

Whole House Backup Generator Installation

By Terry G. Glagowski / W1TR - 2012-11-02 22:19
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by

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Installation of a whole house backup generator was driven by the
2011 Halloween Northeaster **Storm Alfred**,
a power outage event in the North East USA that lasted for well over a week.

The author and XYL originally had plans for a whole house generator when the house was built in 2004,
but deferred the project due to cost since there had only been a handful of power outages in 8 years,
the longest of which was 6 hours.

Postscript

Hurricane Sandy arrived on 27 Oct 2012 and *this* time we had the generator installed and operating to
ride out the storm in style with electrical power. Fortunately there was no other damage.

Halloween: Trick or Treat





Introduction

- System Engineering
 - Generator Type
 - Generator Size
 - Fuel Type
 - Fuel Tank Size
- Acquisition
 - Generator
 - Fuel Tank
- Installation
 - Electrical
 - Generator
 - Fuel
- Operation
- Maintenance
- Conclusion



Why a Whole House Generator?

- A portable generator requires a makeshift connection to the house power or installation of a transfer switch. (some legal, some not, but in an emergency... Who cares!)
- **SAFETY !**
- A portable generator (3-8 KW) will typically NOT power the entire house, especially pumps, stoves, A/C, etc.
- A portable generator has many manual steps to start it. (Can your wife do this while you are away?)
- A portable generator (typically gasoline) requires constant refueling (perhaps every 4-8 hours).
- But a portable generator *IS* a less expensive solution, typically \$1-2K versus \$6-9K for a whole house generator.

What Size Generator?

- How much is ***your*** electric bill?
 - How many KWH in the worst month (Jul-Aug, Jan-Feb) ?
 - Divide KWH by (24*days-in-month) to get average KW for the month (***mine was 3.7 KW worst month***, 2.7 KW average month)
- What are ***your*** power requirements?
 - Total power requirements for major appliances
 - Include start surge for those with motors
 - Lights, Computers, TVs, Refrigerators, Stoves, etc. (add the wattages)
 - Amateur Radio Equipment (transceivers, amplifiers)
 - ***I*** have 2 ½ refrigerators, freezer, well pump, furnace, A/C, 2 ovens, a stovetop, washer, dryer, computers, TVs ... AND Radios !
- ***My*** Guestimate:
 - Round the worst case 3.7 KW up to **4 KW for good measure**
 - 4 KW x 3 for the estimated surge + 3KW for Radio = **15 KW ballpark**
 - My Choice: 20K Generac Guardian and automatic 200 amp transfer switch the 15 KW was only \$500 less expensive and the case quality was better for the 20 KW model.

What Kind of Fuel?

- **Gasoline: simple, readily available**
 - hard to store.
 - storage life is not very long.
 - what about supply during an outage?
- **Diesel: less simple, NOT as readily available, use heating oil?**
 - also hard to store.
 - storage life is longer than gasoline but not indefinite.
 - What about the smell?
 - You can use home heating oil but...
will you need a larger oil tank for the furnace then?
- **Propane: readily available, but in quantity by truck delivery only**
 - requires a separate on-site tank.
 - has excellent / long storage life.
 - runs clean.
- **Natural gas: (not available in Ashford, CT)**
 - No storage since it is supplied by the utility via pipe (IF AVAILABLE !).
 - generators are de-rated 10-15% for natural gas.
 - Will the Utility always supply gas during a disaster? (NY, NJ during Sandy)

What Size Fuel Tank?

- Time Requirement: **10 Days Without Refueling**
Halloween 2011 / Storm Alfred Outage was **8+ Days**
- What is the fuel consumption rate?
For $\frac{1}{2}$ load (10KW) 2 gal/hr, for $\frac{1}{4}$ load (5 KW) 1 gal/hr?, for $\frac{1}{8}$ load (2.5 KW ?)
- $10 \text{ Days} * 24 \text{ Hours} * 2 \text{ Gal/Hr} = 480 \text{ gallons} !$
- Tanks come in 100, 250, 300, **500**, 1000 or larger.
- What if the tank isn't 100% full? (5-10 days?)
- But 1 Gal/Hr is more realistic (10-20 days then?)
- A 500 Gal Tank is only filled to 80% (400 Gal!)
- You can't use the last drop in the tank (350 Gal?)

Acquisition: Generator

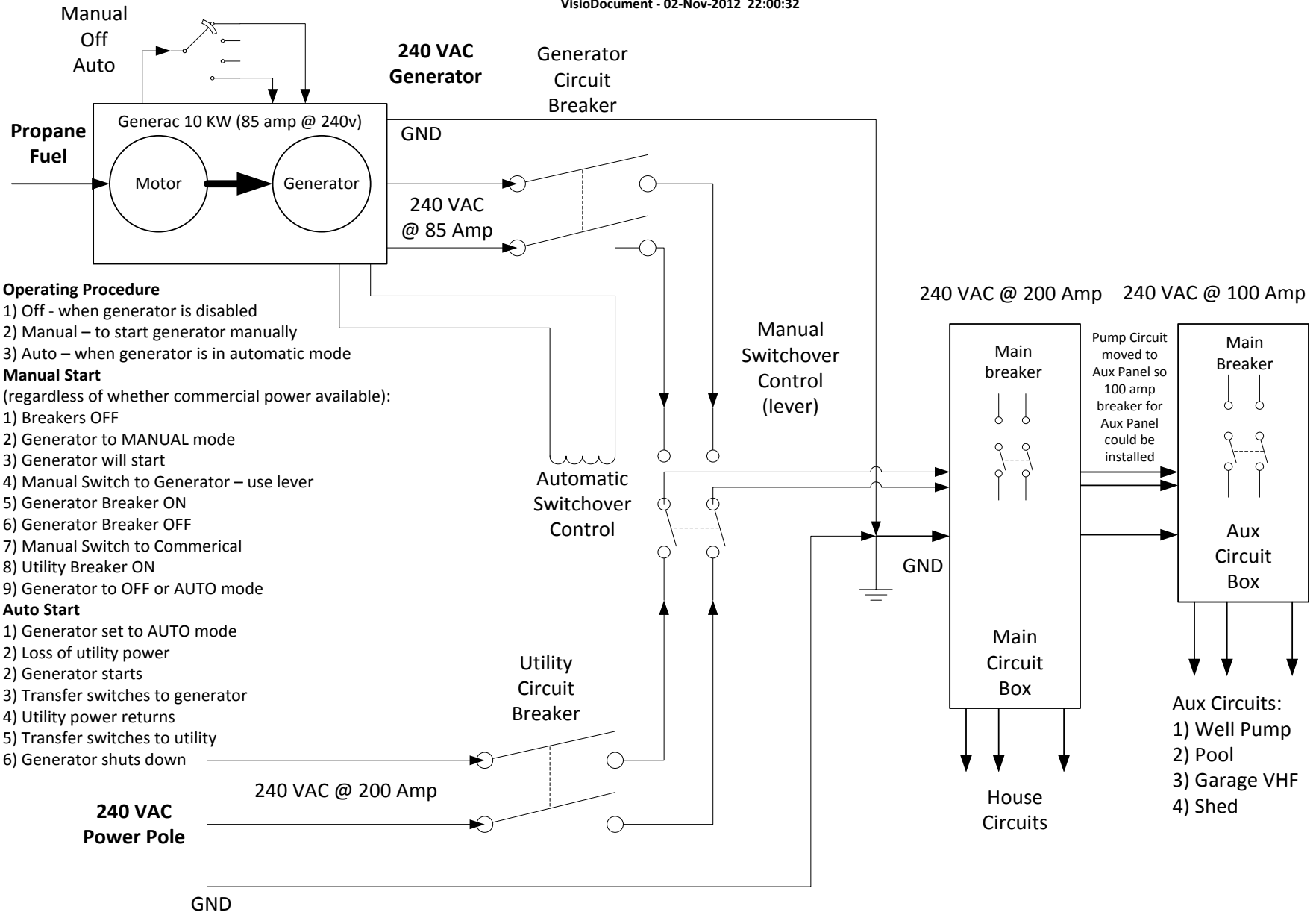
- Brands: **Generac**, Kohler, GE, Cummins Onan, ...
- Vendors: Home Depot, **Lowes**, Electrical Houses
- Lead Time: approximately 3 months
- Cost (20KW Generac, Lowes)
 - \$5500 Generator
 - \$1000 Transfer Switch 200 A
 - \$800 Electrical Work

Acquisition: Propane Tank

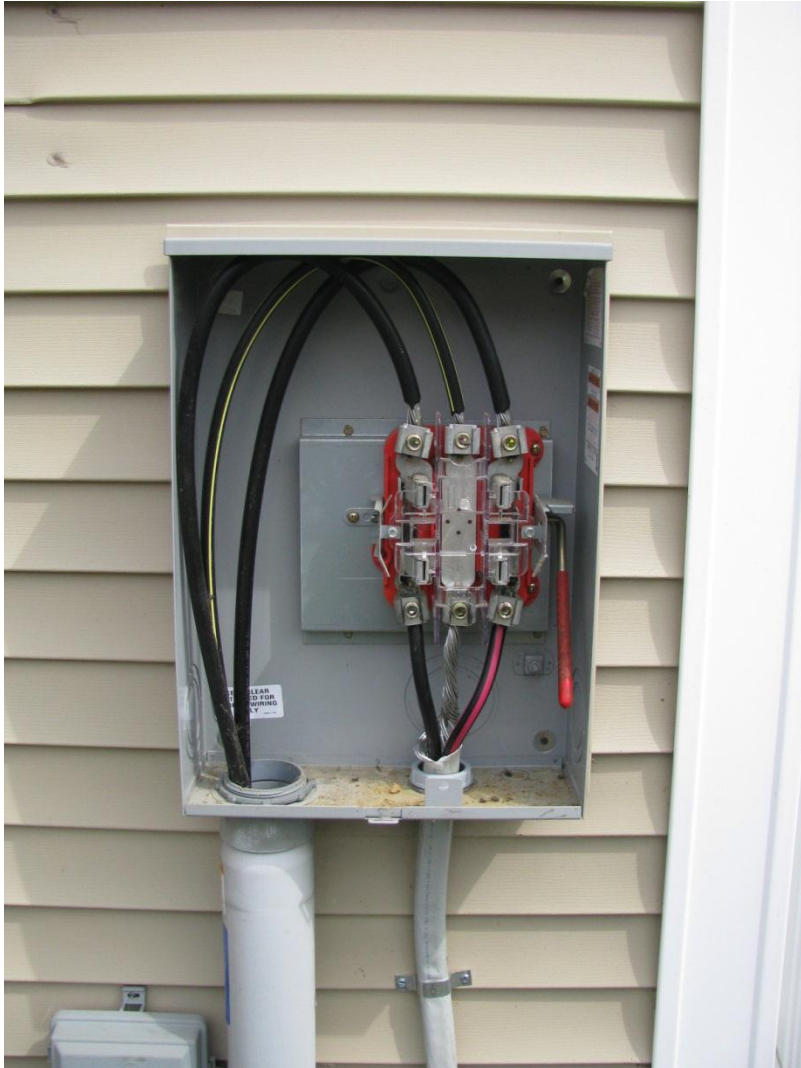
- Many Brands
- Lease from Propane Vendor, **no cost lease**
also buy heating fuel oil from them to get this deal, and at Co-op price.
- Installation Cost: \$650 incl. materials
installed by propane vendor
- Cost to dig fuel line trench: \$400
\$200 equipment rental
\$200 labor (Frank / K1MAA)
- Current fuel cost \$2.65/gal, varies

Generator Electrical Distribution System

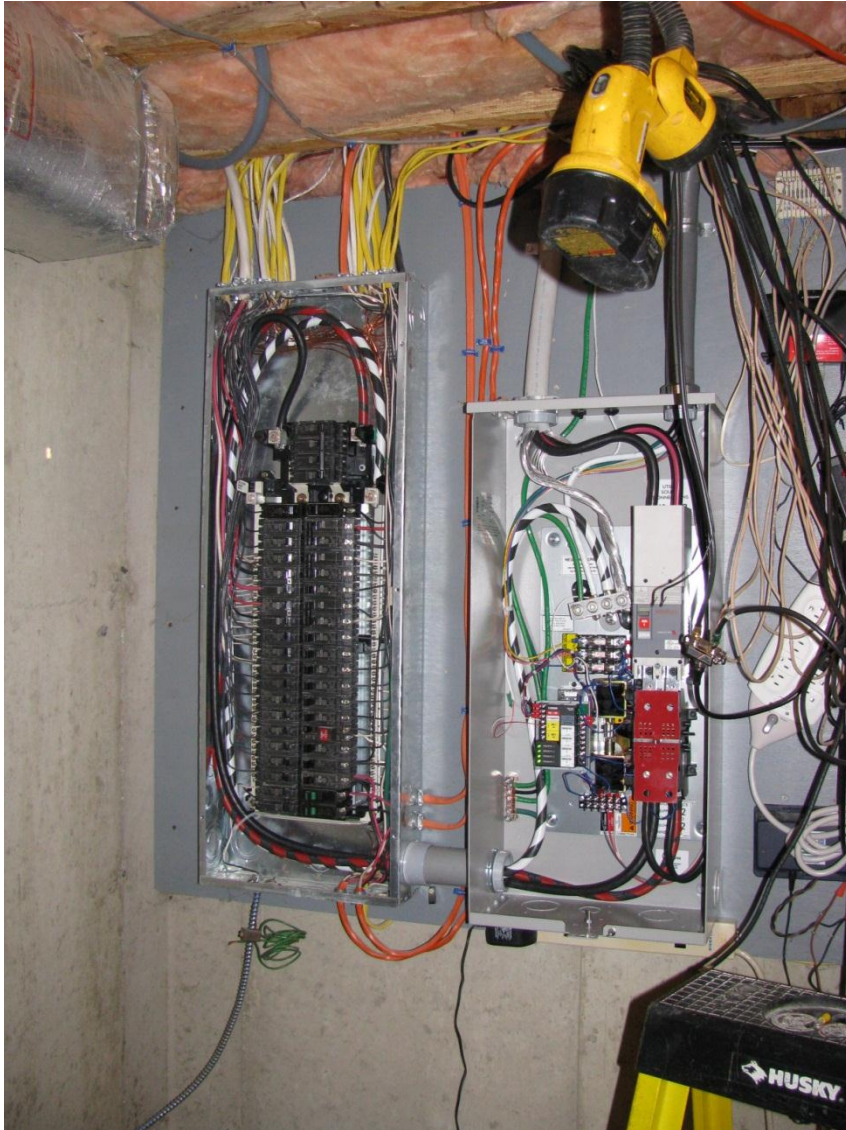
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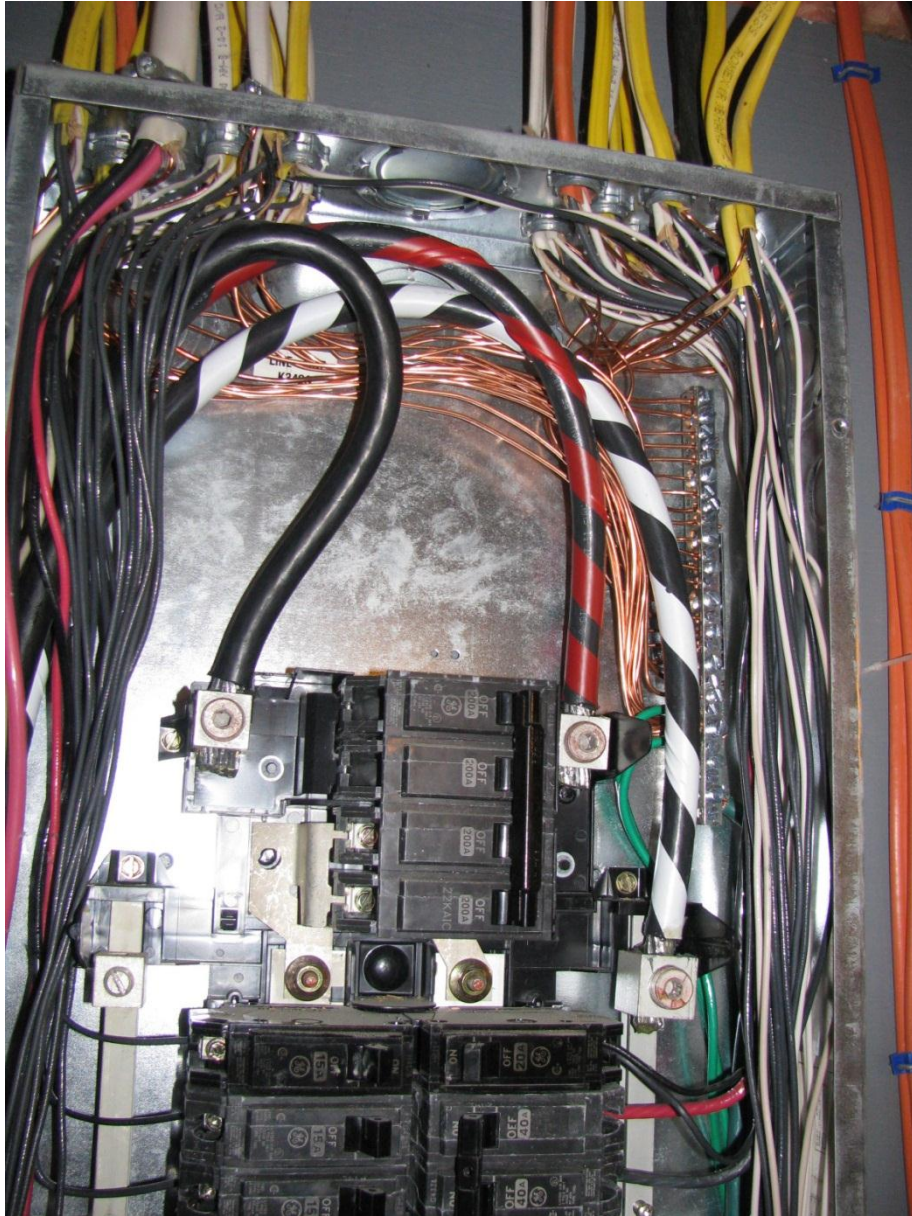
Installation Details: Main Power Feed



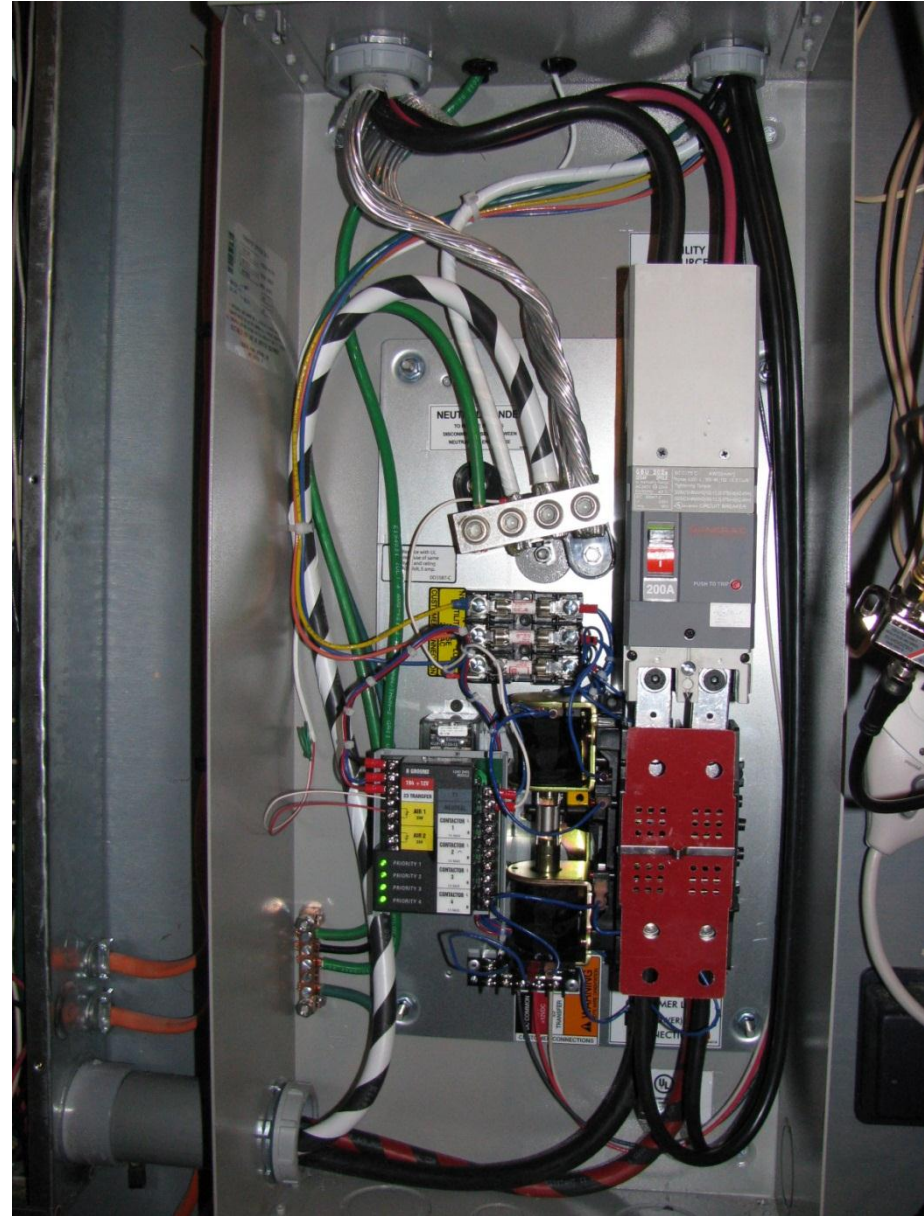
Installation Details: Transfer Switch



Main Box



Transfer Switch



Installation Details: Generator





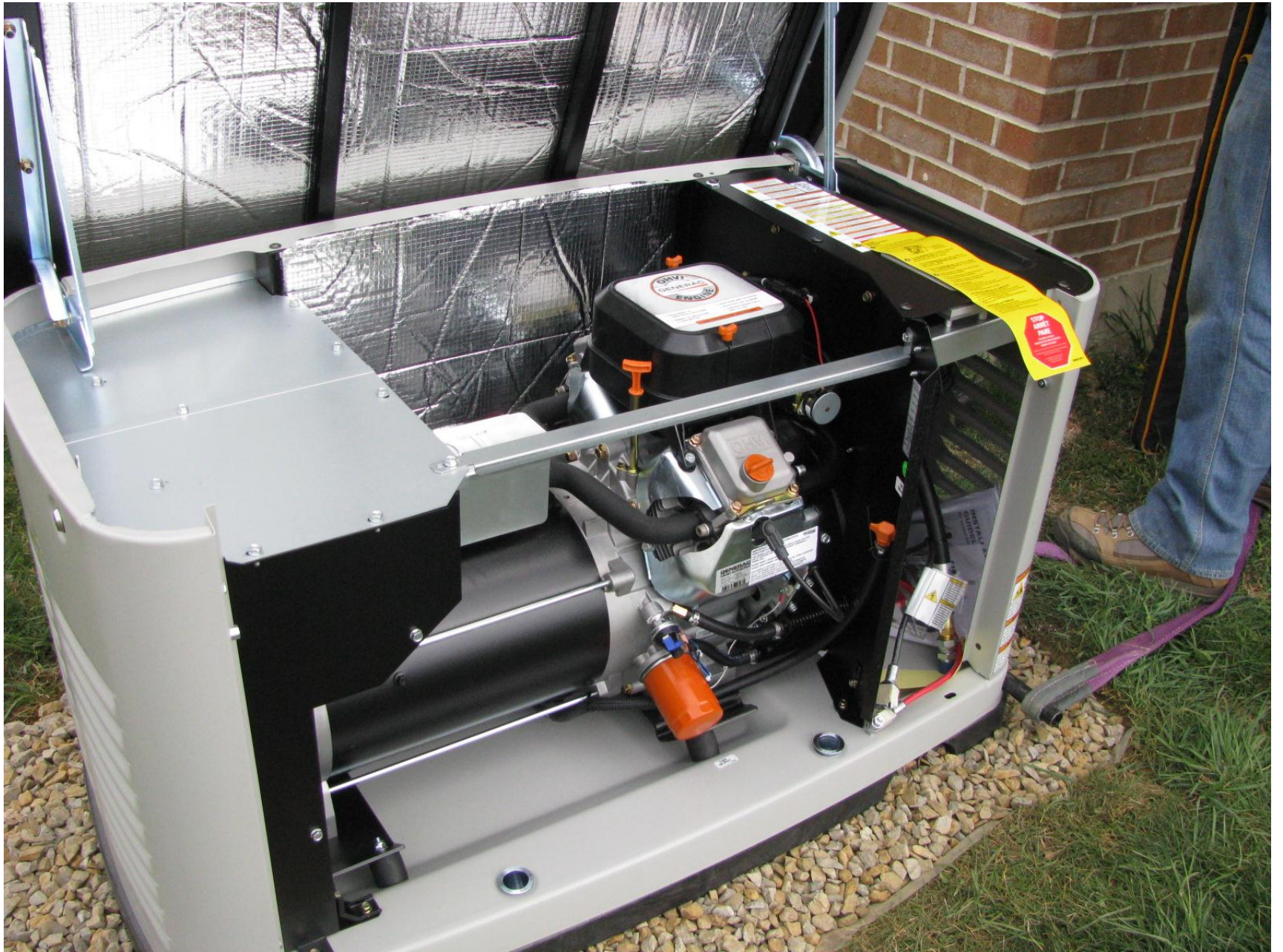












Generator and Motor Specifications

- Model: Generac Guardian 20KW
- Power: 20KW Propane, 18KW Natural Gas
240 VAC @ 85 Amp
- Engine V-Twin GT-999
2cyl, 36hp, 999cc, ohc, 1:9.5 comp ratio
- Oil 1.9 qt
 - SAE 30 above 32° F
 - SAE 10W30 between -10° F to +40° F
 - Synthetic 5W30 below 10° F
- Fuel Consumption
 - 1/2 load - 1.98 ga/hr (specs), 10 KW
 - Full load - 2.90 ga/hr (estimated), 20 KW
 - ¼ load – 0.99 ga/hr (estimated), 5 KW
 - **Actual House Load – 1.32 ga/hr (measured), 3 KW load est.**

Installation Details: Fuel Line

Call Before You Dig !





Frank, K1MAA (KB1LKB)





Installation Details: Tank









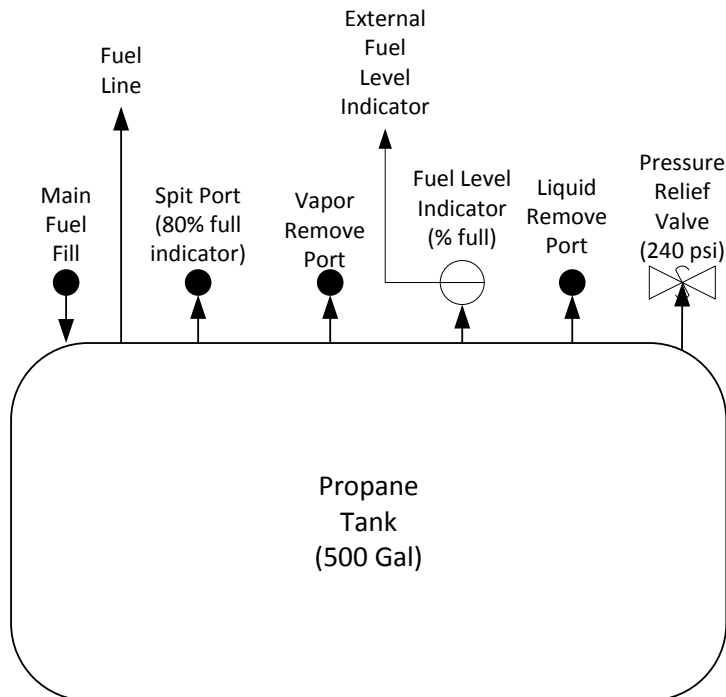
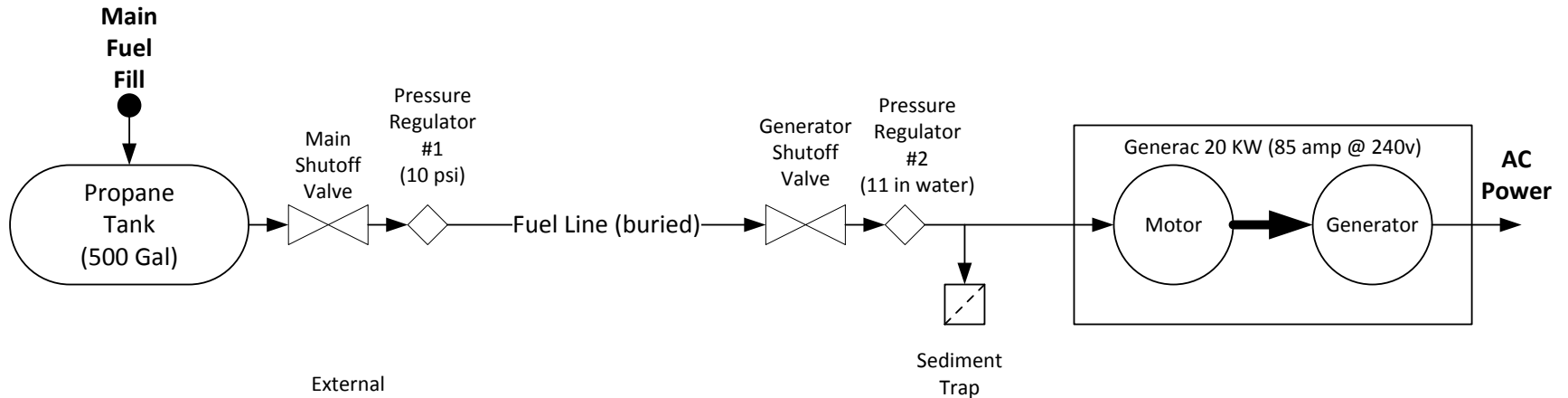






Generator Propane Fuel System

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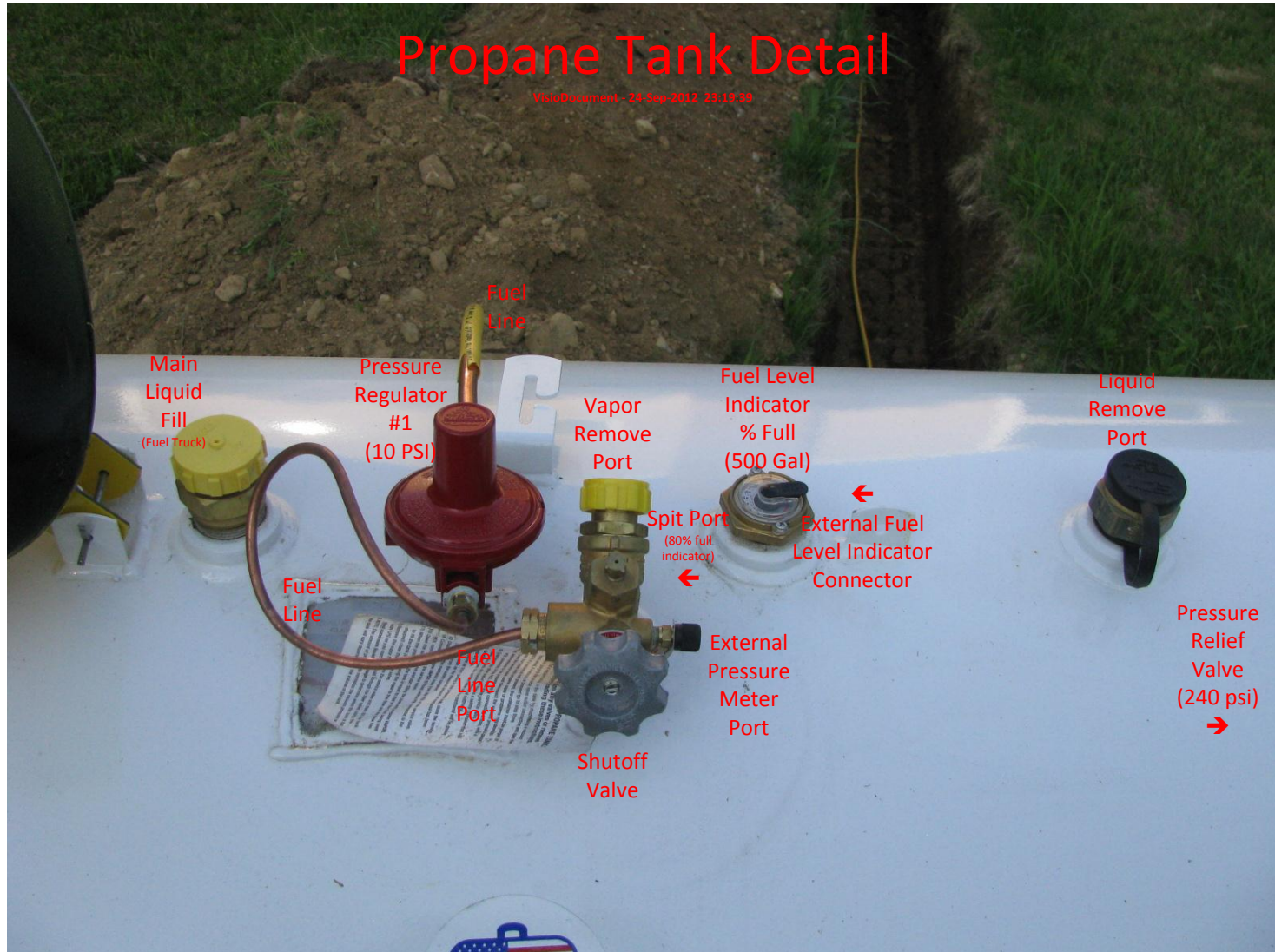
Initial Tank Filling Procedure

- 1) Tank comes filled with vacuum
- 2) Remove vacuum, fill with propane vapor thru Vapor Remove Port
- 3) Fill with propane liquid thru Liquid Remove Port (≈ 25 gallons)

Routine Tank Filling Procedure

- 1) Refuel when 20% or lower (100 gallons)
- 2) Fill thru Main Fuel Fill until Spit Port indicates 80%
- 3) Observe that Fuel Level Indicator reads 80%

Fuel System Pictorial Detail



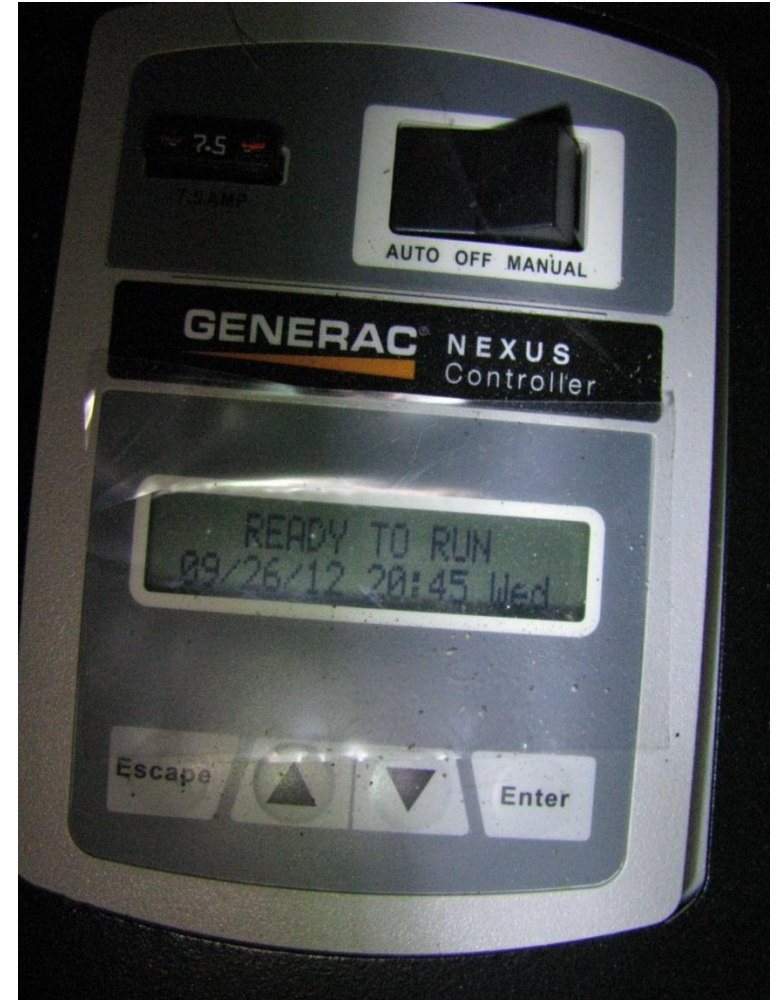
Operation

- **OFF**
 - Generator Control Switch = OFF (service generator)
- **Manual Transfer**
 - Both Utility and Generator Breakers OFF
 - Lever on transfer switch = GENERATOR
 - Generator Control Switch = MANUAL (start generator)
 - Generator Breaker ON
 - Power Supplied by Generator
 - Generator Breaker OFF
 - Lever on transfer switch = UTILITY
 - Generator Control Switch = OFF / AUTO (stop generator)
 - Utility Breaker ON
 - Power Supplied by Utility
- **Automatic Transfer . . .**
 - Generator Control Switch = AUTO
- **Weekly Auto Test**
 - Generator Control Switch = AUTO
 - Set for 10 am Saturday Mornings
 - 10 min generator run without power transfer

Automatic Transfer

- Utility Service Fails
 - Voltage below 80% nominal
 - 15 second delay
- Engine Start / Warmup – 10 second delay, up to 4 tries
- Generator Voltage Ready – Voltage 50% of nominal
- Transfer House to Generator
- Power Supplied by Generator During Outage
- Utility Service Restored
 - Voltage above 90% nominal
 - 15 second delay
- Transfer House to Utility
- Engine Cool Down – 60 seconds
- Engine Off
- Power Supplied by Utility Service

Generator Control Switch



Manual Transfer Switch

UTILITY SERVICE DISCONNECT

ON

OFF

GENERIC



WARNING To reduce the risk of electric shock or personal injury, DISCONNECT ALL SOURCES OF SUPPLY BEFORE SERVICING. AVERTISSEMENT - COUPER TOUTES LES SOURCES D'ALIMENTATION AVANT DE FAIRE L'ENTRETIEN ET LES RÉPARATIONS.	UTILITY
Manual Operation 1. To manually operate switch, attach handle to operating lever between solenoid coils. 2. Pull down lever to connect standby or push lever up to connect utility to load. 3. When servicing has been completed, be sure to remove handle from switch.	MANUAL OPERATING HANDLE SWITCH POSITION
	GENERATOR

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Operational Test

- Test Run
 - Ambient House Load 3KW
 - + 4 Stove Burners
 - + 2 Ovens
 - 67 Amps (85 rated max) 16KW Total
 - Voltage Normal and Stable at 121 VAC
- Real Outage: one Sunday – two outages
 - 10 minutes in the morning
 - 40 minutes in the evening
 - UPS systems kept computers, TV, Internet, Radios working during transfer gap (25 sec)

Maintenance

- Oil & Filter Changes
 - Change oil and filter After first 8 hours
 - Change oil and filter every 200 hours / 2 years thereafter
 - Inspect oil level every 24 hours / 1 month
- Air Cleaner change – every 500 hours / 2 years
- Spark Plug change – every 500 hours / 2 years
- Battery Check
 - Check charge every 6 mo
 - Check electrolyte level every 6 mo
- Tune Up – every 200 hours / 2 years
- General Cleaning / Inspection – as needed

Conclusion

- The Halloween 2011 Storm will probably NEVER happen again! (barn door now locked AFTER horses already escaped!)
- **Update after Storm Sandy – YES IT DID HAPPEN AGAIN !**
Fuel consumption: measured 75 gallons of propane for 56.75 hours operation
1.32 gallons per hour – if 350 usable gallons in tank, 265 hours or 11 days operating time!
- Empty Pockets: that's what credit cards are for!
Actually, an 18 month interest free loan!
- Piece of mind: **Priceless !**
- Field Day – Plan B when it Rains – Home Class 1E
- Tax Deduction?
Support of USAF MARS emergency operations!
- Next Power Outage... ;-) ;-)
Turn on all flood lights, crank up Hi Fi,
roll out the beer and BBQ, invite neighbors to party!