



Customer Requirements Customer-owned Transformer Vault Room

C-SV-3000

Scope

This standard documents the requirements for customer-owned vault rooms containing transformers and switches that are owned, operated, and maintained by Tacoma Power.

It does **not** address transformer vault rooms that are part of the downtown network system, or spot networks.

In This Standard

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General Requirements

Vault Room Location Ground floor rooms adjacent to an exterior wall usually provide the best location for vault rooms in terms of access and natural ventilation. Interior rooms may be acceptable if clear access to install and replace the transformers, forced air cooling, and fire/smoke dampers are all provided.

Approval of Vault Plans Final drawing approval will be in the form a letter from the New Services Engineering Department to the customer.

Code & Municipal Requirements

- National Electrical Code, Article 450, Section 41 through 48 and Article 500.
- Uniform Building Code

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Developer and Tacoma Power Requirements

Customer Requirements

If a customer is to obtain permanent power on a firm schedule, the procurement of long-lead time transformers and associated equipment must often be initiated over **one year** in advance.

The customer shall be responsible for providing detailed construction drawings with plan and profile views that incorporate the “customer requirements” items listed below. Tacoma Power will use the customer provided AutoCAD drawings to prepare construction drawings combining both the customer and Tacoma Power required items.

The following equipment will be supplied and installed, to Tacoma Power specifications, by the customer:

- Painted vault
- Doors (a man door may be required in addition to equipment door)
- Ventilation louvers/screening and baffles
- Fire and heat detectors, and annunciation to the building's fire control panel
- Thermostats for forced air
- Forced air fans and controls
- Oil spill sill and seal (size specified by Tacoma Power)
- Secondary cables from panel to transformers (when applicable)
- Secondary lugs when sizes other than #4/0, 250 kcmil or 350 kcmil
- Exterior warning horns/lights and signage
- Sump (when required)
- Vault room grounding plan including cast-in electrical grounds (refer to “Grounding” section, page 10)
- Ceiling inserts and threaded rod studs for conduit hangers
- Vault power circuit
- Primary and secondary ducts to and into the vault
- An acceptable pathway to transport the transformer from the street
- Anchorage for seismic bracing
- Pulling eyes
- Primary and secondary routing, with concrete encasement when exceeding 15 feet within the building



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Developer and Tacoma Power Requirements *(continued)*

Tacoma Power Requirements The following equipment will be supplied and installed by Tacoma Power:

- Primary cables
- Secondary cables to customer's busway at vault wall
- High voltage switches
- High voltage tap boxes
- Transformers
- Conduit hanger horizontal elements
- Light fixtures and secondary panel and wiring in vault wall
- Secondary compression lugs (#4/0, 250 kcmil, 350 kcmil)
- Sump pump with oil sensing switch and wiring (when required)
- Door lock core

Transformers

Table 1

Physical Characteristics of Vault-Style Transformers

MID#	KVA	Voltage	Profile	Oil (gal)	Wgt. (lbs)	Width (in)	Depth (in)	Height (in)
46669	500	120/208V	Low	300	7000	54	72	72
46700	500	480/277V	Low	273	7000	54	72	72
46668	500	120/208V	High	273	7000	54	72	72
[1]	500	480/277V	High	273	7000	54	72	72
46702	1000	120/208V	Low	434	11000	56	74	84
46703	1000	480/277V	Low	434	10500	56	74	84
40627	1000	120/208V	High	434	12000	56	74	84
35638	1000	480/277V	High	434	11000	56	74	84
46704	1500	480/277V	Low	564	16000	58	76	86
35639	1500	480/277V	High	564	15000	58	76	86
[1]	2500	480/277V	Low	808	16500	60	78	86
35640	2500	480/277V	High	808	16500	60	78	86

Notes [1] non-stock item
 Low profile transformers have end-mounted bushings
 High profile transformers have top-mounted bushings
 Dimensions shown are maximums and include cooling fins and all protrusions.

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Vault Room Dimensions

Vault Dimensions & Clearances

Typical floor areas are shown in Table 2. Exact dimensions will depend on the transformer sizes, the switchgear requirements, and the vault configuration:

Follow these steps in planning vault room dimensions & clearances:

Step one	Determine the total load and secondary voltages(s) to be served from this location.
Step two	Consult with Tacoma Power as to the number of transformers required and the need for any special equipment.
Step three	When planning for the space required for a transformer, refer to the dimensions of the next larger size in order to accommodate a larger transformer. For example, if a 500 kVA is required, plan for a 1,000kVA replacement due to: <ul style="list-style-type: none"> • Increase in load • Replacement due to a stocking problem in an abbreviated time frame
Step four	<p align="center">Clearances and Working Space requirements</p> <p><u>Ventilation Space:</u></p> <ul style="list-style-type: none"> • 3 feet of either side for transformer. • 3 feet behind the transformer. • For multiple transformer installations allow for 4 feet of ventilation space between units. <p><u>Switching Space:</u></p> <ul style="list-style-type: none"> • 10 feet from the transformer with end-mounted high voltage bushings. • 10 feet from the front of any switches. <p><u>Cabling Space:</u> for transformers that have high voltage and secondary voltage bushings on the top of the unit, a cabling space of 3 feet above the unit is required.</p>

Table 2

Minimum
Vault Room
Characteristics

No. of Transformers	Transformer Profile	Clearance height (ft)	Width (ft)	Length (ft)	Equipment door (ft)	Man door (in)
one	High	12	15	20	8H x 8W	42 x 84
	Low	9	15	30	7H x 8W	42 x 84
two *	High	12	20	30	8H x 8W	42 x 84
	Low	9	20	40	7H x 8W	42 x 84

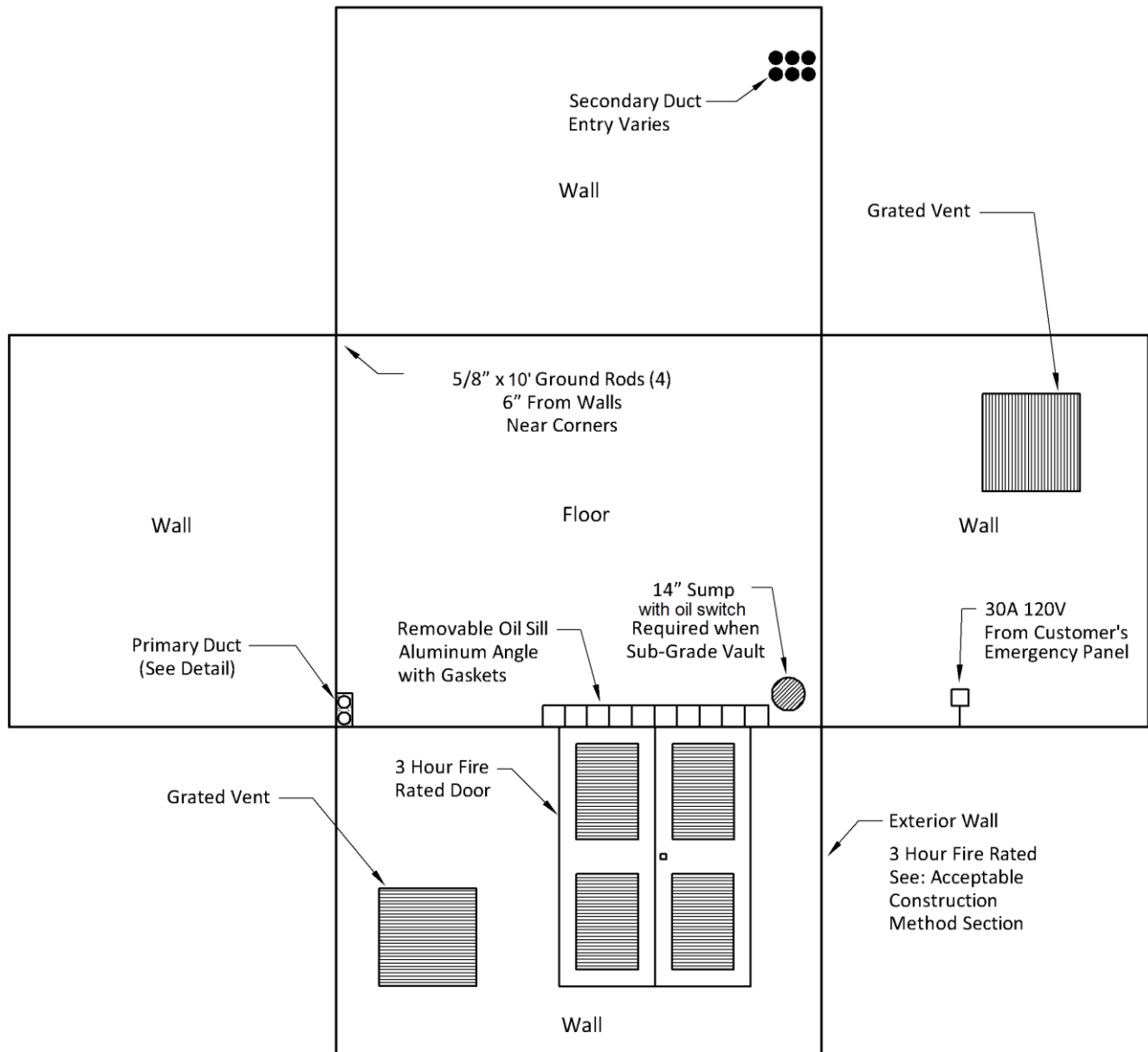
* When load or voltage considerations require a second transformer

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Fig 1 - Typical Vault

Dimensions & Construction Requirements

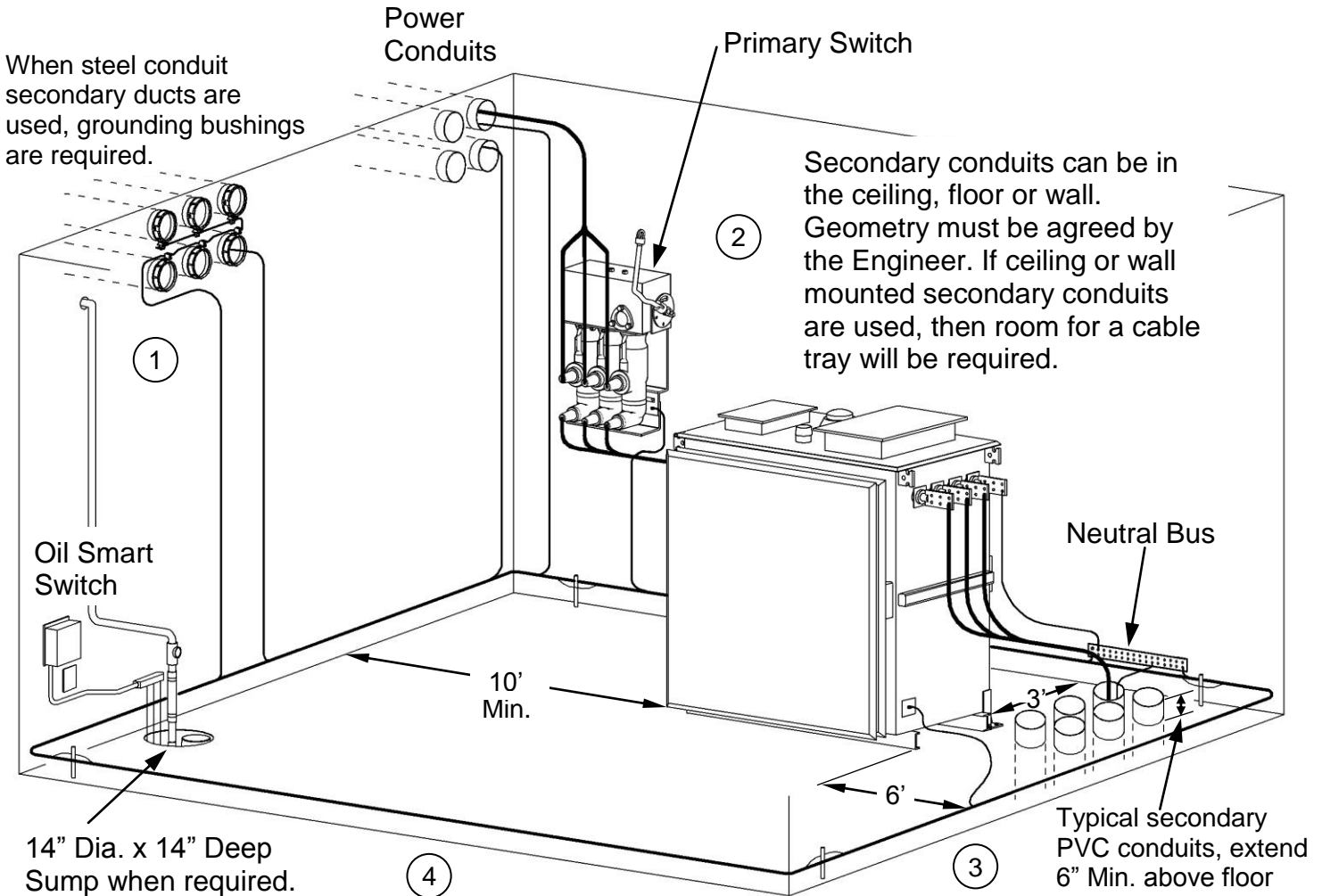


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Figure 2 - Typical Vault Equipment Layout

Typically – Doors & ventilation grates located on walls ①, ② or ④.



Note: **Tacoma Power crews shall construct a 4/0 Cu ground bus** around the perimeter of the vault room, except at the access door where it shall turn up, across, and down to wrap the door. The ground bus shall be tapped to each piece of equipment (not daisy-chained), so the ground wire to one piece of equipment can be cut without leaving other pieces of equipment ungrounded. The ground bus shall be located 12" above the vault floor.

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Walls, Ceiling, & Floor

- General**
- The vault shall be free of all non-utility power equipment, pipes, structural supports, or duct systems.
 - Vault room shall have a minimum fire resistance of 3 hours according to ASTM Standard E-119.
- Paint**
- All paint shall be manufactured by the Parker Paint Company, Tacoma, Washington, or approved equal, and be applied in accordance with manufacturer's recommendations.
- All interior surfaces, excluding the floor, shall receive:
- A 14-day minimum concrete curing time.
 - One coat of Parker's Alka-Prime (#1827) tinted with raw amber at ¼ ounce per gallon.
 - One coat of Parker's White Flextron (#2350).
- Vault Floor**
- Requirements for the vault room floor include:
- The vault floor shall be at the same finished grade (elevation) as the surface area outside the vault door.
 - The vault floor, when in contact with the earth, shall be of reinforced concrete not less than **6 inches thick**.
 - When vault is constructed with vacant space or other stories below it, the floor shall have adequate structural strength for the installed equipment as well as the dynamic load imposed during construction. Contact Tacoma Power's engineer to determine the amount of equipment to be placed in the vault. Refer to Table 1 for equipment weights.
- Vault Ceiling**
- Requirements for the vault room ceiling include:
- The minimum un-obstructed ceiling height depends on the transformer utilized (see Table 2). The ceiling may require more height to provide adequate ventilation around the equipment, or to provide for cable racking systems.
 - Concrete ceilings must have standard SAE ½" diameter threaded imbeds installed on a 3-foot grid pattern across the entire ceiling. Imbeds shall be rated for 2,000 lbs or as agreed to by Tacoma Power.
- Transformer Earthquake Restraints**
- Provisions for transformer earthquake restraints must be designed into all floors, including post-tension designs.



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Walls, Ceiling, & Floor *(continued)*

- Vault Walls** Typically, doors and ventilation grates are located in the walls and ceiling. Sufficient wall space for racking cables above the equipment and vents shall be reserved. Contact the Engineer for any specific requirements. Walls must be either solid reinforced concrete or concrete filled, reinforced CMU block from floor to ceiling.
- Cable Support Grips** For vertical primary and secondary cable runs longer than 20 feet, the customer shall provide support racks or hooks for Tacoma Power cable support grips at intervals specified by Tacoma Power. The grips shall be of non-magnetic material with one grip per each cable.
- Duct Sealing** Tacoma Power is responsible for sealing and fire blocking the inside of all primary ducts surrounding the cables entering the building or vault room.
- The customer is responsible for sealing the exterior of all ducts or inserts where they penetrate through the transformer vault room walls. Also, the customer is responsible to install fire blocking of the secondary cables and secondary bus as it leaves the vault.
- Pulling Eyes** Tacoma Power will locate the required pulling eyes prior to construction. The size and number will be determined by the vault size and equipment location. Other pulling eye requirements are:
- They shall be constructed with #8 rebar interlaced with the wall rebar and capable of withstanding a minimum of 20,000 pounds of tension.
 - Normally installed in the ceiling above the primary conduit or on the wall opposite the primary conduit for pulling primary cables.
 - Installed in the walls located 6" above the floor, in appropriate locations to aid in the moving of the equipment within the vault.
 - Installed directly across from all duct bank entrances into the vault.
 - Some pulling eyes may be required outside the vault room along the equipment transport route.

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Walls, Ceiling, & Floor *(continued)*

**Drains, Sumps,
& Oil
Containment**

Vaults with standard vertical door access shall have a sealed but **removable sill** of sufficient height to confine the oil within the vault from the largest transformer. Refer to Table 1 for gallons of oil per transformer. The assumption is only one transformer in a group will leak at a time. For post-tension floors, imbeds are required to bolt the oil seals in place.

It is the customer's responsibility to assure that water does not enter the vault room. Where water intrusion to a transformer vault is possible, then a sump and pump will be required in the design as detailed in this standard.

Where water intrusion is expected, vaults shall include a 14" diameter (or square) by 14" deep sump with metal grate cover. The sump shall be accessible and have adequate room around it for maintenance. The maintenance space must take into consideration electrical working clearances from high voltage equipment. The sump must be located along a wall and out of the pathway for replacing the transformer. The sump should be placed near any known water entry points, and the vault floor sloped toward the sump. See figures 1 & 2.

A 1-inch water discharge pipe shall be installed and extend to the street through the curb or to an acceptable drain pipe or as approved by Tacoma Power. Provisions must be made for natural drainage to the sump or appropriate drain of the transformer vault floor. Tacoma Power will provide the sump pump and an oil smart switch.

If the room has a floor drain within the containment system, an oil-water separator shall be installed that will block the flow of oil. In these cases, a sump will not be required.

**Secondary Bus
Requirements**

Both wireways and secondary buses are acceptable. The vault secondary bus is to be provided by the customer. Vault entry locations of duct and bus must be approved by Tacoma Power's engineer.

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Walls, Ceiling, & Floor *(continued)*

Figure 3

Warning Signs



Prior to energization, warning signs will be installed that meet ANSI Z535.5 and declare:

- Danger High Voltage
- Authorized Workers Only
- Tacoma Power Transformer Room

They shall be located on the exterior of all access doors to the transformer vault.

Power Conduits The number of ducts will be determined by the specific design. The following conduit requirements shall be approved by the Tacoma Power Engineer prior to construction:

Type & Size	<ul style="list-style-type: none"> • Electrical PVC of either Schedule 80 or 40 as required by code and Tacoma Power standard. • Steel EMT with grounding bushings at each end of conduit segment. • 4" minimum diameter, or as specified.
Number Bends	<ul style="list-style-type: none"> • From Tacoma Power's designated source there shall be no more than 180 degrees of bends in the conduit route. • If additional bends are needed, pulling boxes shall be added to the conduit route as designated by the Tacoma Power Engineer.
Entry	<ul style="list-style-type: none"> • Conduits shall enter the transformer vault's floor, ceiling or walls no closer than 6-inches from a corner, wall-ceiling junction, beam, column, door, window, vent etc. • Conduits must penetrate into the transformer vault room by at least six inches.
Extension Thru Building	If the distance the primary conduit travels within the building envelope exceeds 15 ft. then the primary conduit must be concrete encased.
Placement Exterior To Building	<ul style="list-style-type: none"> • In accordance with Tacoma Power Standard C-UG-1100. • If the project is served from an overhead system, the customer is required to install a pole riser(s) per Tacoma Power standard C-UG-1200.



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Vault Access

General Door Specifications Vaults shall be continuously accessible to Tacoma Power personnel for inspection and maintenance. If possible, the vault door shall directly access the outside of the building. It may be required that the customer provide an easement.

- Man Door**
- Man access doors shall be equipped with a panic exit device.
 - Man access doors shall swing out from vault room.
 - Man doors may be accessed from within buildings if 24-hour access is available.
 - Man doors shall be a tight fitting Class “A” self-closing fire door with a minimum fire rating of 3.0 hours.
 - See Table 2 for man door sizes.

Locks All egress doorways will be secured with a mortise-type lock and Best brand lock body by Customer. The Best Brand 6 pin core will be provided by Tacoma Power with their exclusive lock. Holders of keys shall be limited to authorized Tacoma Power personnel.

- Equipment Door**
- All transformer vaults require a permanent equipment door for transformers (see Table 2 for dimensions). Passageway to vault door(s) shall have adequate clearance for transportation and handling equipment outside the vault room along the equipment transport route.
 - A lift-out ceiling slab typically consists of removable steel reinforced concrete, and is specifically positioned over an open space in the vault. The size of the access lid is determined by the size of the intended equipment plus clear opening space for lifting.
 - The slab may be one piece or in sections, but no portion shall weigh more than 15,000 lbs. The slab must be structurally rated for the environment it supports i.e.; H20 if located in streets or sidewalks etc.
 - 45ft vertically clear lifting space must exist above a lift out slab. Adequate area and street structure must be available adjacent to the lift-out lid to accommodate a crane with stiff leg extensions. Boom-swing space and temporary lid storage space within boom reach must be available while the equipment access hole is being utilized. The location for the crane must be accessible and allow for 3-dimensional lifting and swinging space of 40 ft. clear. The access shall meet NESC Section 113.

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Vault Access *(continued)*

- If the hatch is required to be waterproof-sealed, the customer is responsible for removal and replacement of these seals.
- Vault ventilation grates and man access hatches can be integrated within the lift-out section if strength and drainage considerations are properly addressed.

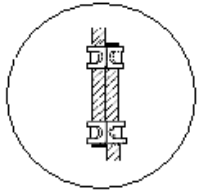
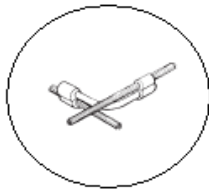
Grounding

All ground wire connections to ground rods shall be with an exothermic weld (Cadweld®), or one approved by the Tacoma Power Engineer.

Various methods may be used to develop a system to ground the transformer(s) and associated equipment in the vault room.

Grounding for this system may utilize one or more of the following

Grounding System Elements:

 <p>PARALLEL CONNECTION</p>	 <p>CROSS CONNECTION</p>	<p>When connecting ground wires to ground grids or building steel, parallel-connections and cross-connections shall be utilized.</p>
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Element I
Ground Rod System

A $\frac{5}{8}$ " x 10' copperclad ground rod shall be driven in each corner of the vault into at least 6' of undisturbed or compacted earth. See Fig. 1. Additional ground rods along the walls shall be placed on a 12' maximum interval. #4/0 bare copper wires shall be Cadwelded® to the ground rods, brought through the vault floor slab, and located approximately 6" from the walls. A driving head shall be used to prevent damage to the ground rod to accommodate the Cadweld connection. The space between the rods and the floor shall be sealed to prevent water intrusion. Stranded ground wire passing through the slabs or walls shall be solder blocked when water intrusion is anticipated.



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Grounding *(continued)*

Element II
Ground Grid in
Earth Contact
Floor Slab

Vault room grounding will utilize the reinforcement rebar mesh pattern in the floor, or a 2'x2' ground grid mesh of #2 copper in the vault floor slab. A #2 Cu grounding tail shall be bonded to the rebar mesh steel, or the grid mesh, along the vault walls and brought up 18" above the floor slab; additional tails to be repeated on a maximum of 8' intervals for Tacoma Power to tie into the vault room's ground ring.

Element III
Column Steel
System

The vault grounding grid shall be tied to the building's grounding electrode system and building structure to create an equal potential zone in the vault room. #4/0 Cu tails will be attached to each column in the room.

Vault Room
Location

The location of the vault room will determine which of the grounding system elements will be utilized.

<i>When the vault floor is in contact with earth</i>	<i>If the vault floor is <u>not</u> constructed on soil</i>
Vault room grounding will utilize elements I & II .	Vault room grounding will utilize element III .

Fire Detection and Suppression Equipment

Tacoma Power does not recommend fire suppression systems in transformer vault rooms. The three hour fire containment vault design is to protect the building and public from fire and smoke.

Fire detection equipment (smoke and temperature) shall be located where they can be tested and maintained without climbing over or on top of electrical equipment. Smoke detectors are to be annunciated to the building fire control center. Refer to the following section on "Dampers".

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Ventilation

Maximum Vault Temperature Adequate ventilation shall be provided to limit ambient temperatures in the vault to **115°F** (46°C) during continuous operation of the ultimate transformer installation and during maximum temperature conditions of the locality.

Natural Ventilation (Preferred) Natural ventilation provides the most reliable and maintenance free means of ventilation. The transformer vault shall be located so it can be ventilated directly to the outside air without the use of flues or ducts. The net area of all ventilating openings, after deducting the area occupied by screens, gratings or louvers, shall not be less than **3.0 square inches per kVA of transformer capacity** for the ultimate transformer size. Designs should have both an intake grate at a lower elevation and an exhaust grate at an upper elevation.

In case of sidewalk service vaults with grade-level gratings, all ventilation area may be provided in one or more openings in the roof. Vent locations must be located to **shelter** electrical equipment from falling or driven water or debris.

The location of vents shall be approved by Tacoma Power's engineer in order to accommodate all planned equipment and drainage considerations.

Forced Air Ventilation or Refrigeration If natural ventilation to the outside air is not available, forced ventilation or refrigeration will be provided by the building owner. Forced air ventilation or refrigeration solutions must be designed by the building owner's HVAC mechanical engineer, and approved by the Tacoma Power engineer. Forced air ventilation shall be a minimum of **2.1 cubic feet per minute (CFM) per kVA of transformer capacity** for the ultimate transformer size.

Forced air ventilation shall be thermostatically controlled with an adjustable owner-maintained thermostat installed inside the transformer vault to turn the fan on at **75°F**.

The minimum allowed ventilation ducting size is determined by duct design, fan CFM, total transformer KVA, room size, and heat load.

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Ventilation *(continued)*

- Gratings** Vault ventilation gratings that must be installed within a sidewalk must be non-skid design and have vent gaps of $\frac{1}{4}$ inch maximum width. Ventilation gratings are to be avoided within a 5-foot wide clear foot traffic zone along the direction of the sidewalk. Grating covers must meet H20 loading. They must have a locking mechanism that is designed to be below the top grade of the grate. Tacoma Power must pre-approve all grate designs for location, ventilation, pedestrian travel when opened, etc.
- Alarms** If the fan fails or the room temperature exceeds **130°F**, a warning light and audible alarm shall sound in the building management system, and at the vault just outside the man door. If fire detection systems in the vault are activated, then all vault room exhaust fan(s) shall be disabled and dampers closed. Signage at the warning light shall state "If light is on or horn sounds, contact Tacoma Power at (253)-502-8602 and report this address - *list address*."
- Dampers** All ventilation openings to building or garage interiors shall be provided with durable gratings or screens and louvers as well as automatic closing fire/smoke dampers that operate in response to a vault fire. Such dampers shall possess a standard fire rating of not less than 3 hours. This same requirement exists for exterior gratings if near or adjacent to occupied space or doors and windows that open or building ingress/egress pathways.
- Louvered vents must have blocking baffles when located in close proximity to energized parts (required on a case-by-case basis).
-

Other Equipment

Fig 5

**Fault
Interrupter**



Fault interrupter with wall mounted control box is shown with standard side mounted operating handle.

Tacoma Power MID# 47733, 3 Φ submersible, vacuum bottle interrupter, 200 amp load-break bushings, mounting bracket for vault applications to include parking stands, and grounding provisions for up to #4/0 copper wire.

Lighting & Outlets

Requirements for lighting and outlets in vault rooms are:

- The customer must provide one 30 amp, 240/120 volt circuit to the vault. This circuit is to be fed from the building's emergency panel and labeled as to its source panel and breaker number.
- Tacoma Power will design and install the transformer vault breaker panel, lighting system, outlets, and switches. The customer is responsible for this equipment and materials.

High Voltage Tap Boxes

When high voltage tap boxes are installed in a vault room, the space must be designed to accommodate the following:

- The tap boxes shall be mounted 36 to 40 inches above the floor.
- A 10' by 10' working space shall be provided in front of the tap boxes. This space may be shared with the working space that is required by other pieces of equipment.
- The cables shall be racked on the wall and secured to the racking, not laid on the floor.
- The portions of the cables close to the elbow shall be free to move and not be trapped under other cables. There shall be enough slack to easily move the elbows from the tap boxes to the parking stands. The cable shall not come out of the floor directly below a tap box because this does not provide adequate slack.
- The cables may approach the tap box from above and/or below.
- Walls must be made of reinforced concrete.