# Whole House
# Backup Generator Installation

Updated 18-Feb-2022 17:20

By Terry G. Glagowski / W1TR / AFA1DI - 18-Feb-2022 17:20
Originally Presented at the 27-Sep-2012 CMARA Meeting
Again on 17-Feb-2022

by


## Terry G. Glagowski

W1TR / AFA1DI


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 8 days in Ashford.

I survived the **Blizzard of 1978** in a residence less than a mile away down the road on Lake Chaffee.
Although there were 3 feet of snow, there were no power outages!

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 from 2004 to 2011,
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 for 3 days in style with electrical power. Fortunately there was no other damage.

**ALSO**: Later thatnight after the 17-Feb-2022 presentation, we lost power at 4:30 AM after several long hits.
The generator DID NOT START, and with 40 KT winds, pouring down rain, dark as coal, I chose NOT to investigate just then.
The next morning at 0900L, I discovered a number of software faults that needed to be cleared before the generator would start.
I cleared them all and let **all systems go**, and will read the manual about the faults, perhaps due to the multiple hits.
Eversource restored power at 12:30 PM, so this was an 8 hour outage.

# 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


20KW
CENTURION

# 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, a 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.
  - May require new flow valve at street connection to utility main.
  - 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 ½ load (10KW) 2 gal/hr, for ¼ load (5 KW) 1 gal/hr?, for 1/8 load (2.5 KW ?)
- 10 Days * 24 Hours * 2 Gal/Hr = 480 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?)

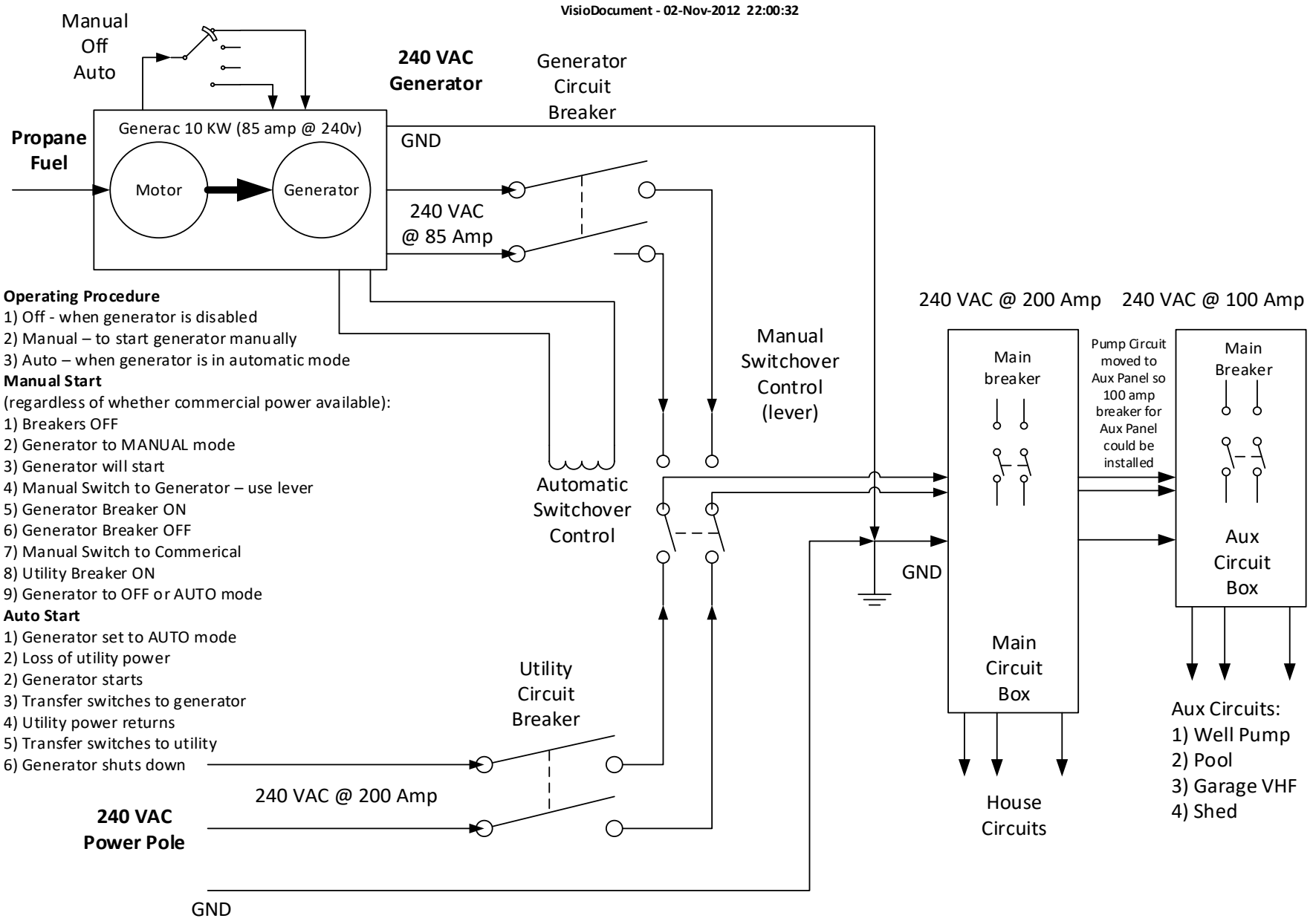
# Acquisition: Generator

- Brands: Generac, Kohler, GE, Cummins Onan, …
- Vendors: Home Depot, Lowes, Electrical Houses
- Lead Time: approximately 3 months
- Cost (20KW Generac, Lowes)
  - $5500 Generator (20 KW)
    (recent Lowes Ad: 20 KW no longer available)
    (recent Lowes Ad: 22 KW $4797 but unavailable)
    (recent Lowes Ad: 24 KW $5997 including automatic transfer switch)
  - $1000 Automatic Transfer Switch 200 A
  - $800 Electrical Work
  - $650 Propane Tank Installation ($100 / YR rental)
  - $400 Trench Installation

# Acquisition: Propane Tank

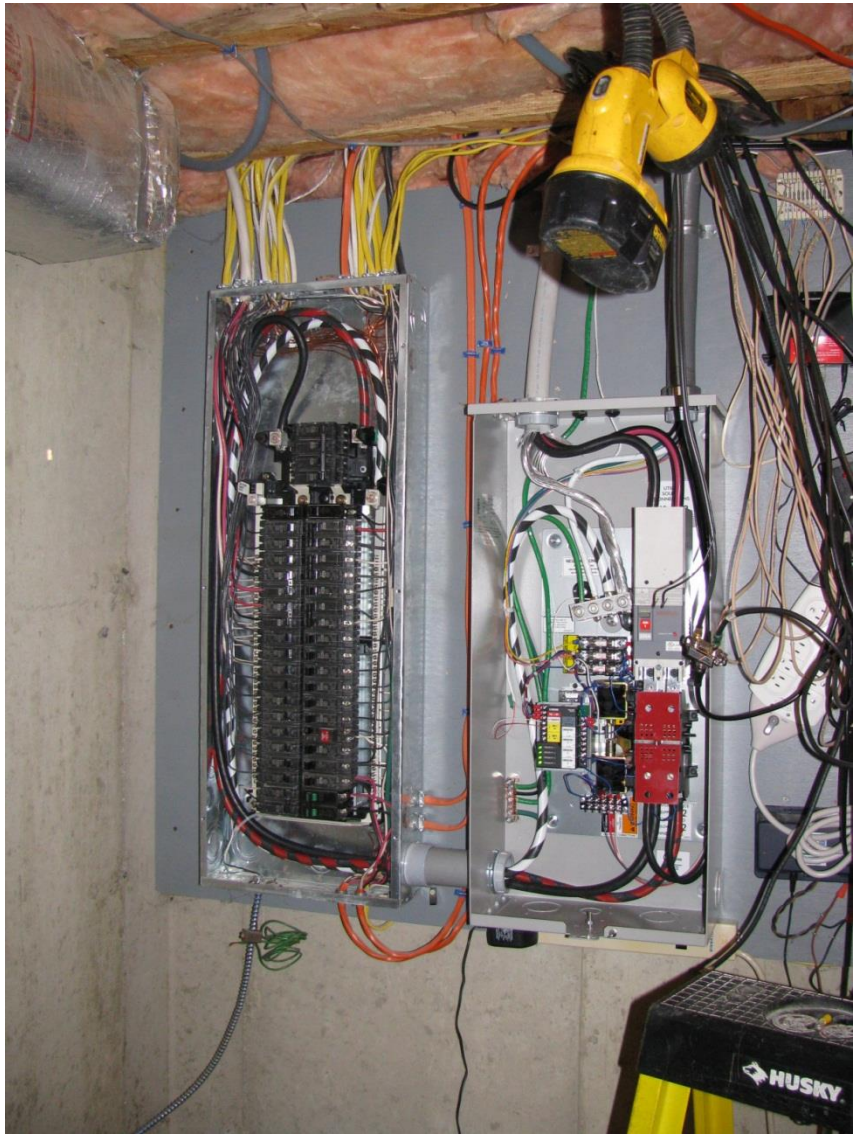
- Many Brands
- Lease from Propane Vendor
  also buy heating fuel oil from them to get this deal, and at Co-op price.
  Lease from Superior Oil $100/yr, free with minimum quantity propane.
- Installation Cost: $650 incl. materials
  installed by propane vendor
- Cost to dig fuel line trench: $400
  $200 equipment rental
  $200 labor (Frank / K1MAA SK)
- Current fuel cost $2.65/gal (2011), varies
  https://www.eia.gov/dnav/pet/pet_pri_wfr_a_EPLLPA_PRS_dpgal_w.htm
  Residential Propane Weekly Heating Oil and Propane Prices (October - March) (eia.gov)
  $3.70 Feb 2022

# Generator Electrical Distribution System

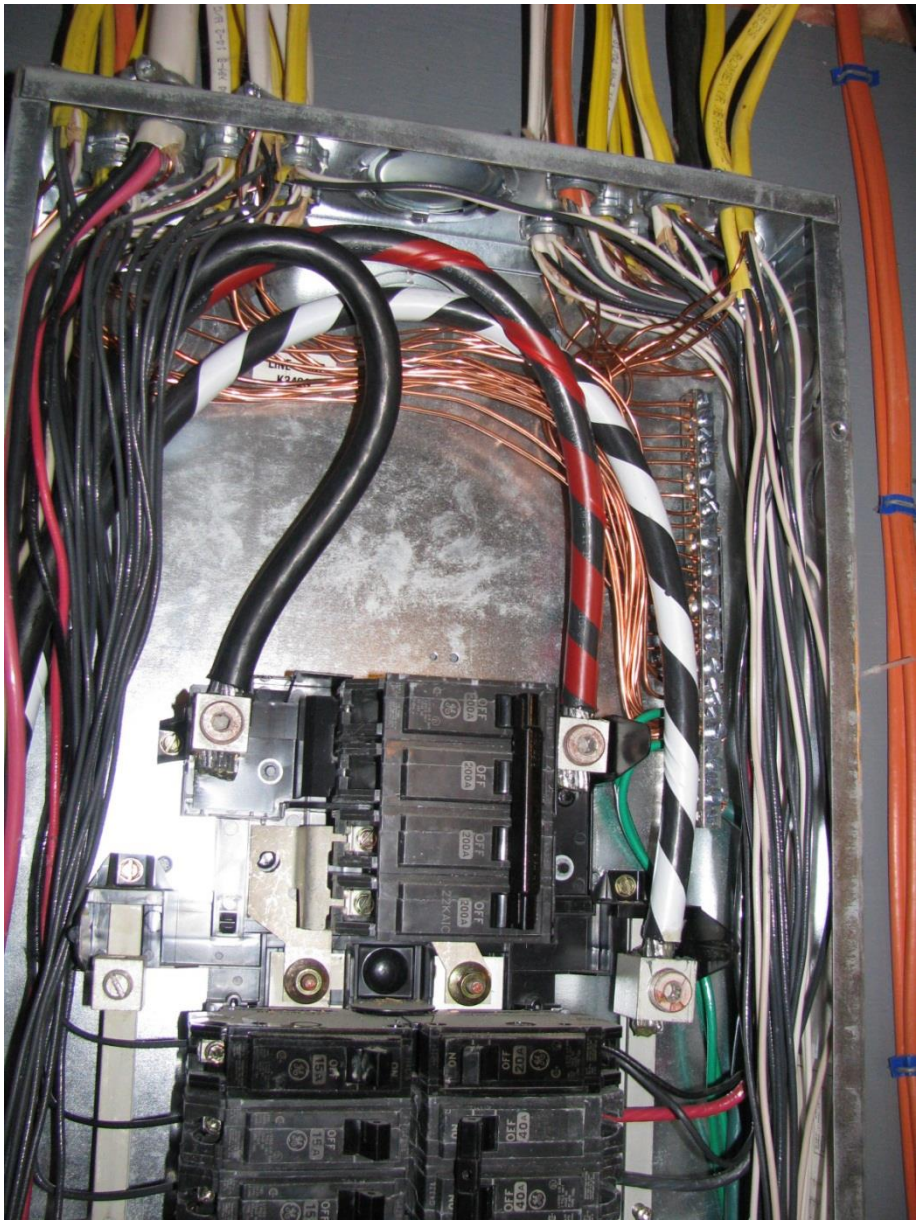


# Installation Details: Main Power Feed

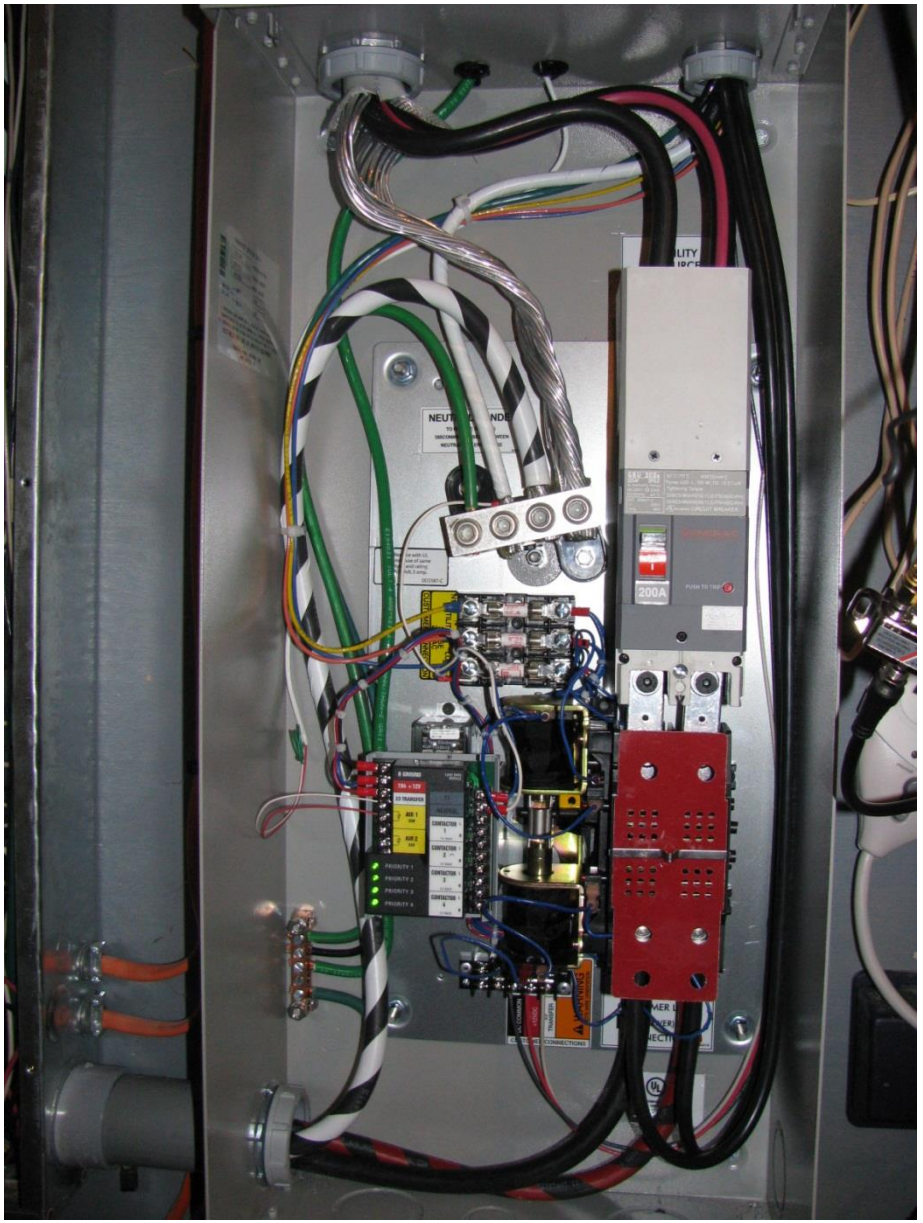
# Installation Details: Transfer Switch




## Main Box



## Transfer Switch



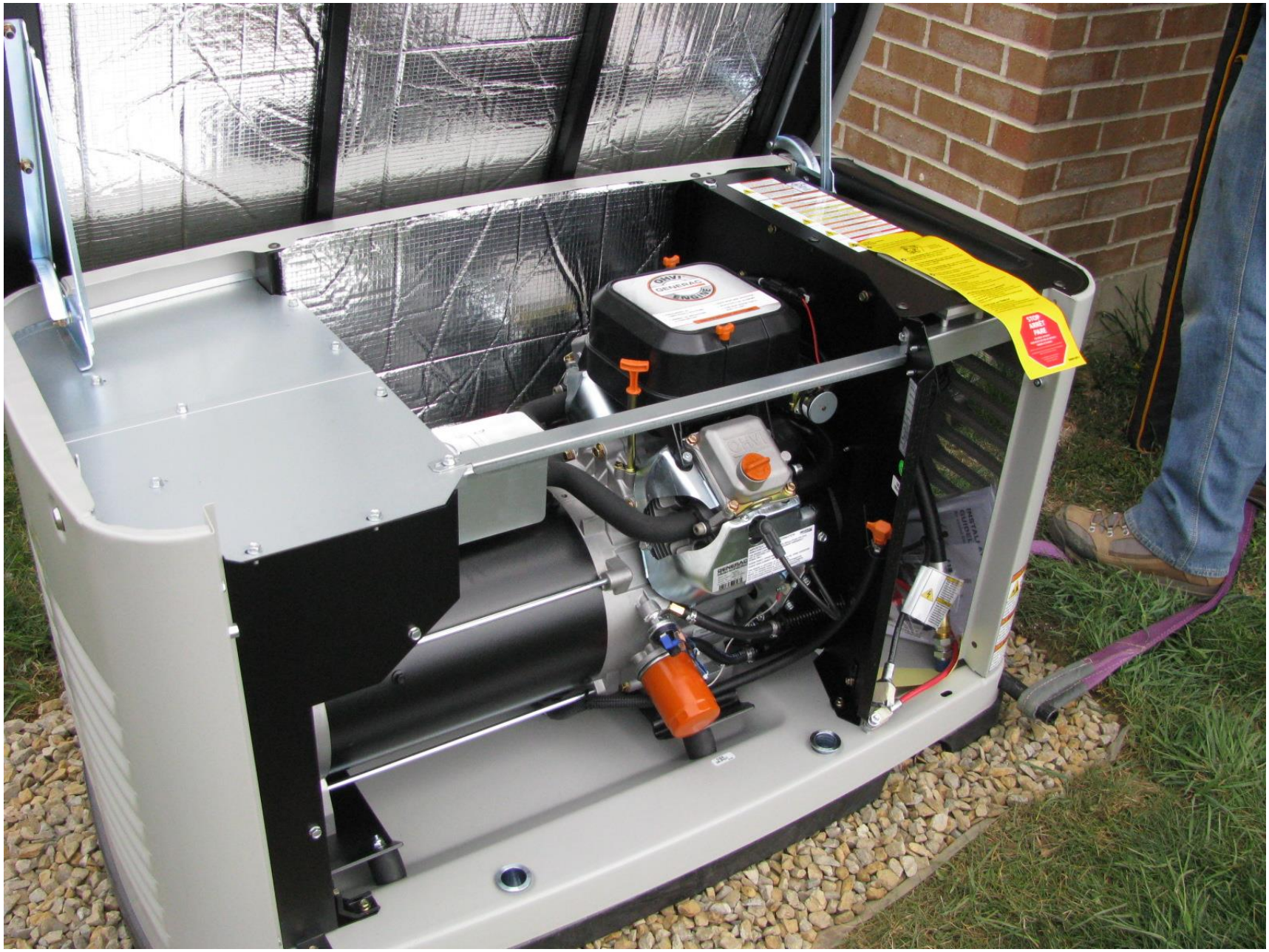
# Installation Details: Generator


YORK


OH7265B


20kW
CENTURION


LOWE'S
LOWE'S
RIDGID


GENERAC
STOP
ENGINE
PARK

# Generator and Motor Specifications

- Model: Generac Guardian 20KW
- Power: 20KW Propane, 18KW Natural Gas
  240 VAC @ 85 Amp
  Noise: 88 dBA at 6 ft outside
  44 dBA inside near wall next to generator, windows closed
  Quiet room is about 30 dBA.
- 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 !



YANMAR
B08-3
Frank, K1MAA (KB1LKB)


YORK
YANMAR
YANMAR
B08

# Installation Details: Tank


JOMAC


JOMAC
3016


Superior Plus
1-800-232-0326

# Generator Propane Fuel System

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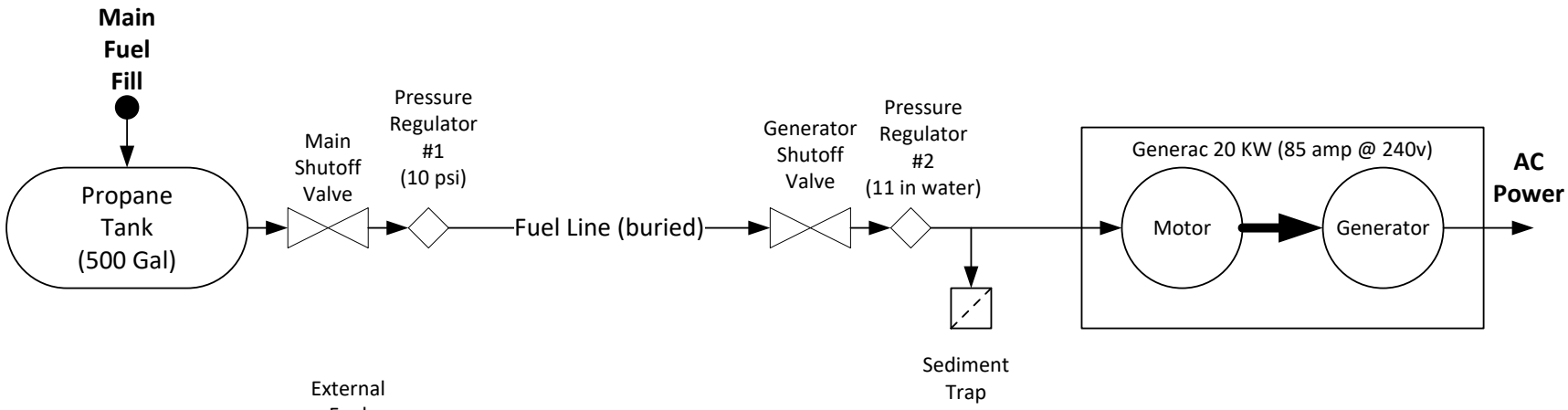
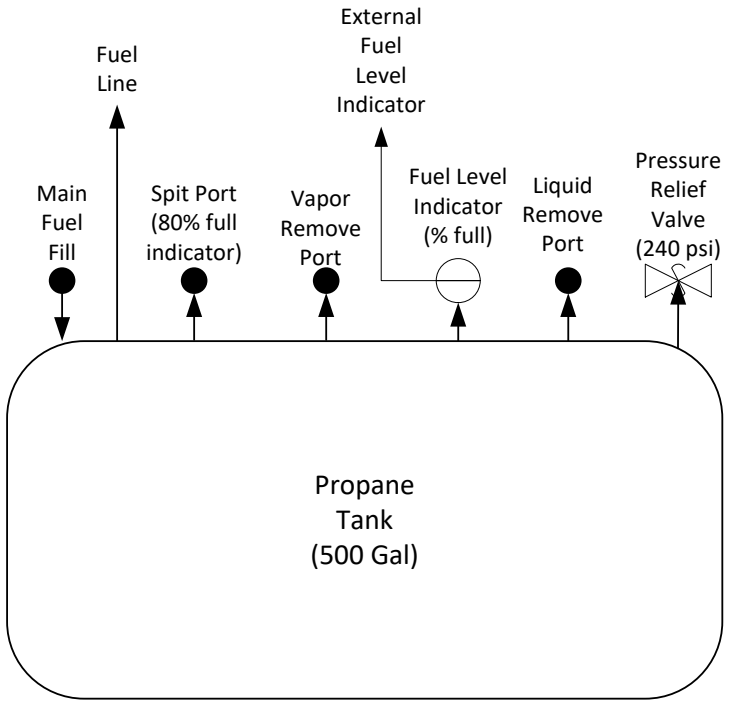



**Initial Tank Filling Procedure**

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

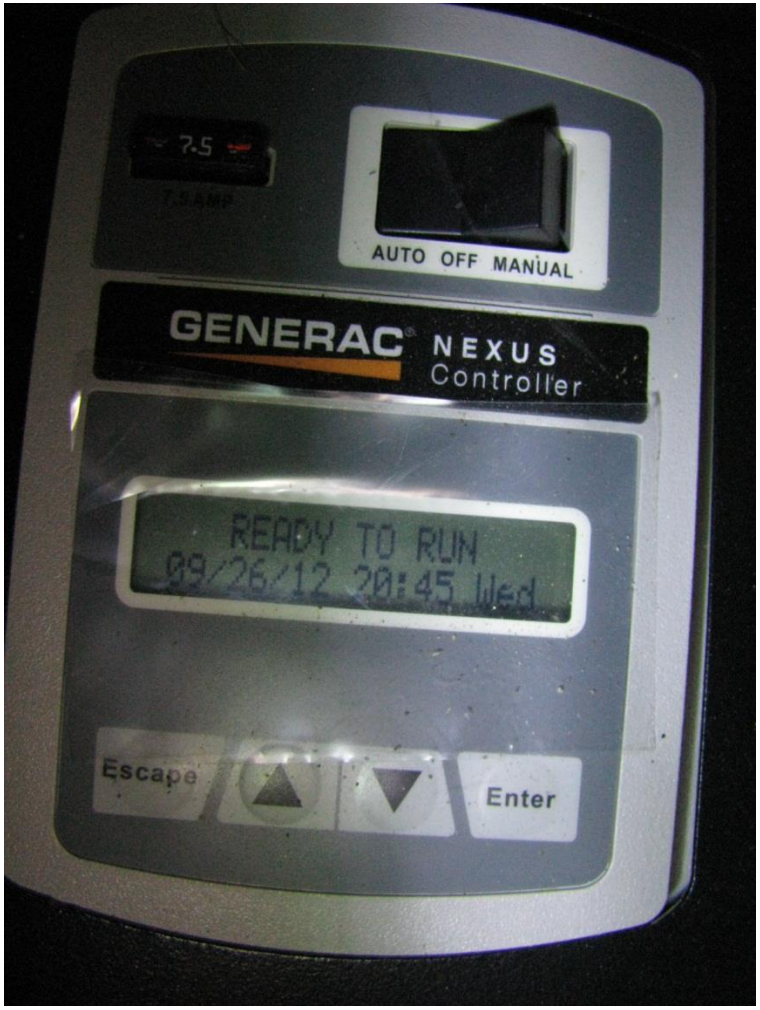
# Operation

- **OFF**
  - Generator Control Switch = OFF (service generator)
- **Manual Transfer** (several trips between generator and cellar)
  - 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


# 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

# MARS COMEX Operation

- Manual Cutover Possible but Not Practical
  - Generator Switch is in Generator Housing (outside)
  - Cutover Switch is in the Cellar (inside)
  - Cutover Switch Cannot be Manually Operated Under Load
    Will Cause Burnt Contacts
  - Automatic Operation is Within Milliseconds
    Will Avoid Burnt Contacts
  - Multiple Trips To and From the Generator are Required
  - Disruption to the Household
  - Too Bad there is No "Button" to Perform Manual Cutover
    When there is No Commercial Power Loss
- MARS Station Power Usage
  - Computer Only = 157 watts
  - Computer + Radio Receive = 309 watts
  - Computer + Radio Transmit = 646 watts (not including KW amplifier)
- Photos of 1500 VA APC UPS Display:



# Conclusion

- The Halloween 2011 Storm will probably NEVER happen again!
  (barn door now locked AFTER horses already escaped!) (8 Day outage)
- The Blizzard of 1978 left 3 feet of snow but no power outages!
- Update after Storm Sandy (Oct 2012) – 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!
- It happened again later on the very day of the presentation (17-Feb-2022, technically the 18th).
- Empty Pockets: that's what credit cards are for!
  Actually, an 18 month interest free loan on Lowes Credit Card was $500 / month.
  Lowes prices have not inflated that much since 2011 (but hold your breath!)
  Check their sub-contractors for installation prices.
  There ARE less expensive options with portable generators and temporary hook ups: convenience vs cost.
- Piece of mind: Priceless !
- Field Day – Plan B when it Rains – Home Class 1E
- Tax Deduction? (Tax rules may have changed)
  Support of USAF MARS emergency operations!
- There have been a number of power outages since 2012
  varying in duration from several minutes to several hours
- Cutover to Emergency Power Without Commercial Power Loss
  Is Difficult, and Not Practical to run emergency power for MARS COMEX or ARRL Field Day.
  Too bad there is not a control for manual cutover to Emergency Power.
- Next Power Outage… ;-) ;-)
  Turn on all flood lights, crank up Hi Fi,
  roll out the Beer and BBQ, invite neighbors to party!