US Army Corps
of Engineers
Afghanistan Engineer District

AED DESIGN REQUIREMENTS MECHANICAL AND PLUMBING

Various Locations,
Afghanistan

08 APRIL 2010

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MECHANICAL DESIGN GUIDE

1. General

1.1 The purpose of this document is to provide requirements to Contractors for any project requiring mechanical, plumbing, and special piping design and construction.

1.2 This document in not meant to be an all inclusive "how to be a mechanical designer'. It is meant to supplement an experienced engineer/designer's product specific to work in AED.

2. Project Narrative, Design Analysis, Specifications and Drawings:

2.1 Each project design submittal shall contain the project narrative booklet, design analysis booklet, specifications and the drawings. Catalogue cuts of the selected equipment and fixtures shall also be included in the submittal with the design analysis. The project narrative booklet shall contain the RFP section 01010 and 01015 and provide a concise narrative for the project. The project narrative booklet shall contain all charrette meeting minutes, any incidental meeting minutes, discuss any changes to the project scope, explains the design approach and any clarification for the design reviewer. Each booklet and drawing set shall be indexed and organized by the site plan, civil plan, mechanical, electrical, communication and other applicable disciplines. Each section shall be indexed and tabbed to clearly identify the separate disciplines. Do not mix the plumbing and mechanical drawings.

2.2 Specifications shall be tailored for the project. Do not insert the complete guide specs without editing and deleting or revising the specifications to match the design features.

2.3 Provide the plumbing and mechanical legend, symbols and notes on the first sheet of the plumbing and mechanical drawing sections. Use the legends and symbols consistently throughout the drawings.

2.4 Design analysis shall contain the heating and cooling load analysis, exhaust and ventilation calculations, plumbing load analysis and any other specific mechanical system analysis. The heating and cooling load analysis shall be prepared using a recognized computer program such as Trane "Trace" or Carrier "HAP". If other computer programs are used, provide a narrative on how to interpret the analysis. Hand calculations are also acceptable, provided that it is organized and easily understood. Provide a summary sheet for each of the analysis. This summary sheet should list all the spaces in a table form for which the heating and cooling loads were performed for and indicate the resulting heating and cooling loads. The Trane and Carrier programs automatically generate this summary sheet which shall be included in the design analysis.

2.5 The mechanical plans shall have a sheet dedicated for the mechanical equipment schedule. All mechanical details shall be labeled and shall indicate where the detail applies or target to the applicable drawing plans. Mechanical details shall be inserted at the end of the mechanical plans.

2.6 The plumbing plans shall have a sheet dedicated for the plumbing fixture schedule. All plumbing details shall be labeled and shall indicate where the detail applies or target to the applicable drawing plans. Plumbing details shall be inserted at the end of the plumbing plans.

3. Building Layout

3.1 Layout the facilities in accordance with the approved master plan. Once the buildings are properly laid out, coordinate with the civil and provide the water and sanitary distribution system to each of the buildings. Coordinate the building tie in with the mechanical plans.

3.2 Provide a mechanical space for each building which contains plumbing fixtures requiring cold and hot water, and compressed air. The electric hot water heater and air compressor shall be installed in the mechanical room. The mechanical room shall be located central to the building or next to the toilet space or area which the equipment serves to eliminate long pipe runs and to reduce friction and heat loss from the piping. The mechanical room shall be provided with an electric resistance heater to heat the space to 55 F during the winter.

3.3 Provide separate mechanical and electrical spaces.

3.4 For multi story structure, ensure that the toilets are stacked; i.e. the second floor toilet is over the first floor toilet. This simplifies the plumbing installation.

3.5 In general, plumbing shall be exposed and installed tight to the walls and ceilings. Plumbing shall be installed parallel to the building lines. Where buildings are provided with pipe shafts and/or pipe chases, the plumbing shall be installed in the shafts or chases.

4. Mechanical

4.1.1 Exhaust fans shall be provided for each mechanical room, janitor closet, toilet/shower room, utility rooms, flammable storage, propane storage, work rooms and general storage rooms. Exhaust fans shall be of the centrifugal, wall mounted or in-line type for large spaces requiring ducted exhaust systems.

4.1.2 Avoid roof mounted exhaust fans as much as possible to preclude water leaks.

4.2 Small spaces will not require a ducted exhaust system and a wall mounted propeller fan will suffice.

4.3 Makeup air openings shall be provided for all exhaust fans. Positive closing motorized damper which are interlocked with the exhaust fan is recommended to prevent any dust and contaminant infiltration.

4.4 Small spaces with a wall mounted propeller fan may be provided with door undercuts or door or wall openings for the makeup air.

4.5 Fire dampers are required for all opening in fire rated walls. If a door louver is provided and the wall and door is fire rated, a fire damper is required at the door louver.

4.6 Makeup air openings at exterior walls shall be provided with a bird screen, motorized damper and 2 inch thick washable filter assembly.

4.7 Cooling and heating shall be provided for each building as specified in the RFP.

4.8 When a split packaged heat pump unit is specified, ensure that the indoor fan coil unit is located at the center of the wall and positioned such that the air throw evenly covers the entire space. Combination cooling and heating devices shall be installed above the window. Heating only units shall be installed below the window. Units shall be capable of low ambient operation. See Appendix A for typical installation details.

4.9 Administrative spaces and private offices and spaces which require heating only shall be provided with wall mounted convection or fan powered heaters.

4.10 Barracks shall be provided with industrial quality electric unit heaters securely mounted from the ceiling or walls. Unit heaters shall be provided with a fan to blow the heated air out into the spaces. Install unit heaters such that the orientation allows the unit heater to blow parallel to the exterior wall. Space the unit heaters according to the air throw. Installing the unit heaters at the perimeter of the room allows for a “ring” effect and maximizes comfort to the occupants.

4.11 A smoke detector shall be installed in the supply duct for central forced air ducted systems where the supply air is greater than 2000 CFM. The smoke detector shall be installed downstream of the filter but before any branches in the duct system. Comply with NFPA 90A.

4.12 Clothes dryers shall be provided with a flexible exhaust hose. Coordinate with the architect to ensure that an opening is provided behind the dryer unit. A duct shall pass through the wall. Provide a gravity damper and the open end shall be provided with a bird/rodent screen. Do not install an insect screen at the outlet. Lint and dust will collect on the insect screen and the dryer vent will eventually get clogged.

4.13 Provide range hoods with centrifugal exhaust fans over all cooking surfaces and equipment producing heat and moisture. The front edge of the range hood shall extend approximately 6 inches from the edge of the cooking surface.

4.14 Vehicle tailpipe exhaust systems shall be provided for the vehicle maintenance bays. The exhaust fan shall be ceiling or wall mounted and a hose reel attached to the suction side of the exhaust fan. The discharge from the wall mounted exhaust fan shall be hard ducted to the exterior and bend up and discharge above the building roof. Flexible connections shall be provided where the ducts connect to the exhaust fan. Centrifugal type exhaust fans shall be provided.

5. Plumbing

5.1 The water service line shall enter the mechanical space and the building isolation valve shall be installed in the mechanical space. This will eliminate the need for an exterior valve box and prevent the water lines from freezing.

5.2 Interior plumbing (hot and cold water, drains and vents) shall not be installed in the concrete or CMU walls. If the interior spaces are provided with furred out walls, the plumbing system shall be neatly installed in the furred out walls. All piping shall be installed tight to the wall and parallel to the building surfaces.

5.3 All interior exposed plumbing shall be insulated and provided with stainless steel jackets. This will be more aesthetically pleasing than bare exposed piping and prevent the piping from freezing in the event of any power failure.

5.4 All wet spaces, which require constant washdown and water cleaning operation, shall be provided with a floor drain. The floor slope shall be coordinated with the architect to ensure that the water drains to the floor drain.

5.5 Floor drains shall be provided next to or close to each electric water heater.

5.6 Floor drains which are specified for spaces which are not washed down on a regular basis and where the P-trap may dry out shall be provided with a trap primer. (The requirement for a trap primer is limited and will normally not be provided.)

5.7 All plumbing fixtures and drains shall be provided with a P-trap. The exception is for western style water closet which has an integral trap.

5.8 Incorporate circuit venting or combination drain and vent piping to minimize on the vents. Comply with Section 911 and 912 of the IPC. In principle, vents shall be provided for all trapped fixture drains IAW the IPC.

5.9 Consolidate the vents as much as possible to minimize vent penetrations through the roof. Do not provide a vent cap or cowl on the vent terminal.

5.10 Provide water hammer arrestors at quick closing valves, such as for a clothes washer, and in accordance with PDI-WH 201. Do not install water hammer arrestors if not warranted.

5.11 Floor trench shall be provided in front of all cooking stoves and dish washing areas in the DFAC. Floor trench detail is provided in the attached standard details.

5.12 Clothes washing machines shall be provided with a plumbing utility box or arrangement as shown in the standard details (Appendix G).

5.13 All plumbing lines passing through concrete walls, floors and slabs shall be provided with a pipe sleeve.

5.14 All exposed piping subject to freezing, shall be provided with insulation with aluminum or stainless steel jackets.

5.15 Eastern style water closets shall be oriented on the north-south axis. Each eastern style water closet shall be provided with a water spigot with a flexible hose and water spray assembly and installed on the right hand side of the water closet as the occupant faces the stall door. Provide flush tank type eastern style water closet. Flush tank shall be installed high on the back wall of the water closet. Water tank shall be durable cast iron construction.

5.16 The IPC requires floor cleanouts every 100 feet intervals. In Afghanistan, due to the lack of long pipe routers, recommend that cleanouts be provided every 25 feet intervals.

5.17 Cleanouts shall be provided on drain stacks serving two or more floors. Cleanouts shall be provided at the base of the stack.

5.18 Provide isometric view for the cold/hot water system and another isometric view for the sanitary drain/vent system. Identify each fixture on the isometric views.

5.19 Do not provide drinking water fountains for any facility. The water quality is very bad and all facilities will use bottled water.

5.20 Provide emergency eye wash and shower units for POL storage, battery maintenance and charging rooms and other areas as specified in the RFP.

5.21 Provide air compressor(s), compressed air piping and compressed air drops for the vehicle maintenance facilities and power plant buildings and as specified in the RFP. The compressed air drops shall be provided with moisture filter, isolation valve and the end of the pipe shall be fitted with a quick disconnect coupling.

5.22 Isometric diagrams shall be provided for the compressed air piping system.

5.23 Water drops shall be provided for the vehicle maintenance bays. Isometric diagrams shall be provided for the water system.

5.24 Exterior hose bibs or hydrants shall be freeze proof type.

5.25 Coordinate roof drains with the architects. Roof gutters shall connect to the downspouts. The downspout shall discharge onto concrete splash blocks or french drains. All discharged water shall drain away from the building. Coordinate with civil.

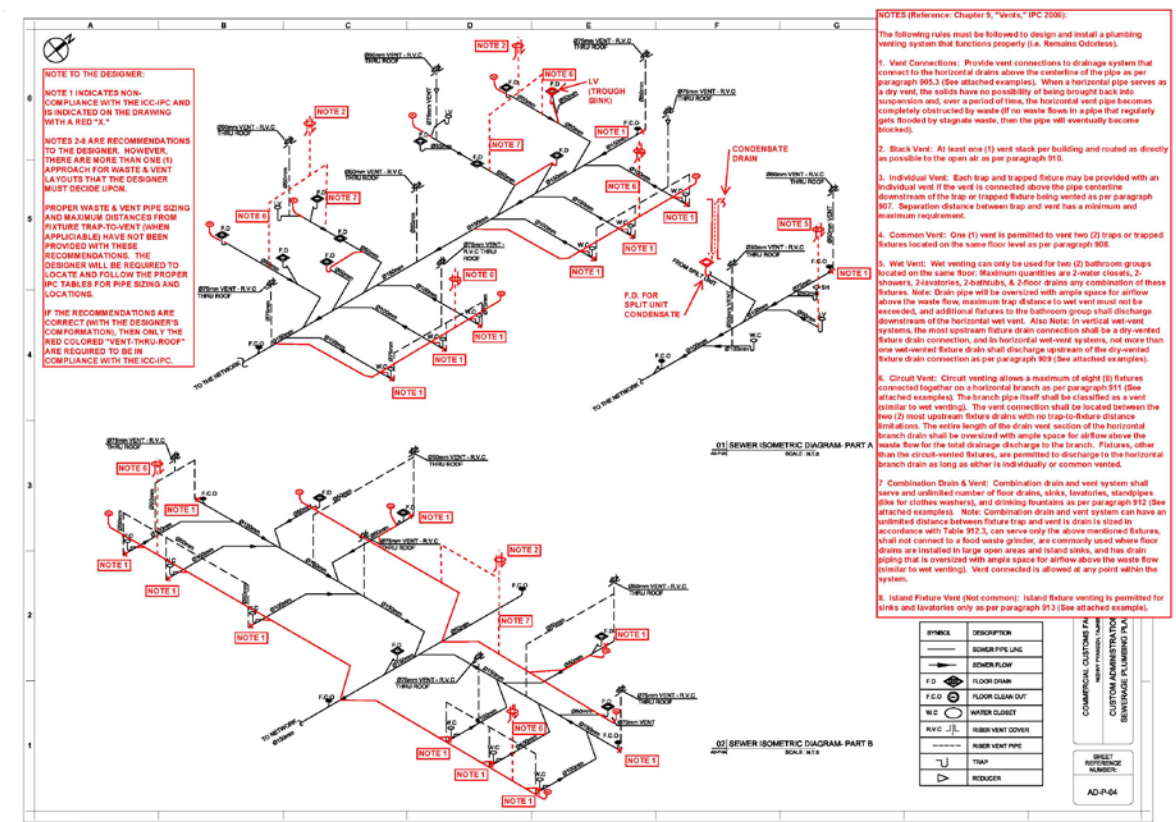
5.26 Drains from vehicle maintenance facilities which contain oil shall be directed through an oil water separator.

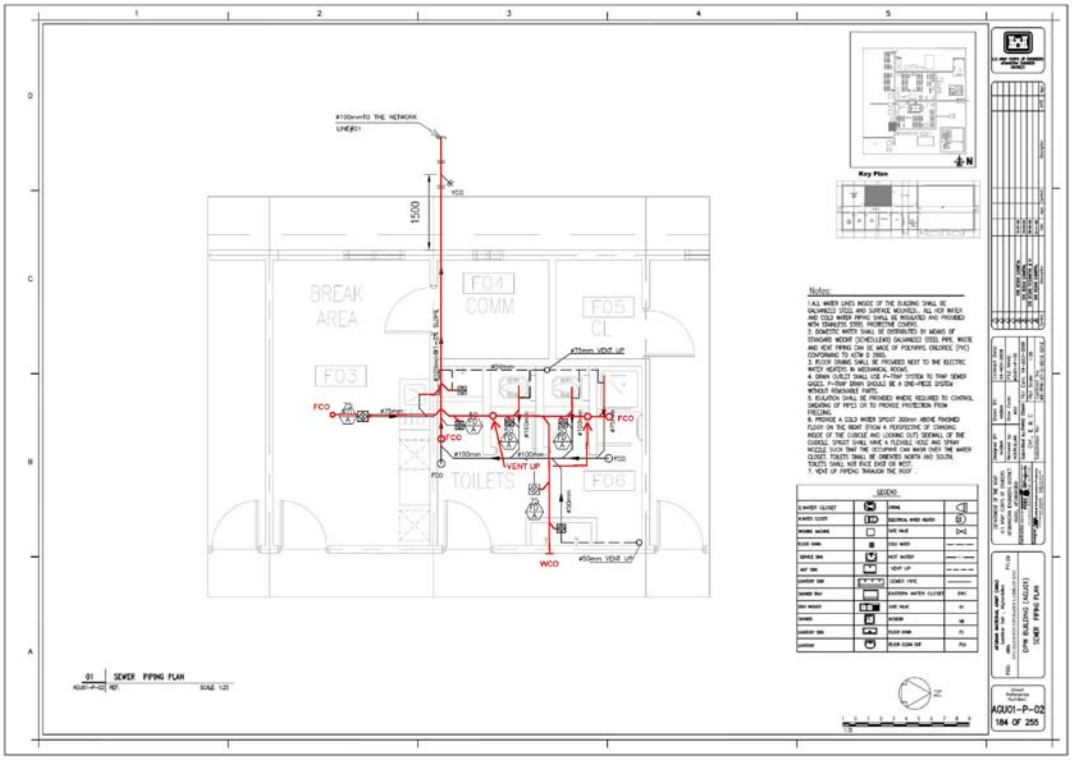
5.27 Drains from kitchen and dishwashing areas shall be directed through a grease trap.

5.28 Do not discharge sanitary sewers into grease traps or oil water separators.

5.29 Provide an expansion tank of the electric hot water heater for water systems with a back flow preventer. The back flow preventer creates a closed system and an expansion tank is required to absorb expansion for the hot water.

Sanitary Drain and Vent Guide

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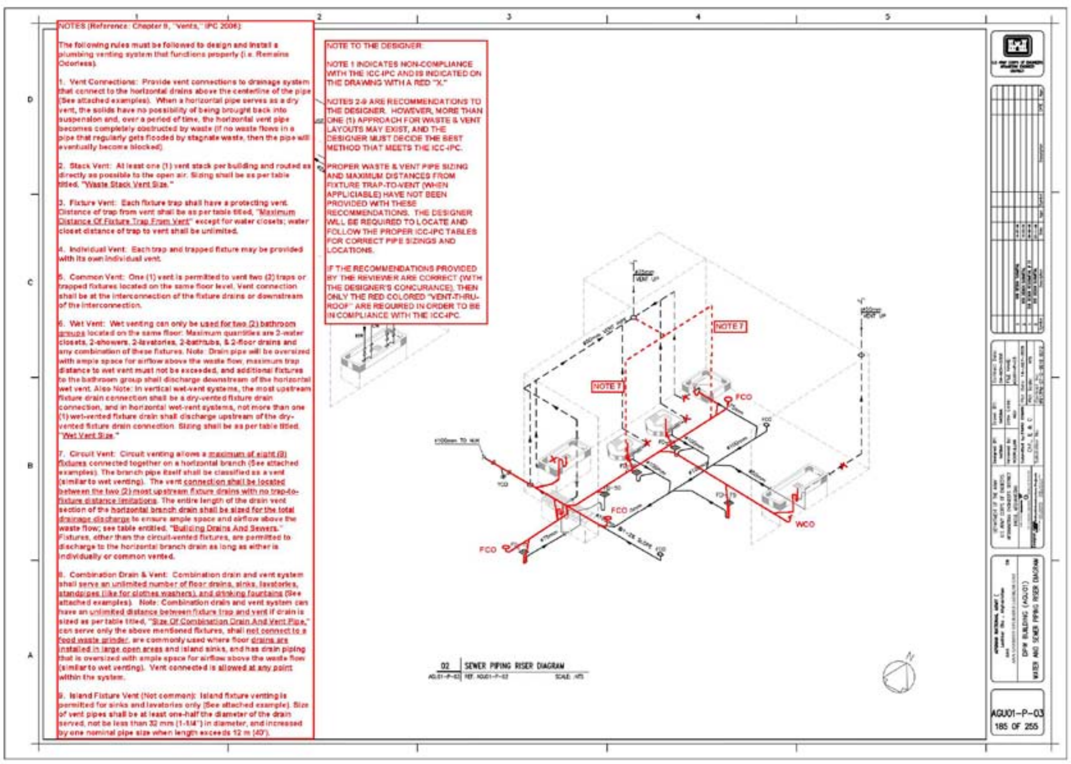
NOTES (Reference: Chapter 9, "Vents," IPC 2006):
The following rules must be followed to design and install a plumbing venting system that functions properly (i.e. Remains Odorless).
1. Vent Connections: Provide vent connections to drainage system that connect to the horizontal drains above the centerline of the pipe (See attached examples). When a horizontal pipe serves as a dry vent, the solids have no possibility of being brought back into suspension and, over a period of time, the horizontal vent pipe becomes completely obstructed by waste (if no waste flows in a pipe that regularly gets flooded by stagnate waste, then the pipe will eventually become blocked).
2. Stack Vent: At least one (1) vent stack per building and routed as directly as possible to the open air. Sizing shall be as per table titled, "Waste Stack Vent Size."
3. Fixture Vent: Each fixture trap shall have a protecting vent. Distance of trap from vent shall be as per table titled, "Maximum Distance Of Fixture Trap From Vent" except for water closets; water closet distance of trap to vent shall be unlimited.
4. Individual Vent: Each trap and trapped fixture may be provided with its own individual vent.
5. Common Vent: One (1) vent is permitted to vent two (2) traps or trapped fixtures located on the same floor level. Vent connection shall be at the interconnection of the fixture drains or downstream of the interconnection.
6. Wet Vent: Wet venting can only be used for two (2) bathroom groups located on the same floor. Maximum quantities are 2-water closets, 2-showers, 2-lavatories, 2-bathtubs, & 2-floor drains and any combination of these fixtures. Note: Drain pipe will be oversized with ample space for airflow above the waste flow, maximum trap distance to wet vent must not be exceeded, and additional fixtures to the bathroom group shall discharge downstream of the horizontal wet vent. Also Note: In vertical wet-vent systems, the most upstream fixture drain connection shall be a dry-vented fixture drain connection, and in horizontal wet-vent systems, not more than one (1) wet-vented fixture drain shall discharge upstream of the dry-vented fixture drain connection. Sizing shall be as per table titled "Wet Vent Size."
7. Circuit Vent: Circuit venting allows a maximum of eight (8) fixtures connected together on a horizontal branch (See attached examples). The branch pipe itself shall be classified as a vent (similar to wet venting). The vent connection shall be located between the two (2) most upstream fixture drains with no trap-to-fixture distance limitations. The entire length of the drain vent section of the horizontal branch drain shall be sized for the total drainage discharge to ensure ample space and airflow above the waste flow; see table entitled, "Building Drains And Sewers." Fixtures, other than the circuit-vented fixtures, are permitted to discharge to the horizontal branch drain as long as either is individually or common vented.
8. Combination Drain & Vent: Combination drain and vent system shall serve an unlimited number of floor drains, sinks, lavatories, standpipes (like for clothes washers), and drinking fountains (See attached examples). Note: Combination drain and vent system can have an unlimited distance between fixture trap and vent if drain is sized as per table titled, "Size Of Combination Drain And Vent Pipe," can serve only the above mentioned fixtures, shall not connect to a food waste grinder, are commonly used where floor drains are installed in large open areas and island sinks, and has drain piping that is oversized with ample space for airflow above the waste flow (similar to wet venting). Vent connected is allowed at any point within the system.
9. Island Fixture Vent (Not common): Island fixture venting is permitted for sinks and lavatories only (See attached example). Size of vent pipes shall be at least one-half the diameter of the drain served, not be less than 32 mm (1-1/4") in diameter, and increased by one nominal pipe size when length exceeds 12 m (40').
NOTE TO THE DESIGNER:
NOTE 1 INDICATES NON-COMPLIANCE WITH THE ICC-IPC AND IS INDICATED ON THE DRAWING WITH A RED "X."
NOTES 2-9 ARE RECOMMENDATIONS TO THE DESIGNER. HOWEVER, MORE THAN ONE (1) APPROACH FOR WASTE & VENT LAYOUTS MAY EXIST, AND THE DESIGNER MUST DECIDE THE BEST METHOD THAT MEETS THE ICC-IPC.
PROPER WASTE & VENT PIPE SIZING AND MAXIMUM DISTANCES FROM FIXTURE TRAP-TO-VENT (WHEN APPLICIABLE) HAVE NOT BEEN PROVIDED WITH THESE RECOMMENDATIONS. THE DESIGNER WILL BE REQUIRED TO LOCATE AND FOLLOW THE PROPER ICC-IPC TABLES FOR CORRECT PIPE SIZINGS AND LOCATIONS.
IF THE RECOMMENDATIONS PROVIDED BY THE REVIEWER ARE CORRECT (WITH THE DESIGNER'S CONCURANCE), THEN ONLY THE RED COLORED "VENT-THRU-ROOF" ARE REQUIRED IN ORDER TO BE IN COMPLIANCE WITH THE ICC-IPC.
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02 SEWER PIPING RISER DIAGRAM
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6. Propane Stove Cooking Standard

The cooking stove is designed with consideration to the Afghan cooking practice, cleaning and maintenance for these stoves. The following is the standard language placed in project RFPs.

PROPANE COOKING STOVE

Cooking area shall be provided canopy type exhaust only kitchen hoods and associated exhaust fans. These exhaust hoods shall include baffle type aluminum filters to trap grease/oil. The exhaust fan sizing calculations should recognize the use of propane stoves in the kitchen. Sizing should accommodate all propane burning stoves running simultaneously. Additionally, the placement of the exhaust hood should allow enough clearance for an average sized male to stand on top of the stove platform unobstructed, for standing on the stove is common local cooking practice. The higher than average placement of the hood will require the extension of the lip of the hood out further than normal, in order to catch the majority of the smoke and adequately vent the area. Propane tank shall be located outside of the DFAC covered in the fenced storage yard
New propane stoves shall be installed with consideration to ease of cooking operation and daily cleanup. The new propane stoves shall be set into a formed concrete opening such that it can easily be removed for replacement, maintenance and cleaning.

Each propane stove shall be provided with three burners. The propane stoves shall be of commercial quality and be capable of producing the highest BTU heat output with all three burners on. The center burner is low heat, center and middle burner is medium heat and all three burners is high heat. A shut off valve for each burner shall be provided at the face of the propane appliance.

Piping from the propane tanks to the respective propane stoves shall be wrought iron, ASTM B36.10M or steel (black or galvanized), ASTM A53. The steel piping shall terminate in front of the propane stoves with a shut off valve and quick disconnect nipple. A stainless steel flexible hose shall connect from the propane stove to the steel piping. Each end of the flexible hose shall be provided with quick disconnect fittings.

The propane piping shall not be embedded in the concrete floor. Installation of the propane piping in trenches is discouraged. Carefully layout the propane piping such that it can be installed within the concrete platform. Provide pipe sleeves such that the propane piping can be inserted into the pipe sleeves.

Piping passing through the exterior wall shall be provided with pipe sleeves.

6.1 Background Data

Legacy propane stoves appear to be a retrofit of existing wood burning stoves. The propane burners are set into the wood stove fire box and are not easily accessible for cleaning and maintenance. The wood burning fire box doors is removed and the remaining opening exposes the workers to the high heat from the propane burners. The fire box is not lined with fire brick and the concrete will deteriorate and crumble when subjected to repeated cycles of high heat.

Figure 1 – Legacy Wood Burning Stove

Rather than repair/converting wood cooking stoves; cooking stoves are removed in its entirety and replaced with propane cooking platforms as shown in the following photographs. The propane appliance is set into the opening. This installation is considered superior to a wood stove retrofit since the heat is directed upwards from the cooking surface and concentrated on the cooking pots. There is no heat loss from the opening in front of the retrofitted wood stoves.

Figure 2 - Legacy Converted Propane Stove (set into the firebox and not accessible for cleaning and replacement)

The cooking pots appear to be with a deep tapered/rounded bottom. Provide metal stands above the cooking platform such that these pots can be set into the stands. The bottom of the pots will be above the propane burners.

The height of the cooking stove appears to be 3 tiles high, approximately 36 inches or more. At this height, it is difficult for the Afghans to get on top of the cooking platform. The opening at the front of the retrofitted wood stoves is not efficient (heat loss out of the front) and subjects the workers to the heat. The propane hose is subjected to the heat and is a fire hazard.

The cooking platform is the height of the propane stoves; approximately 18 to 24 inches high which facilitates standing on the cooking platform to perform cooking operation such as stirring the large cauldrons and moving it on and off the propane burners.

Figure 3 – Cooking Platform

Legacy gas piping is buried in the slab and is not conducive to repair and replacement. AED proposes that the propane piping pass through the concrete platform. Pipe sleeves will be installed in the concrete platform to allow installation of the propane piping in the sleeves. This installation will better facilitate repair and replacement of the propane piping.

Figure 4 - The propane stove dropped into the concrete platform.

Figure 5 - The propane stove dropped into the concrete platform.

The rubber hose and clamped ends should be flexible braided metal hoses with quick disconnect fittings Metal corner nosing prevents chipping and cracking of the edges and corners. Propane hoses are away from any heat source.

Figure 6 - The propane stove dropped into the concrete platform.

Appearance is neat and the propane stoves are very functional. All the heat is directed upwards to the underside of the cooking pots.

6.3 Refer to appendix for standard drawings.

7. Afghani Cooking Style Kitchen Hood

7.1 The cooking style in Afghanistan differs greatly from the cooking styles in United States. The most noticeable difference is in the appliance itself. Instead of the grilles and deep fryers typically seen in American kitchens, the main cooking appliance in Afghanistan is a propane burner (See Figure 5).

Figure 5: Propane Stove

A chef, having placed a large pot on the burner, will stand beside the pot to stir it. This style of cooking requires the chef to stand on the appliance, which is an important consideration in the design of the kitchen hood.

In the United States, the chef normally stands in front of the kitchen appliance, like a grille or deep fryer. The chef is cooking about 3 feet above the floor and standing on the floor. The kitchen hood is typically mounted 6.5 feet above the floor for clearance so the kitchen hood is only 3.5 feet above the cooking surface.

In Afghanistan, the kitchen hood needs to be 6.5 feet above the surface of the propane stove so the chef has enough clearance to stand on the stove. The pots are about two (2) feet high and normally boiling water to cook the food. The steam from the cooking is released at the surface of the water in the pot and, for this design guide, the surface of the water will be considered the cooking surface. If the pot is half full, the water level would be at about one (1) foot above the surface of the stove and about 5.5 feet from the hood. The increased distance from the cooking surface to the hood requires the hood to extend past the front of the stove more and a greater exhaust rate to adequately capture the steam released.

7.2 Overhang

The 2007 ASHRAE Handbook – HVAC Applications recommends a front overhang of 9 to 18 inches for canopy style and a 10 inch setback for back shelf/proximity style. The wall-mounted canopy style is typical for an exhaust hood in Afghanistan so it will be the focus of this design guide. The International Mechanical Code minimum overhang for a canopy is 6 inches on all sides. The exception is ‘the hood shall be permitted to be flush with the outer edge of the cooking surface [meaning no overhang] where the hood is closed to the appliance side by a noncombustible wall or panel.

It is the recommendation by this design guide for the propane stove is enclosed by noncombustible materials on all of the sides except the front. The back of the stove is normally enclosed by an exterior wall of non-combustible construction. The sides can be enclosed by side panels or non-combustible walls.

The front overhang for the hood should be the maximum recommended by ASHRAE due to the distance from the cooking surface, which is 18 inches.

7.3 Exhaust Rate

The air exhaust rate is determined by the duty category of the appliance and the type of hood. The duty categories are determined by the following table (Table-1):

Light Duty (400˚F)	Electric or Gas	Ovens, Steam-jacketed kettles, Compartment steamers, Cheesemelters, Rethermalizers
Medium Duty (400˚F)	Electric	Discrete element ranges (with or without oven)
	Electric or Gas	Hot-top ranges, Griddles, Double sided griddles, Fryers, Pasta cookers, Conveyor ovens, Tilting skillets/braising pans, Rotisseries
Heavy Duty (600˚F)	Gas	Open-burner ranges (with or without ovens)
	Electric or Gas	Underfired broilers, Chain (conveyor) broilers, Wok ranges, Overfired (upright) salamander broilers
Extra-Heavy Duty (700˚F)	Solid fuel	Appliances using solid fuel such as wood, charcoal, briquettes, and mesquite to provide all or part of the heat source for cooking.

Table-1: Appliance Types by Duty Category
(Taken from ASHRAE Handbook – HVAC Applications, 2007)

The propane stove should be considered a gas open-burner range without an oven since it functions as one but at a larger scale. The duty category for a gas range is heavy as shown in the table above. The exhaust rate for a wall-mounted canopy at a heavy duty is 400 cfm per linear foot of hood.

7.3 Calculating Exhaust Rate for Wall Mounted Canopy Hoods

The following steps should be followed to calculate the exhaust rate for a kitchen hood serving a propane stove (Afghan Style Cooking):

7.3.1 Determine the dimensions of the kitchen hood by the dimensions of the propane stove. Add 18 inches of overhang to the front of the hood and add 12 inches on each side, if the side is not enclosed by non-combustible materials (a wall or side panel). The overhang of the kitchen hood is determined by the distance from the edge of the hood to the edge of the cooking ‘surface’. The hood should extend 12 inches beyond the edge of the burner.

7.3.2 Calculate the exhaust fan capacity (CFM) by multiplying the length of the hood (feet) by 400 CFM.

7.3.3 For hoods other than canopy type hoods, comply with Section 507 of the IMC.

7.4 Make Up Air

The kitchen hood has to exhaust a large amount of air to remove the effluents created from cooking. This exhaust air has to be introduced into the space from the outdoors to prevent a negative pressure inside the building relative to the outside which can be large due to the amount of air exhausted. The air from the outside used to replace the exhaust air is called make up air.

Some typical components of a make up air system are as follows:

- Wall Louver: This is a louver that is located on an exterior wall. The louver is installed to let air in but keep out weather and animals. It should have a two (2) inch washable filter to prevent dust from entering the kitchen.
- Ductwork
- Make up air fan
- Plenum

Every make up air system needs a wall louver to keep out the weather, insects, and animals. It is highly recommended to introduce the make up air near the exhaust hood to minimize drafts. The ideal design would temper (meaning cool or heat as necessary) the air before letting it in the space but tempering the air requires an additional air conditioning unit with heat. Normally, the additional air conditioning unit, called a make up air unit, is not provided to reduce the initial installation costs and reduce the complexity of the installation and system.

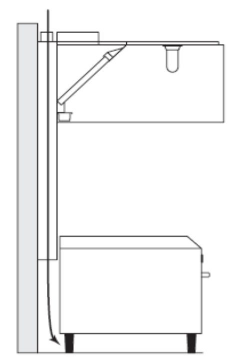
There are multiple techniques to introduce the make up air into the kitchen. Some are listed below:

- Back Supply Plenum
- Air Supply Plenum
- Perforated/Register Face
- Non-Directional Perforated Ceiling Diffusers
- Air Curtain
- Variable Supply Plenum
- Short Circuit
- 4-way diffuser

Some of these techniques are not practical due to the desire to keep designs in Afghanistan as basic as possible. Other techniques should not be used because they might draw odors and fumes out of the exhaust hood. The techniques that are not practical are the variable supply plenum, due to the complex construction, and the short circuit, because of the complex construction unless the hood is bought with the short circuit all ready constructed into the hood. The techniques that might draw odors and fume out from under the hood are the 4-way diffuser, air curtain, and short circuit. The other techniques (Back supply plenum, air supply plenum, perforated face, and non-directional perforated ceiling diffusers) should be tried before using one of the previous mentioned methods. This design guide will cover the recommended techniques for make up air.

Back Supply Plenum
This make up air techniques takes the air from outside and directs it behind (and underneath) the cooking appliance. The air is directed behind the cooking appliance by a six (6) inch deep plenum that runs the entire length of the hood. The plenum should terminate approximately 31.25 inches above the finished floor and flow freely underneath the appliance.

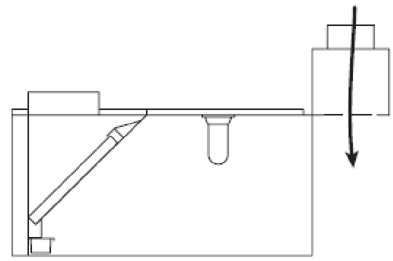
This make up air system works better for American style cooking because the cooking appliance can be pulled out from the wall to allow the plenum behind it. This allows the plenum to be able to deliver the air somewhat underneath of the appliance. This technique can be useful when the system supplies untempered air since the cold air in the winter will be underneath the appliance and will heat up before it gets near the chef. It also delivers the air near the floor which prevents the creation of drafts by the cold outside air being introduced into the space.


Back Supply Plenum

The difficulty with using the back supply plenum for Afghan style cooking is, because of the platform constructed around the propane stove, the plenum cannot get behind or below the cooking appliance, in this case the propane burner. The untempered air is introduced into the space right next to the chef when he is standing on the platform next to the burner and stirring the pot. The main complication with this make up air system is the back supply plenum would get in the way of the chef when he is on the platform trying to stir. The plenum also reduces the space the chef has around the pot. There are better options for the make up air system so the back supply plenum make up air system is not recommended for Afghan style cooking.

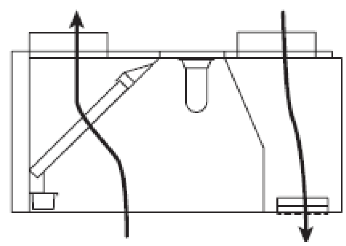
Air Supply Plenum
This system uses a plenum in front of the hood to deliver the outside air. The plenum must be design and constructed properly to prevent the make up air from pulling out vapors from under the hood. The plenum must be designed so the velocity of the air leaving the plenum is keep low enough as to not create a low pressure pocket that draws the air out from under the hood.

This technique is similar to an air curtain system. The difference between the two systems is the bottom of the air curtain is level with the bottom of the hood but the bottom of the air supply plenum is 14 to 20 inches above the bottom of the hood. The advantage of the air supply plenum over the air curtain is the greater amount of CFM per linear foot the air supply plenum can provide over the air curtain. The optimum flow rate for the air curtain is 65 CFM per linear foot but the optimum for the air supply plenum is 110 CFM per linear foot. The 110 CFM per linear foot is the recommended amount for a plenum that is 12 inches deep.



External Air Supply Plenum

The flow rate can be increased to 180 CFM per linear foot if the depth of the plenum is increased to 24 inches. The increase in supply air reduces the differential between the supply air and exhaust air which means less air has to be supplied from other sources. The air supply plenum (and the air curtain) also introduces the air near the hood which is preferred if the air is untempered.



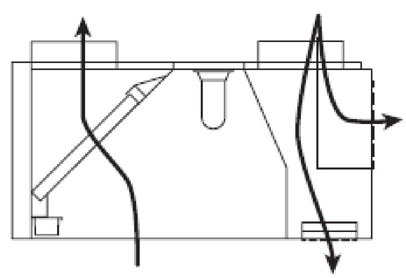
Integrated Air Supply Plenum

Perforated/Register Face

The perforated face plenum is similar to the air supply plenum system and the air curtain system. In the perforated face system, a plenum is placed on the front of the kitchen hood similar to the air curtain and air supply plenums. The plenum in the perforated face system discharges the air to the front of the plenum instead of downwards like the air curtain and air supply. A perforated grille is placed on the discharge side of the plenum, hence the name perforated face.

The recommended supply rate for the perforated face is 150 cfm per linear foot of plenum and the velocity of the air leaving the perforated face should be no greater than 150 feet per minute.

A register face make up air system is just like a perforated face. The difference is a register is utilized instead of a perforated grille. Registers should only be used in larger kitchens where there are longer throws and sufficient space for the air to decrease in velocity near the ceiling without disrupting the air flow of the hood. The advantage of this system is the large amount of air that can be made up per linear foot without affecting the exhaust. The chief concern with



Perforated Air Supply Plenum

the register face system is the need clearance in
front of the hood so the air does not hit an obstruction and be directed downward to produce drafts. The air hitting an obstruction could also affect the functioning of the hood. The two previous reasons are why the register face make up air system is acceptable for large kitchens only, unless the design can be shown that the air supplied from the register decreases to a velocity of 50 feet per minute, or less, before it hits any obstruction.

The recommended supply rate for the register face is 250 cfm per linear foot of plenum.

Non-Directional Perforated Ceiling Diffusers
This system is the least complex out of all the ducted systems. The drawback for this system is the creation of drafts is untempered air is used, which is normally the case in Afghanistan. The air from the outdoors is usually not cooled or heated and, with this system, the air could blow directly on the cooks working in the kitchen. The advantages of this system over the wall louvers only system are there is a make up air fan to overcome the static pressure loss caused by the filter (normally a two (2) inch washable filter near the louver) and the air is ducted so that it is nearer the exhaust hood.

There is no limit to the amount of air that can be made up from this system. The potential to draw out odor and fumes from under the exhaust hood is determined by the air velocity at the edge of the hood. The air velocity at the edge of the hood should be kept to 50 feet per minute or less. As many diffusers as possible should be used to minimize the air through each diffuser and maximize the kitchen hood performance. There is no set minimum or maximum amount of diffusers needed. The only design criterion is the 50 feet per minute, or less, at the edge of the hood. It is highly recommended to use non-directional perforated panels, instead of 3 or 4 way diffusers, to keep the airflow even and at a low velocity.

A system in the United States would typically use ceiling diffusers in combination with another make-up air technique.

Wall Louvers Only
A typical make up air system submitted by local Afghanistan contractors is a wall louver without a fan or ductwork. This system is by far the most simple and least complex make-up air technique. It just requires a hole in the wall to the outdoors, a wall louver (preferably with a motorized damper linked the kitchen exhaust hood fan), and a two (2) inch washable filter for dust and dirt. The wall louver shall be coordinated with the architectural drawings.

The advantage of this system is the simplicity of it. The disadvantages are the untreated air from the outdoors will be drawn into the kitchen and the kitchen hood exhaust fan has to be sized for the drop in static pressure of the hood and the filter/wall louver assembly. The untempered outside air coming in through the louver could cause the workers in the kitchen to become uncomfortable.

The amount of air made up from this system is dependent on the size of the wall louver. The wall louver should be sized with 50% free area and 400 feet per minute.

Make Up Air Summary Table

Make Up Air System	Dimensions	Recommended Supply Rate	
	Inches	CFM/linear ft.	FPM
Back Supply Plenum	6 wide	145	290
Air Supply Plenum	12 wide	110	150
Air Supply Plenum	24 wide	180	150
Perforated Face	16 high	150	150
Register Face	12 high	250	-
Non-Directional Perforated Ceiling Diffusers	Varies (24 x 24 recommended)	Note 1	-
Wall Louvers	Varies (Note 2)	-	400

Note 1: Air velocity at the edge of the hood shall be 50 feet per minute or less
Note 2: Size with 50% free area and 400 feet per minute air velocity.

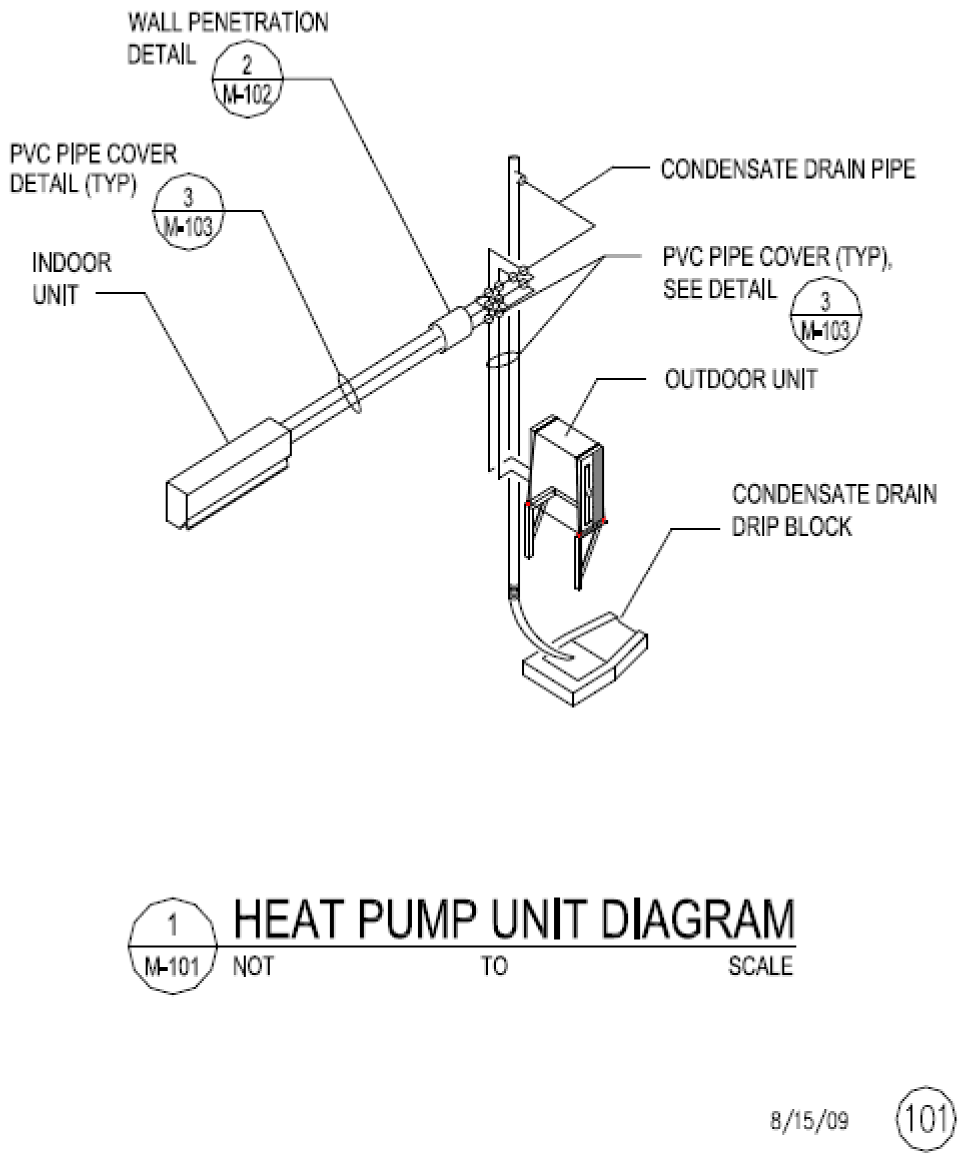
7.5 Ductwork

The ductwork for the exhaust system should be sized by the air velocity inside the duct. The recommended air velocity is 1,500 feet per minute. The minimum velocity shall be 500 feet per minute according to ASHRAE. Lowering the velocity will make the duct larger so it is recommended to keep the velocity 1500 feet per minute or more. The maximum air velocity shall be 2,250 feet per minute for the exhaust ducts. The static pressure drop can be large due to the high velocities in the duct so the exhaust fan must be able to handle the increase. The ductwork should be short because the stove is typically placed against an exterior wall. The make-up air ductwork should be sized according to industry standard air velocities and static pressure drops.

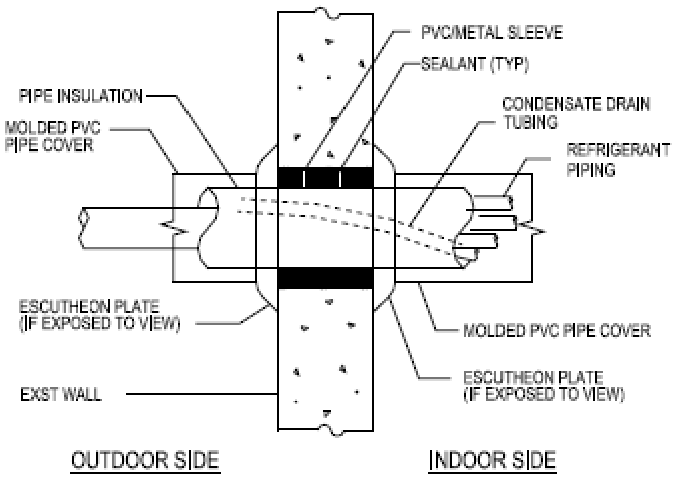
End Narrative

Appendix A

Heat Pump Installation Typical Details



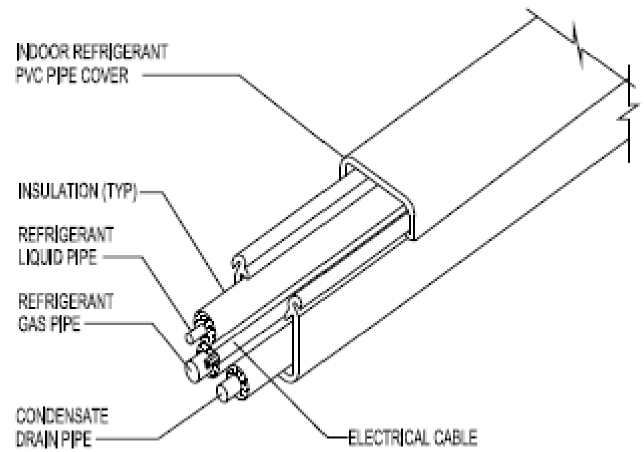
Heat Pump Installation Typical Details Cont'd



3 / M-102 WALL PENETRATION DETAIL
NOT TO SCALE

1. Drill hole at wall so that the outer edge is lower to allow condensate drain water to flow outward.

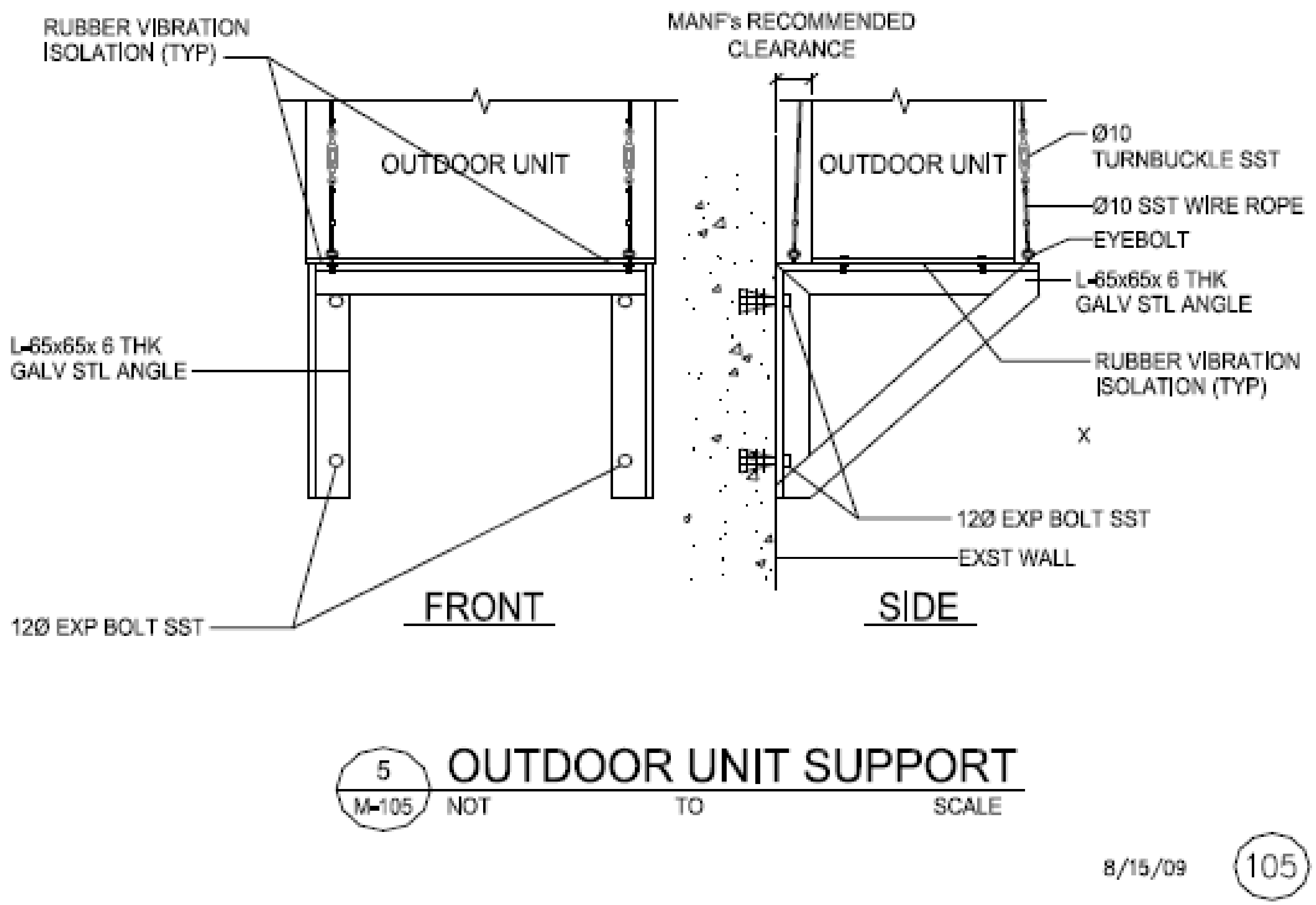
8/15/09 (102)



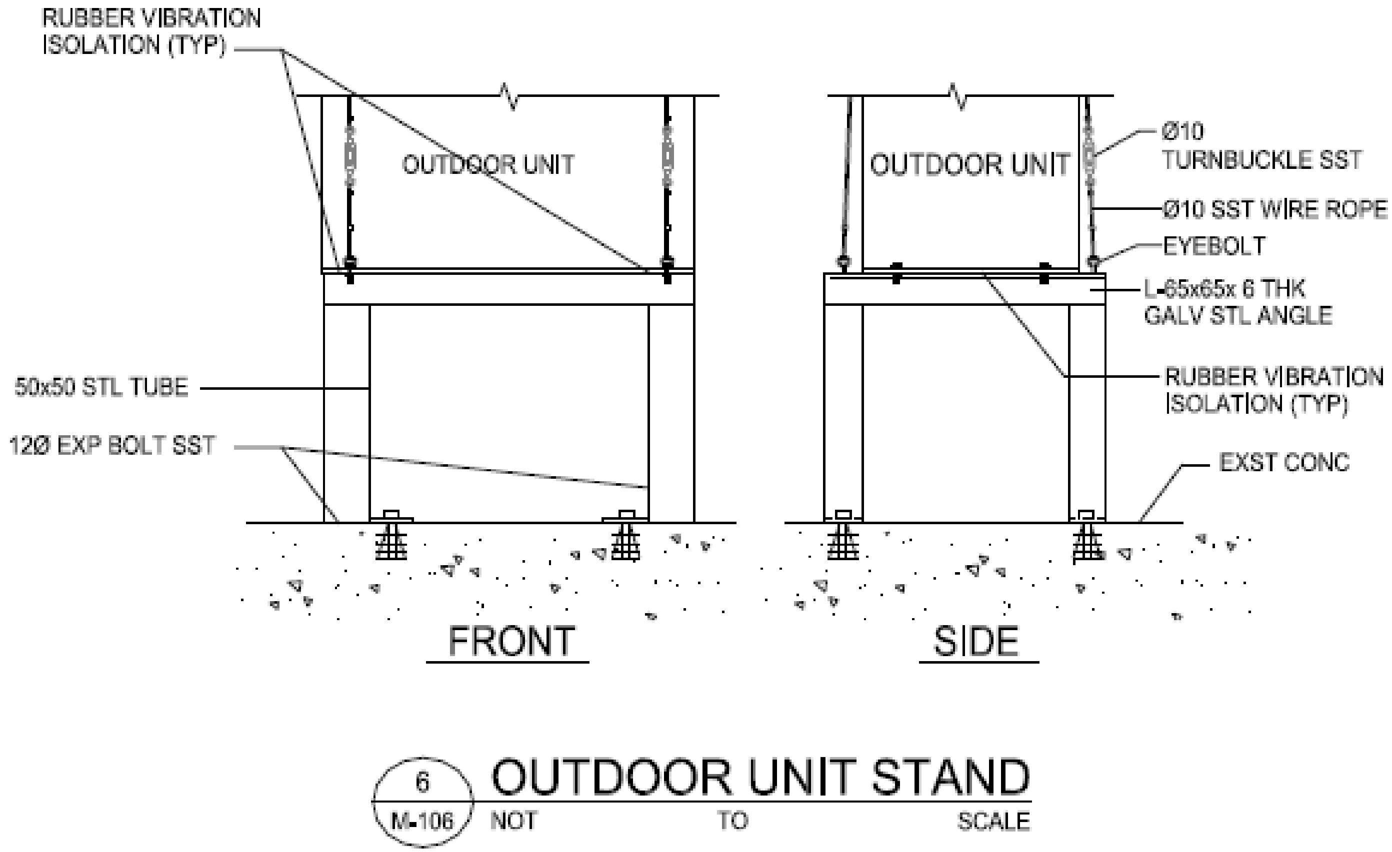
4 / M-103 PVC PIPE COVER DETAIL
NOT TO SCALE

8/15/09 (103)

Heat Pump Installation Typical Details Cont'd



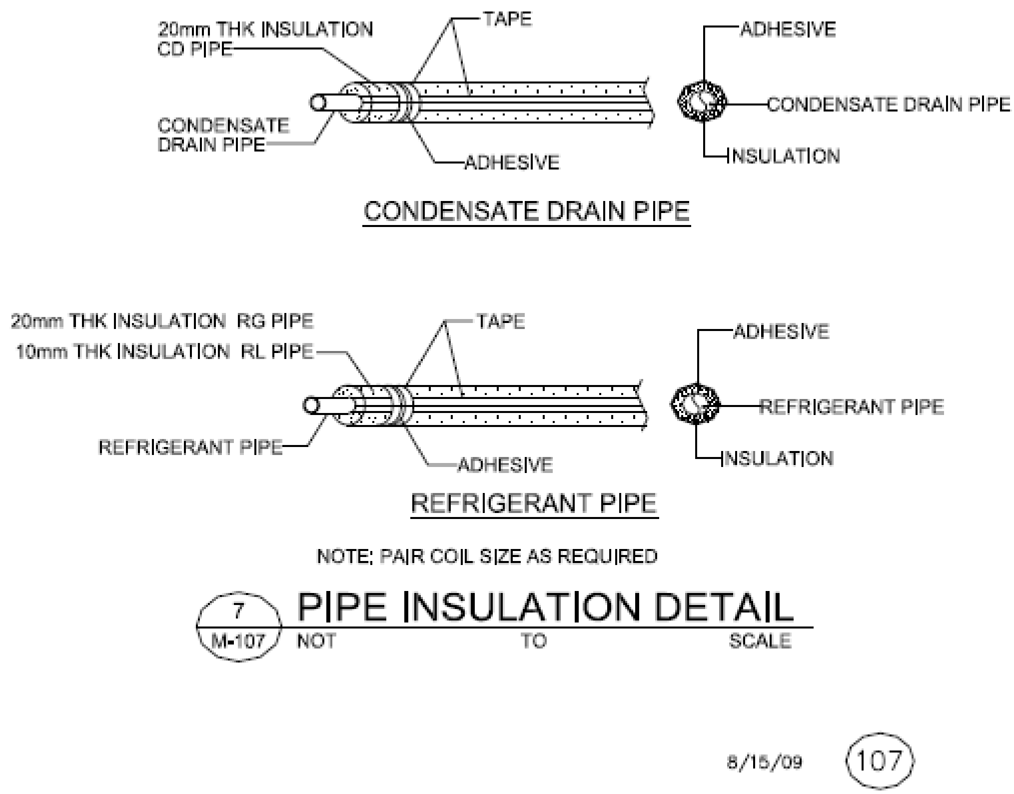
Heat Pump Installation Typical Details Cont'd



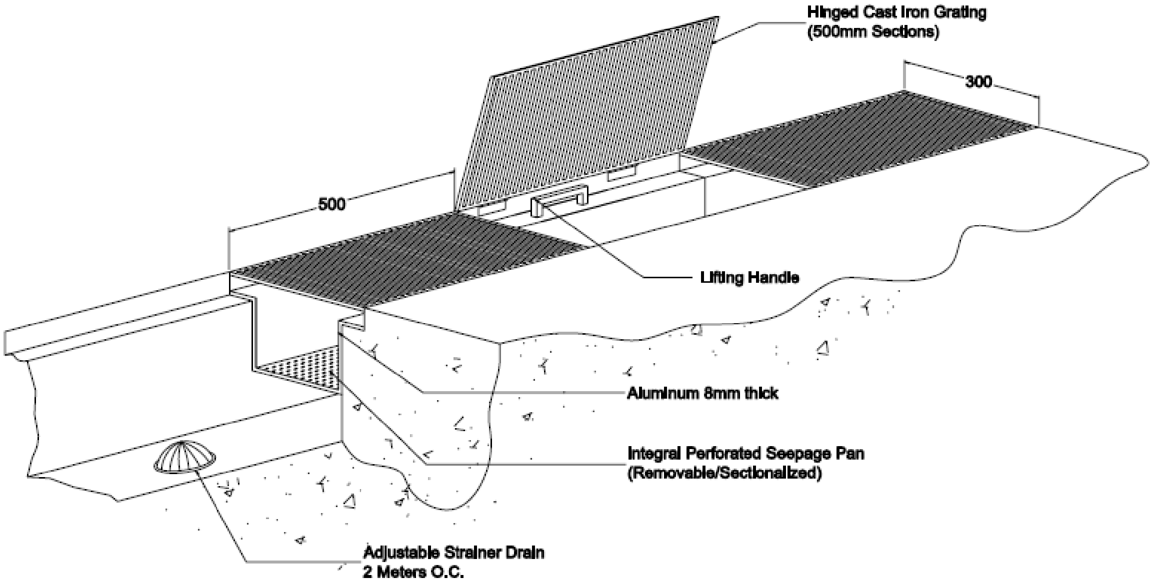
1. Maintain manufacturer's recommended clearances around outside condensing unit.

8/15/09 (106)

Heat Pump Installation Typical Details Cont'd

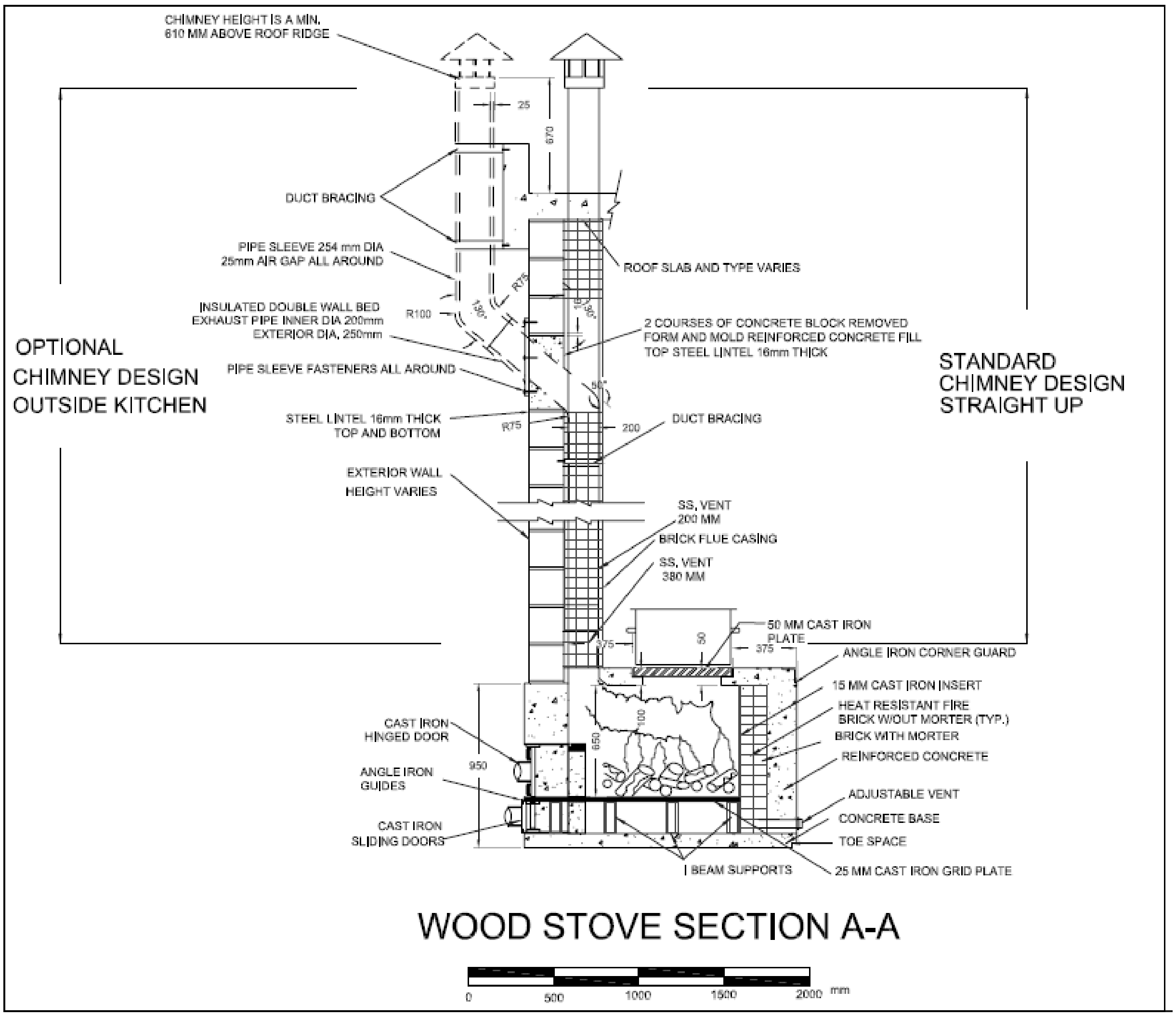


Appendix B

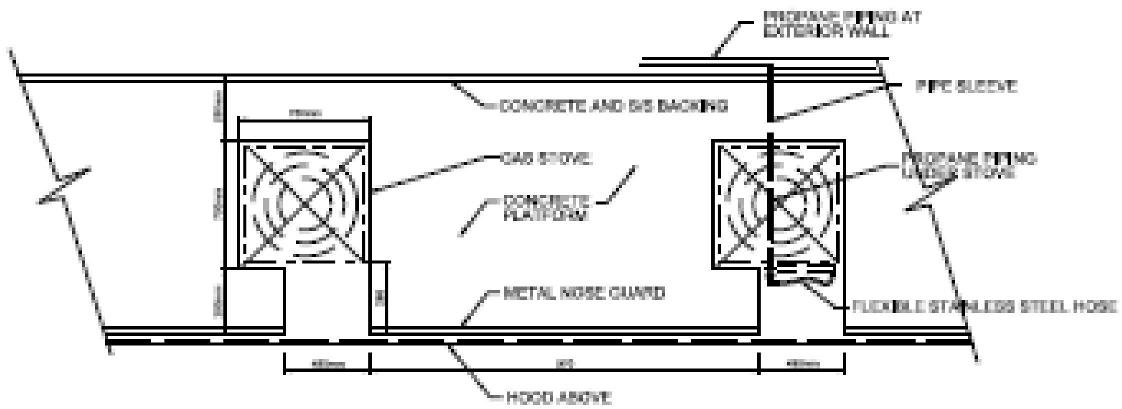


FLOOR TRENCH DETAIL

Appendix C


CHIMNEY HEIGHT IS A MIN. 610 MM ABOVE ROOF RIDGE
DUCT BRACING
PIPE SLEEVE 254 mm DIA 25mm AIR GAP ALL AROUND
INSULATED DOUBLE WALL BED EXHAUST PIPE INNER DIA 200mm EXTERIOR DIA. 250mm
PIPE SLEEVE FASTENERS ALL AROUND
STEEL LINTEL 16mm THICK TOP AND BOTTOM
EXTERIOR WALL HEIGHT VARIES
OPTIONAL CHIMNEY DESIGN OUTSIDE KITCHEN
ROOF SLAB AND TYPE VARIES
2 COURSES OF CONCRETE BLOCK REMOVED FORM AND MOLD REINFORCED CONCRETE FILL TOP STEEL LINTEL 16mm THICK
DUCT BRACING
SS. VENT 200 MM
BRICK FLUE CASING
SS. VENT 380 MM
STANDARD CHIMNEY DESIGN STRAIGHT UP
50 MM CAST IRON PLATE
ANGLE IRON CORNER GUARD
15 MM CAST IRON INSERT
HEAT RESISTANT FIRE BRICK W/OUT MORTER (TYP.)
BRICK WITH MORTER
REINFORCED CONCRETE
ADJUSTABLE VENT
CONCRETE BASE
TOE SPACE
25 MM CAST IRON GRID PLATE
I BEAM SUPPORTS
CAST IRON HINGED DOOR
ANGLE IRON GUIDES
CAST IRON SLIDING DOORS
WOOD STOVE SECTION A-A
0 500 1000 1500 2000 mm

Appendix D

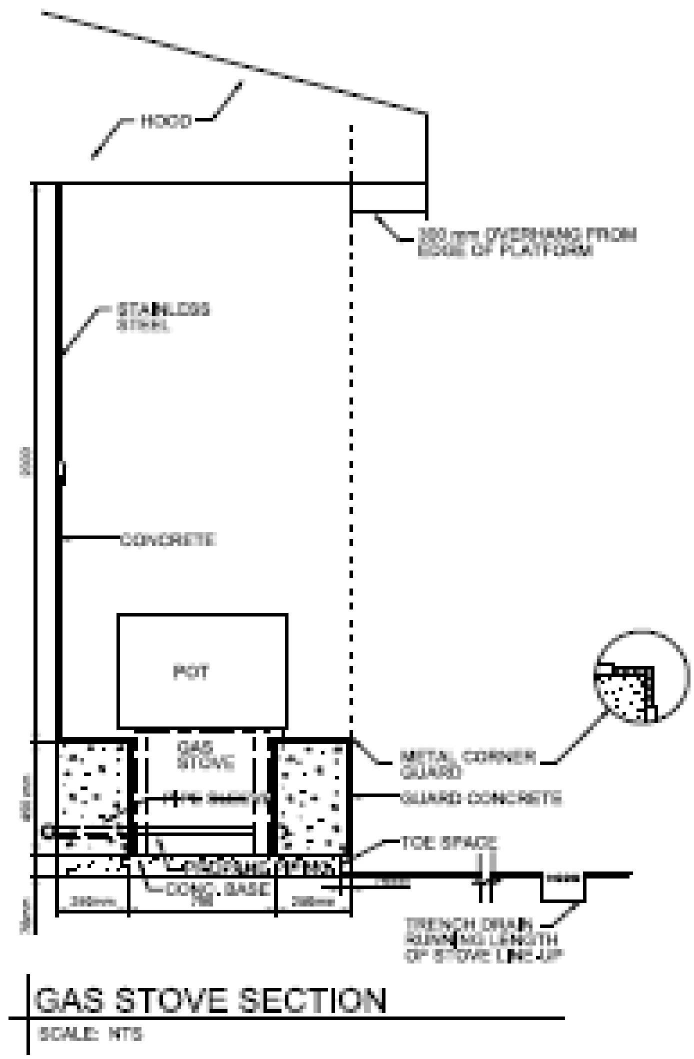


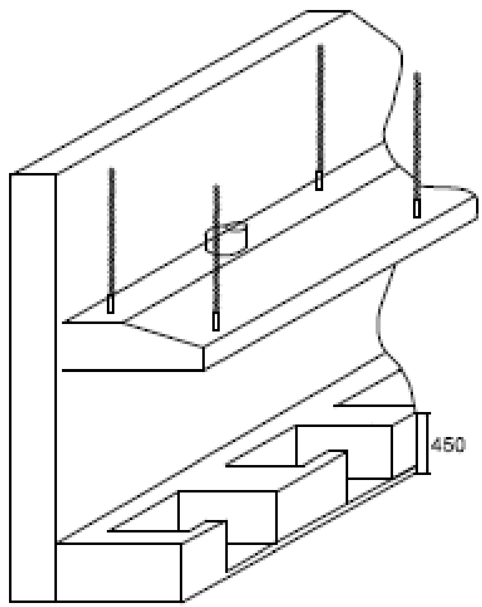
GAS STOVE PLAN

SCALE: NTS

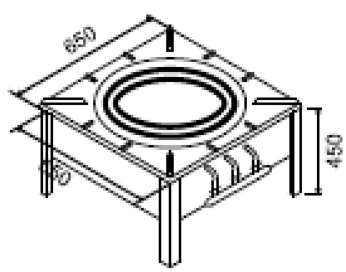
NOTES:

- DIMENSIONS SHOWN ARE BASED ON A SPECIFIC STOVE MODEL
- CONTRACTOR SHALL ADJUST THE DIMENSIONS BASED ON THE ACTUAL STOVE DIMENSIONS
- THE SURFACE OF THE STOVE SHALL BE FLUSH WITH THE CONCRETE PLATFORM


HOOD
STAINLESS STEEL
CONCRETE
POT
GAS STOVE
METAL CORNER GUARD
GUARD CONCRETE
TOE SPACE
CONC. BASE
TRENCH DRAIN RUNNING LENGTH OF STOVE LINE-UP
GAS STOVE SECTION
SCALE: NTS

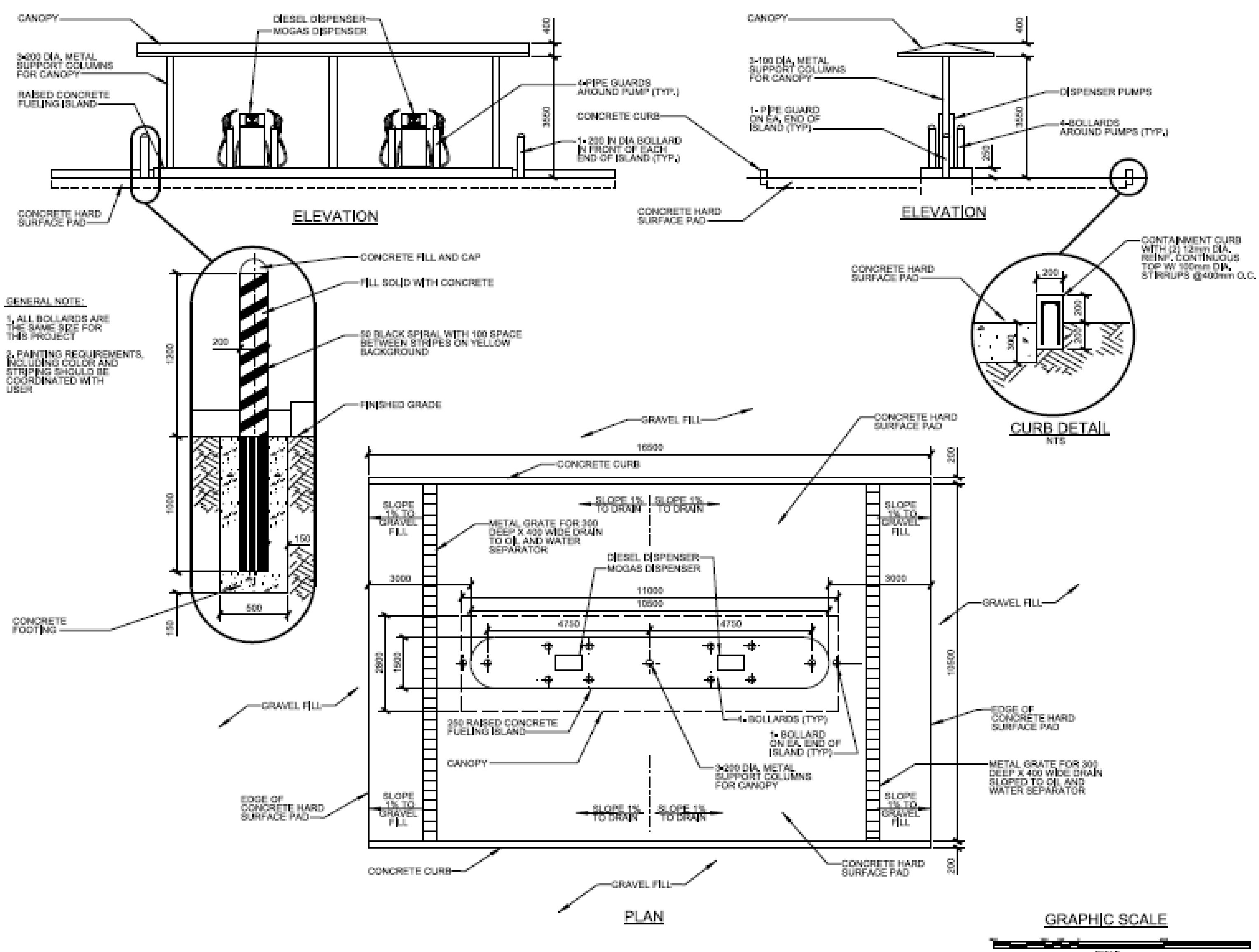


ISOMETRIC VIEW
SCALE: NTS



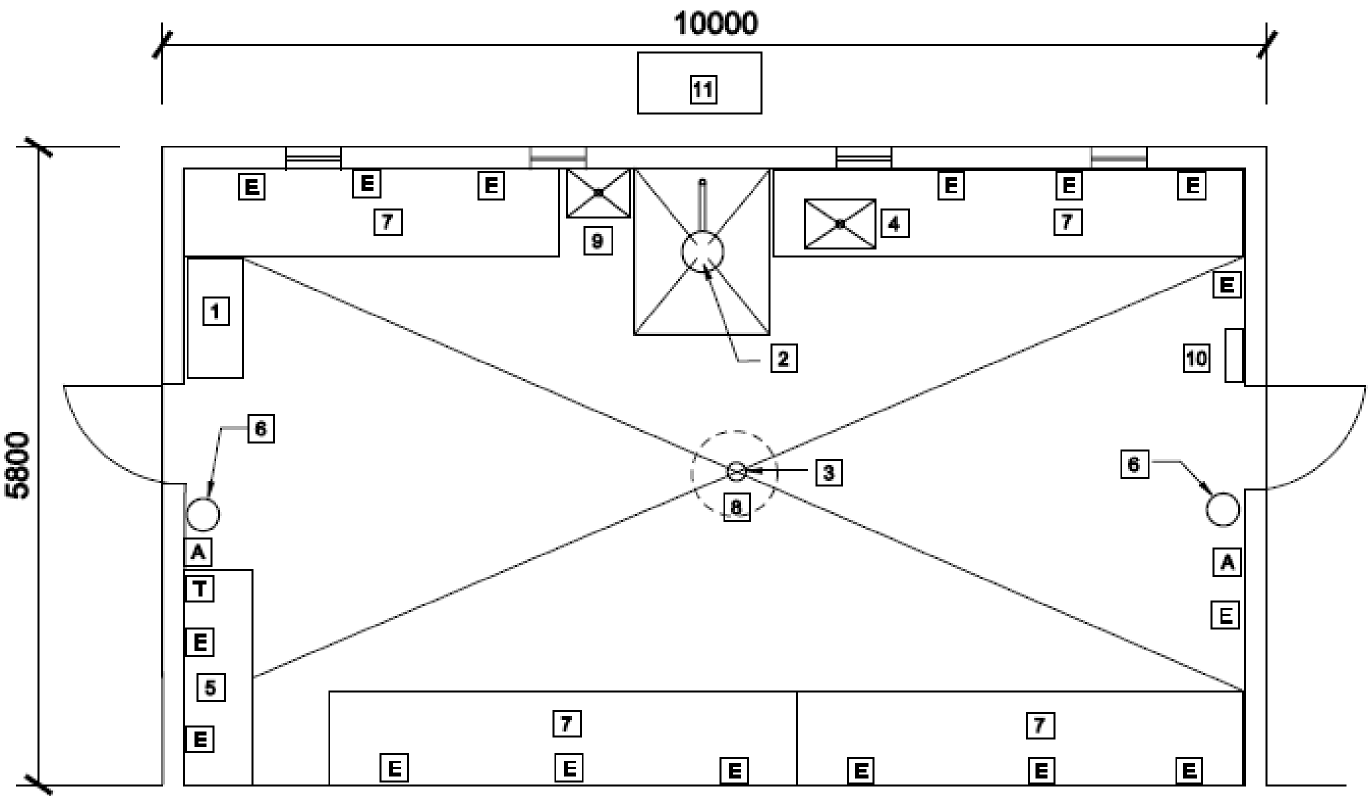
GAS STOVE VIEW
SCALE: NTS

Appendix E



Vehicle Fueling Station

Appendix F



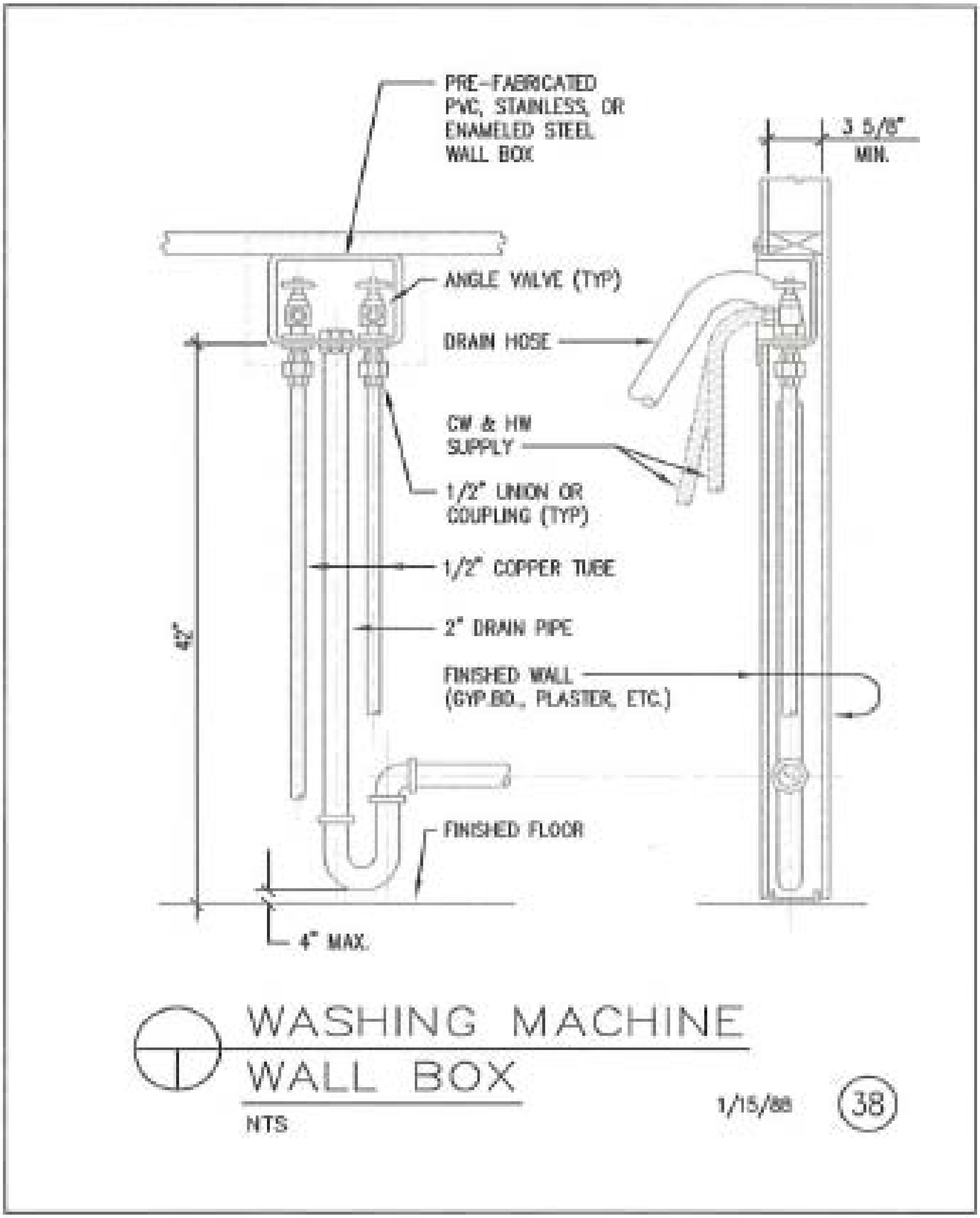
LEAD ACID BATTERY SHOP

1	LOCKER
2	EMERGENCY EYEWASH AND SHOWER
3	ACID-RESISTANT FLOOR DRAIN
4	BASE CABINET AND SINK
5	BENCH AND SHELVES
6	FIRE EXTINGUISHER
7	BATTERY BENCH
8	EXHAUST FAN
9	DUMP SINK
10	ELEC PANEL
11	ACID HOLDING TANK
E	ELEC CONVENIENCE OUTLET
T	TELEPHONE OUTLET
A	COMPRESSED AIR OUTLET

1. FLOOR SHALL BE ACID RESISTANT
2. PROVIDE 3 FOOT WIDE NON-SLIP MATTING IN FRONT OF ALL CHARGING BENCHES
3. WALLS SHALL BE CMU ONE HOUR FIRE WALL WITH 45 MINUTE RATED DOOR. COMMON WALL SHALL BE 2 HOUR FIRE WALL
4. DOOR SHALL BE PROVIDED WITH FIRE RATED PANIC HARDWARE
5. CEILING SHALL BE WATER PROOF
6. SINK AND FLOOR DRAIN SHALL EMPTY INTO EXTERIOR ACID HOLDING TANK
7. ROOF VENTILATOR SHALL BE INSTALLED AT THE HIGHEST POINT AND PROVIDE MINIMUM OF 3 ACH
8. PROVIDE WALL MAKEUP AIR OPENING WITH MOTORIZED DAMPER AND 2 INCH THICK WASHABLE FILTERS

Appendix G

Washing Machine Wall Utility Box


PRE-FABRICATED
PVC, STAINLESS, OR
ENAMELED STEEL
WALL BOX
3 5/8"
MIN.
ANGLE VALVE (TYP)
DRAIN HOSE
CW & HW
SUPPLY
1/2" UNION OR
COUPLING (TYP)
1/2" COPPER TUBE
2" DRAIN PIPE
FINISHED WALL
(GYP.BD., PLASTER, ETC.)
42"
FINISHED FLOOR
4" MAX.
WASHING MACHINE
WALL BOX
NTS
1/15/88
38

Appendix H

Sample Equipment Schedule

PLUMBING FIXTURE SCHEDULE					
SYMBOL	DESCRIPTION	WASTE	VENT	COLD WATER	HOT WATER
P-1	WATER CLOSET (WC), FLUSH TANK	100	40	15	NA
P-1A	WATER CLOSET (WC), FLUSH TANK, HANDICAPPED	100	40	15	NA
P-2	LAVATORY	32	32	15	15
P-3	COUNTERTOP SINK	32	32	15	15
P-4	SERVICE (JANITOR) SINK	40	32	15	15
P-5	FLOOR DRAIN	50	32	NA	NA
P-6	WC SPIGOT WITH FLEXIBLE HOSE & SPRAY NOZZLE	NA	NA	15	NA

Minimum requirements are shown. Use of AE’s standard/template is acceptable provided that it captures the data noted.

CONVECTOR (CNV) SCHEDULE, ELECTRIC					
SYMBOL	MINIMUM CAPACITY KW	VOLTAGE V	PHASE ø	HERTZ HZ	
CNV-01	2.0	230	1	50	WITH INCORPERATED THERMOSTAT

WATER HEATER (WH) SCHEDULE									
SYMBOL	TYPE	MINIMUM STORAGE L	RECOVERY @ 50°C RISE LPH	MATERIAL & WORKING PRESS KPA	ELEMENT TOTAL KW	VOLTAGE V	PHASE ø	HERTZ HZ	REMARKS
WH-01	ELECTRIC VERTICAL	400	205	SEE SPECS	12.0	220	1	50	

WATER PUMP (P) SCHEDULE										
SYMBOL	SERVICE	MINIMUM CAPACITY LPM	TOTAL DYNAMIC HEAD KPA	TYPE	MAXIMUM SPEED RPM	MOTOR				REMARKS
						MAXIMUM HP	VOLTAGE V	PHASE ø	HERTZ HZ	
P-01	DOMESTIC WATER	380	90	CLOSE-COUPLED END-	1,800	2.00	220	1	50	

Minimum requirements are shown. Use of AE's standard/template is acceptable provided that it captures the data noted.

CEILING FAN (CF) SCHEDULE						
SYMBOL	FAN DIAMETER MM (IN)	MAXIMUM POWER W	ELECTRICAL			REMARKS
			VOLTAGE V	PHASE ø	HERTZ HZ	
CF-01	1,320 (52)	65	220	1	50	3-SPEED REVERSIBLE MOTOR

NOTES:
1. PROVIDE WITHOUT LIGHT FIXTURE.
2. BOTTOM OF FAN MOUNTING HEIGHT: MINIMUM 2,500 MM A.F.F.
3. PROVIDE WITH REMOTE WALL-MOUNTED ON-OFF SWITCH SHOWN ON ELECTRICAL DRAWINGS.

SPLIT PACKAGE UNIT (SU) SCHEDULE															
SYMBOL	TYPE	REFRIGERANT	NOMINAL COOLING CAPACITY		NOMINAL HEATING CAPACITY		FAN COIL SECTION					COMPRESSOR-CONDENSOR SECTION			
							NOMINAL AIR FLOW	MINIMUM OUTSIDE AIR	RESISTANT HEATER	COVERAGE	VOLTAGE	PHASE	HERTZ	RUNNING	POWER INPUT
			BTUH	KW	BTUH	KW	CMH	CMH	KW	SM	V	ø	HZ	AMPS	W
SU-01	HEAT PUMP	R-22	9,000	2.50	9,392	2.70	450	NA	NA	17	230	1	50	4	940
SU-02	HEAT PUMP	R-22	12,000	3.20	12,294	3.60	500	NA	NA	22	230	1	50	6	1,100
SU-03	HEAT PUMP	R-22	18,000	5.10	19,124	5.60	680	NA	NA	35	230	1	50	9	1,895
SU-03	HEAT PUMP	R-22	22,000	6.10	22,539	6.60	750	NA	NA	42	230	1	50	10	2,190
SU-03	HEAT PUMP	R-22	30,000	8.80	31,390	9.20	1,304	NA	NA	60	230	1	50	14	3,000

Data based on Chigo Units

Heating capacity based on outdoor temperature of 7 C

Minimum requirements are shown. Use of AE's standard/template is acceptable provided that it captures the data noted.

Appendix J

Sample Calculations

Plumbing Calculation Sample

ESTIMATED NEW PLUMBING DEMAND-BUILDING

1. WATER SUPPLY

FIXTURE	QTY	F U	FIXT w/HW Total FU	F U	FIXTURE w/ CW Total FU
Water Closet	0			10	0
Urinal	0			5	0
Lavatory	12	1.5	18	1.5	18
Bathtub	0	3	0	3	0
Shower	12	3	36	3	36
Kitchen Sink	0	1.5	0	1.5	0
Service Sink	1	2.25	2.25	2.25	2.25
Dishwasher	0	1	0	0	0
Laundry Sink	0	2.25	0	2.25	0
Washing Machine	6	3	18	3	18
Drinking Fountain	0			0.25	0
Hose Bibb	0			6	0
Total			74.25		74.25

Total Fixt Units = Total FU/CW less total FU/HW plus 4/3 of the total FU/HW = 99 F U

Approximate Total Demand = 65 GPM (246.025 Ltr/Min)

2. SANITARY DRAINS-BUILDING

FIXTURE	QTY	D F U	TOTAL DFU
Water Closet	0	6	0
Urinal	0	4	0
Lavatory	12	1	12
Bathtub	0	2	0
Shower	12	2	24
Kitchen Sink	0	2	0
Service Sink	1	2	2
Dishwasher	0	2	0
Laundry Sink	0	2	0
Washing Machine	6	3	18
Drinking Fountain	0	1	0
Total			56 D F U

Discharge line = 4 inch diameter

Plumbing Calculation Sample Cont'd

3. HOT WATER SYSTEM-BUILDING ###

FIXTURE	QTY	HW DEMAND/ FIXT(GPH)	SUBTOTAL (GPH)	
Lavatory	12	4	48	
Bathtub	0	20	0	
Shower	12	30	360	
Kitchen Sink	0	10	0	
Service Sink	1	20	20	
Dishwasher	0	15	0	
Laundry Sink	0	28	0	
Washing Machine	6	20	120	
Total			548	GPH

Probable Maximum Demand = 548 GPH X 0.3
= 164.4 GPH (622 Ltr/Hr)

Storage Capacity = 164.4 GPH X 1.25
= 206 Gallons (778 Ltr)

Required Recovery = 164.4 x 1 Btu/lb/ F x 8.33 lb/gal x (140 F - 40 F)
= 136,945 BTU/HR. (34,510 Kcal/Hr)

End Plumbing Calculation Sample

Appendix

Sample Calculations

LPG (PROPANE-BUTANE) TANK CALCS FOR GAS STOCK POT STOVE(S)

XX (User entered data)

Gas Stock Pot Stove Energy Requirements:

Quantity of stoves =	4	stove(s)		
Qty of tea makers =	1	maker(s)		
Burners per stove =	3	burners/stove		
Energy consumption:				
Max (3-burners) =	10,570	kcal/hr/stove	12.3 kW/stove	41,945 Btuh/stove
Medium (2-burners) =	6,540	kcal/hr/stove	7.6 kW/stove	25,953 Btuh/stove
Min (1-burner) =	3,680	kcal/hr/stove	4.3 kW/stove	14,603 Btuh/stove
Tea burner =	3,680	kcal/hr/maker	4.3 kW/maker	14,603 Btuh/maker

Total hourly LPG consumption:

Max (3-burners) + Tea burner =	45,960 kcal/hr	53.4 kW	182,384 Btuh
Medium (2-burners) + Tea burner =	29,840 kcal/hr	34.7 kW	118,415 Btuh
Min (1-burner) + Tea burner =	18,400 kcal/hr	21.4 kW	73,017 Btuh

Hours of operation:

Morning =	3.0	hrs
Noon =	3.0	hrs
Night =	3.0	hrs

Total hours of operation per day = 9.0 hrs/day

Daily LPG consumption:

Max (3-burners) + Tea burner =	413,640 kcal/day	480.6 kW	1,641,456 Btuh
Medium (2-burners) + Tea burner =	268,560 kcal/day	312.1 kW	1,065,732 Btuh
Min (1-burner) + Tea burner =	165,600 kcal/day	192.4 kW	657,154 Btuh

Energy consumption for: 28 #days:

Max (3-burners) + Tea burner =	11,581,920 kcal/#days	13,457.8 kW	45,960,776 Btuh
Medium (2-burners) + Tea burner =	7,519,680 kcal/#days	8,737.6 kW	29,840,504 Btuh
Min (1-burner) + Tea burner =	4,636,800 kcal/#days	5,387.8 kW	18,400,311 Btuh

LPG (PROPANE-BUTANE) TANK CALCS for GAS STOCK POT STOVES (Cont'd)

LPG Tank Sizing:

Gas composition:

Propane =	60.0 %
Butane =	40.0 %

Net heating value:

	Liquid	Gas	Gas Density	
Propane =	11,080 kcal/kg	22,250 kcal/cu.m	2.01 kg/cu.m	0.125 lbs/cu.ft
Butane =	10,930 kcal/kg	20,900 kcal/cu.m	1.91 kg/cu.m	0.119 lbs/cu.ft
LPG average =	11,020 kcal/kg	21,710 kcal/cu.m	1.97 kg/cu.m	0.123 lbs/cu.ft

LPG consumption per "hour:"

Max (3-burners) + Tea burner =	4.2 kg/hr	2.1 cu.m/hr	9.2 lbs/hr	74.8 cu.ft/hr
Medium (2-burners) + Tea burner =	2.7 kg/hr	1.4 cu.m/hr	6.0 lbs/hr	48.5 cu.ft/hr
Min (1-burner) + Tea burner =	1.7 kg/hr	0.8 cu.m/hr	3.7 lbs/hr	29.9 cu.ft/hr

LPG tank filling capacity: 85.0 %

LPG tank capacity for 28 "day" supply:

Max (3-burners) + Tea burner =	1,236.5	kg per	28	days
	2,725.9	lbs per	28	days
	643.3	gal per	28	days
	27.3	100lb tks/	28	days
Medium (2-burners) + Tea burner =	802.8	kg per	28	days
	1,769.8	lbs per	28	days
	417.7	gal per	28	days
	17.7	100lb tks/	28	days
Min (1-burner) + Tea burner =	495.0	kg per	28	days
	1,091.3	lbs per	28	days
	257.6	gal per	28	days
	10.9	100lb tanks/	28	days

End LPG (PROPANE-BUTANE) TANK CALCS

Hydro Pneumatic/Expansion Tank Sample Calculation

$V(m^3) = Qm^3/H \times 1.1/(P_{on} + 1)/ (P_{off} + 1)) / N_{sh}$

V(m3) = the *water* volume of the hydro pneumatic (HP) tank expressed in m3.
The HP tank physical size will be larger to account for the air volume at the top of the tank

Q(m3/h) = low demand or distribution demand (i.e. at night) flow rate (m3/h).
This is typically taken as the ADD (Average Daily Demand).
If another value is used, provide rational for using the value.

The 1.1 factor is a 10% reserve water volume in the HP tank, so the tannk will not run dry at low level. This factor can be at the discretion of the designer.

Pon = HP tank pressure (bar) to stiop the pumps after having filled the HP tank. The pumps can be a booster pump from a storage tank or a well pump feeding directly into the HP tank. Control is the low-pressure switch, usually set at 1.5 bar (22 psi), which is about the lowest reliable pressure to perate a fixture.

Poff = HP tank pressure (bar), to stop the pumps after the HP tank is filled. Control is the high pressure switch, which is usually set at 4.0 bar (58 psi) as higher pressure will cause leakage at the fixtures. The pump discharge head must be sufficient to fill the HP tank to the upper set pressure and the HP tank must be rated at this pressure.

Nsh = Pump starts per hour. This varies from 4 to maximum of 15, with 6 being the standard frequency.

ADD	14000	gallons per day
	2.207917	cubic meters per hour
V=	0.809569	cubic meters per hour
	809.5694	liters

End - Hydro Pneumatic/Expansion Tank Sample Calculation

Sample Calculations Cont'd

Hot-Water Demand per Fixture
(ASHRAE Handbook-HVAC Applications)

XX (User entered data)

EWH-0x (Based On the Table Titled, "Hot Water Demand per Fixture for Various Types of Buildings" for "Apartment," Final Temperature: 60 C)

Water heater entering water temperature = 10.0 C
50.0 F

Water heater leaving water temperature = 60.0 C
140.0 F

DEMAND FACTOR = 0.30

STORAGE CAPACITY FACTOR = 1.25

	Qty.	Fixture (l/hr)	Total (l/hr)
Basin, public lavatory	12	15.00	180
Kitchen Sink	1	38.00	38
Showers	12	114.00	1368
Washers	6	76.00	456
	0	0.00	0
	0	0.00	0
	0	0.00	0
Service Sinks	1	76.00	76

Maximum possible demand = 2118 l/hr
Probable maximum demand = 635 l/h

BASIC WATER HEATER SIZE FROM ASHRAE CALCULATIONS

Heater element capacity = 635 l/h
Sum of element capacities = 37.0 kW

Storage tank capacity = 794 l
210 gal

Tank usable water before dilution = 80 %

Storage tank usable capacity = 635 l
168 gal

Total usable water per hour = 1271 l

ADJUSTED WATER HEATER SIZE FROM EQUIPMENT SCHEDULE.
NOTE: DECREASING HEATER ELEMENT CAPACITY WILL INCREASE TANK SIZE.

Sum of element capacities = 37.0 kW
Heater element capacity = 635.7 l/h

Storage tank capacity = 794 l
210 gal

Tank usable water before dilution = 80 %

Total usable water per hour = 1271 l

Sample Calculations Cont'd

EXAMPLE: Domestic Water Heaters For Army Barracks (SI)
(UFC-3-420-01, Plumbing Systems, Appendix E, 25 Oct 04)

Number of building occupants =	168	people
Number of shower heads (h) =	12	heads
Number of occupants/shower head (occ) =	14	occ

Duration Of Peak Demand:

Shower duration per occupant =	9.5	min/occ
Duration of the peak usage (d) =	133.0	min
	7,980	sec
	2.22	hr

Note: The duration (d) is calculated assuming that the peak usage period will be 9.5 minutes per occupant. Therefore, if two (2) occupants share a bathroom, the duration is 19 minutes, three (3) occupants would be 28.5 minutes, etc.

Initial Estimate of Hot Water Storage:

Storage estimate per occupant =	50	l/occ
	13.2	gal/occ
Storage tank capacity (St) (initial estimate) =	8,400	l
	2,219	gal

Hot Water Volume Needed At Peak Demand:

Temperature (Td) of water delivered to shower valve =	43.0	C

Sample Calculations Cont'd

	316.2	K
	109.4	F
	569.1	R
Temperature (Ts) of water in storage tank =	60.0	C
	333.2	K
	140.0	F
	599.7	R
Water used per occupant during peak (P) demand =	90	l/occ
	23.8	gal/occ
Volume (Vp) of domestic hot water required at peak =	14,348	l
	3,790	gal

Note: There is no diversity in the number of building occupants. The peak volume (Vp) of domestic hot water is calculated assuming 100% building occupancy.

Note: The equation does not take laundry or dining facilities into account. Add additional hot water requirements if laundry or dining facilities will be requiring hot water during the peak demand period.

Water Heater Recovery Rate:

Ratio (M) of usable water to storage tank capacity (60 - 80%) =	80	%
Recovery rate (RR) at the required temperature =	0.96	l/s
	3,441	l/h
	909	gph

Note: The recovery rate (RR) is an output condition. Insure that manufacturer's data for the water heater indicates sufficient recovery capacity to satisfy the RR with the actual inlet water temperature and desired storage temperature.

Water Heater Recovery Rate-Storage Ratio Adjustments:

BASIC WATER HEATER SIZE FROM UFC CALCULATIONS

Heater element capacity =	3441	l/h
Sum of element capacities =	308.1	kW
Storage tank capacity =	8400	l
	2,219	gal

Sample Calculations Cont'd

Total usable water per hour =	10,161 l

ADJUSTED WH SIZE FROM EQUI;MENT SCHDDULE	Sum of element capacities (kW) =	500.0 kW
	Heater or coil capacity =	5,585.0 l/h
NOTE: DECREASING WH ELEMENT CAPACITY WILL INCREASE TANK SIZE.	Storage tank capacity =	5,721 l
		1,511 gal
	Tank usable water before dilution =	80 %
	Total usable water per hour =	10,161 l

End Sample Calculations Sizing Electric Water Heater