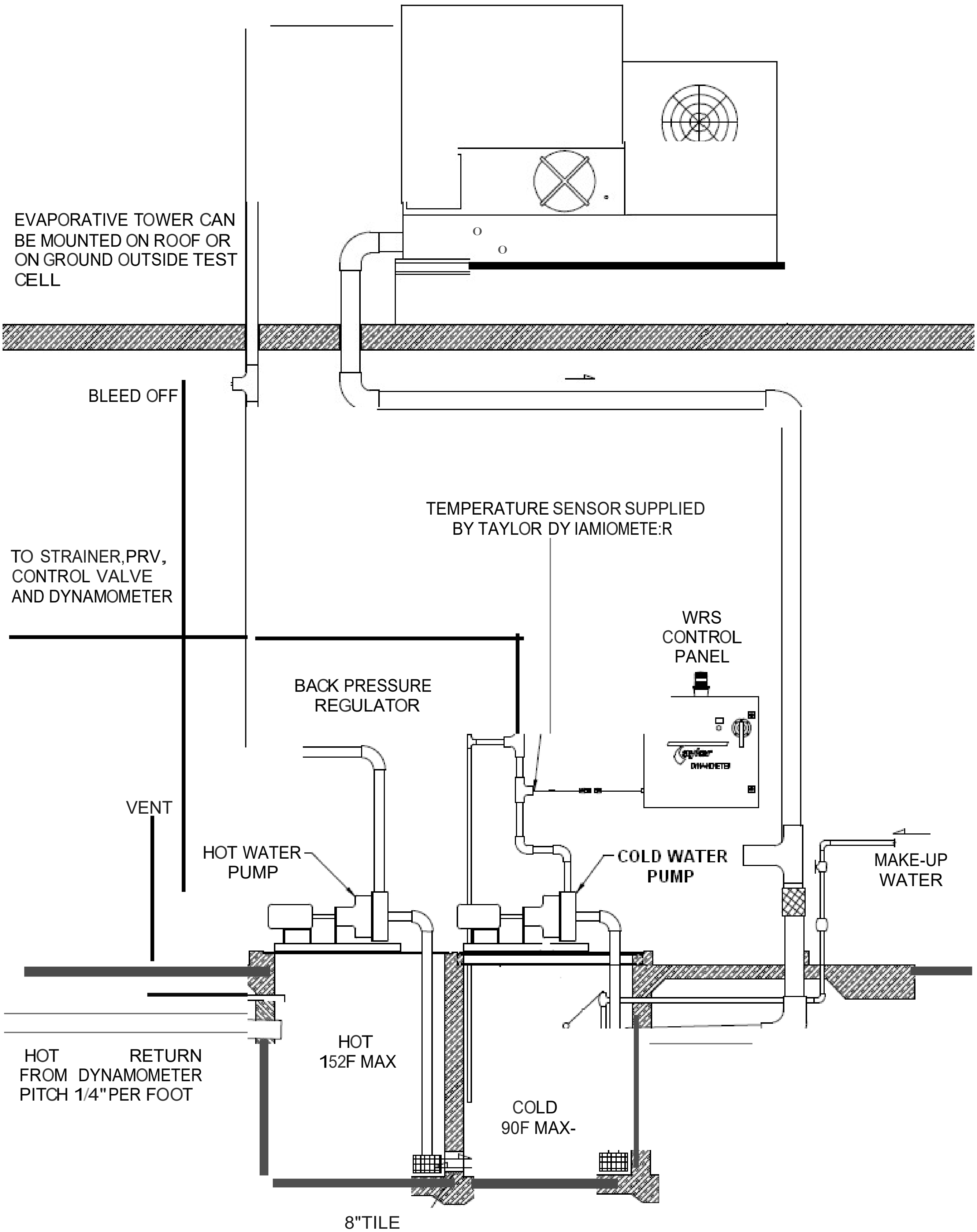


illustration 33 — 'JYpical Water Recovery System

Multiple Pump Water Installations

For some installations, multiple cold and hot water pumps allow greater flexibility and energy savings. The use of two to four similar pumps combined in parallel to achieve the required flow rate allows the pumps to be turned on as required by engine load. Customers with dual dynamometers or a large dynamometer that is used for testing a large quantity of comparatively small engines should consider this design.

The engine size being tested determines the number of water pumps operating based on the volume of water required. A pressure sensor for the cold water pumps and a temperature sensor for the hot water pumps may control operation. Many times there may be a fluctuation in the number of water pumps operating during a test cycle. This is because the volume of water needed is less than the combined output of the pumps running. In these situations, one water pump operates intermittently while the water pump(s) operate(s) continuously.

The initial cost of multiple pumps is higher; however, the cost of operation (electric power consumed) is less. In the event of a pump failure, the dynamometer can still be used for smaller engines by operating on the remaining functional pumps.

SCAC Usage with Water Recovery System

The maximum inlet temperature for separate circuit aftercoolers (SCAC) varies from 30°C to 55°C (85°F to 130°F) depending on the aftercooler. Recycled supply water must either be provided colder than the engine requirement or a separate water supply of proper temperature must be made available. In areas where the recycled water supply temperature may be a problem, two water supply lines may be required – a fresh water line and a recycled water supply line (see Illustration 34). By manually turning two valves, the SCAC aftercooling column can use either fresh or recycled supply water, depending on the maximum inlet temperature allowed. The same SCAC water connections can be used for both fresh and recycled water.

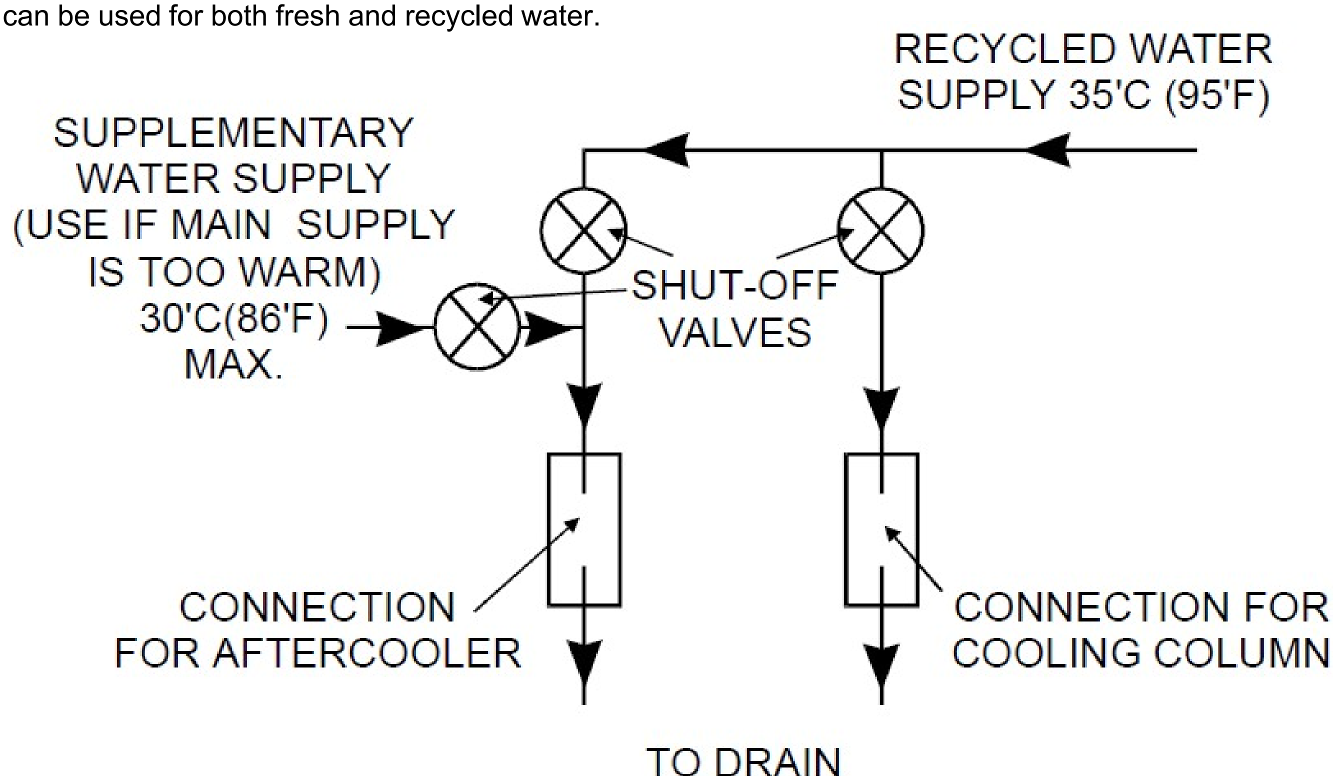


Illustration 34 – SCAC Water Hook-up with a Water Recovery System

When conditions require the use of fresh water for the SCAC system, the fresh water is drained to the water recovery tank. Any excess water is then drained through the recover tank overflow.

Make-up Water

Fresh make-up water is required for all water recovery systems. Loss of water in the system occurs when hoses are disconnected and by evaporation. The amount of water loss due to evaporation varies with the heat exchanger used. In some cases it may represent 3-5% of total hot pump flow. A float valve in the cool water sump can automatically control the supply of fresh make-up water.

Water Recovery Storage Tank

Water recovery storage tank capacities vary from a minimum of 4000L (1000gal) for a small dynamometer package with an evaporative cooling tower to a small lake for non-cooling recirculating systems used for large dynamometers. As a general rule the total sump capacity should be six times the total pump flow for an active cooling system. Because of its size, the tank is usually below ground. If placed above ground, dynamometer system return water must be pumped back to the tank and other considerations must be made in climates where freezing is expected. If buried, the tank can be located outside the building or under the floor of the dynamometer room. Passive recirculating systems (those with no form of forced cooling) must be designed with a thorough knowledge of heat rejection and engine test profiles. Consult Taylor Dynamometer for further details.

When outside sumps are installed in cold weather climates, they must be below the frost line and have the pumps protected from freezing through submersion, draining or location inside the building to prevent freezing. If the tank pumps and controls are located within a dynamometer room, they should be mounted to prevent obstructing the room while allowing easy access for service. If the sump is under the dynamometer room floor, a steel lid covers the access to the pumps, motors and tank.

Heat Exchangers

These types of heat exchangers are used in water recovery systems:

Aboveground Water Storage Tank – Water-to-air heat exchanger (Storage Tank). Least effective. Relies upon ambient temperature differential to provide cooling over a period of time.

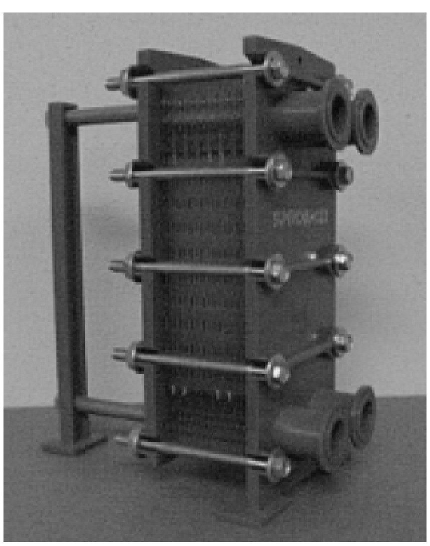


Illustration 35 – Plate Style Heat Exchanger

Water-to-Water Heat Exchanger – Ideal for installations with an abundance of water (fresh or salt) that cannot become mixed with the engine jacket water or dynamometer. Plate or tube styles are available (see Illustration 35). Cooling water is pumped through a series of baffles within the heat exchanger, while hot dynamometer water circulates around but not in contact with cooling water. The warm water is then discharged through the exchanger as cool water. The heat is transferred from the hot dynamometer water to the cooling water and returned to its source. More than one heat exchanger may be required depending on the sizing of the water recovery system.

Consideration for protection from freezing and minimizing plumbing distances should be made when locating this equipment.

Radiator – Water-to-air heat exchanger. When positioned properly it can be used for supplemental heating. More than one radiator may be required depending on the sizing of the radiator, the engines to be tested and the water recovery system.

Cooling Tower – Evaporative heat exchanger. This is the most effective means of cooling for most applications. Illustration 36 illustrates the operating principles for an evaporative cooling tower. When hot water is sprayed into a current of cool air, the heat from the water is dissipated (evaporated) into the air. The heated, moist air then leaves through the fan(s). The cooled water falls to the bottom of the cooling tower and drains into the cold water sump. No special provisions to prevent freezing are needed in cold climates, as long as the cooling tower has a free-fall, dry sump.

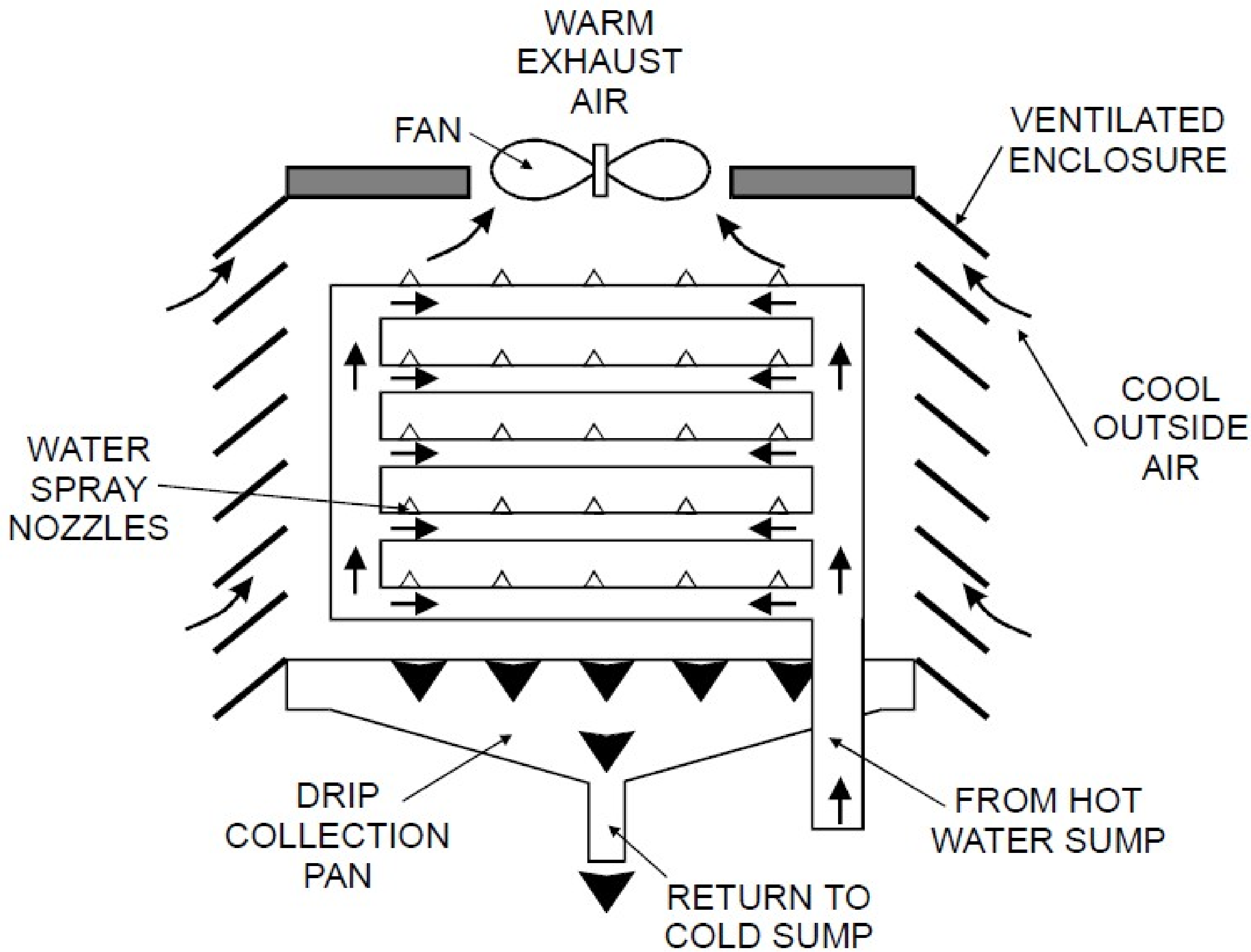


Illustration 36 – Cooling Tower Operating Principles

Illustration 37 – Cooling Tower

Installation of Cooling Towers and Radiators

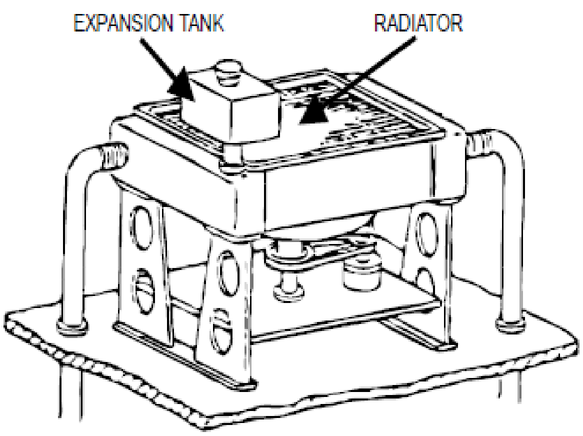


Illustration 38 – Vertical Discharge Radiator

Cooling towers and radiators can be installed on the roof or ground. They need good ventilation for proper cooling. A ventilated decorative wall designed to hide the units usually encloses roof-mounted installations. Ground-mounted installations should be surrounded by enclosure to protect equipment and personnel. The enclosure can be a wire fence or a ventilated decorative wall. Vertical discharge radiators (see Illustration 38) are available when it is desired to reduce height for appearance reasons or to direct the noise upward.

Types of Water Recovery Systems

The major difference between water recovery systems is the type of heat exchanger used. These are the five major types of water recovery systems:

Water Tower System – When a customer-owned fire protection water supply system is required with a 375,000 to 750,000L (100,000 to 200,000gal) water storage tank, this tank may also serve as the dynamometer water recovery system (check with local authorities). Because the tank is above ground with a relatively large amount of water, it may be used as a heat exchanger (water-to-air) for smaller dynamometer systems or for occasional users. A formal heat calculation must be performed to determine length of test time available for a given volume of water.

Since the water tower is needed for fire protection, very little extra expense is necessary to add dynamometer water recovery. It is inexpensive to operate and maintain when compared to other systems. Illustration 39 is a plumbing schematic for a water tower recovery system. The engine/ dynamometer wastewater drains into a sump and is pumped to the water tower. The sump and its pump must be able to handle up to 643L/min (170gpm) for 746kW (1000hp) installations. A float control valve should be used to prevent the dry operation of pumps. The water line from the sump should enter the bottom center of the tower and extend above the water level, which allows water to aerate. Aeration helps heat dissipation.

This system may also be used in conjunction with a plate or tube style heat exchanger to eliminate the concern of contamination.

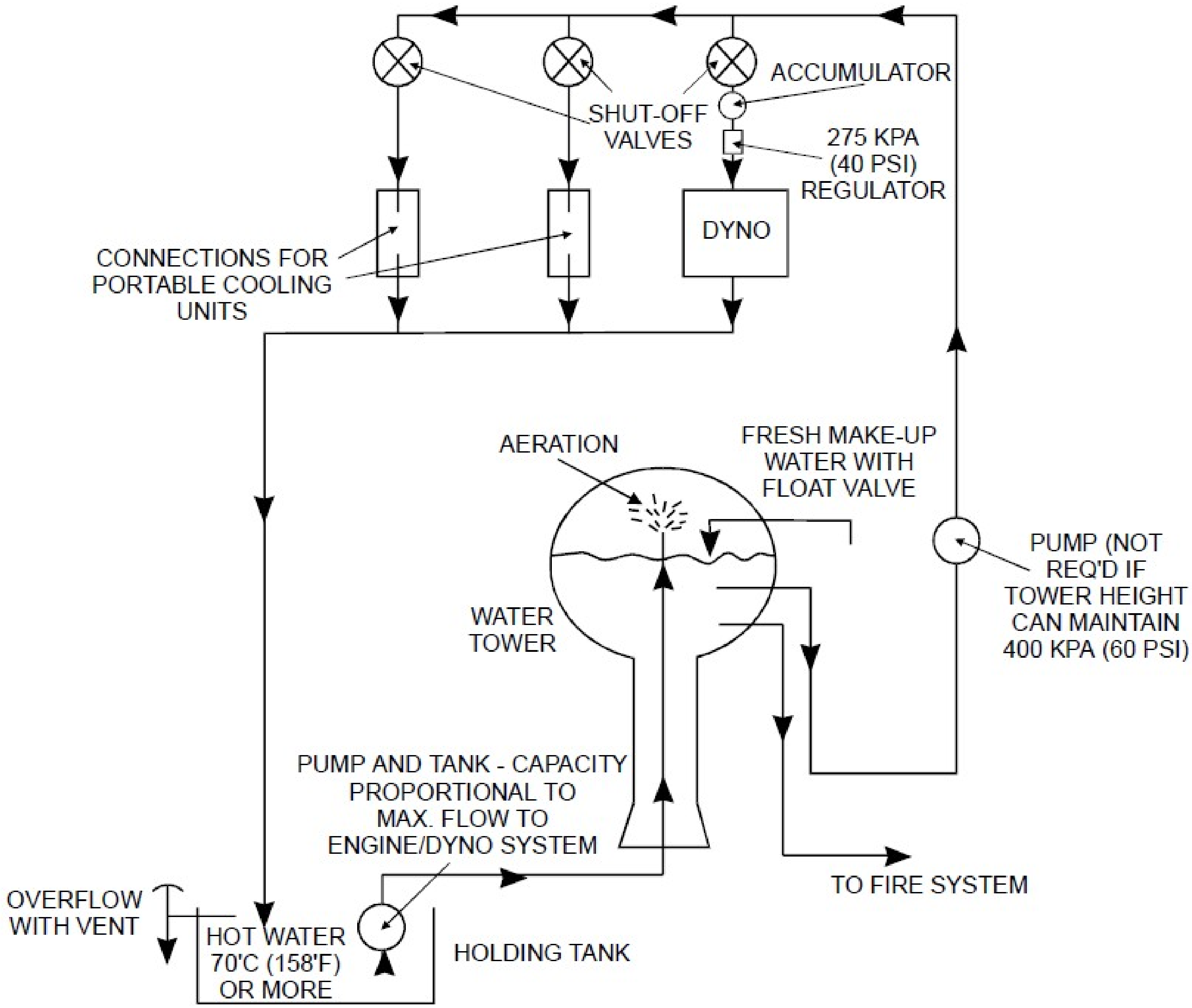


Illustration 39 – Water Tower Recovery System

The different dynamometer supply line and fire protection supply lines leave the water tower at different levels. This provides the appropriate pressure and volume for each system. The fire protection supply line is lower on the tank than the dynamometer supply line because it requires more pressure and volume. If the water is not high enough to maintain 447kPa (65psi) at full flow, an additional pump is required.

Lake Water System – In regions where there is enough rainfall, a lake might be considered for use in cooling recovered engine/dynamometer water. Ample property must be available to accommodate a lake. The lake must be able to maintain approximately 375,000L (100,000gal) of water during low rainfall periods for heat dissipation of engines through 746kW (1000hp). This capacity is equivalent to approximately 0.2 hectare (one-half acre) lake at a minimum depth of 1.5 to 1.8m (5’ to 6’) excluding fluctuation due to evaporation and rainfall. Larger reservoir sizes will be required for increased dynamometer sizes and extended periods of operation.

In addition to dynamometer water recovery, the lake can have other functions:

1. The lake can also serve as a retention pond, where local regulations require collection of property run-off water.

2. The lake can be used to enhance property landscaping. To further highlight the landscape in warm climates, a water fountain can be added to the lake for returning the hot water. The aeration helps dissipate the heat; however, it also adds to evaporation. This can be negligible depending on the size of the lake.

The lake water system is relatively inexpensive to install, operate and maintain when compared to other systems.

Illustration 40 is the plumbing schematic for an engine/dynamometer water system using a lake water recovery system. Lake water is used only to cool the recycled dynamometer water. This is accomplished by running the lake water through a water-to-water heat exchanger. The lake water should not be used as fresh water supply water for the dynamometer system because of contamination.

The system's lake water supply inlet and return outlet should be spaced apart to prevent return water from heating the supply inlet water. The inlet must be installed at sufficient depth below the lake's surface to allow for fluctuation of the water level. In cold climates, both the inlet and outlet must be below the maximum amount of freezing on the lake's surface.

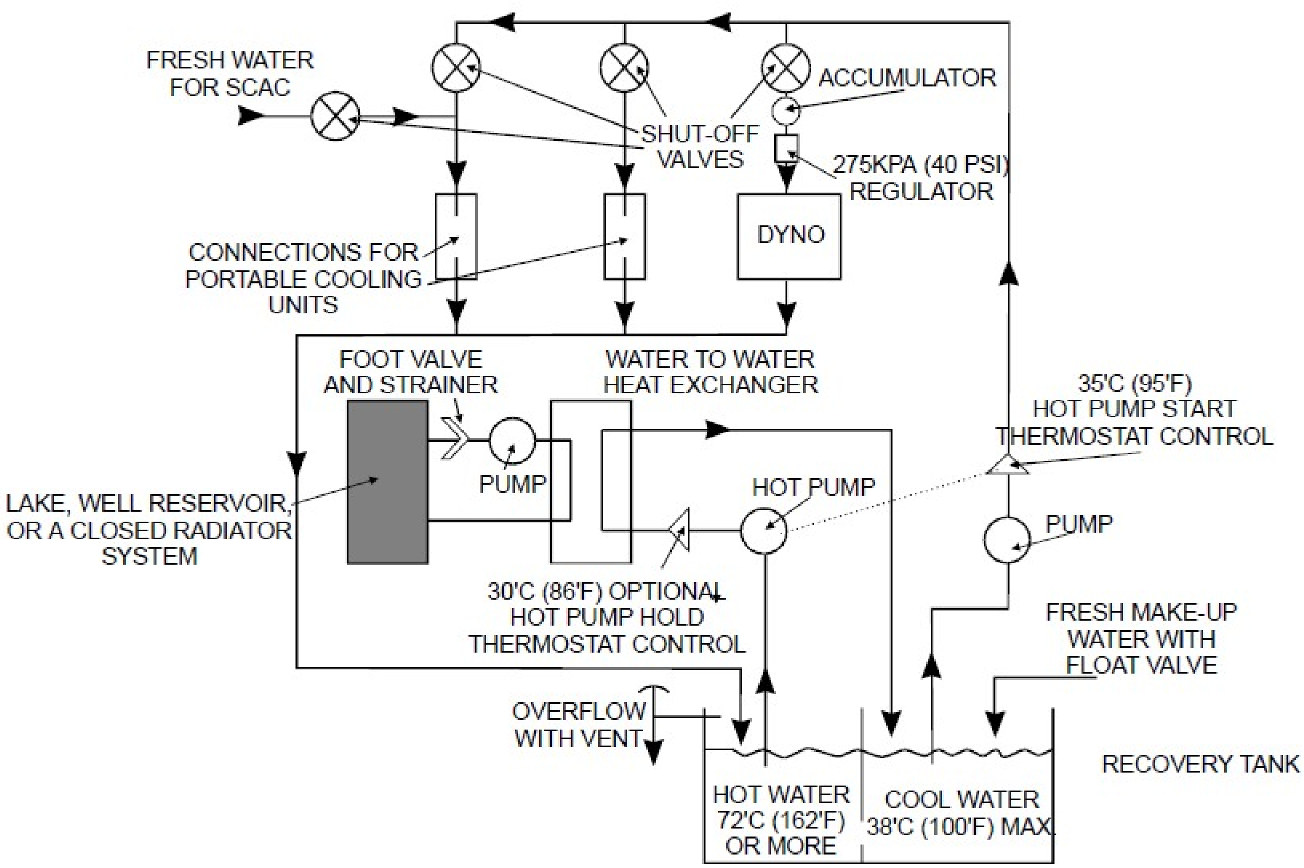


Illustration 40 – Lake, Well, Reservoir and Closed Radiator Recovery System

Recirculated Water Well System – In areas where ample water supplies exist and underground and local regulations permit, a recirculated well water system can be used for dynamometer water recovery. Depending on the well depth required, this system could be relatively inexpensive to install. Maintenance and operation costs are also relatively inexpensive.

The recirculated well water system requires two wells. One is for supply water and the other is for return water. Only the supply well has a pump. The return well disperses the return water back into the ground. There are two methods of using recirculated well water:

- *Method 1* (See Illustration 40) – Requires typical water recovery system of a heat exchanger and storage tank. This method runs well water through a water-to-water heat exchanger to cool dynamometer system water. The wells are sized according to information on flow rate sizing (refer to "Sizing the Water Recovery System").

Caution: Steps should be taken to prevent contamination of the hot well.

- *Method 2* (See Illustration 41) – This method uses the recirculated well water as supply water for the dynamometer water system. This eliminates the need for a heat exchanger. This method conserves water while providing fresh water to the engine/dynamometer. When using this method, both wells must be able to handle the flow requirements of the dynamometer and the engine.

To prevent the heating of supply water by return water, the wells should be spaced apart in both methods. Also, the return well should be downstream from the supply well. The distance between wells will vary with the size of the underground water reservoir or river.

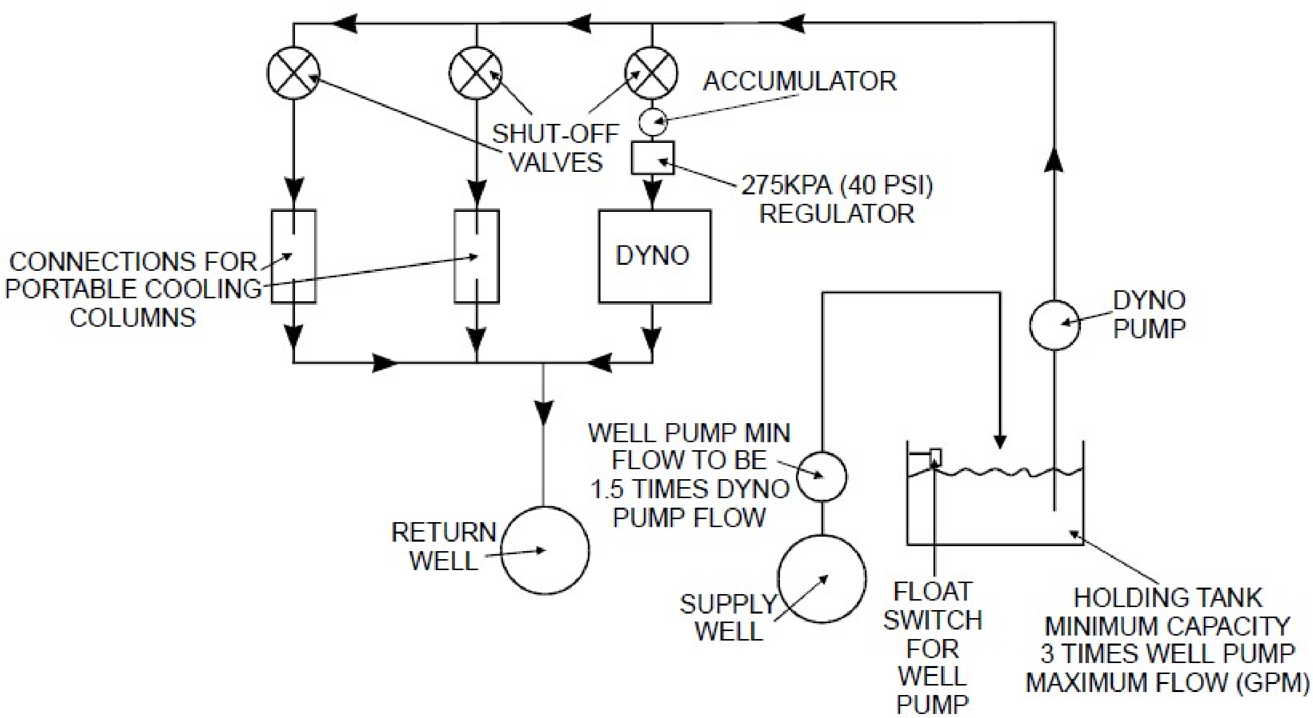


Illustration 41 – Well Water Recovery System

Radiator and Cooling Tower System – Illustration 42 is a plumbing schematic for both radiator and cooling tower recovery systems. The layout illustrates a free-fall open drain design for the cooling tower or radiator circuit. This allows water in the circuit to drain automatically to the storage tank when the system shuts down. When this layout is used in a cold weather climate antifreeze is not required.

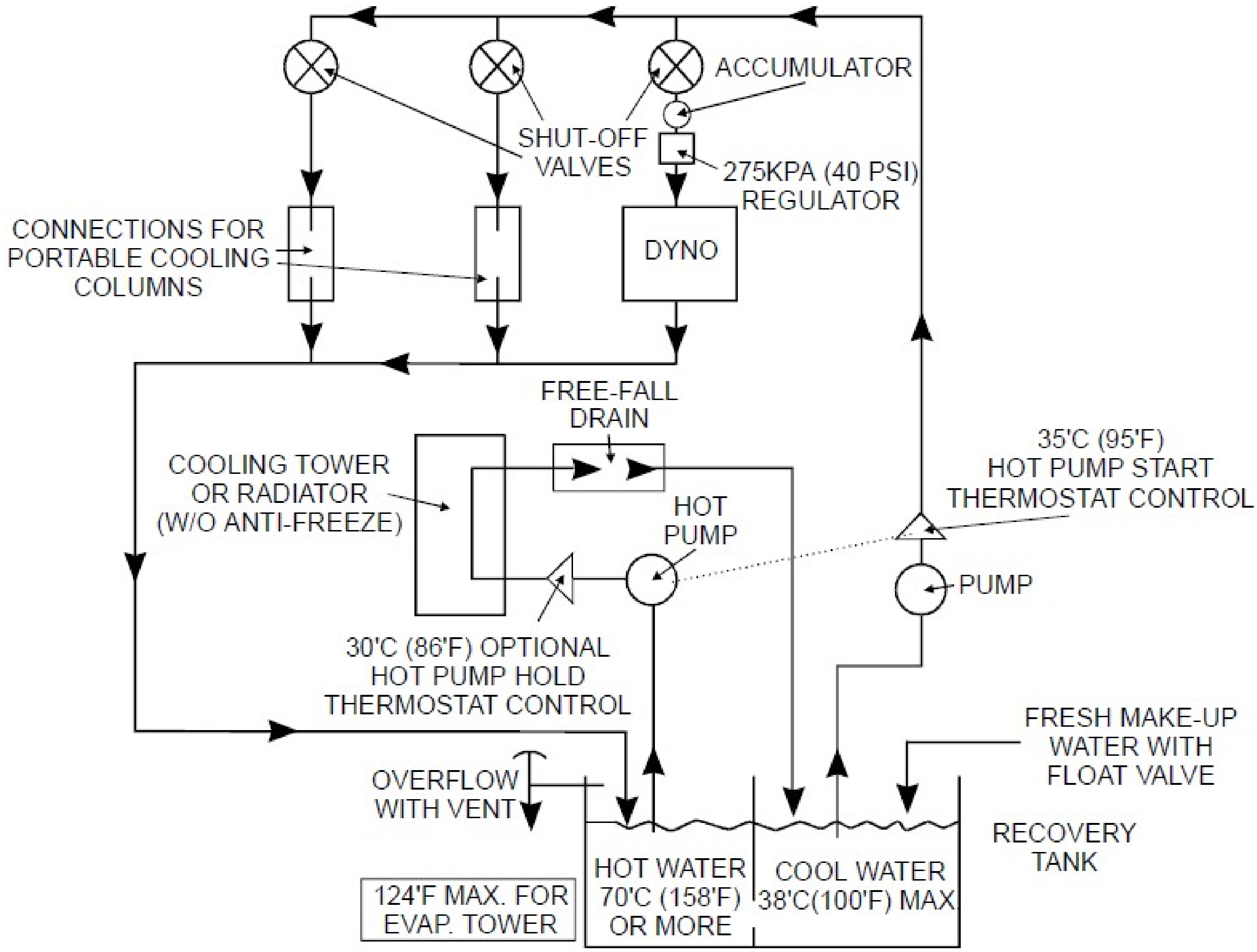


Illustration 42 – Cooling Tower or Open Drain Radiator Recovery System

If you want a closed radiator system with the radiator continuously filled with coolant, antifreeze must be added in cold weather climates. To prevent antifreeze contamination of the dynamometer water system, an additional pump and water-to-water heat exchanger must be added (see Illustration 43). The antifreeze water only circulates in the system between the radiator and the water-to-water heat exchanger. The heat exchanger has the same Btu and flow rate capacity as the radiator. An expansion tank is needed for the overflow of hot radiator coolant.

Radiator/Cooling Tower Comparison

Most water recovery systems are either cooling tower or radiator systems. The other recovery systems are normally applicable in only certain regions because of weather conditions, available resources or local regulations. Usually, the cooling tower system is the first choice because of considerably less capital investment, even though operation and maintenance costs are higher. In areas where water is in short supply, the cooling tower system may not be the best choice because of the amount of make-up water required. When used radiator equipment is available, the capital investment for a radiator system may be reduced to comparable levels with cooling tower equipment costs. Refer to the following comparison charge for additional information.

Comparison	Cooling Tower	Radiator
Equipment Costs (Capital Investment)	Much less expensive	Much more expensive
Operational & Maintenance Costs	Moderate to high	Low
Make-Up Water Consumption	Large amounts due to evaporation (3,8L (1 gallon) of water per 150kW (200hp) per minute of make-up water)	Very low
Ambient Conditions (High Temperature or Humidity)	Humidity sensitive - in high ambient humidity conditions, cooling tower must be sized accordingly larger	Temperature sensitive - in high ambient temperature conditions, radiator(s) must be sized accordingly larger
Cold Weather Climates	No adjustments are necessary	Needs an additional pump and a water-to-water heat exchanger for each radiator so antifreeze can be used
Operational Noise Levels	Lower noise level	High noise level - the level can be reduced using vertical discharge radiators that direct noise upward rather than out. Vertical discharge systems are more expensive
Water Treatment to Prevent Lime Build-Up & Other Deposits	Must be done by: 1) Chemical water treatment 2) A combination of chemical treatment and an overflow to the sewer, thus wasting a portion of the water 3) Increase the amount of waste water to the sewer and eliminate chemical treatment	None
Physical Size & Weight	Large and heavy	Small and light

Sizing the Water Recovery System

The sizing information in this section pertains to water recovery systems having radiator, evaporative cooling tower or water-to-water heat exchangers. It does not apply to water tower (storage) recovery systems. The pipes, pumps, storage tank and heat exchanger have to be sized for the most extreme ambient condition. This is based on the highest temperature and humidity and the lowest barometric pressure expected for the area. These local weather conditions affect the sizing of the water recovery portion and to a lesser extent, the pipe sizing of the basic dynamometer water system due to increased or decreased flow requirements.

Sizing the Heat Exchanger

When determining the Btu capacity required for the heat exchanger, the total heat load between the dynamometer maximum rating and the maximum engine power rating should be evaluated. Sizing the system for intermittent duty or with a cooling down period between tests can save a small percentage of the initial investment but will restrict productivity and scheduling. Adequately sizing the system will ensure many years of proper dynamometer and engine operation.

NOTE: The function of the dynamometer and engine cooling system depends greatly on the water supply system. Inadequate water supplies will create the inability to achieve loads and cause the overheating of engines.

The recovery system should be designed to handle the full engine output of the largest engine continuously. The term continuous means that the test time is infinite for all engines within the kilowatt (horsepower) rating of the dynamometer installation.

- Extended duration test times to facilitate troubleshooting
- Tolerance for unusual weather conditions.
- The ability to operate in minimal condition for small engines through the use of parallel pumps and motor controls.
- A stable water temperature to minimize dynamometer load changes due to changing temperature differentials.

Relationship of kW (hp) to Btu

The unit used to quantify an amount of thermal energy in the United States is the British Thermal Unit (Btu), which is the quantity of heat or thermal energy required to raise the temperature of one pound of water one degree Fahrenheit.

.746kW (1hp) produces 2545 Btu per hour or 42.5 Btu per minute.

Multiply the dynamometer's power rating (hp) * 5090 to obtain the desired Btu per hour heat rejection of the combined engine and dynamometer.

NOTE: The kilowatts (horsepower) generated in the engine cooling system assumes .75kW (1hp) per flywheel kilowatt (horsepower).

To convert kilowatts (horsepower) to Btu per minute, use this calculation:
1kW = 57 Btu per minute
1hp = 42.5 Btu per minute

Where:
Total heat exchange kilowatts (horsepower) in Btu = Engine kW (hp) + Dynamometer kW (hp)
or
Total heat exchange kilowatts (horsepower) = 2 x Engine kW (hp)

Safety Margin = 1.5

Therefore:
Total kilowatt Btu/minute = 2 x Dynamometer kW x 57 x 1.15
Total horsepower Btu/minute = 2 x Dynamometer hp x 42.5 x 1.15

Heat Exchanger/Tank Btu Sizing for Continuous Full kW (hp) Load

When designing for continuous operation at the full capacity of the dynamometer installation, the heat exchanger is sized to provide twice the engine kilowatt (horsepower) rating of the dynamometer installation, plus a 10 to 15% safety margin.

For continuous full-load capacity, the recovery storage tank must hold approximately 4,000-20,000L (1,000-5,000gal) of water dependant on the dynamometer size and the ambient conditions. This requires tank sizes ranging from approximately 1.0m (3') – 2.0m (6') wide x 2.4m (8') – 5.5m (18') long x 2.4m (8') – 3.0m (10') deep divided into two equal size compartments with a water level ¾ full. These capacities provide enough water to fill the entire engine/dynamometer water system. Included are pipes, portable cooling columns, engine, dynamometer and a maintained water level in the tank to ensure proper operation. This water supply is required from start-up to shut down without adding or dumping water except for make-up of evaporated water.

Flow Rate Sizing of Recovery Systems

The flow rate of the hot water (heat exchanger) circuit (including pump(s), piping and heat exchanger) is based on the temperature differential between the supply water temperature into the heat exchanger and the discharge temperature of the now cooled water, returning to the cold water sump, at the worst condition. The smaller the temperature differential, the greater the flow rates through the exchanger. To show the relationship of flow rate to temperature differential, the following formula is used:

Flow Rate in L/min = total of Btu of H.E. x .252
Allowable Temperature Differential in °C

Flow Rate in gpm = total of Btu of H.E. / 8.3
Allowable Temperature Differential in °F

The flow rate of the cool water (dynamometer) circuit (including pump(s) and piping) will be the same as the basic water system.

Water Recovery Requirements for a Multiple Dynamometer Installation

When installing multiple dynamometer rooms, the water recovery installation requirements are similar and are based on the combined kilowatt (horsepower) ratings. The following are the water recovery requirements for the various combinations of rooms.

1. The heat exchanger(s) must be sized to provide 100% of the cooling of the test cells.

2. The capacity of the water recovery storage tank must be sized appropriately for the system.

3. Separate cool water pump installations should be provided for each dynamometer. Thus, separate water supply lines are required from the cool water compartment to each engine/dynamometer water system. Multiple pumps allow for flexibility and economy of operation.

4. The main discharge lines that drain to the hot water compartment from each dynamometer room can be combined or remain separate before connecting to the recovery tank.

Initial Water Recovery Requirements when an Additional Dynamometer in the Future

If an additional dynamometer room will be a future installation, two options are available:

1. The recovery system can be sized for the current requirement. When the proposed room is installed, an additional heat exchanger is added to the system for continuous 100% cooling.

2. The recovery system can be sized for the total combined requirements. The purchase of one large heat exchanger is more economical than multiple units.

Heat Recovery Systems

Dealers in cold weather climates may want to consider recovering a portion of the heat produced by the engine and dynamometer to supplement the building heating system. Both fresh water/waste and recovery systems can be used for heat recovery.

It is not practical to recover all the heat generated by the dynamometer and engine because the water discharge temperature varies with each circuit of the water system as listed below:

Dynamometer Water Discharge Temp.	65°C (150°F) Approx.
Engine Jacket Water Discharge Temp.	85°C to 90°C (185° to 195°F) Approx.
Engine SCAC Water Discharge Temp.	30°C to 45°C (85° to 110°F) Approx.
Engine Air-to-Air Aftercooler Water Discharge Temp.	55°C (130°F) Approx.

As shown, aftercooler water (both SCAC and air-to-air) does not have much Btu capacity. If it is mixed with other discharge water, it reduces the Btu capacity of the engine jacket and dynamometer discharge water. Therefore, the discharge water from separate circuit aftercoolers (SCAC) and air-to-air aftercoolers should not be used for heat recovery. Aftercooler water should be drained directly to the sewer (if reasonable) for both fresh water/waste and water recovery systems. Remember that aftercooler water is low volume [approx. 110L (30gal) an hour] at low temperatures.

NOTE: Provisions can be made to allow aftercooler water to be recovered during the summer. This is accomplished by providing two discharge drains at the aftercooler connection. One drain connects to the sewer for use during the heating season. The other drain connects to the hot side of the water recovery tank for use during the non-heating season.

Only the heat from the engine jacket and dynamometer discharge water is used for supplementary building heat. The two water sources are combined before recovering the heat. The dynamometer water, which has a lower temperature and greater quantity, will reduce the water temperature of the jacket water. The combined temperature should be approximately 70° to 75°C (160° to 170°F).

Heat recovery is an addition to either a fresh water/waste system or a water recovery system. The sizing information in this section is concerned with only the heat recovery portion of the system.

Sizing for the rest of the system is covered in both the "Engine/Dynamometer Basic Water System" and "Sizing the Water Recovery System".

NOTE: The schematic illustrations of various heat recovery systems show basic requirements. Additions may be required because of local regulations or dealer requirements. For example, the shot off valves for system maintenance are not shown.

Heat Recovery for Hot Water Heat

Heat recovery for hot water heating should only be considered if the furnace boiler temperature will not exceed 75°C (170°F). If the boiler temperature exceeds 75°C (170°F), the engine/dynamometer discharge water cools the boiler water which makes heat recovery impractical. The type of dynamometer water system used determines the method of recovering heat for supplementing hot water heat systems. Engine/dynamometer heat can be recovered from fresh water/waste systems and water recovery systems. The following are methods of heat recovery for supplementing hot water heating systems for each dynamometer water system.

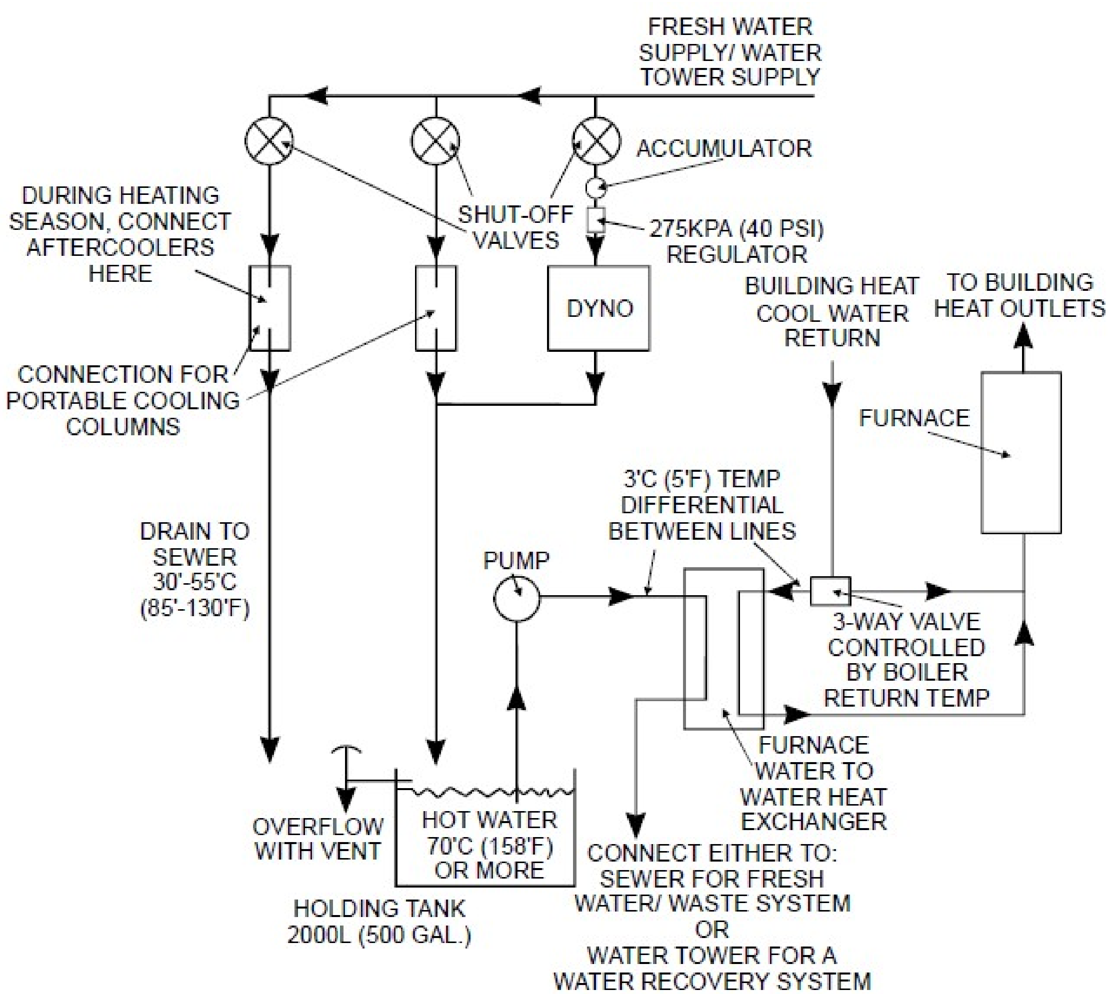


Illustration 43 – Heat Recovery, Cooling Tower or Wastewater System

Fresh Water/Waste System with Hot Water Heat (see Illustration 43) – The engine jacket and dynamometer discharge water drains into a holding tank and is pumped through a water-to-water heat exchanger before going to the sewer. Aftercooler discharge water drains directly into the sewer.

The flow rate of the pump and flow rate/Btu capacity of the heat exchanger are sized up to the Btu per hour heat loss of the building. Excess water that the heat exchanger does not need is drained to the sewer through the holding tank overflow. Multiple pumps are used to ensure a continuous water supply to the heat exchanger during low horsepower loading. A float control valve in the holding tank controls activation of the pumps.

Water Tower System with Hot Water Heat (see Illustration 43) – Heat recovery is accomplished by adding a water-to-water heat exchanger between the holding tank and the water tower. Only jacket and dynamometer discharge water is recovered and pumped through the water-to-water heat exchanger before it is returned to the water tower. Aftercooler discharge water drains directly into the sewer.

This pump is sized for the maximum flow rate of the jacket rate and dynamometer combined water circuits. Thus, flow rates ranging from a minimum of 190L/min (50gpm) for a 238kW (500hp) system with a 16°C (60°F) cold supply water, through 3,200L/min (850gpm) for a 2380kW (5000hp) system with a 38°C (100°F) cold supply can be expected. Use multiple pumps in 380L/min (100gpm) increments to ensure continuous water supply to the heat exchanger during low kilowatt (horsepower) loads. A float control valve in the holding tank controls activation of the pumps.

The flow rate capacity of the heat exchanger is the same as the pump. The Btu capacity of the heat exchanger is sized up to the Btu per hour heat loss of the building.

Cooling Tower or Open Drain Radiator System with Hot Water Heat (see Illustration 44) – With this system, a separate water-to-water heat exchanger that connects to the furnace boiler is added. When using this with a radiator water recovery system, the radiator(s) must free-fall drain when the system shuts down to prevent freezing. The cooling tower is designed with free-fall drains. The aftercooler discharge water does not mix with the other discharge water. It is drained to the sewer.

The capacity of the furnace water-to-water heat exchanger is sized up to the Btu per hour heat loss of the building. Diverter valves are discussed at the end of this section.

Lake Water, Recirculated Well Water or Closed Radiator System with Hot Water Heat (see Illustration 45) – A separate water-to-water heat exchanger connecting to the furnace boiler is added. The aftercooler discharge water is separated and drained to the sewer.

The capacity of the furnace water-to-water heat exchanger is sized up to the Btu per hour heat loss of the building. Diverter valves are discusses at the end of this section.

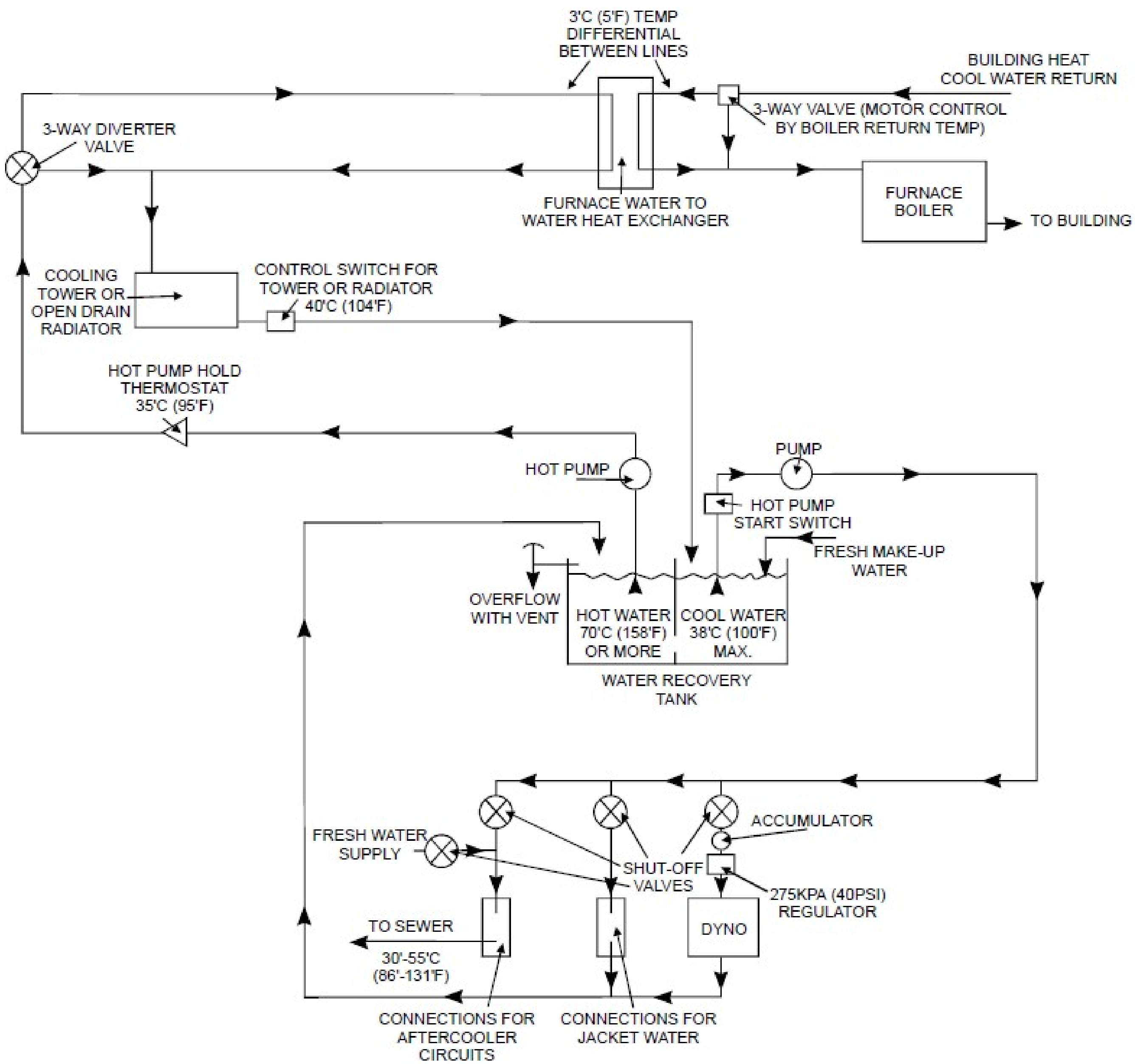


Illustration 44 – Heat Recovery, Open Drain Radiator or Cooling Tower Water System

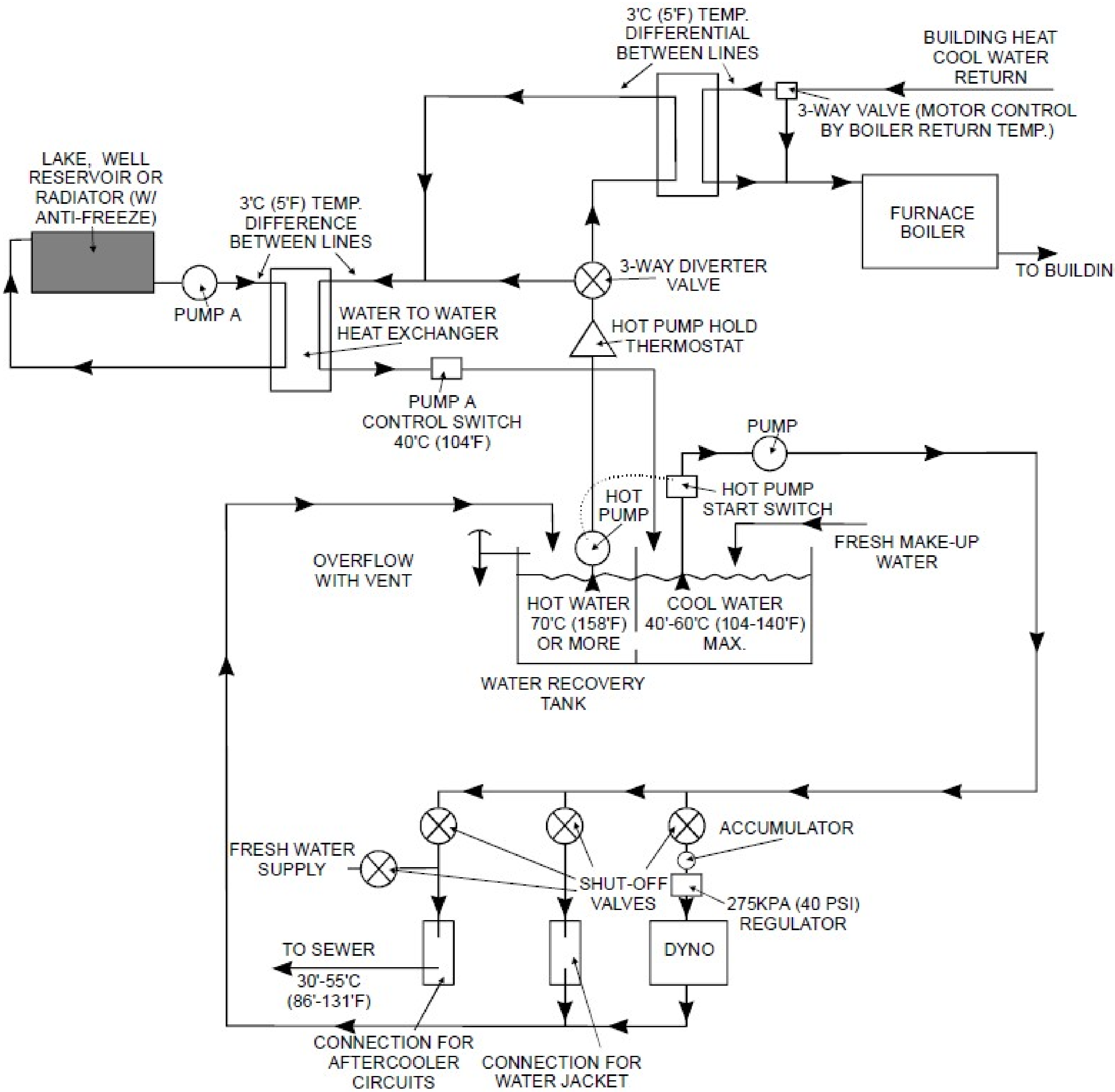


Illustration 45 – Heat Recovery, Lake, Well, Reservoir or Closed Radiator Water System

Heat Recovery for Forced Air Heat

The type of dynamometer water system used determines the method of recovering dynamometer heat or supplementing forced air heat systems. Engine/dynamometer heat can be recovered from fresh water waste systems or water recovery systems. Even though each type of dynamometer water system requires a different method of heat recovery, the installation for connecting the dynamometer water system to a forced air heating system is the same for all heat recovery systems (see Illustration 46). This installation should be next to the furnace.

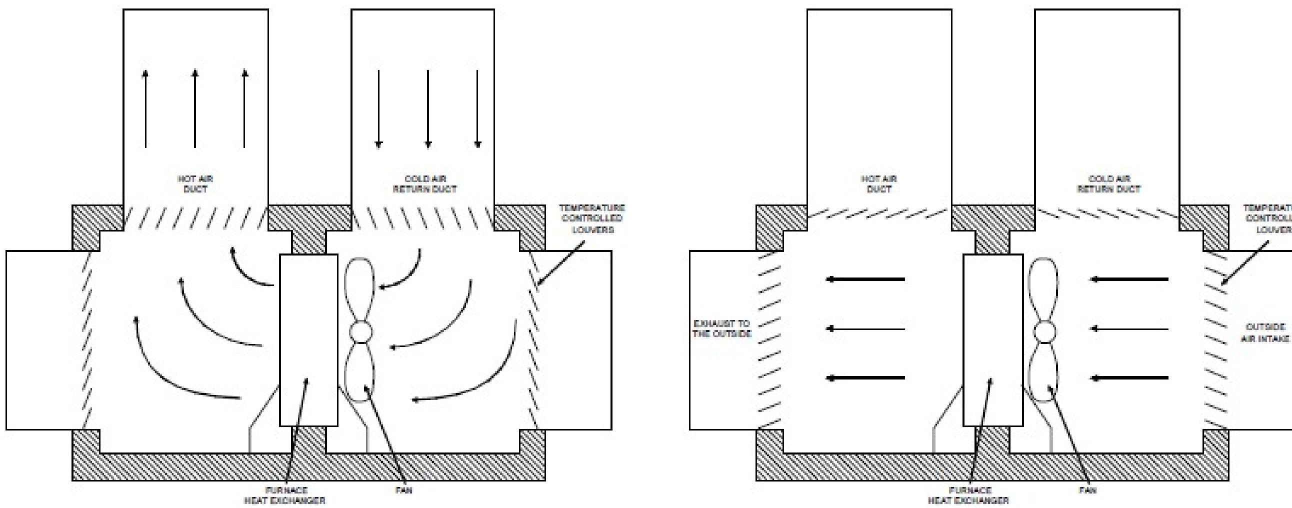


Illustration 46 – Connecting Water system to Forced Air Heating System

The following are methods of heat recovery for supplementing forced air heating systems for each dynamometer water system:

Fresh Water/Waste System with Forced Air Heat (see Illustration 47) – Engine jacket and dynamometer discharge water drains into a holding tank and is pumped through a radiator before it is dumped into the sewer. Aftercooler discharge water drains directly into the sewer. Heat transfer to the building forced air heat system is accomplished by an enclosure around the radiator as shown in Illustration 46. The radiator may also be secured within an exterior wall. Reversal of the direction of fan rotation either draws air away from or moves air through the radiator.

The flow rate of the pump and flow rate/Btu capacity of the heat exchanger are sized up to the Btu per hour heat loss of the building or the dynamometer system requirements, whichever is lesser. Excess water that the heat exchanger does not need drains into the sewer through the holding tank overflow. Use multiple pumps to ensure continuous water supply to the heat exchanger during low kilowatt (horsepower) loads. A float control valve in the holding tank controls activation of the pumps.

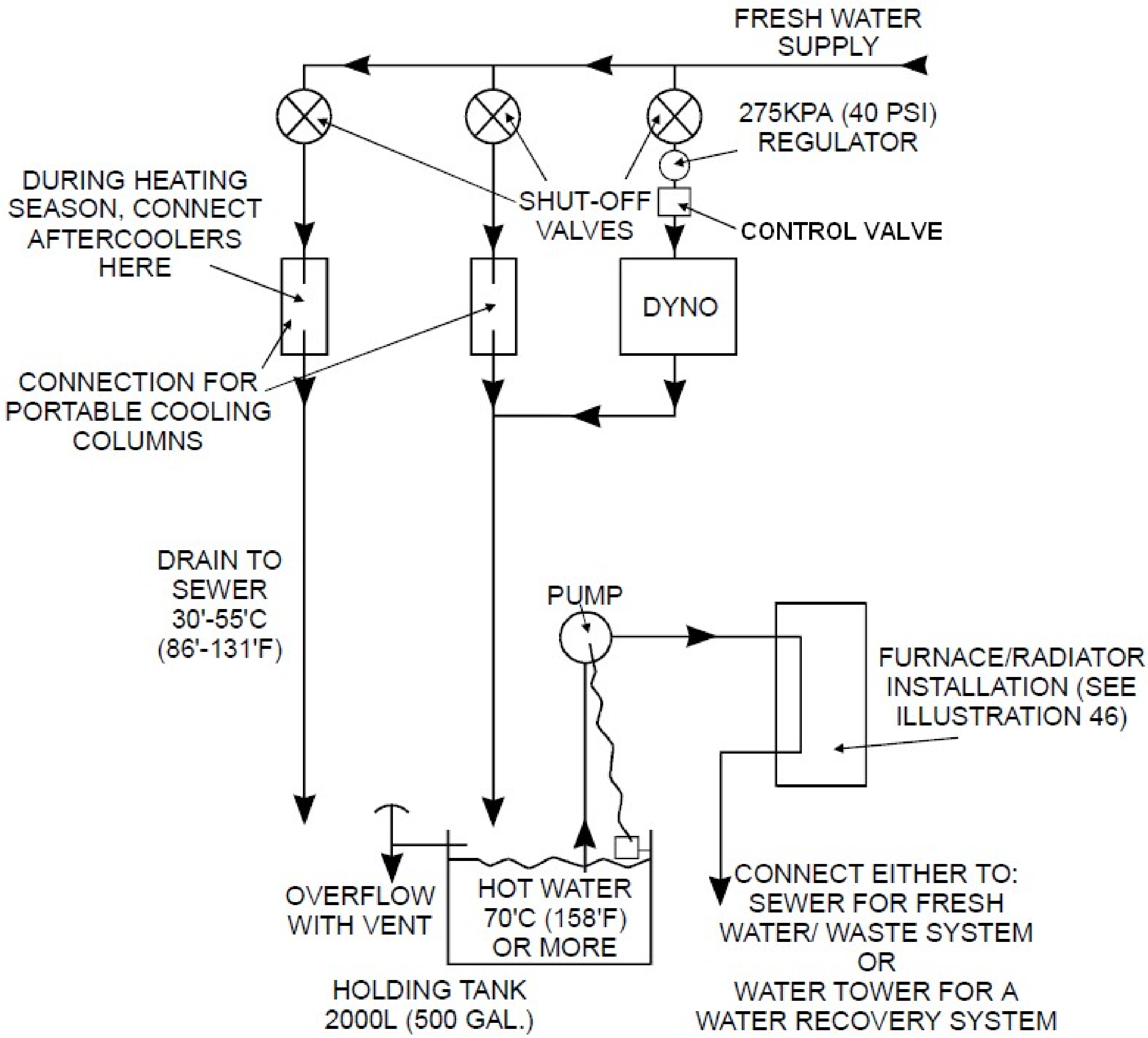


Illustration 47 – Heat Recovery, Cooling Tower or Wastewater System

Water Tower System with Forced Air Heat (see Illustration 47) – A radiator is added to the water tower system between the holding tank and the water tower. Only jacket and dynamometer discharge water is recovered and pumped through the radiator before being returned to the water tower. Heat transfer to the building forced air heat system is accomplished by an enclosure around the radiator as shown in Illustration 46.

The pump is sized for the maximum flow rate of the jacket and dynamometer combined water circuits. Multiple pumps should be used in 380 L/min (100gpm) increments to ensure continuous water supply to the radiator during low kilowatt (horsepower) loads. A float control valve in the holding tank should control activation of the pumps.

The flow rate capacity of the radiator is the same as the pump(s). The Btu capacity of the radiator is sized up to the Btu Per hour heat loss of the building.

Radiator Water Recovery System with Forced Air Heater (see Illustration 48) – The illustration shows a closed radiator system (with antifreeze); however, this schematic can be used for open drain radiators (no antifreeze) by removing the water-to-water heat exchanger and its supply pump. Heat transfer to the building forced air heat system is accomplished by an enclosure around the radiator as shown in Illustration 46. The size of the radiator is determined by the requirements for water recovery and not affected by heat recovery. This heat recovery system (closed or open drain) is the lease expensive to install. The only additional equipment needed is the radiator enclosure installation (see Illustration 46) and the separation of aftercooler discharge water.

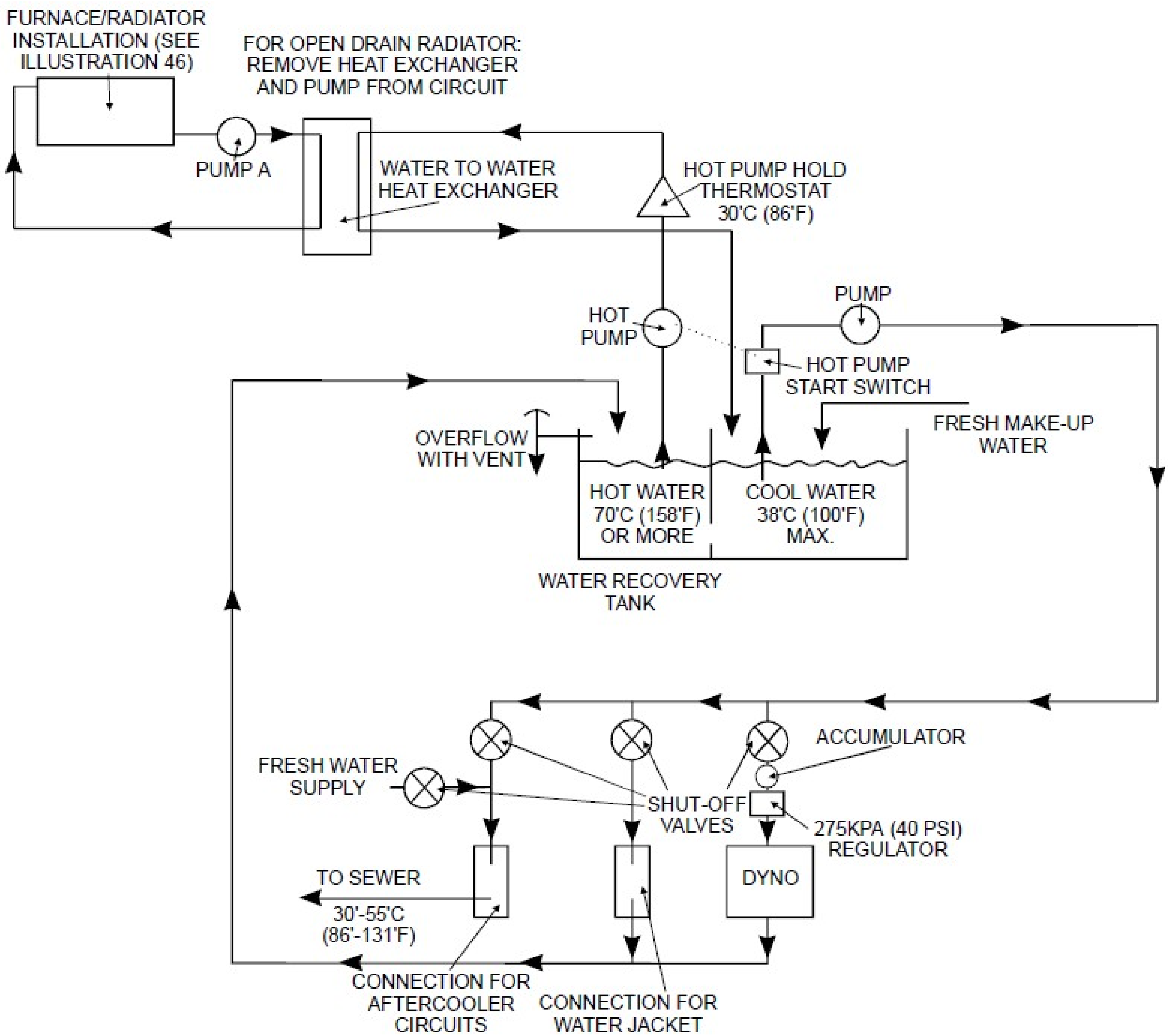


Illustration 48 – Heat Recovery, Open or Closed Radiator Water System

Cooling Tower Recovery System with Forced Air Heat (see Illustration 49) – A radiator is added to the cooling tower water recovery system. Heat transfer to the building forced air heat system is accomplished by an enclosure around the radiator as shown in Illustration 46. The radiator must be an open drain system to prevent freezing when the dynamometer system is shut down. Freezing is not a problem for the cooling tower since it is designed with free-fall drains. Aftercooler discharge water is separated and drained to the sewer.

The capacity of the radiator is sized up to the Btu per hour heat loss of the building or the dynamometer. Diverter valves are discussed at the end of this section.

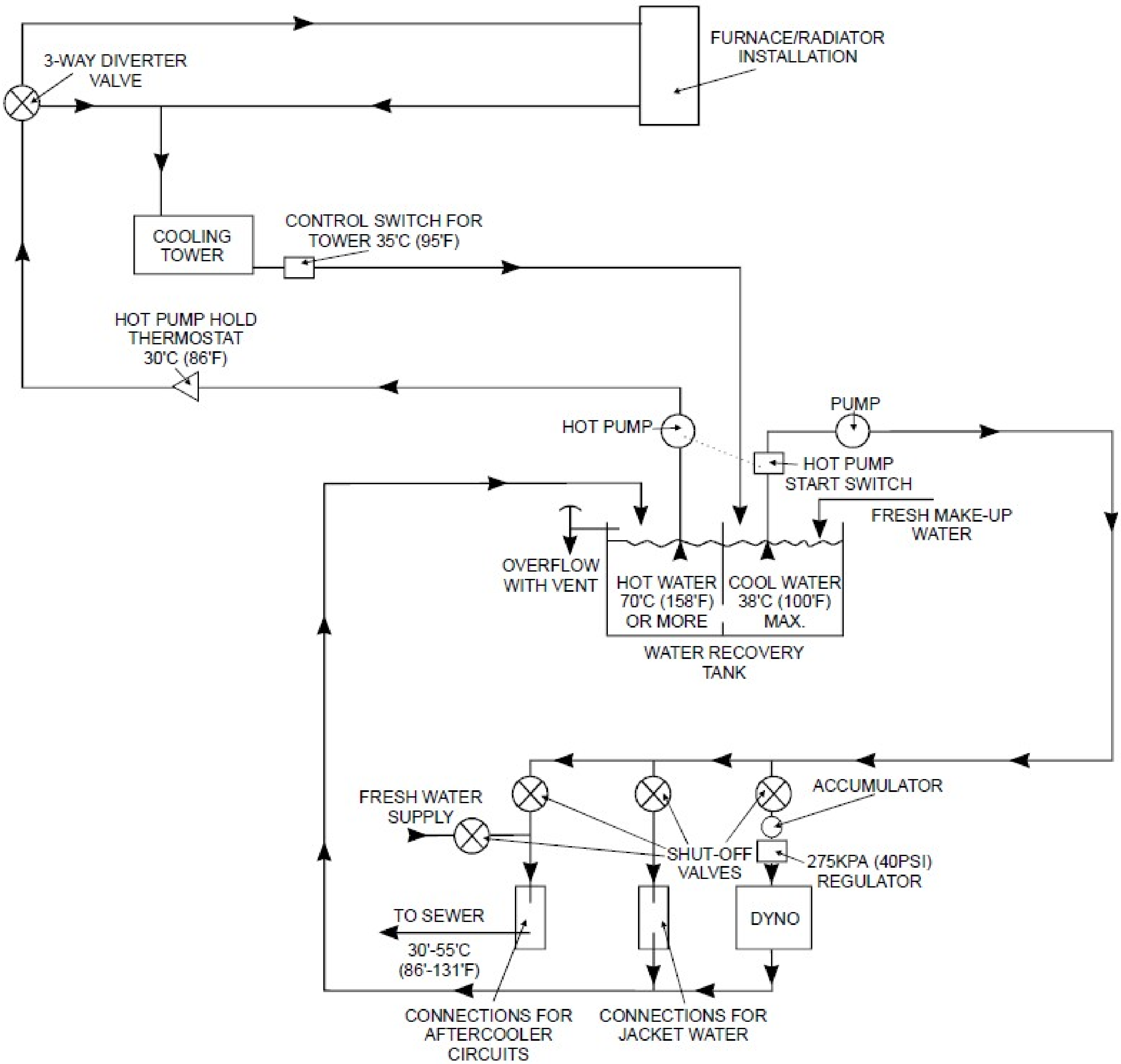


Illustration 49 – Heat Recovery, Cooling Tower Water System

Lake or Recirculated Well Recove.y System with Forced Air Heat (see Illustration 50)- A radiator is added to the water recovery system. Heat transfer to the building forced air heat system is accomplished by an enclosure around the additional radiator as shows in Illustration 46. The radiator must be an open drain system to prevent freezing vvhen the dynamometer system shuts down. Aftercooler discharge water is separated and drained into the sewer.

The capacity of the radiator is sized up to the Btu per hour heat loss of the building.

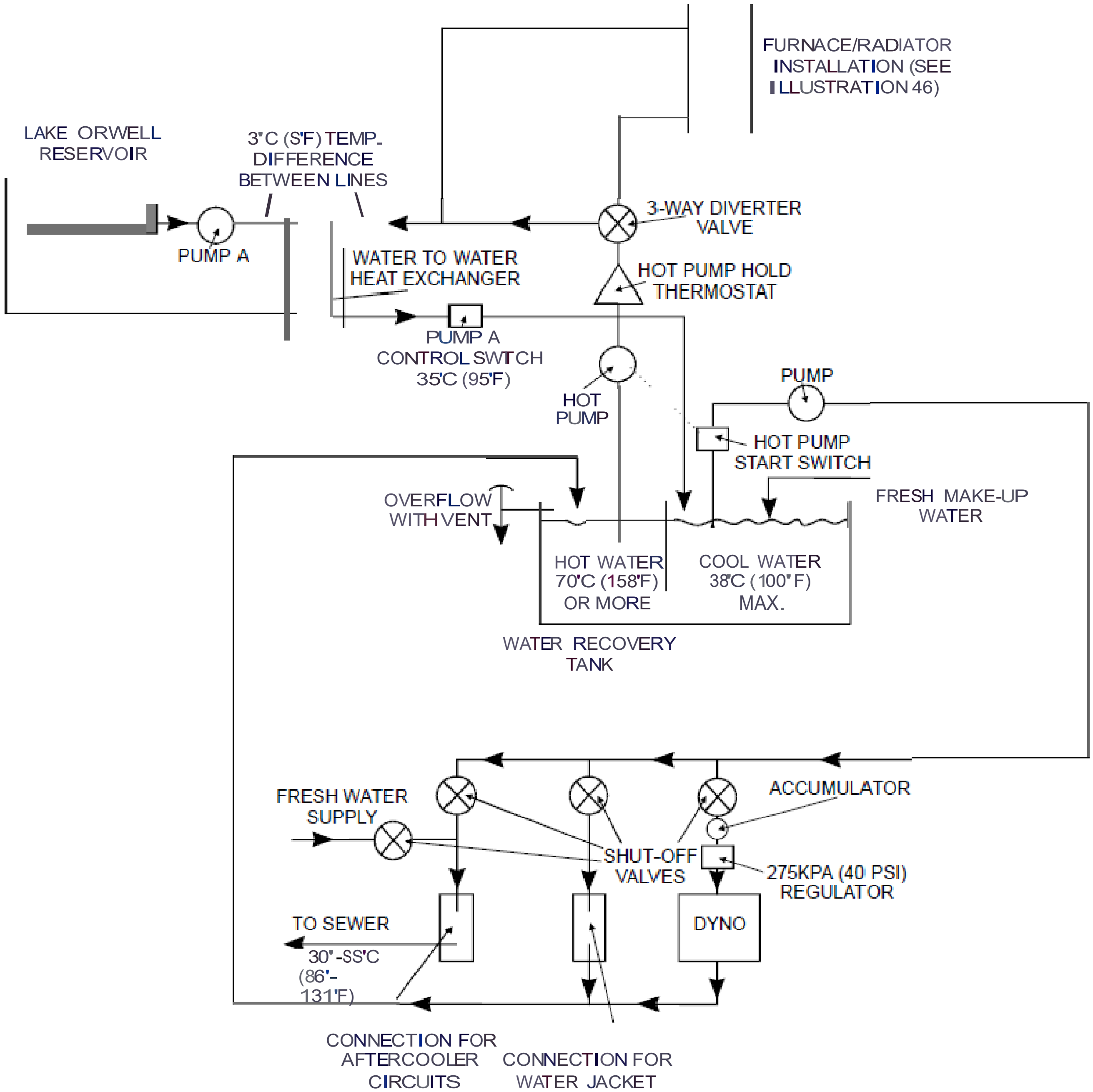


illustration 50- Heat &covery, Lam, Well or Reservoir Water System

Diverter Valves

The following information applies to Illustrations 44, 45, 49 and 50.

If the furnace heat exchanger flow rate is less than the capacity of the hot pump, a three-way diverter valve equipped with a stop is required. The diverter valve will limit the flow rate to the furnace heat exchanger to prevent a flow that exceeds pump capacity. Reducing the pipe size to the furnace heat exchanger will limit the flow rate partially but normally will not provide the exact maximum flow rate required. A diverter valve is recommended instead of two gate valves, to prevent accidental closing of the valve controlling direct flow to the water recovery heat exchanger. An accidental closing would produce a high restriction and low water flow to the engine and dynamometer. Overheating would result.

If the flow rate capacity of the furnace heat exchanger is equal to the hot pump capacity, the diverter valve is not necessary.

Ventilation/Exhaust Systems

NOTE: The recommended duct and pipe sizes given here are guidelines only. They are either the minimum size required for correct air volume at maximum flow or are larger to accommodate standard sizes. The size recommendations may require modification to adapt to individual standard sizes. In regions where airflow consultants are available, they should be contacted for final sizing.

The ventilation/exhaust system must be able to:

- Remove engine exhaust.
- Ventilate room to remove heat, fumes and smoke.
- Provide air supply for engine combustion.

There are two types of ventilation/exhaust systems. A hood system is shown in Illustration 51 and a pipe system is shown in Illustration 52. The hood system is preferred since it does not require connection to the engine, thereby reducing the test times and labor. If an overhead crane travels over the dynamometer room ceiling, the standard hood system must be modified because of crane interference with the hood and/or its exhaust stack. The hood system cannot be used in the following situations:

- When a crane slot is used for crane coverage within the room.
- When the overhead crane hook height is less than 6.0m (20'). There is not enough room between the ceiling and the crane to elbow the exhaust stack away from the crane travel path.

As a result, the pipe system or a special hood design with hinged access may be required. If a jib crane is installed in the room, clearance height must be considered.

The primary difference between the two systems is the method of room ventilation. The design, operation and sizing of the make-up air system are similar for both systems. The make-up system is indicated by a series of narrow arrow lines as shown in Illustrations 51 and 52.

Hood System Operation

As shown in Illustration 51, the hood fan pulls make-up air into the room and removes both engine and room exhaust. This exhaust contains heat, smoke and fumes. In addition, a non-powered small rotary ventilator should be installed near the center of the ceiling to permit the escape of any smoke or fumes that spill outside the hood. No engine exhaust connection is needed.

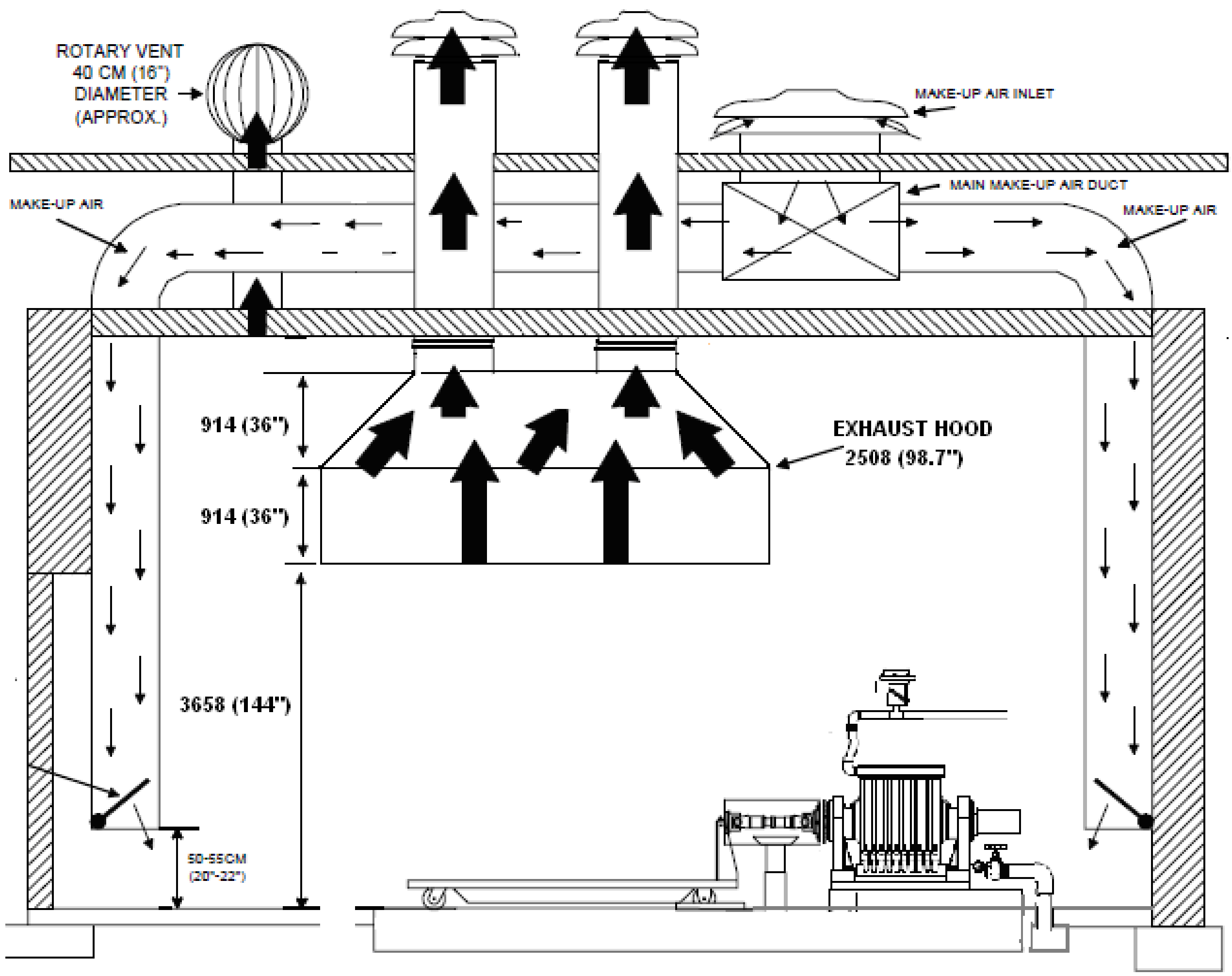


Illustration 51 – Hood Ventilation and Exhaust System

Taylor Dynamometer manufactures hoods in one, two or three fan configurations depending on the capacity of your test cell.

Pipe System Operation

As shown in Illustration 52, the swivel exhaust pipe(s) can be powered by a fan to remove engine exhaust. A separate fan-powered room air exhaust system is necessary to pull make-up air into the room and to discharge heat, smoke and fumes.

To prevent overhead crane interference, the exhaust pipe has the stack extending up the wall. In addition, the pipe(s) can be designed to swing out of the way when you move engines in or out with a crane. The exhaust pipe(s) is connected to the engine with a flexible pipe. The swivel pipe(s) telescopes to allow length for different engine models.

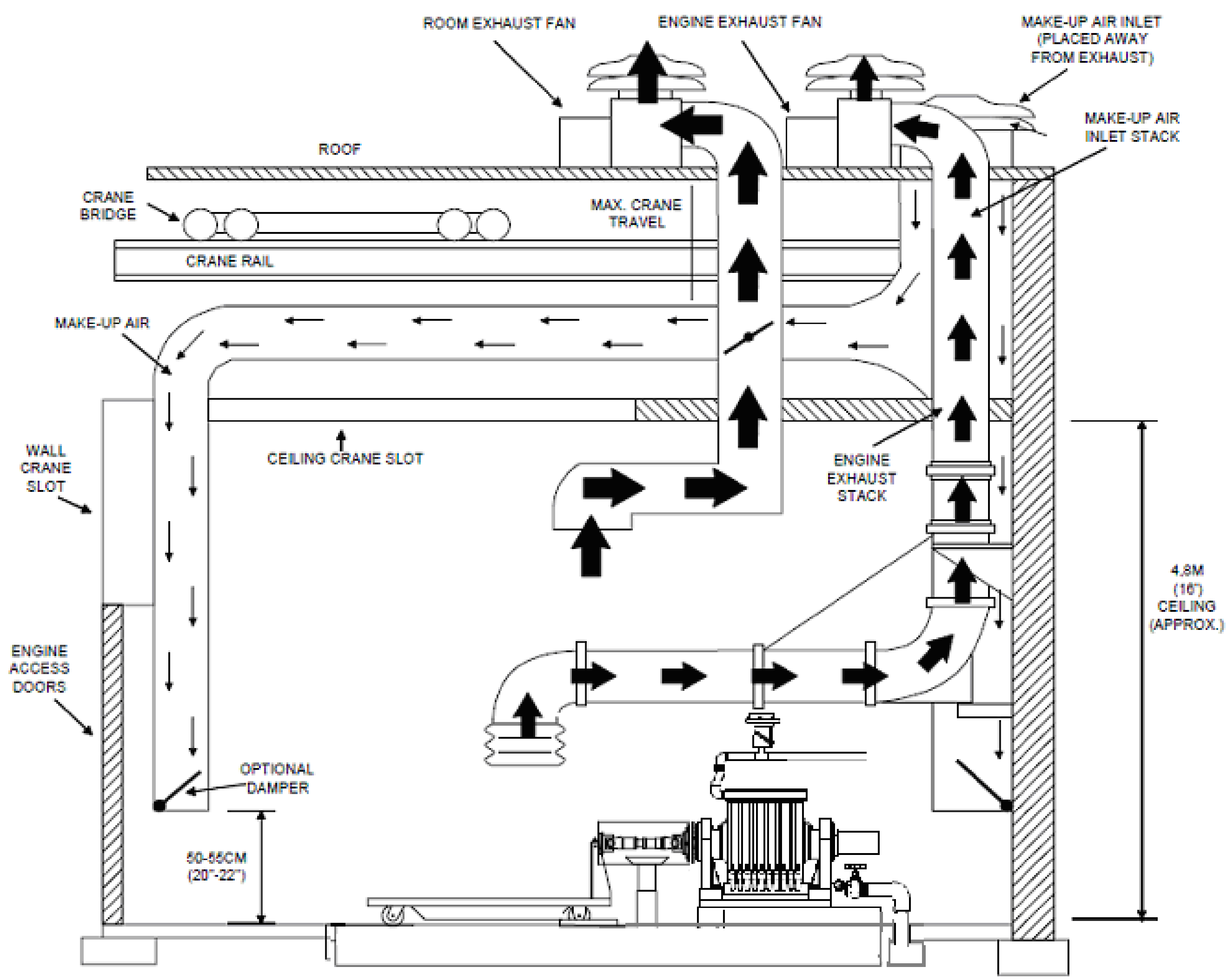


Illustration 52 – Pipe Ventilation and Exhaust System

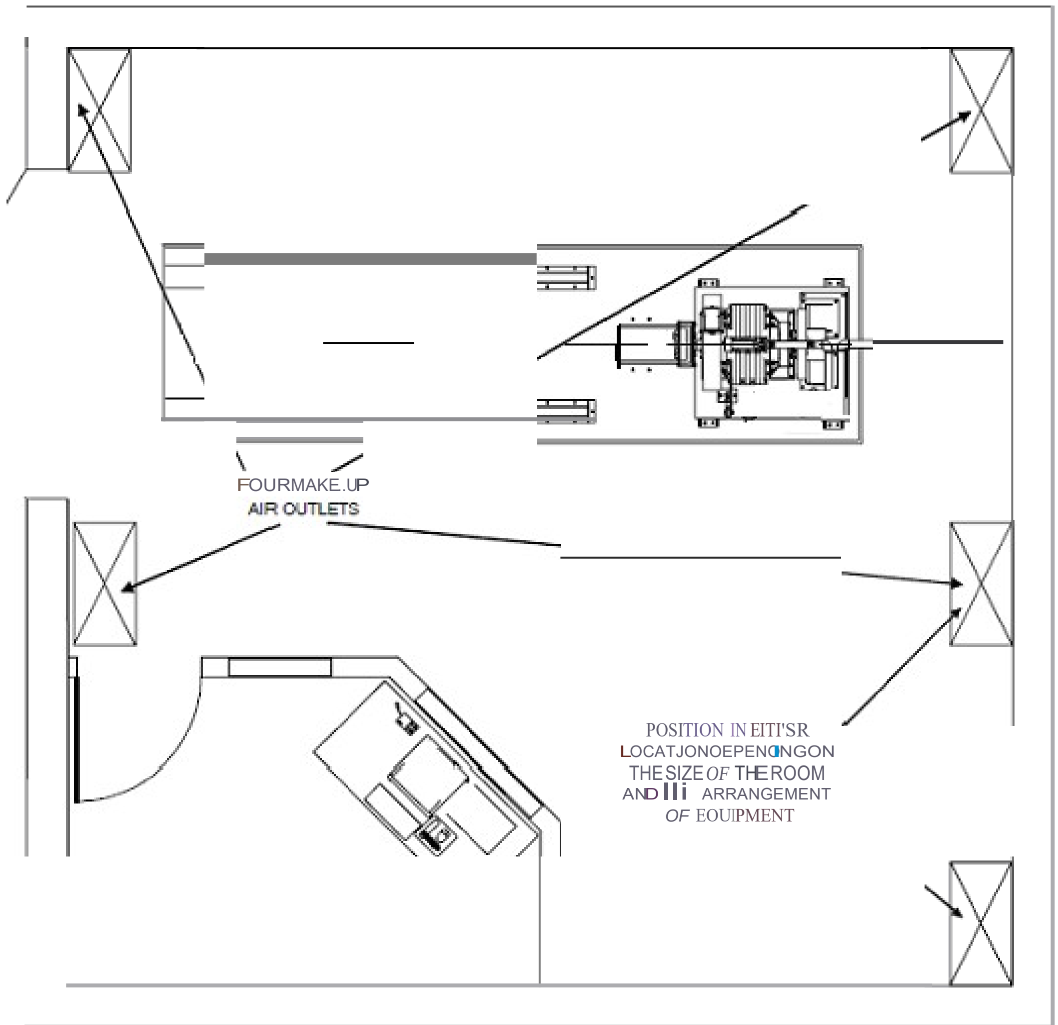
Make-up Air (Supply) System

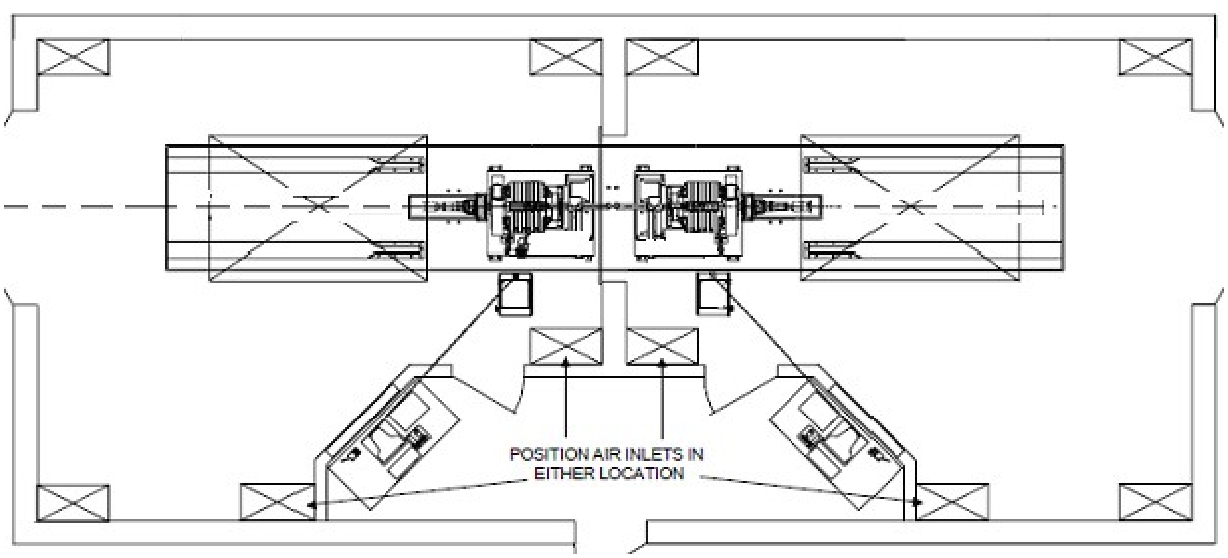
Both pipe and hood ventilation/exhaust systems need a variable volume of make-up air for engine combustion and the ventilation of heat, fumes and smoke. The volume of air required depends on the kilowatt (horsepower) size of the test engine. Make-up air must remove the heat radiated from the dynamometer, cooling tower, exhaust gases and engine.

To prevent the release of heat, noise, fumes and smoke into other areas outside the room, the room air pressure must be maintained at .25kPa (1” H_2O) less the atmosphere air pressure.

NOTE: Maintaining a differential pressure between the observation booth, the dynamometer test cell, the adjoining shop and outside areas of the building can cause difficulty in opening exit doors. Doors may need to be equipped with vacuum breakers to allow easy exit.

Make-up air should enter the room at floor level near all corners of the room (see Illustration 53). The air is pulled through the make-up air duct system and into the room by the exhaust hood fan (for hood systems) or the room exhaust fan (for pipe systems). The air spills out at floor level and sweeps around all sides of the engine as the air moves upward to the exhaust fan. The make-up air outlet should extend to within 50 to 55cm (20” to 22”) of the floor (see Illustrations 51 and 52). If the air outlet is too high, make-up air will not flow across the entire engine. If the air outlet is too low, airflow will be restricted.





Rlustration 53-Location ofMaloz-vp Air Ouflets

Illustrations 54, 55 and 56 show different duct designs for the make-up air system. The numbers of air inlets are altered with each example. As the number of air inlets decreases, the inlet duct size must increase to provide the same volume of air. Normally, the air inlets are on the roof; however, they can also be on the side of the building near the eave. The ducts that connect the make-up air outlets in Illustrations 54 and 55 should be above the room ceiling when height clearance permits. Various combinations and modifications of these examples may be required in some situations. For example, combining designs 54 and 56 together provides a make-up air system with three inlets.

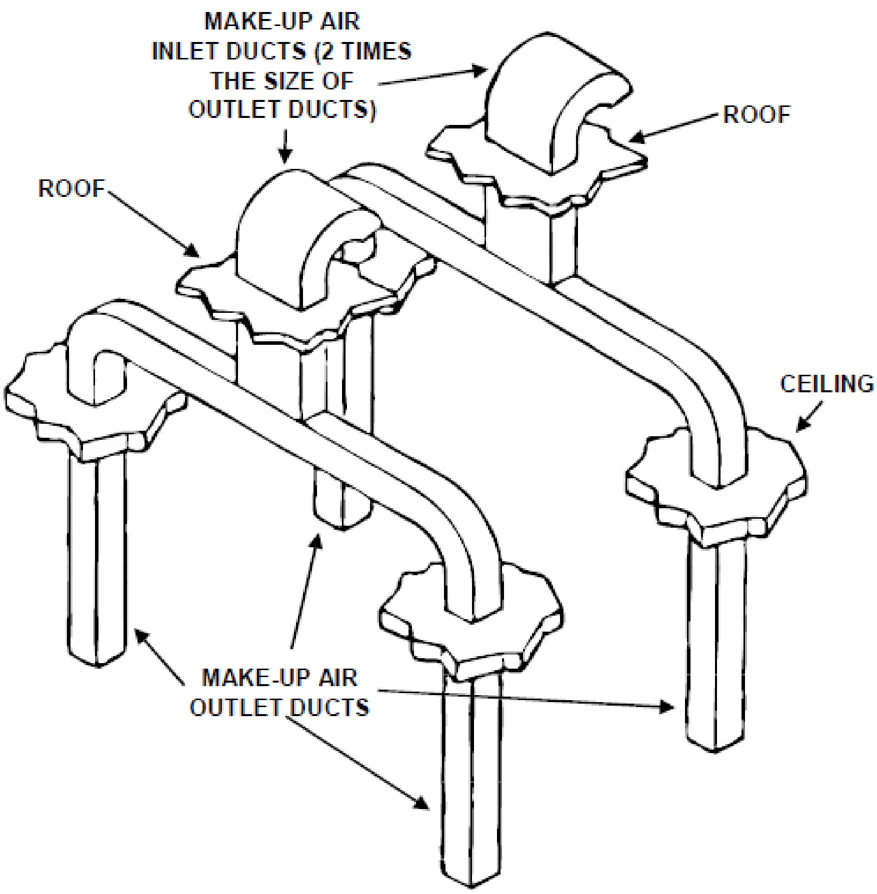


Illustration 54 – Design 1 of Make-up Air Supply System

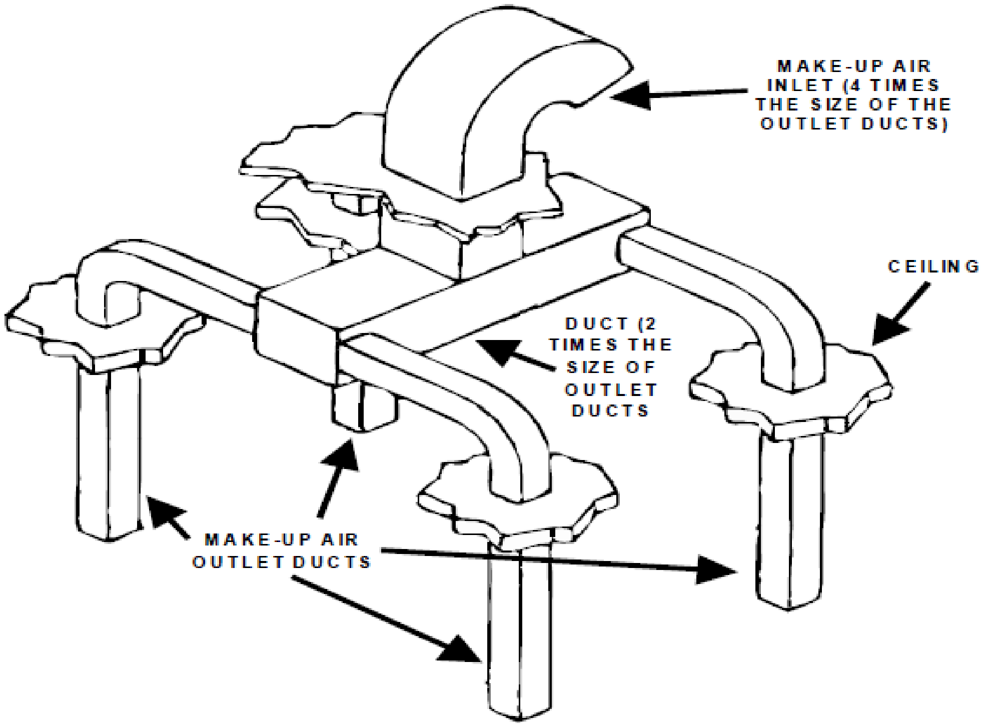


Illustration 55 – Design 2 of Make-up Air Supply System

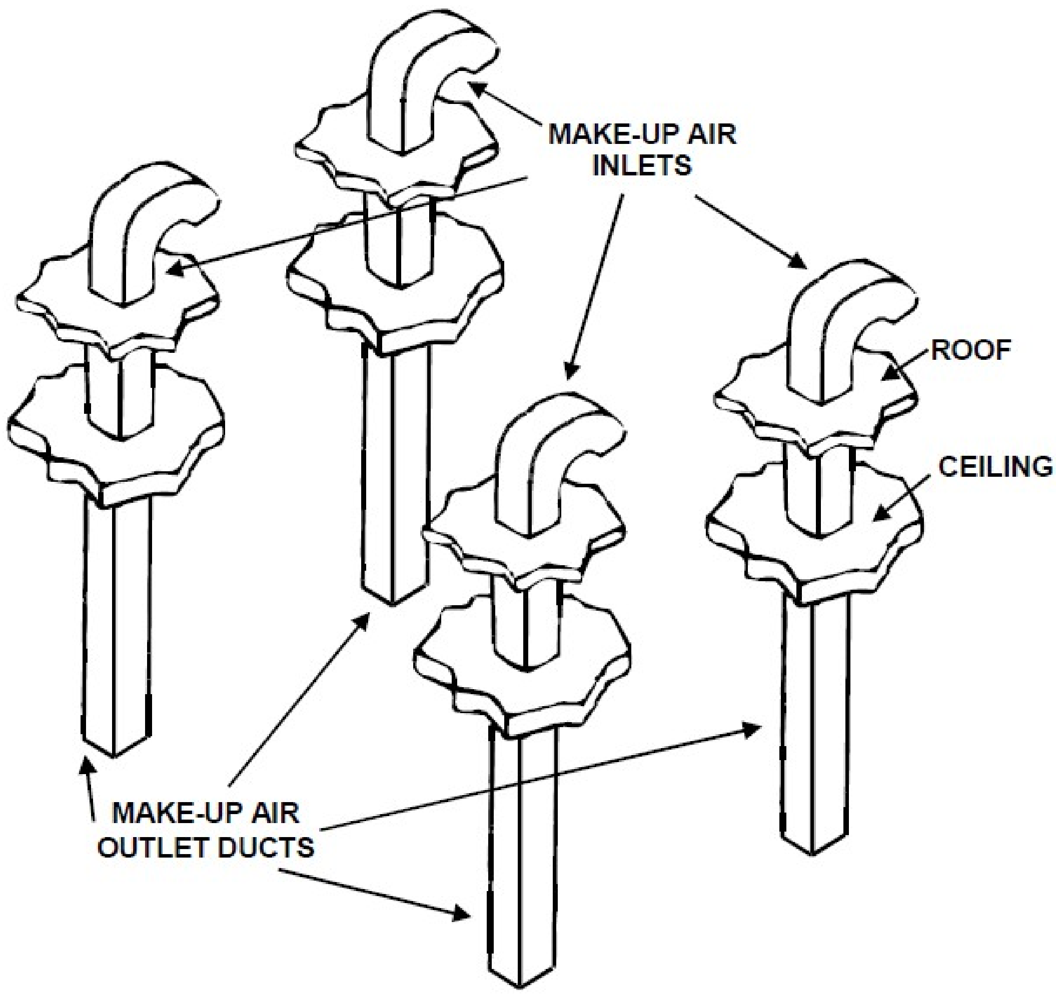


Illustration 56 – Design 3 of Make-up Air Supply System

Make-up Air Outlet Duct Size for Hood and Pipe Systems

To determine make-up air duct sizes, the total exhaust flow must be determined (see “Hood System – Sizing”). Divide the exhaust fan airflow in meters^3 by 450. This number represents the required total area of the air ducts in square meters (divide the exhaust fan airflow in cfm by 1500 to get the required total area of the air ducts in square feet). Divide the total area by the number of ducts (usually 4) to obtain the area of each duct.

2238 kW (3000hp) Installations	4 outlets @ 0.63m^2 (6.7ft^2) each total of 2.5m^2 (27ft^2) minimum

Dampers for Cold Weather Climates

In climates where the temperature reaches 10°C (50°F) or below, you may need dampers in the make-up air ducts and room exhaust duct (see Illustrations 51 and 52). When the system is not operating, the dampers close preventing cold air from entering and heat from leaving. During an engine test, the exhaust damper will regulate the amount of cold air being pulled into the room. This allows engine heat to warm the room at a comfortable level.

The make-up air dampers at each outlet can be free-fall louvers or electric, controlled from the operator control area. If the make-up air dampers are electrically operated, they should be wired to the exhaust fan power switch. This allows the dampers to open automatically before the fan starts. The room exhaust damper (in the hood stack or room exhaust duct) should be electric and controlled from the operator control area. The damper motors must be fail-safe (open) design to allow full air flow in the event of a motor failure.

Exhaust Fan

The specifications for both hood and pipe system exhaust fans are:

- Vane-type fan
- Rated at 0.5kPa (2”) water differential (high volume-low pressure)
- Non-overloading design
- Belt drive to motor
- Steel blades
- Located on roof to direct sound upward

NOTICE

The airflow velocity of the exhaust/ventilation system must stay under 7.6m (25’/sec) to prevent excessive air noise. In addition, to prevent excess engine exhaust from spilling out of the hood or exhaust pipe at start-up, the engine exhaust fans are oversized. The fan sizes presented in this bulletin meet these requirements.

Illustrations 57 and 58 suggest a 2.5m (8') wide hood. The hood should be centered above the engine mounting area.

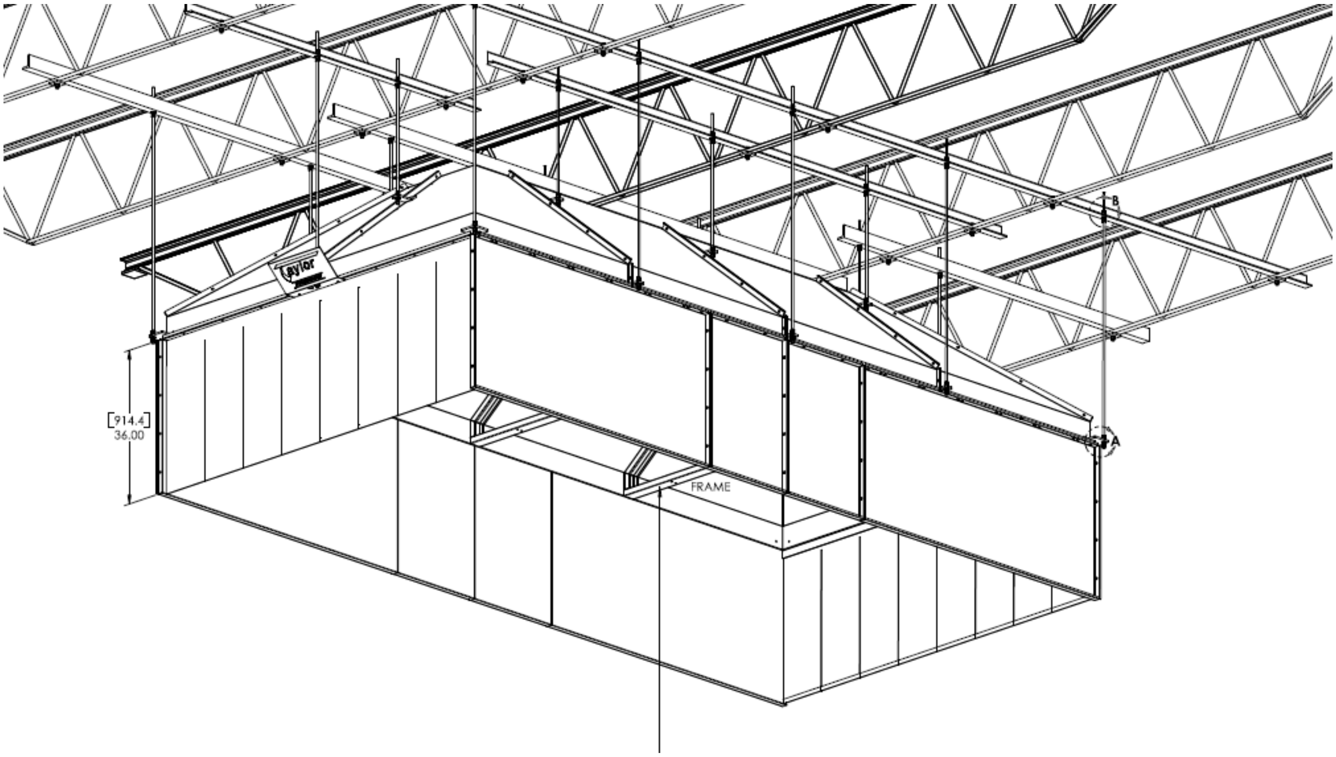
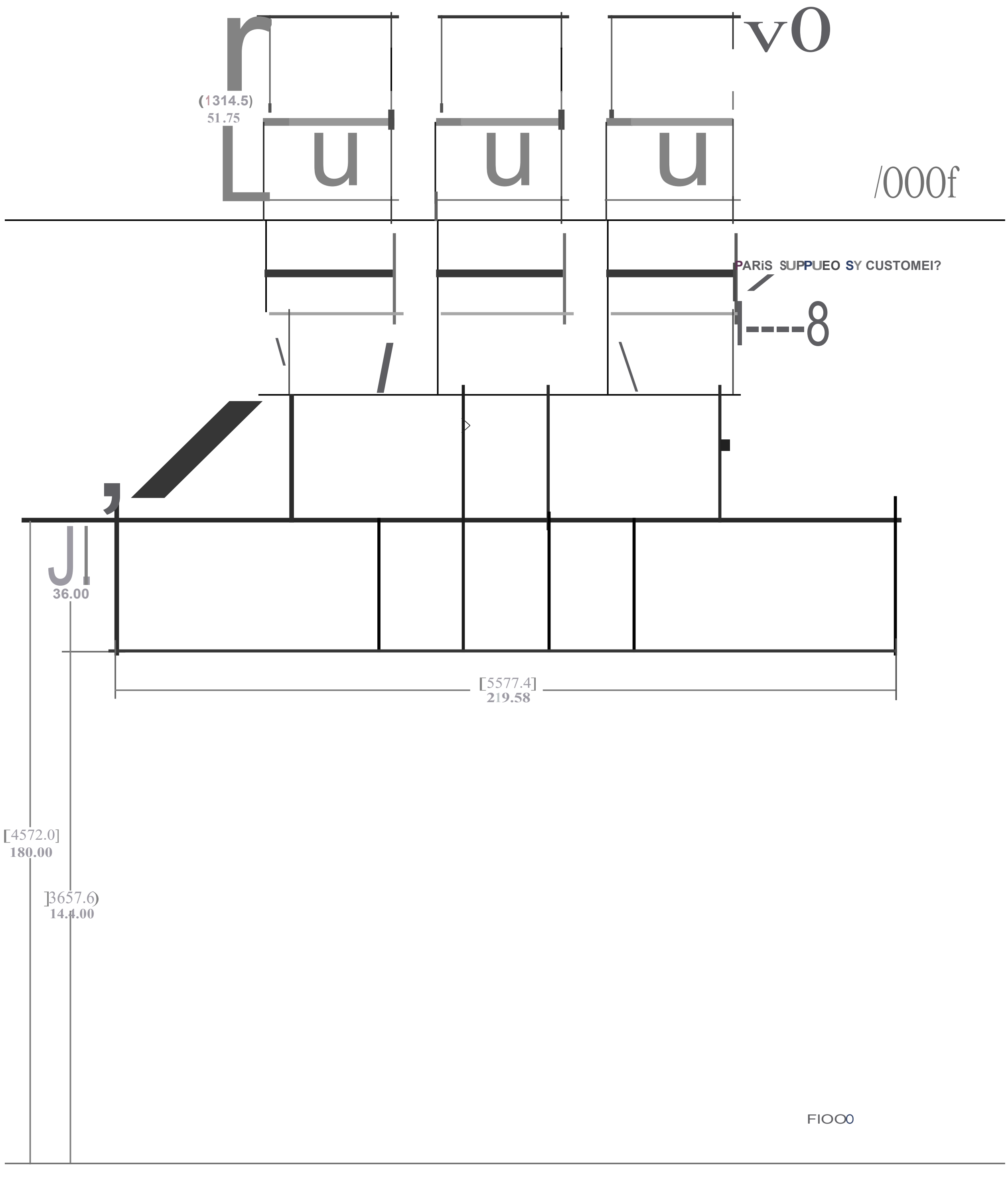


Illustration 57 – Exhaust Hood

Illustration 58 – Exhaust Hood above Engine

A multiple (two or four) exhaust fan installation (or multi-speed fan) may be needed with hood arrangements because of the high volume of air required. The number of fans operating will depend on the size of the engines being tested. These fans can be manually controlled. The initial cost of multiple fans is higher, but they cost less to operate in terms of electric power consumption. If there is a fan failure, the dynamometer can still be used for smaller engines. V\lhen using multiple exhaust fans, a separate exhaust stack must be installed for each fan (see Illustration 59). Thus, two fans require two separate exhaust stacks at the top of the hood.



R/ustration 59 -Multiple Fan E>:haust Hood Design

A muffler may not be necessary with an exhaust hood because exhaust gases expand within the room and hood before entering the exhaust stack. Check with local authorities for requirements. The large volume of air may cause some noise at the exhaust outlet. To ensure control of sound emission, the exhaust fan outlet on the roof should face away from surrounding businesses and buildings.

Exhaust Hood Installation to Allow Overhead Crane Travel

It is possible to allow the use of an exhaust hood with an overhead crane traveling above the room, when there is no crane slot in the ceiling. A minimum hook height of 6.0m (20') is required to allow enough room above the ceiling to direct the stack(s) away from the crane travel path. Illustrations 60, 61 and 62 show three available options.

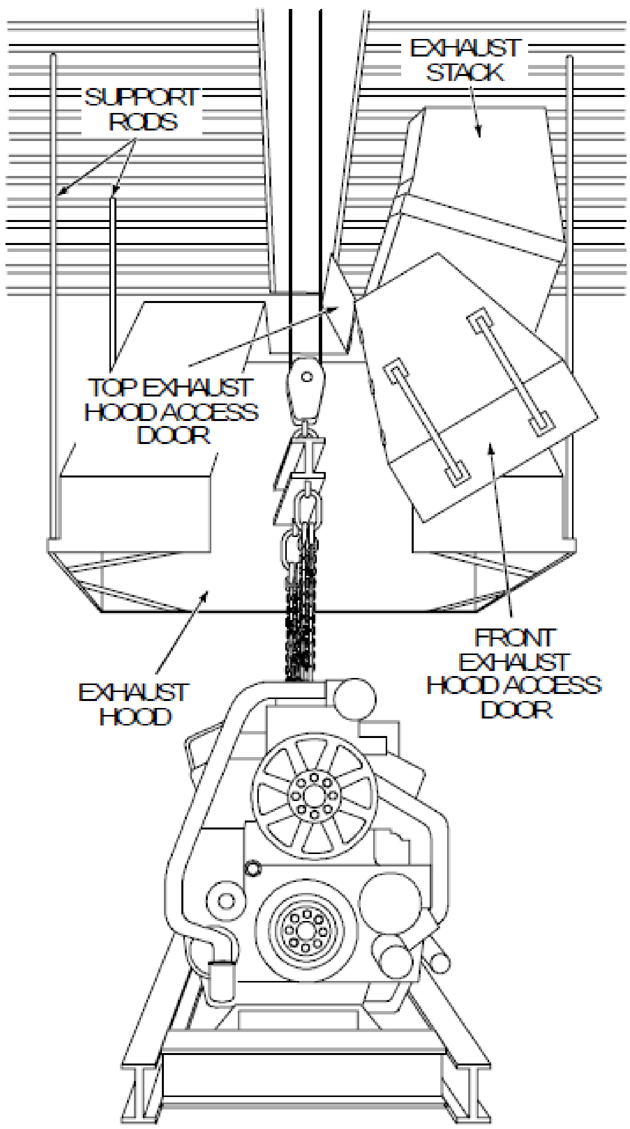


Illustration 60 – Split Exhaust Hood for Overhead Crane Travel

As shown in Illustration 61, the bridge girder can only travel to within approximately 1.2m (4') of the wall before the crane's end truck contacts the wall stop. This 1.2m (4') area can be used to extend the exhaust stack(s) up to the roof.

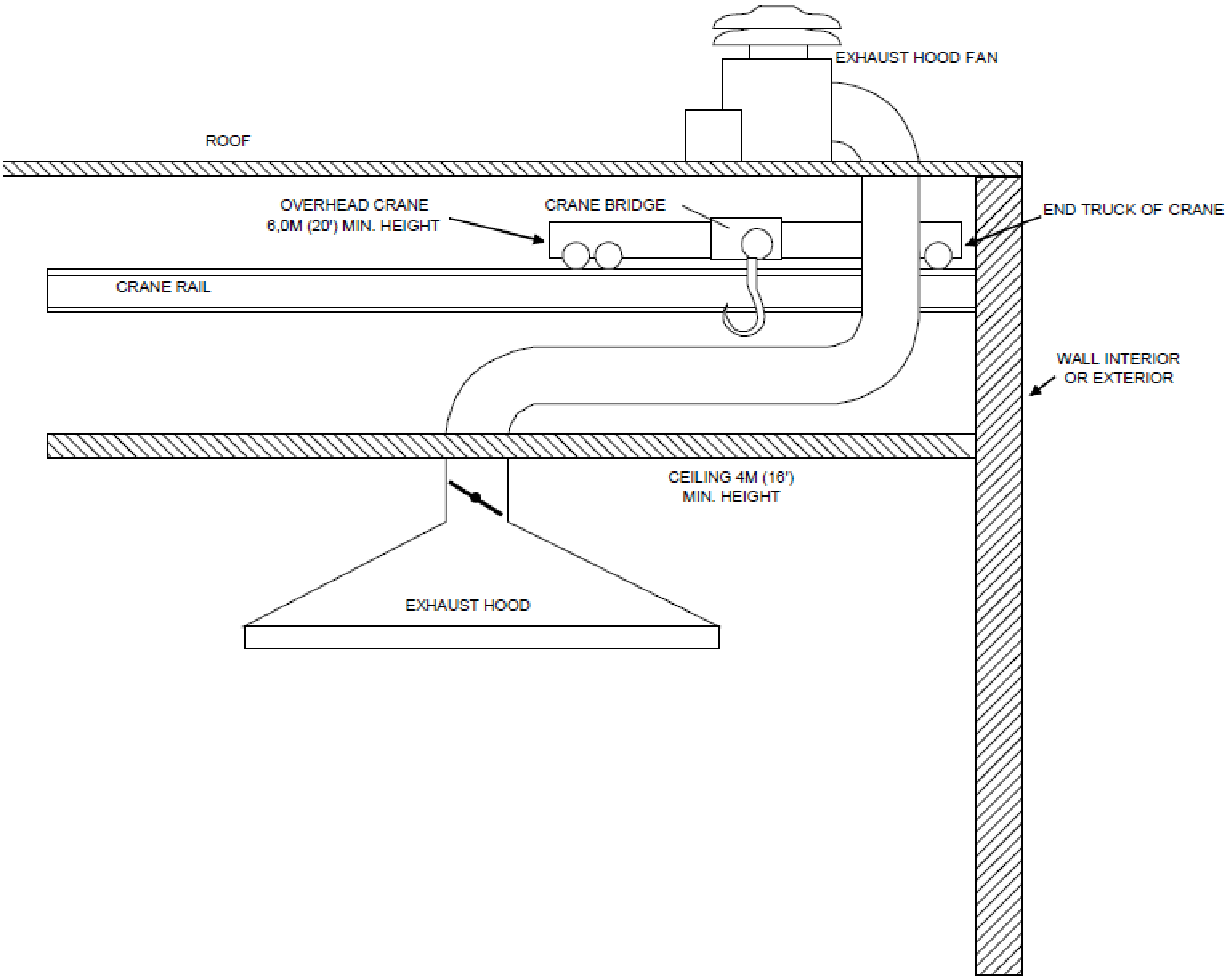


Illustration 61 – Exhaust Stack Modification 1 for Overhead Crane Travel

Depending on the orientation of the room to the direction of the crane travel, you may want to extend the hood exhaust stack(s) under the crane rails and up to the roof (see Illustration 62). If the crane rail runs along an outside wall, the exhaust stack(s) should still extend to the roof after going under the rail. This will help direct the sound upward.

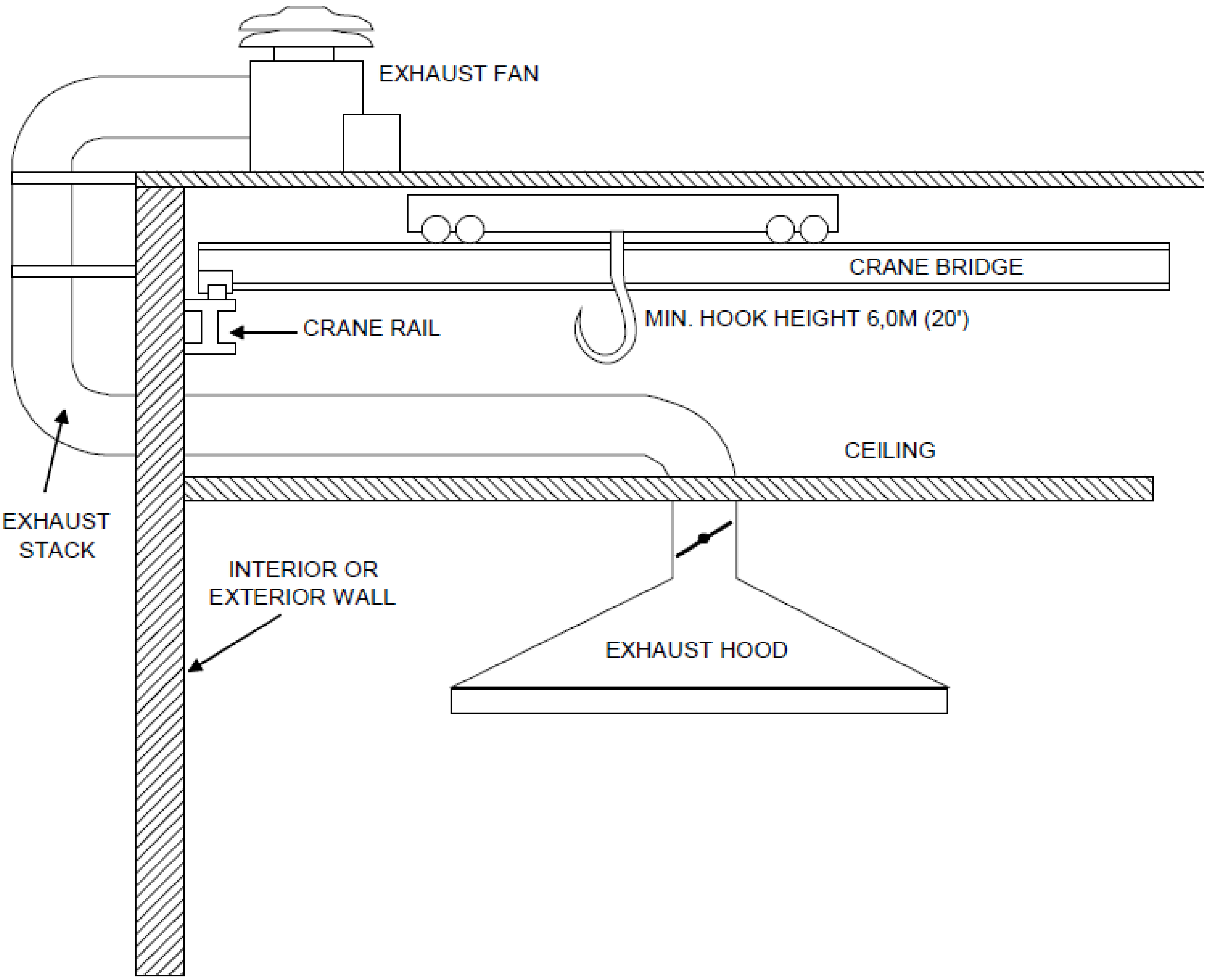


Illustration 67 – Exhaust Stack Modification 2 for Overhead Crane Travel

Hood System - Sizing

The exhaust fan for a hood installation should be sized by the following formula:

Dynamometer Rating in kW x ½ = exhaust fan size in meters^3 per minute (hp x 13 1/3 = exhaust fan size in cfm). For multiple fan installations, divide the total airflow requirement by the number of fans.

The velocity through the exhaust stack (or stacks if more than one fan) should be maintained at 305 meters per minute (1000ft per minute) or less.

Exhaust Pipe Design and Construction

Illustration 63 shows a wall-mounted engine exhaust pipe. The swivel joint allows the pipe to swing.

Illustration 64 shows a close-up of the rotating collar. A flexible stainless steel pipe assembly is attached to the telescoping pipe for connecting to the engine exhaust (see Illustration 52). The flexible pipe loosely slips over the engine exhaust. To make adjusting the length of the pipe easier, a cable and pulley system can be installed.

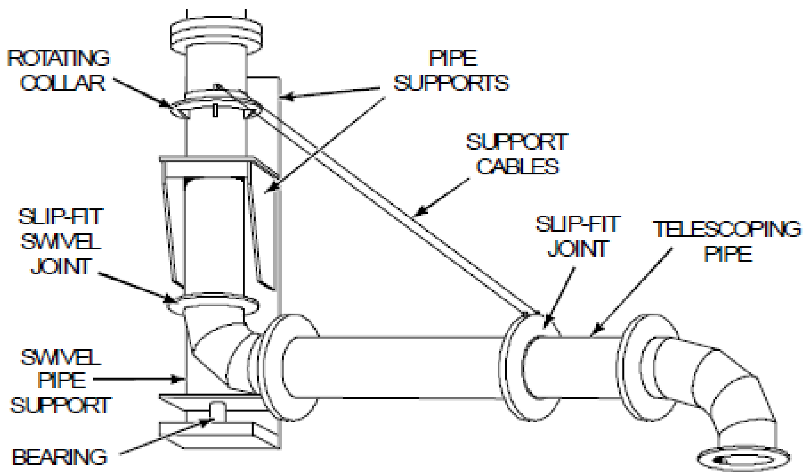


Illustration 63 – Swivel Exhaust Removal System

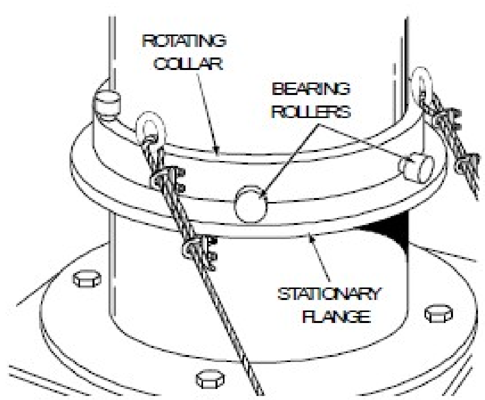


Illustration 64a – Detail of a Swivel Exhaust System Rotation Center

Illustration 64b- Engine Exhaust Pipe ConfiguraJion

The exhaust pipe becomes extremely hot (approximately 540°C (1000°F)). It should be insulated, shielded or isolated to avoid building damage or personal injury. The telescoping pipe should be 2.4 to 3.0m (8' to 10') above the floor to isolate it from personnel. Expansion joints are needed if long runs of pipe are required. A maximum allowable backpressure of 2.5kPa (10" H_2O) is required for all engines.

Exhaust gases that expand through the pipe create noise; however, the noise level at the roof exhaust port is minimal because of the length of pipe required to reach the roof. In some areas a muffler system may be required. Mufflers are designed for a specific engine size and not for a wide variety of engines. It is possible that with certain engines the noise level can increase with a muffler due to a resonating effect from a muffler-engine mismatch. To ensure control of sound emission, the exhaust pipe outlet on the roof should face away from surrounding businesses and buildings.

Room Exhaust

In all cases, provisions must be made for removing residual fumes from the test cell. With exhaust hood systems this may be accomplished by providing an opening at the top of the hood before the fan. For exhaust stack systems, an exhaust fan capable of changing the air within the test cell three times per minute is recommended. Calculate the fan size by multiplying the length x width x height of the room. The duct size should allow a velocity of 762 meters per minute (2500 ft per minute) maximum.

Special Pipe System Requirements to Prevent Overhead Crane Interference

If an overhead crane travels above the room ceiling, the pipe ventilation/exhaust system must be altered to avoid interference with the crane. These alterations apply to test cells with or without a ceiling crane slot.

As shown in Illustrations 65 and 66, the orientation of the room length to the direction of crane travel determines the location and design of the pipe ventilation/exhaust system. The wall at the end of the crane travel is used for locating the various ventilation/exhaust stacks that extend to the roof. A space approximately 1.2m (4') wide along this wall is unobstructed by the crane's bridge gear. The bridge girder cannot travel any closer to the wall because the crane's end truck will contact the wall stop.

The inlet to the room exhaust duct should be approximately centered above the engine mounting area. The room exhaust duct extends along the top or underside of the room ceiling to the wall for extension up to the roof (see Illustrations 65 and 66).

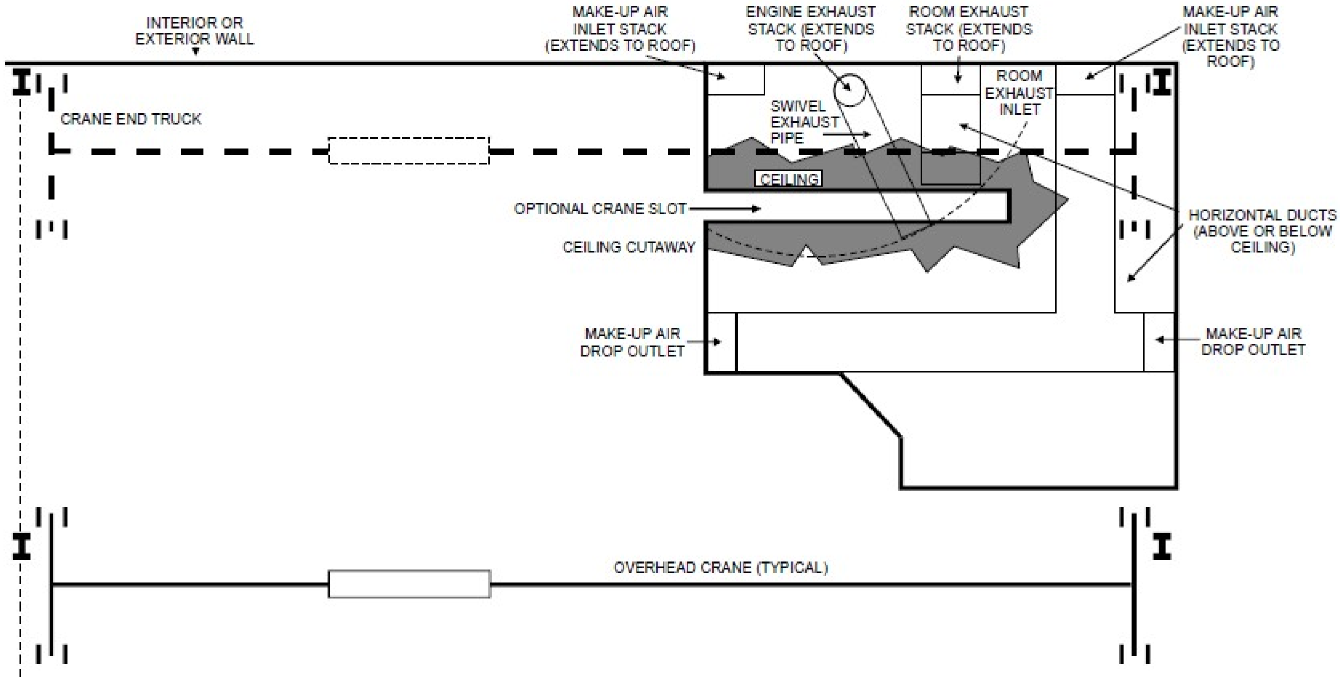


Illustration 65 – Overhead Crane Exhaust Stack Layout 1

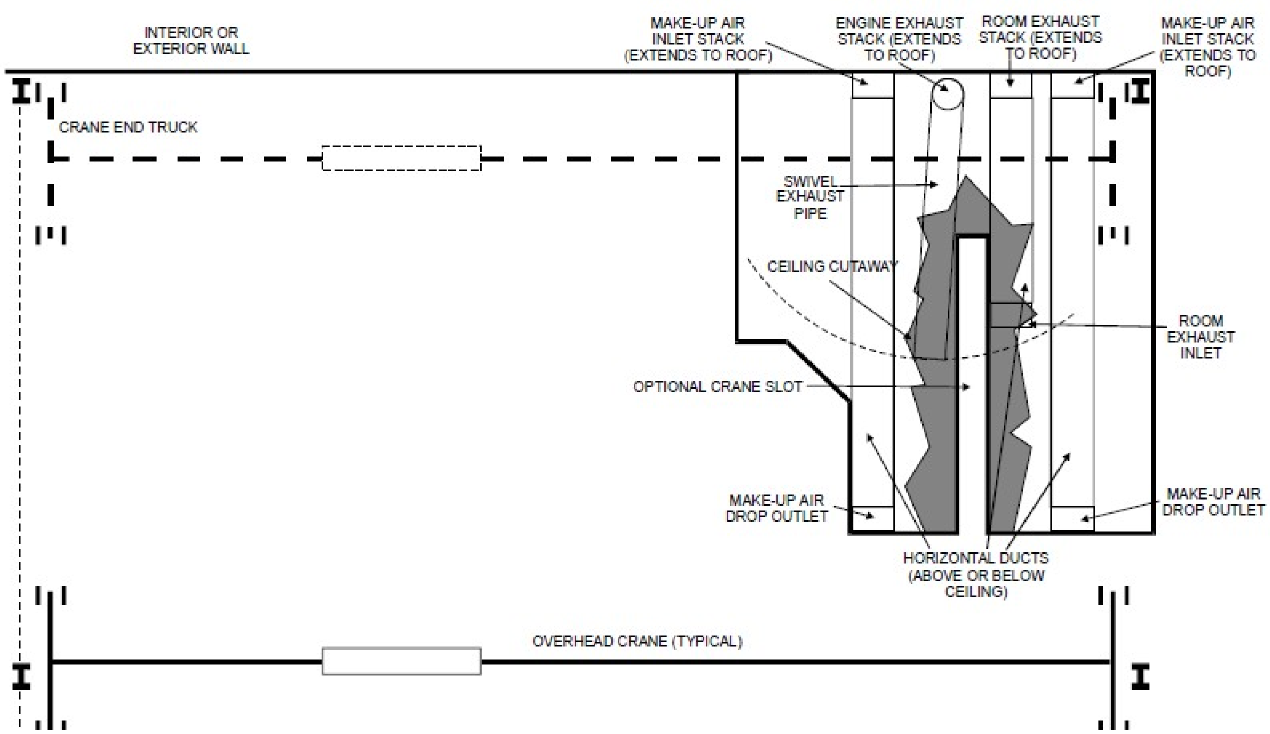


Illustration 66 – Overhead Crane Exhaust Stack Layout

The swivel exhaust pipe is located on either the room end wall or side wall, depending on the orientation of the room length to the direction of the crane travel (see Illustrations 65 and 66). To minimize the length of the horizontal pipe, the mounting location should be in line with:

- The center of the engine mounting area when secured on a size wall.

- The center of the dynamometer shaft when secured on the end wall.

FUEL SYSTEMS

The fuel supply system (see Illustration 67) for the dynamometer installation consists of a Bulk Fuel Storage Tank, an Auxiliary or Day Tank, a Fuel Cooler, or a Fuel Measurement Unit that acts as a Day Tank and includes a Fuel Cooler. All fuel lines between the bulk fuel storage and the engine fuel hookup should be black pipe. Inside diameter of the pipe will vary and should meet the requirements of the largest engine to be tested.

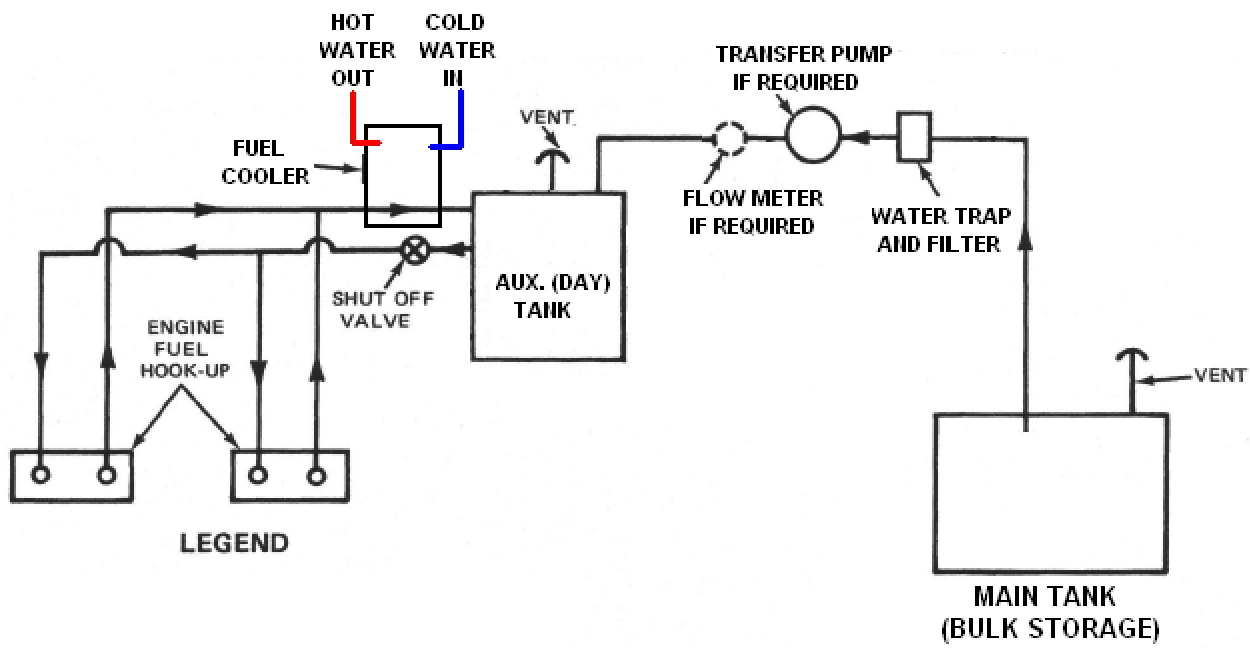


Illustration 72 – Fuel Supply System

Since the fuel connections are centrally located, they should be recessed below floor level to avoid damage when moving engines in and out of the room.

NOTE: The recessed area should be close to the isolated pad to minimize the length of the connection hoses and to prevent cluttering the floor.

The following is a detailed description of each fuel component.

Engine Fuel Hookup Connections

The location of the test engine's fuel system can be on either side of the engine, depending on the model. As a result, there should be a fuel hookup midway along the engine tie-down base, on each side of the isolation pad. The fuel hookup connections consist of two connections (fuel supply and fuel return) at each location. Each fuel connection has a quick disconnect coupling. For the quick identification of the supply and return lines, one connection should be male and the other a female quick disconnect. The quick disconnect couplings must be able to handle high flow rates.

Recessed Trench Design

If local codes do not permit fuel lines buried below concrete, they can be installed in a covered recessed trench. This trench is in a U-shape around the isolated engine/dynamometer pad (see Illustration 68). In addition to fuel lines, the trench is also used for installation of water lines. The lift-off cover provides easy access to the pipe installation. Hinged lids are provided over the hook-up connects. The pipe enters the trench by vertically extending down the end wall to the trench. For a detailed description of the pipe installation and trench construction, refer to the "Miscellaneous Equipment and Mechanical Requirements" section.

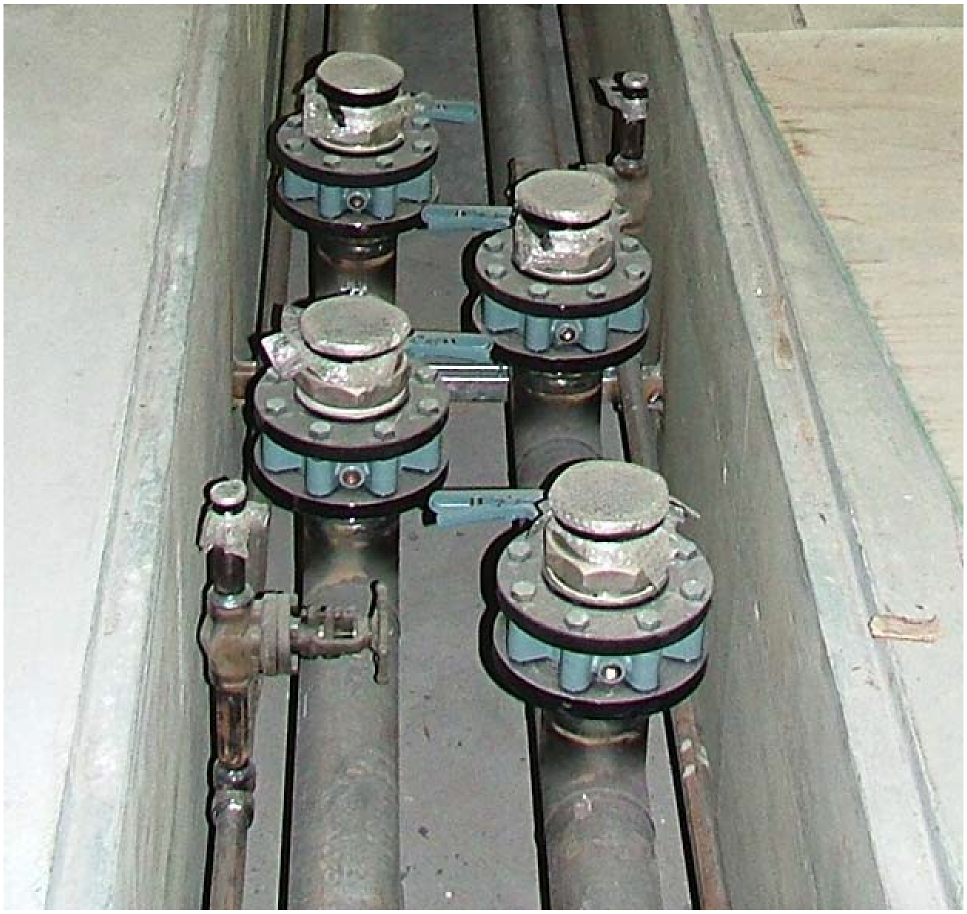


Illustration 68 – Recessed Trench with Water and Fuel Lines

Auxiliary or Day Tank

The auxiliary (or day) tank provides these advantages:

- The engine fuel system can be purged of air without cranking the engine. Thus, the air purging procedure is simplified because the auxiliary tank is typically fitted with a primer pump.
- Only one fuel line is required between the main fuel tank and the auxiliary tank in the dynamometer room.
- Certain local codes may restrict the volume of fuel allowed in the Test Cell. A day tank will allow one to meet those codes.

Illustration 69 shows a typical day tank. Taylor Dynamometer offers UL approved day tanks in several capacities.

Illustration 69 – Auxiliary or Day Tank

Fuel Cooler

The fuel cooler (see Illustration 70) is typically used in conjunction with a day tank to cool the return fuel and maintain a stable fuel temperature during engine testing.

Taylor Dynamometer has a fuel cooler to complete your system. The typical application is in a system that does NOT contain a Taylor Gravimetric Fuel Measurement System (FMU) yet stable fuel temperatures for repeatable engine performance is desired.

Illustration 70 – Fuel Cooler

Gravimetric Fuel Measurement Unit

During a dynamometer test, you may wish to measure the fuel consumption of the engine. When a test is taking place, fuel is drawn from the drum of the fuel measurement unit (FMU) to the test engine and bypass fuel returns to the drum. For engines that heat the bypass fuel, a built-in fuel cooler reduces the fuel to the desired temperature before it is returned to the drum for re-use. Cooling water is used to cool the return fuel. DynPro uses the weight, volume and temperature to determine the API and specific gravity of the fuel used during the test. Taylor's FMU has an optional primer pump available. Illustration 71 shows a mobile unit with connections. Illustration 72 shows a floor mounted unit in a Test Cell.

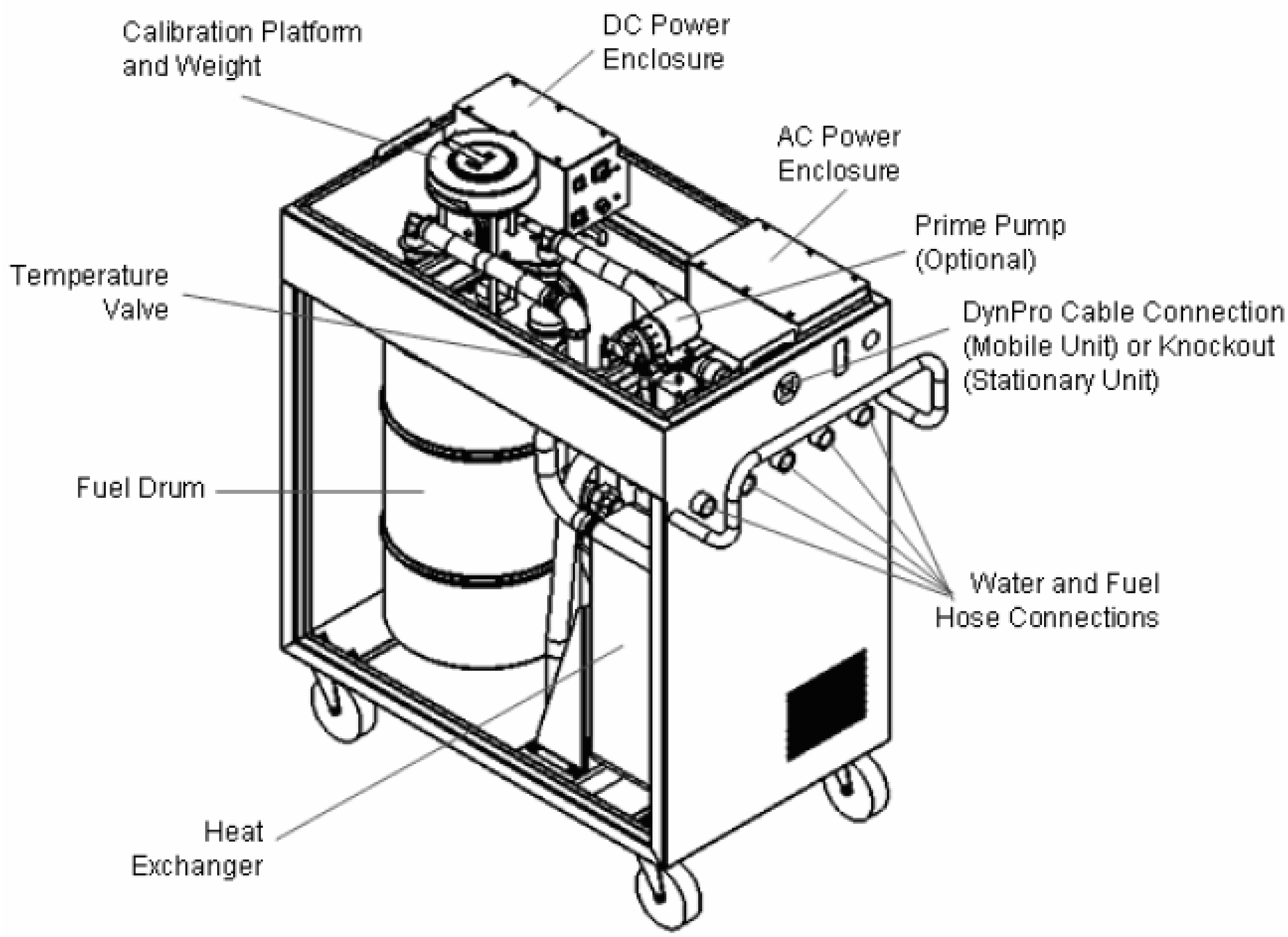


Illustration 71 – Mobile Fuel Measurement Unit

Illustration 72 – Floor Mounted Fuel Measurement Unit

Bulk or Main Fuel Tank

To reduce the effect of the sun heating the fuel supply, the main fuel tank should be shaded. If the fuel temperature exceeds 32°C (90°F), the engine's capability to produce kilowatts (horsepower) is reduced.

When installing two dynamometer rooms that share the same main fuel tank, each room or Test Cell should have its own supply line, auxiliary fuel tank and fuel cooler and/or FMU.

Size and location of the main fuel tank will be determined by local regulations, geographic area and frequency of use. When the main fuel tank is above the auxiliary or day tank, a Head Pressure Isolation Kit is available to protect the FMU.

Depending on the distance of the main fuel tank from the Test Cell, a Fuel Transfer Pump may be required. Local codes shall always apply.

Illustration 73 shows a bulk fuel storage tank.

Illustration 73 – Bulk Fuel Storage Tank

Fuel Transfer Pump

A fuel transfer pump moves fuel from the main tank to the auxiliary tank. When the main tank is below the fuel level of the auxiliary tank, or is more than 20m (60') from the auxiliary or day tank a transfer pump may be required. A water trap and filter system should also be installed.

Miscellaneous Equipment and Mechanical Requirements

This section deals with the numerous miscellaneous room requirements concerning equipment and mechanical needs. Illustration 74 is a typical end view of a dynamometer room showing many of the system components and their relationships.

Illustration 74 – Typical Dynamometer Test Cell

Inertia Block

The dynamometer and engine cart mounting surfaces must be level and flat. Both the dynamometer and test engine should be on an isolated concrete pad to prevent vibration transfer to the rest of the building. They must be on the same pad to prevent twisting. Illustrations 75 and 76 show two view of an isolated engine/dynamometer inertia block. The block is isolated by a 2.5cm (1”) expansion joint. The thickness of the block provides a mass large enough to absorb the majority of the vibration. Typical block thickness ranges from 0.6 to 1.2m (2’ to 4’). Local soil conditions can affect vibration transfer. Local codes shall always apply.

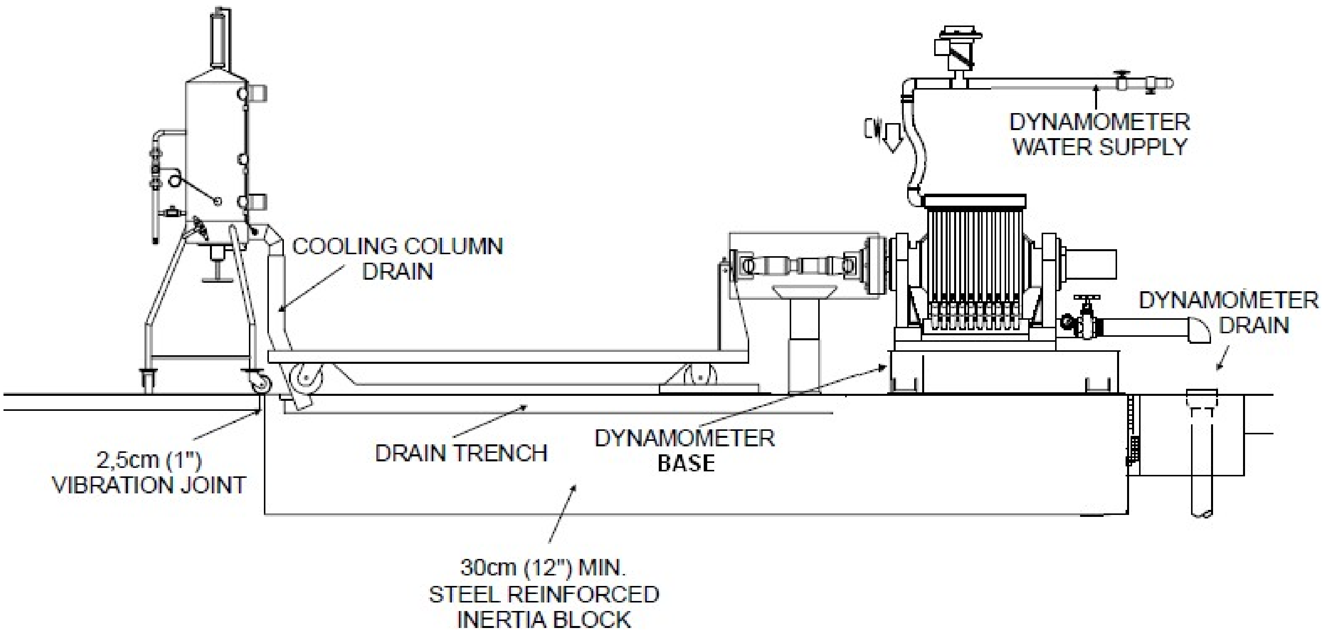


Illustration 75 - Inertia Block and Dynamometer System (side view)

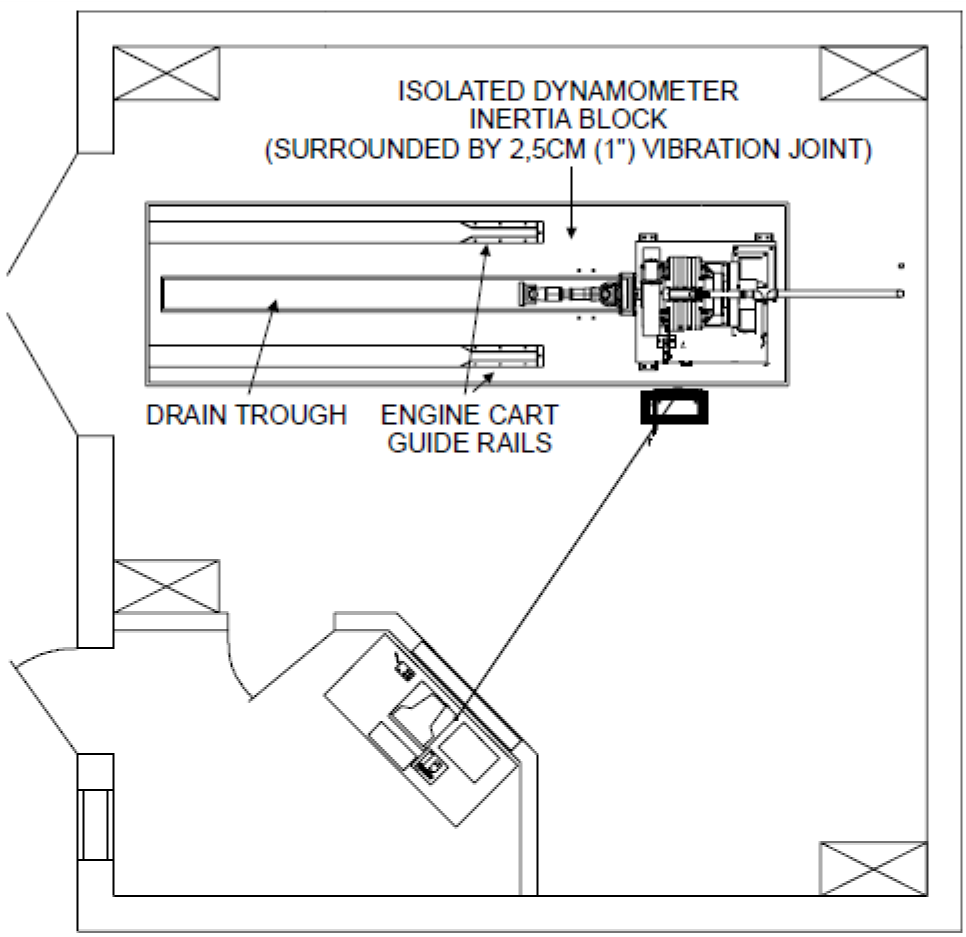


Illustration 76 - Inertia Block and Dynamometer System (top view)

Alternatively, a 3cm (1.25”) steel plate can be used atop the inertia block. Steel bed plates allow engines to be secured in a variety of ways. Illustrations 77 and 78 show use of a steel bed plate and swivel hook.

Illustration 77 – Steel Bed Plate with Engine Cart

Illustration 78 – Steel Bed Plate with Swivel Eye

Engine Carts

Taylor Dynamometer recommends the use of engine carts to provide a positive mounting system for the engine during testing. Guide rails and wear plates are attached to the inertia blocks (see Illustration 79). These guides provide a durable surface upon which the engine carts can travel and also allow the mounting of cart guide angles. The guides quickly position and secure the engine cart for dynamometer testing.

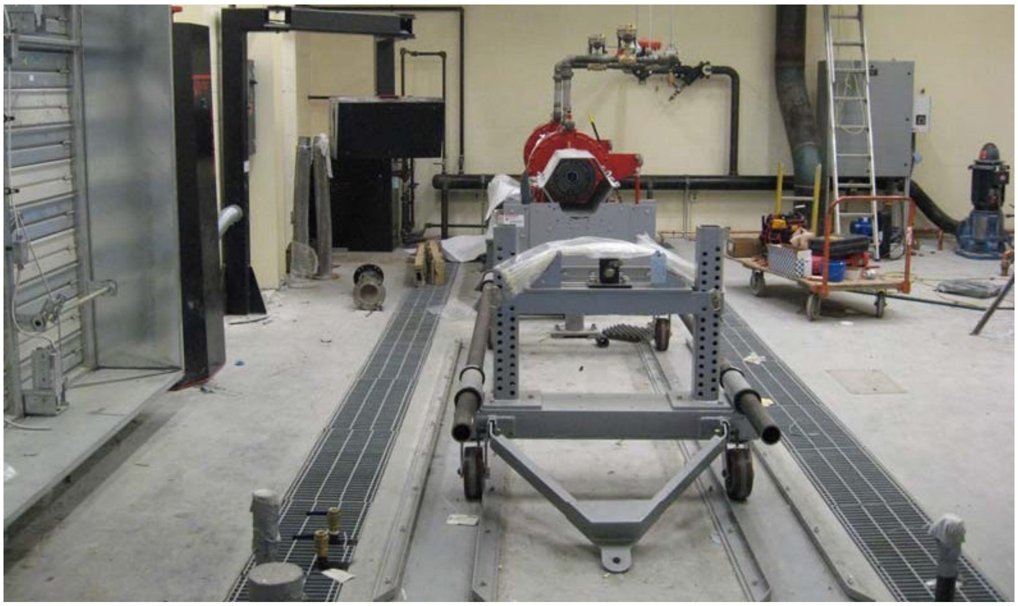


Illustration 79 – Engine Cart, Wear Plates and Guide Rails during Construction

A typical dynamometer centerline height is 80cm (31”) above the floor. This dimension is common when using Taylor Dynamometer carts. Larger engines require a higher centerline. A common centerline height today is 100cm (39.4”). Illustration 80 shows an engine cart, driveshaft guide, and a dynamometer with a centerline height of 80cm (31”).

Illustration 80 – Engine Cart, Driveshaft Guide, Dynamometer C/L 31”

Dynamometer Instrumentation

The following are two methods for monitoring test engine performance:

1. Analog or digital gauges mounted independently or in a panel and hooked directly to the engine. Dynamometer and engine controls are manually operated and the technician must record all measurements by hand.

2. PC based data acquisition and control system is the most common today. This is a more sophisticated method that eliminates individual gauges and manual recording of data. Automated systems ensure repeatable testing and reliable data collection, graphing and printouts. The system has three major components:

    a. An Engine Interface Unit or Sensor Box (see Illustration 81), which can be wall mounted, pedestal mounted or boom mounted.

    b. A PC, monitor and keyboard.

    c. A printer.

Illustration 81 – Wall Mounted Sensor Box with Handheld

Dual Monitoring – Inside/Outside Room

When it is desired to allow the operator to monitor engine performance from either inside the control room or in the test cell, a portable handheld touch screen (see Illustration 82) can be carried while in the test cell.

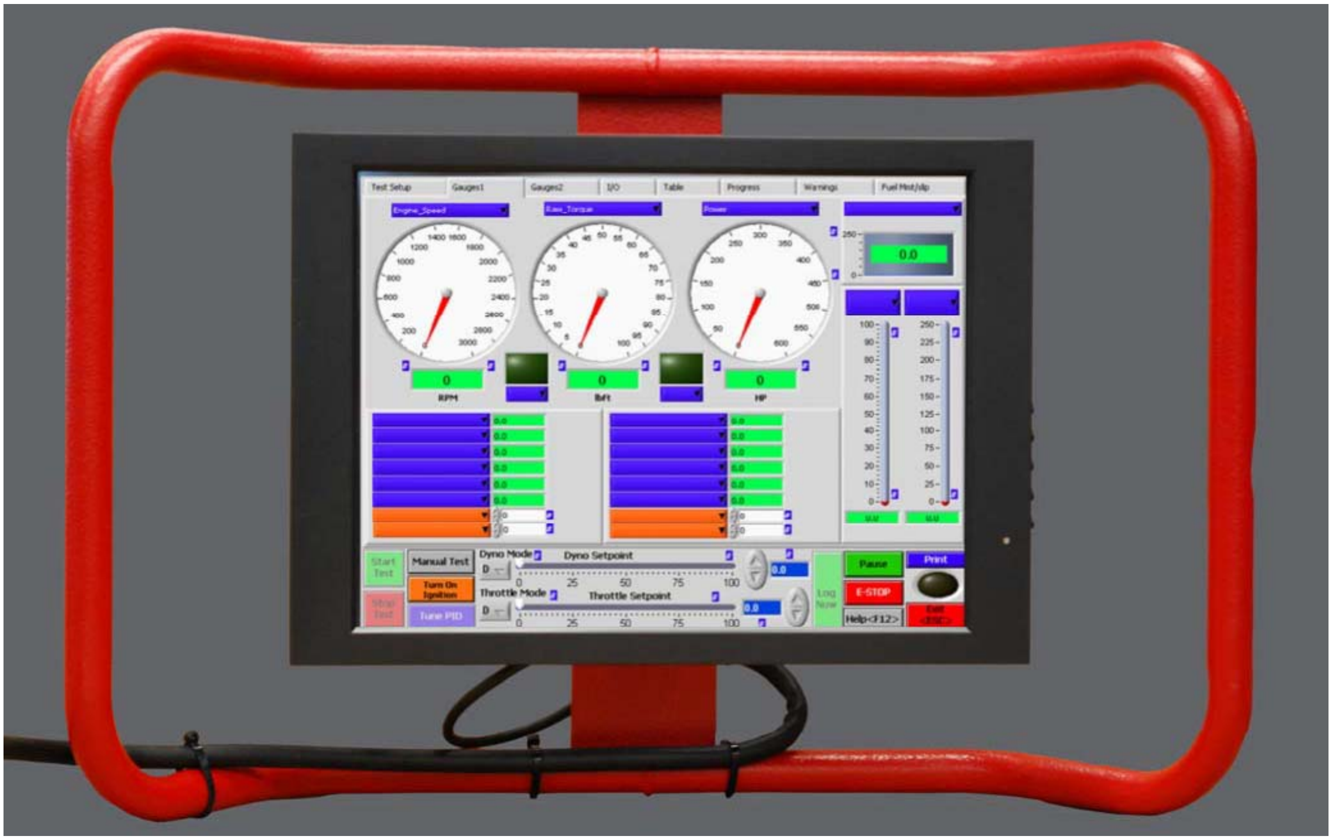


Illustration 82 – Portable Handheld Touch Screen

Instrumentation Requirements

The dynamometer instrumentation and controls are subject to damage by moisture, dirt, temperature and extremes and vibration. Proper observation booth construction with heating, cooling and humidity controls will ensure long life.

For computerized systems a telephone line in the observation booth allows modem connections and a network cable (Category 5 wiring or co-axial cable are two standard network cable types) allows remote access to other computers and shared network hardware.

Instrumentation Specifications

Temperatures

Exhaust Temperature

Range	0 to 814.5°C (32 to 1500°F)
Accuracy	+/- 1%
Resolution	1°C (1°F) or less
Inputs	2 required L & R manifolds

Inlet Air Temperature

Range	0 to 176.5°C (32 to 350°F)
Accuracy	+/- 1%
Resolution	1°C (1°F) or less
Inputs	2 required L & R manifolds 2 required L & R air intakes

Fuel Temperature

Range	0 to 65.5°C (32 to 150°F)
Accuracy	+/- 1% with 100% over-range
Resolution	1°C (1°F) or less
Inputs	1 required

Oil Temperature (Sump Temperature)

Range	0 to 121°C (32 to 250°F)
Accuracy	+/- 1%
Resolution	1°C (1°F) or less
Inputs	1 required
Optional	Alarm at high temperature

Cooling System Water Temperature

Range	0 to 148.5°C (32 to 300°F)
Accuracy	+/- 1%
Resolution	1°C
Inputs	2 required (inlet and outlet Jacket water)
Optional	Alarm at high temperature

Water Temperature – Inlet to Aftercooler

Range	0 to 121°C (32 to 250°F)
Accuracy	+/- 1%
Resolution	1°C
Inputs	1 required

Pressures

Manifold Pressure – Boost

Range	0 to 253kPa (0 to 75 inches Hg)
Accuracy	+/- 1%
Resolution	0.5kPa (0.2 inches Hg)
Inputs	2 required L & R manifolds

Differential Air Pressure – Inlet Restriction

Range	0 to 12.5kPa (0 to 50 inches H_2O)
Accuracy	+/- 1%
Resolution	0.1kPa (0.5 inches H_2O)
Inputs	1 required

Fuel Pressure

Range	4 to 401.5kPa (0 to 60psi)
Accuracy	+/- 1%
Resolution	6.895kPa (1psi)
Inputs	1 required

Differential Fuel Pressure (Gas Engine)

Range	0 to 1.3kPa (0 to 5 inches H_2O)
Accuracy	+/- 1%
Resolution	0.1kPa (0.5 inches H_2O)
Inputs	1 required

Oil Pressure

Range	0 to 689.5kPa (0 to 100 psi) 50% over-range
Accuracy	+/- 1%
Resolution	6.9kPa (1psi)
Inputs	1 required

Dynamometer

Engine Speed or Dynamometer Speed

Range	0 to 4000 rpm
Accuracy	+/- 1 rpm
Resolution	1 rpm
Inputs	1 required

Range	0 to maximum dynamometer rating
Accuracy	0.5% input
Resolution	1kW (1hp)

Flow

Fuel Burn Rate

Range	As determined by engine range
Accuracy	+/- 0.5% input
Resolution	0.25 L/hour (0.1gph)

Instrument Junction Box

A 75mm (3") diameter conduit should be run from the instrument control console typically in the control room to the sensor box near the dynamometer. The conduit is used to run signal cables into the Test Cell near the engine (see Illustration 83). The conduit can be run under the floor or overhead.

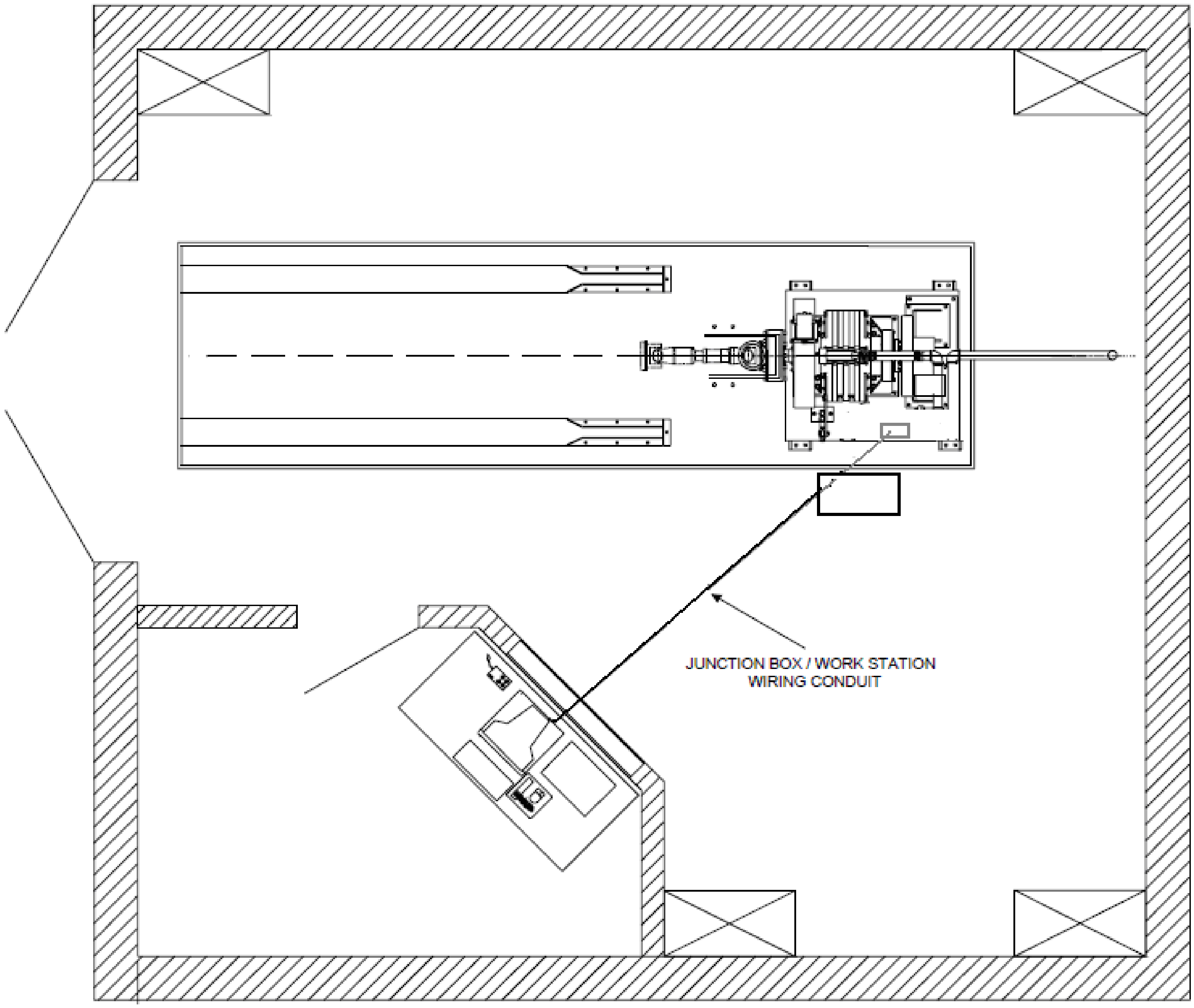


Illustration 83 – Conduit from PC to Sensor Box to Dynamometer Junction Box

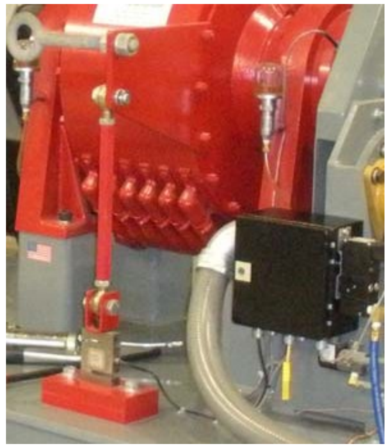


Illustration 84 – Typical Dynamometer Mounted Junction Box

The dynamometer end of the conduit connects to a junction box. Within the box, the instrument leads connect to terminal blocks. Sensors are mounted outside the box to load cell, magnetic pickup and control valve(s). The junction box is also connected to the sensor box by the 75mm (3”) conduit.

Room Heating

In cold weather climates, room heating may be required. The room can be heated by two sources. These heat sources are building heat and test engine heat. When the dynamometer is not operating, the room is heated by the building heat system, which is controlled by a thermostat in the dynamometer room. During the test cycle, heat radiates from the engine. To control radiated engine heat for room heating, dampers are installed in each make-up air outlet and exhaust duct. For additional information, refer to “Ventilation/Exhaust Systems”.

Room Cooling

During hot weather, room cooling can be achieved when the dynamometer is not operating by running exhaust fans.

Lighting

The dynamometer room must have good lighting. Inadequate lighting decreased productivity and increases safety risks. Brightly colored washable paint will assist in reflecting overhead light. When an exhaust hood is installed, fluorescent lighting may also be provided on the inside of the hood.

Compressed Air

Compressed air is needed for the operation of tools, control valves and air starters for the dynamometer. Compressed air outlets for tool usage should be along the walls on both sides of the engine/dynamometer isolation pad.

Either one or two air starters are needed depending on the direction of rotation of the engines you will be testing (see Illustration 85). If only one air starter is installed, rotation can only be in one direction. Two air starters may be required depending on the size of the engine.

A compressed air receiving (storage) tank is needed for the air starter(s) to prevent shop air reduction and pressure drop at the starter. The receiving tank should have a minimum capacity of 90L (240 gallons) at 1380kPa (200psi) and be separated from the main shop air system. This allows an extended cranking time. An adjustable air regulator must be provided to reduce supply pressure to a maximum of 760kPa (110psi) or the starter will be damaged. This tank may be mounted high on the wall or hung from the ceiling. For multiple room installations, each room should have its own air receiving tank.

Illustration 85 – Dual Air Starters on Large Engine Dynamometer

Natural Gas

If natural gas engines are going to be tested, a natural gas outlet should be recessed in the floor near each diesel fuel connection. When using the recessed compartment design, the natural gas connection typically is in a separate compartment. A shut off valve for each location should be on the wall or in the recessed area. Both connections should have a threaded coupling and nipple attached to the gas pipe, to allow for thread replacement. A flex coupling should be attached to the nipple to prevent vibration transfer since rigid pipe and elbows are used for connection to the engine. The gas lines should have a 50mm (2") minimum working pressure of 80kPa (12psi).

Electrical

Electrical outlets should be installed around the inside perimeter of the room. Several outlets can be on reels including a portable light.

Hose Bibs and Drains

One cold water spigot should be in the room for cleaning the floor. An additional hot water spigot can also be added. Floor drains may be located in the recessed fuel and water compartments or trench. These drains may be used for hosing the room floor. The compartment or trench drains and the inertia block drain should be connected to a mechanical oil separator. A water hose on a reel can be mounted on the wall.

Lubrication

Provisions should be made to pre-lubricate (pre-lube) the engine in the dynamometer room to prevent bearing damage during initial startup. A pre-lube pump/motor system capable of 55 to 75L/min (15 to 20gpm) should be mounted on or next to the isolated pad next to the dynamometer. For portable (TD-3100 installations, the pre-lube pump/motor should be installed on the back wall behind the isolated pad.

Centralized lubrication outlets on reels should be located where dynamometer preparation is performed. These outlets should be metered and filtered. If dynamometer preparation is done within the room, the reel can either hang from the ceiling above the dynamometer or be mounted on a wall if a swivel exhaust pipe is used.

Concrete Floor

The floor surrounding the isolation pad should be the same thickness, strength and surface texture as the rest of the engine shop. The floor must be level. A sealer and/or epoxy type paint makes it easier to clean.

Emergency Engine Shutdown and Alarm System

All dynamometer rooms should have a dual emergency shutdown system. An activation switch for this system should be provided in the dynamometer room and the operator control area. Although this system is designed to control engine runaway, it may at times be necessary to shutdown the entire dynamometer facility.

Opening the appropriate electrical circuits can stop the ventilation fans. The engine can be stopped by several methods:

- Taylor Dynamometer's Data Acquisition and Control System (DynPro) offers warnings and "LIMITS" on all channels including all calculated channels. You can program the system to activate any number of relays that will open or close fuel lines, control valves, fans or any other device wired to the system.

- Safety alarms and automatic shutdown devices can also be installed. The following is a list of suggested alarms:

o High water temperature	99°C (210°F)
o High oil temperature	120°C (248°F)
o Low oil pressure	70kPa (10psi)
o Manifold temperature	44°C, 55°C, 66°C, 116°C, 163°C (111°F, 131°F, 151°F, 240°F, 325°F)
o Low water level in cooling tower	

These can be a two-stage system that operates at different settings when the engine is above low idle or at some load condition.

Dynamometer Room Fire Protection and Alarm System

The dynamometer room should have a separate fire protection and alarm system. Since any potential dynamometer room fire will be oil, diesel fuel or natural gas in origin, a water sprinkling system will not be effective. CO_2 should be used to extinguish dynamometer test cell fires.

If an automatic system is installed, the exhaust fans shut off automatically when the fire system is activated. This will prevent the CO_2 from being removed from the room. With an automatic system, a heat/smoke sensitive bulb is mounted to the room ceiling. The bulb activates a compressed cylinder filled with CO_2. A warning alarm (including red light and horn) should be installed to give employees enough time to exit prior to the system discharge. Self-closing fire doors should also be considered.

WARNING: A qualified fire protection consultant or engineer should be consulted before installing any fire protection devices or alarms.

Recessed Compartment Construction

As previously discussed, both fuel and water connections can be located in recessed compartments in the floor. Illustration 86 shows the construction of both water and fuel connection compartments.

A compartment drain is provided for drainage during floor cleaning. The drain should be connected to a mechanical oil separator. The top edge surrounding the compartment should be capped with steel to prevent edge damage to the concrete floor. The steel cap should for a recessed lip around the compartment so the lid is flush with the floor when closed.

NOTE: For water connection compartments, the shut off valve for the water supply quick disconnects should be located on the room wall.

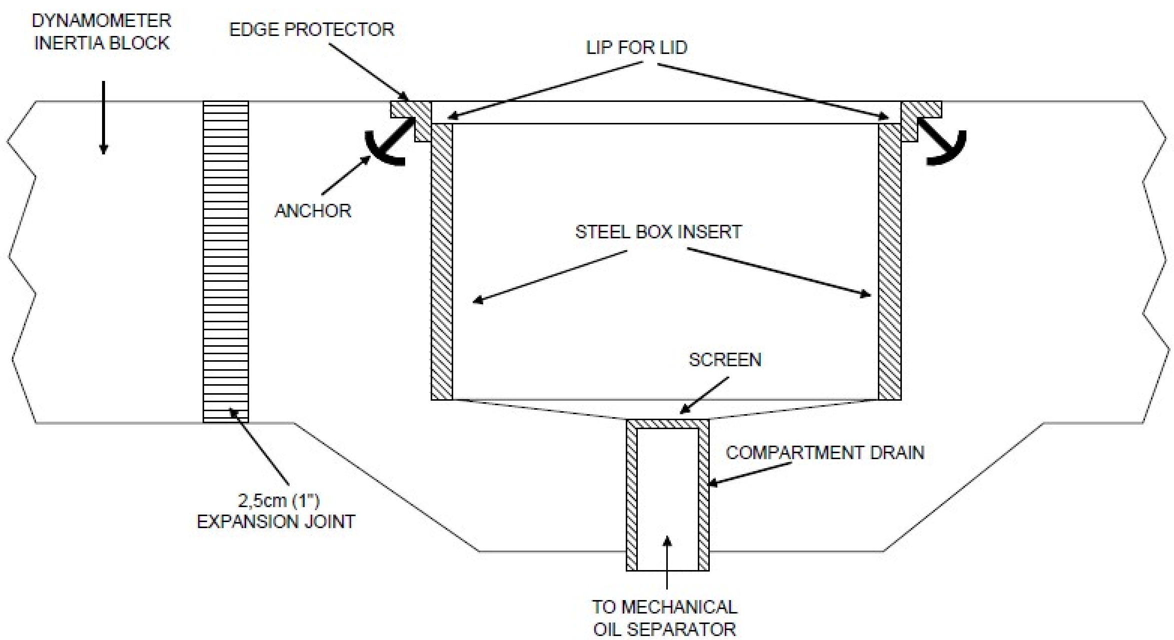


Illustration 86 – Recessed Compartment

The hinged lid covers the compartment when not in use. Lifting holes or recessed drop handles are used to raise the lid without obstructing the flush surface. The lids should have a non-skid surface, such as a raised pattern (diamond) or abrasive floor plate.

Recessed Trench Construction

As previously discussed, both fuel and water connections can be installed in a covered recessed trench. The trench is a U-shape around the isolated engine/dynamometer inertia block (see Illustration 87). The trench method may be used when local codes do not permit buried water and fuel lines below concrete.

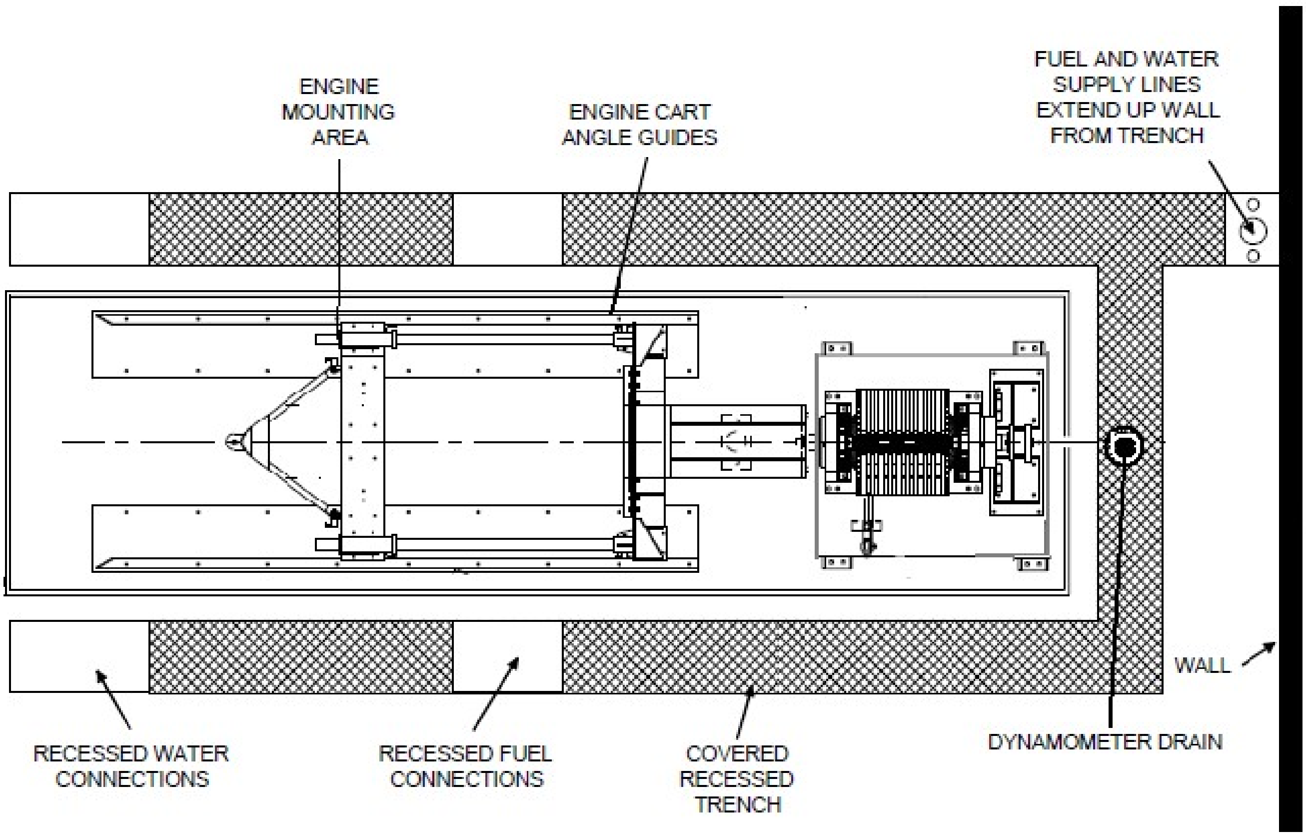


Illustration 87 – Recessed Trench Construction

Trench Construction - Illustration 88 shows construction details of the trench. The bottom of the trench should be sloped to drains for drainage during floor cleaning. The drains should be connected to a mechanical oil separator. To prevent pipes from lying in water during floor cleaning, they are suspended above the trench bottom. The pipes extend vertically with quick disconnect couplings at convenience intervals. The size of the trench is variable depending on the space required for the various pipe installations.

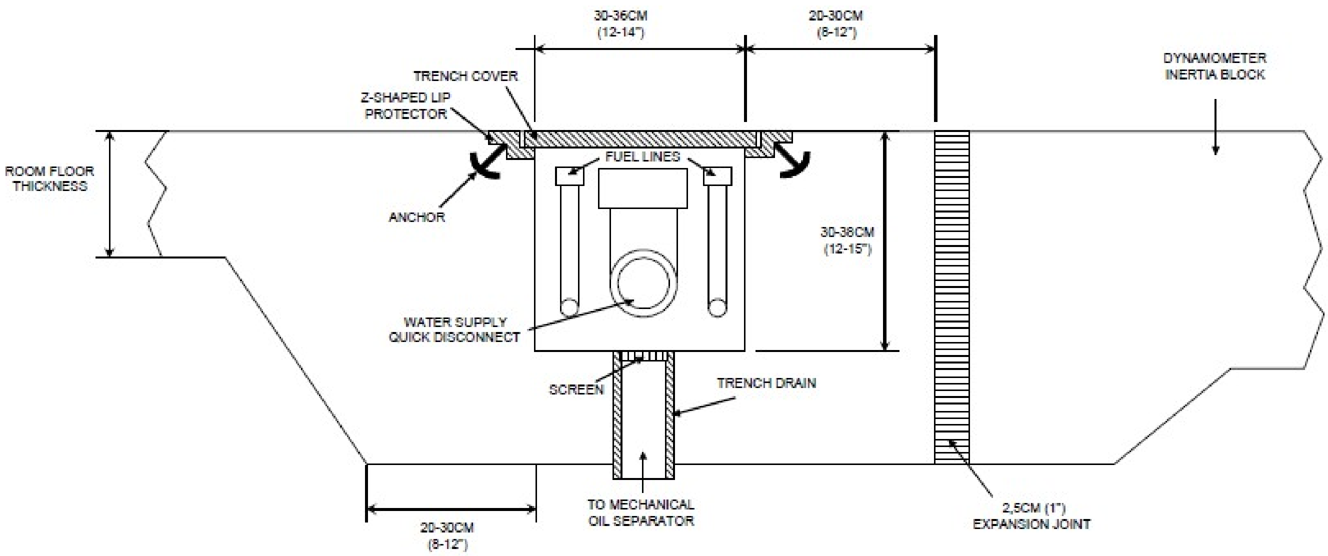


Illustration 88 – Trench Construction, Side Elevation

Illustration 89 – Recessed Trench with Cam Lock Water Lines

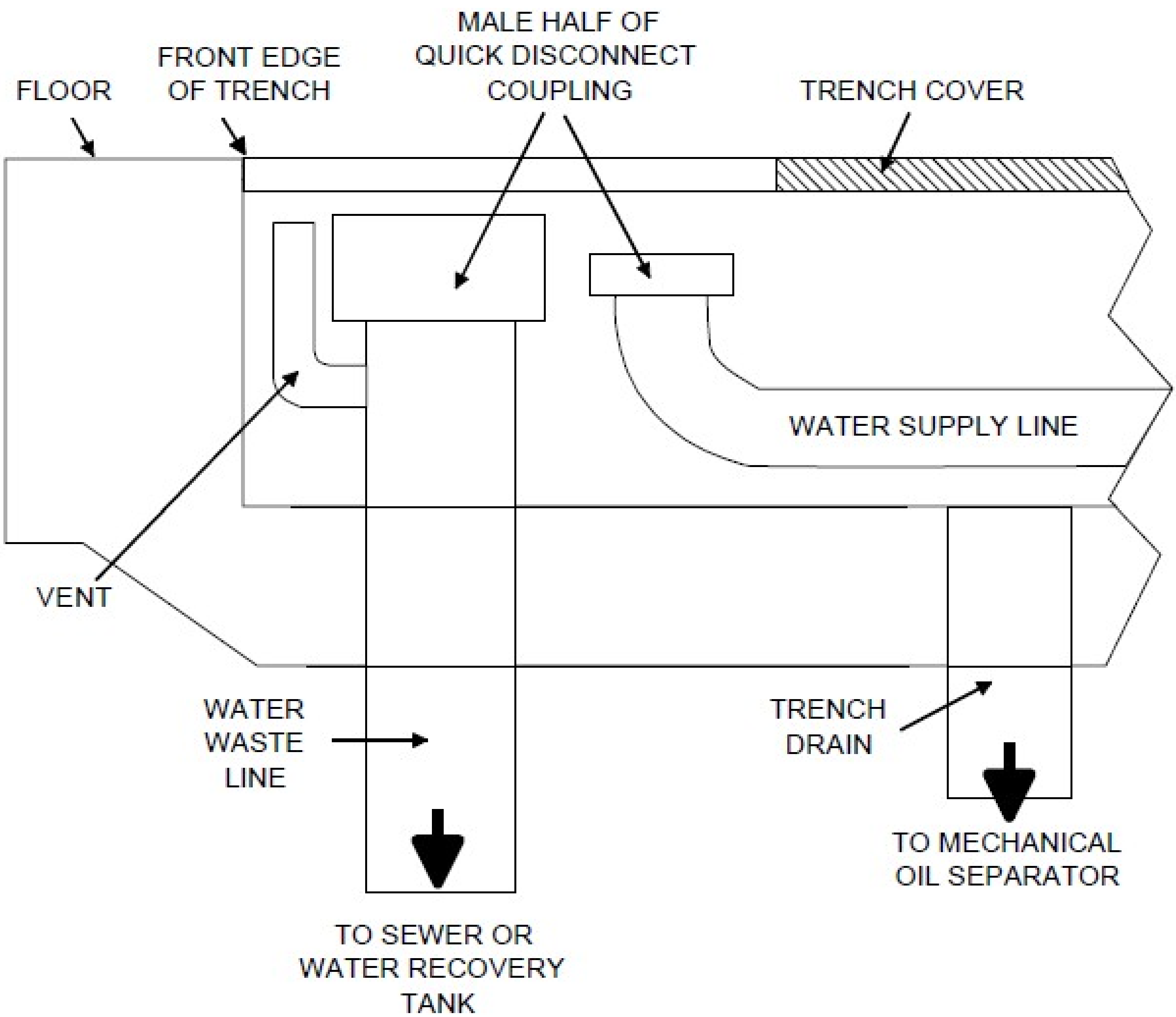


Illustration 90 – Recessed Trench Side Elevation

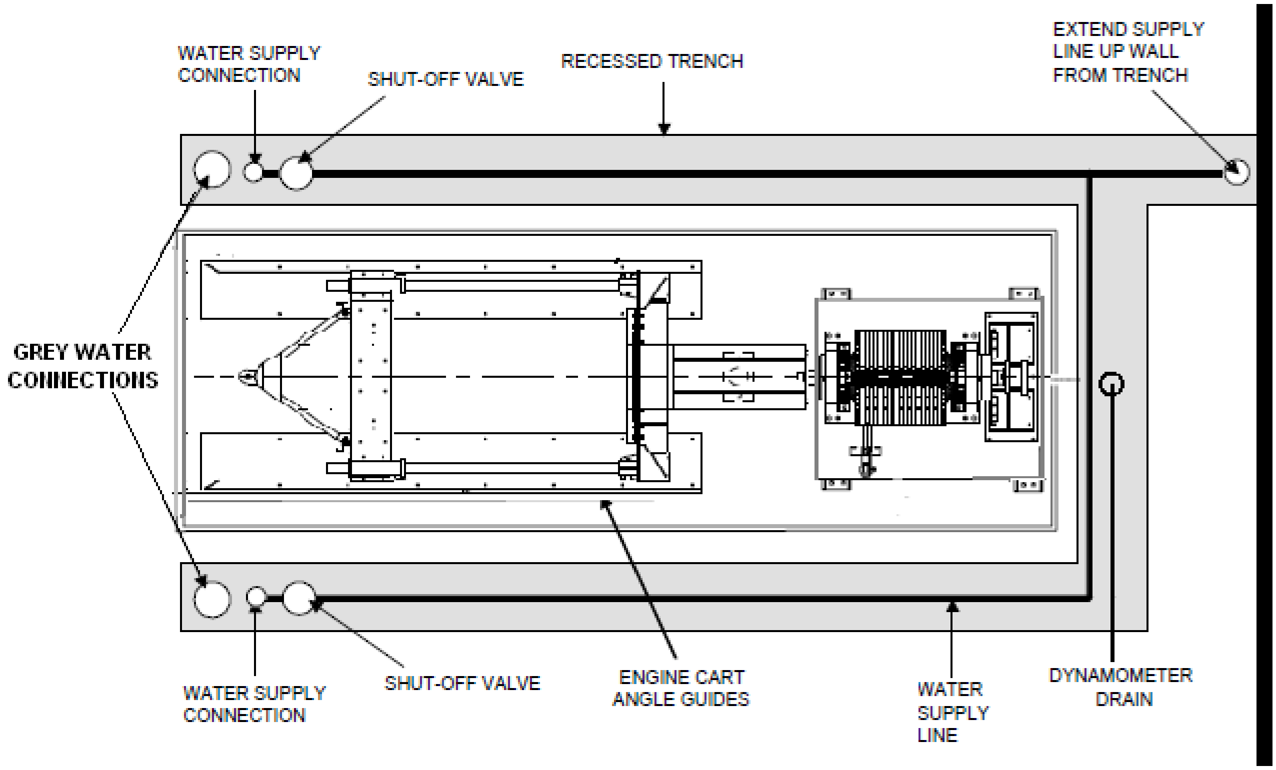


Illustration 91 – Recessed Trench Cold Water Supply Layout

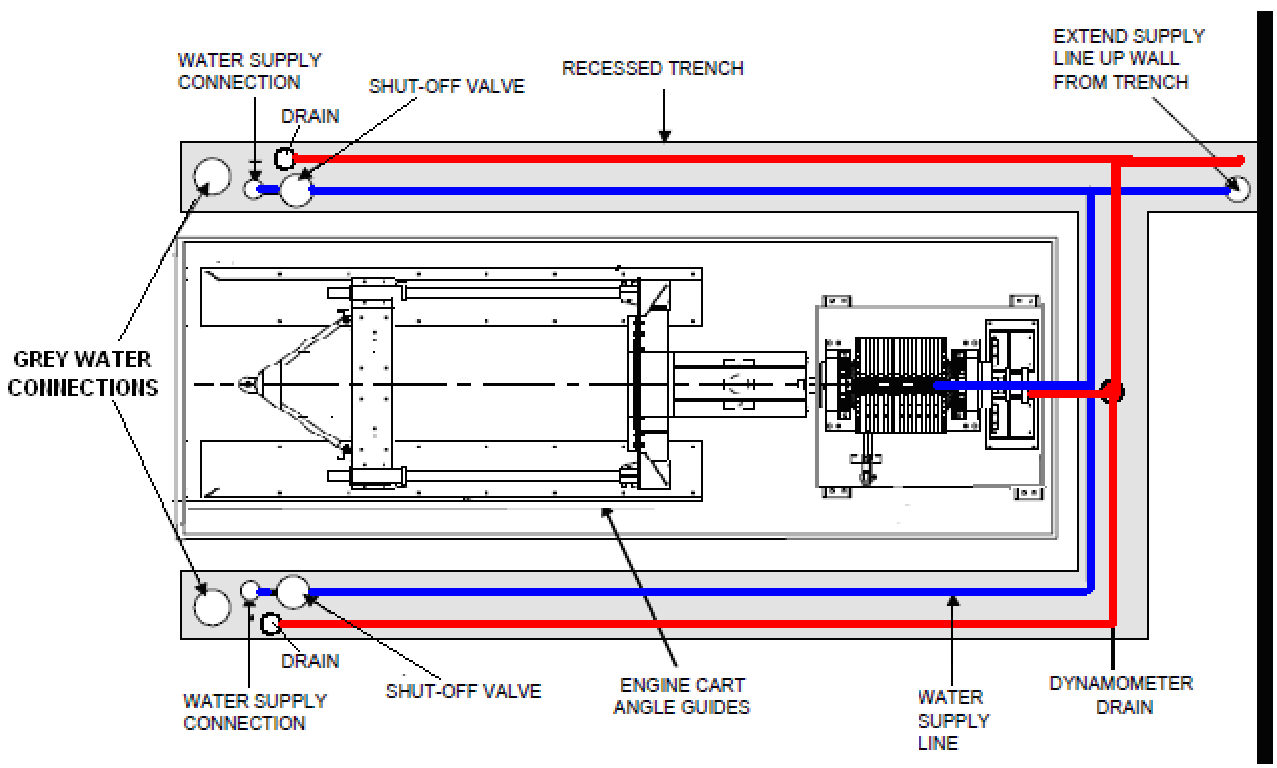


Illustration 92 – Recessed Trench Cold Water Supply and Hot Water Drain Layout

Fuel Line Installation – Illustration 93 shows trench fuel line installation. The fuel lines (supply and return) extend vertically down the end wall into the trench. To ensure ample space between the two connections, the water supply line is installed between the two fuel lines. Also, the fuel connections are staggered approximately 15cm (6") across from each other for greater space between them. At the point where the fuel lines leave the trench, fuel measurement equipment may be installed.

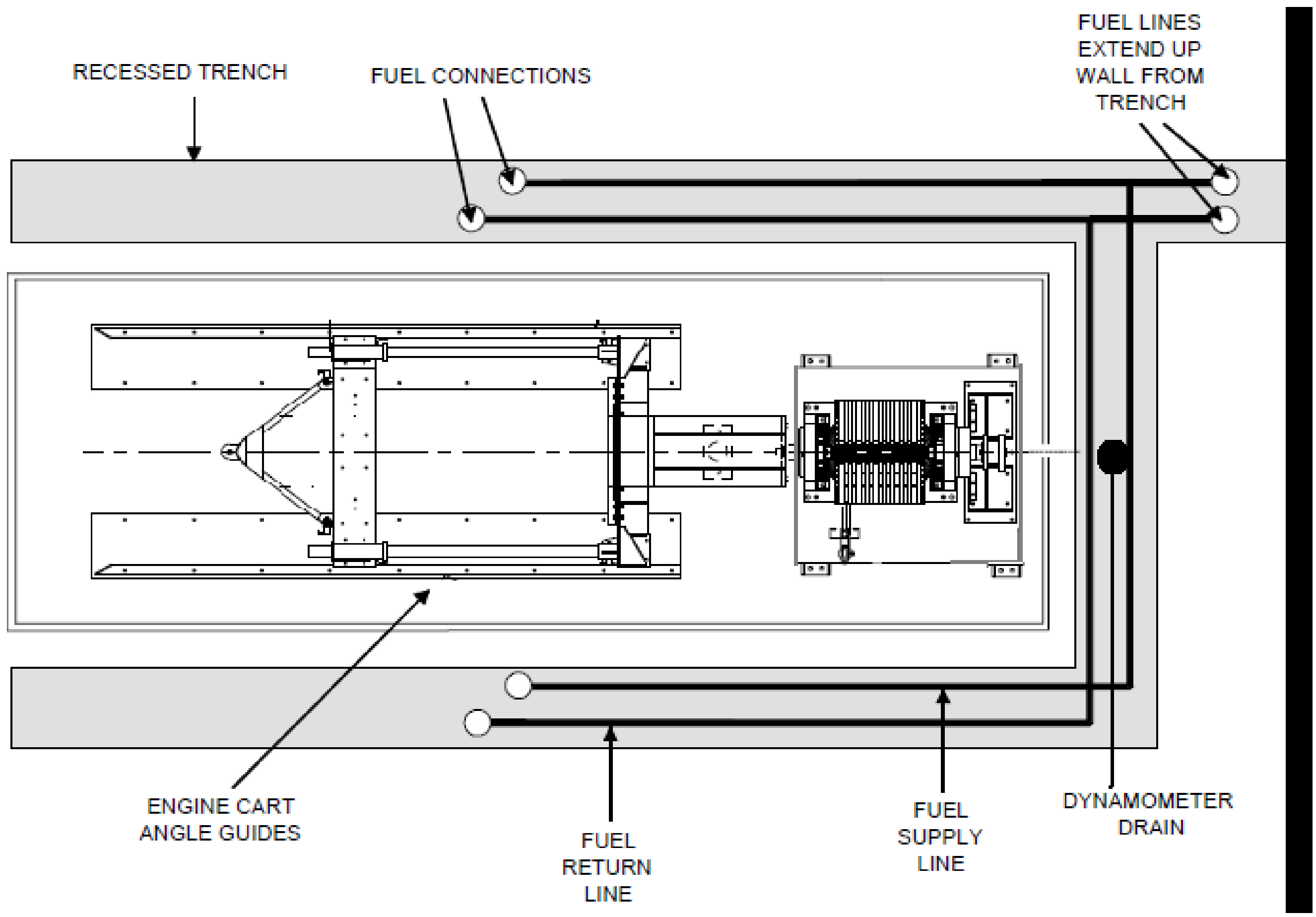


Illustration 93 – Recessed Trench Fuel Lines Layout