NEVADA SOUTHERN RAILWAY

HEAD END POWER (HEP) CAR MANUAL

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Revised 10/4/17

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1.0 Overview

The Head End Power (HEP) Car provides 480 Volt 3-Phase 60 CPS (Cycle Per Second) power to the train for the Air Conditioning/Heating systems. Each car has a transformer to provide 120/240 Volt power for functions such as lighting and the Public Address system. There are two Generator Sets used one at a time - a Generator Transfer Switch selects which generator will be supplying Train Power. Each Genset consists of a Cummins NTA-855-C diesel driving a generator - a 180 KVA ONAN generator on the west (Number 1) Genset and a 250 KVA KATO generator on the east (Number 2) Genset.

Train Power supplies the transformer in the HEP car which provides 120 VAC for interior lighting, two interior receptacles, and external 120 VAC and 240 VAC receptacles.

The Gensets share the fuel tank and the batteries. When starting a unit, make sure that the fuel valves for the other unit are off (right angle to the pipe) or that the other unit is running. The 24 Volt (2x 12V) batteries are recharged from the train power, so running a generator without engaging the Generator Transfer Switch does not recharge the batteries. Once the Generator Transfer Switch has been engaged, make sure that the indicator light on the charger is on - the unit could have been unplugged.

The power on the train is used for ceiling fans, air conditioning compressors, air handler blower motors, ADA car water pump motor, Dining car refrigeration motors. These motors do not take kindly to low frequency nor low voltage - they tend to get hot (as do the transformers in each car when the frequency gets low). Putting the generator from RUN to IDLE lowers both the frequency and the voltage. Remember to have the **generator in RUN before engaging** the Generator Transfer Switch, and the have the Generator Transfer Switch **set to NEUTRAL before putting the generator to IDLE.**

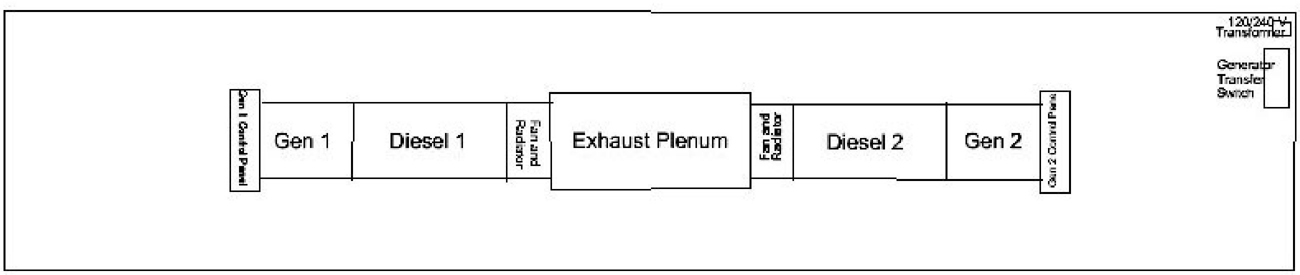
The hand brake for the car is a wheel type on the east end of the car. It can be released from the ground using the release lever on the left (“south”) side of the car. It can be applied either from the doorway of the HEP car or from the doorway of the following car. There is a link on the chain painted white. It does no good to apply beyond this point, but it does make release more difficult.

The night lights (emergency type lights) have internal batteries and are recharged when there is Train Power. They are plugged into the same receptacle as the battery charger, and have red led indicators that should be on when Train Power is present. Once Train Power is off, the lights turn on when either door is open.

2.0 Box Car

The box car #9100089 was obtained from the Union Pacific Railroad and was modified to provide electrical power to the train. The modifications include man-access doors at each end, a fuel tank, side air vents, installation of two gensets, and construction of a central air plenum for the gensets' radiators.

Built	May 1948
Fuel tank Capacity	300 Gallons (260 Practical)
Height	14 Inches (to fill "eyeball", overflow tube height)
Length	96 Inches
Width	48 Inches
Hand brake	Wheel with handle release
Height exterior	15'
Height interior	10'
Length interior	41'
Length overall	45'
Weight car	est. 40,000 pounds (without gensets)
Weight total	est. 50,000 pounds
Wheel bearings	BRENCO 5½ x 10
Width exterior	10'
Width interior	9'



Exhaust plenum is open to the air through the roof.

3.0 Diesel Engines

The engines used for the gensets are Cummins Model NTA-855-C. Use Cummins Bulletin 3379052-07 for complete maintenance instructions.

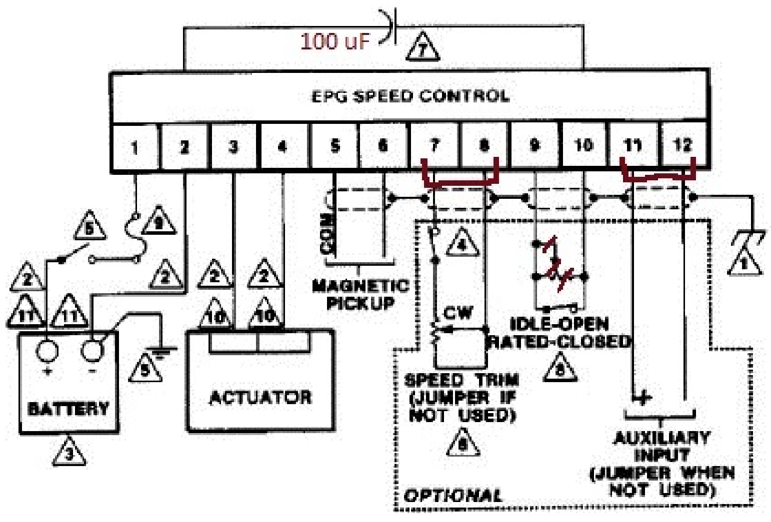
Weight	Approx. 3,000 pounds		
Power	280 HP @ 1,500 RPM (we run 1,800 RPM)		
Oil Capacity	9 Gallons (approx)	SAE 15W-40 CJ-4/SM Heavy Duty Diesel Engine Oil	
Water Capacity	22 Gallons (approx) use 25% GREEN anti-freeze or pre-mix		
Filters Air	CarQuest	#88649 Change/clean	6 mo. or 250 hrs.
Fuel[1]		#86210	6 mo. or 250 hrs.
Fuel[2]		2x #86115	6 mo. or 250 hrs.
Oil		#85970	Bi-Annually or 1500 hrs.
Water		#89073	Annually ~ 22 Gallons

Note 1: Single filter between the tank and the distribution valves
Note 2: Double filters on each engine

In normal operation, the gensets use about 20 gallons of fuel per day. This can increase on very hot or very cold days (air conditioning or heating).

The engines are water cooled by Stuart Radiator model 9133800-B radiators. The fans are belt driven - each fan has three GATES # K060436 pump belts. Air intake is from room-ambient and is exhausted into the central plenum. The non-pressurized water tank is 9.5 in. wide, 36 in. long, and 10 in. high, a maximum capacity of approximately 15 gallons. The water level should be maintained between at least 1/3 full to a maximum of 2/3 full (10 gallons). Approximately 12 gallons are needed for the engine block and lower tank. Coolant water should contain at lease 25% antifreeze (green, such as DEX-COOL).

The governor is a Woodward 8290-184 EPG (Electrically Powered Governor). Use Woodward Manual 82329J and model 524 for our 24 volt system. Page 3 Figure 1-2 Wiring Diagram (Isochronous EPG) is the diagram corresponding to our installation. Two options have been implemented and two have been jumpered. Pins 7 and 8 are jumpered - the SPEED TRIM option is not needed since the RATED (or RUN) speed control is a 25-turn potentiometer that provides sufficient resolution for our application (no need to synchronize with another generator). Pins 11 and 12 are jumpered - no auxiliary input is needed. The RUN/IDLE switch on the side of the control panel is wired to pins 9 and 10 - the potentiometer option for a fast idle is not necessary since by procedure we allow a sufficient warm up time. The capacitor from pin 2 (ground) to pin 10 was implemented as 100 uF to give a two second ramp time (from idle to full throttle) to minimize overshoot (since we start in a no-load configuration) - the capacitor is in the control cabinet wired from system ground to the high side of the RUN/IDLE switch. The magnetic pickup has an out put of approx. 1.3 KHz at idle and approx. 3.5 KHz when generating at 60 Hz.



The four adjustments are:

Start Fuel Limit, Gain, Stability, Rated Speed (frequency adjust).

"When the prime mover starts [is in RUN mode], slowly turn the gain pot back and forth to observe high and low frequency oscillation. ... Eliminate oscillation by slowly turning the gain pot for the stable region between high and low frequency oscillation. If oscillation does not stop at the high-low crossover, turn the stability pot slightly counterclockwise and slowly readjust the gain pot. Continue adjusting the stability pot slightly counterclockwise followed by readjusting gain until the prime mover runs at a steady speed. ... By turning gain slightly clockwise and stability slightly counterclockwise, or vice-versa, it is possible to maintain stable speed and vary transient response."

Caution: It is difficult to achieve stable operation unless a load is applied.

The arm from the Electric Actuator to the Fuel Control has lubrication fittings on each end that should be greased annually.

The two 12 VDC batteries should be serviced annually - check water, clean and seal terminals.

We have had one verified (and an additional probable) failure of the controllers from heat (see Appendix B). A 24 VDC fan was added by each unit to increase air flow through the unit's side vent slots. In order to maintain the warranty, no modifications were made to the controller.

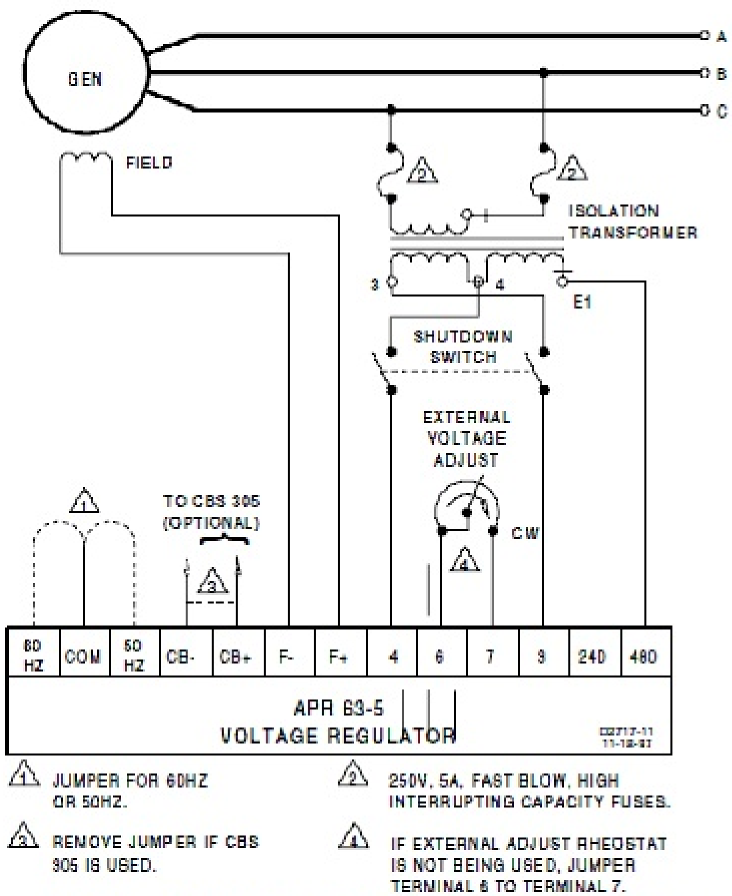
4.0 Generators

The generators sets were obtained as government surplus. Each engine weighs about 3,000 pounds, and each generator weighs about 2,500 pounds.

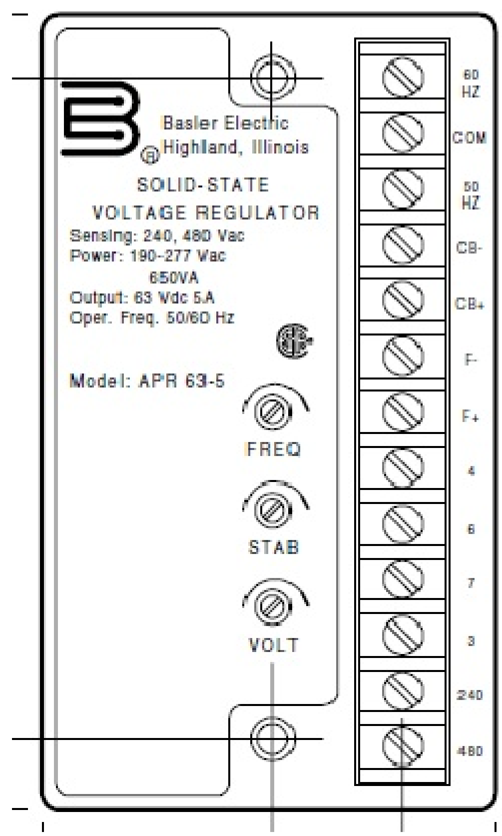
Generator 1 (at the front of the car) is an ONAN Serial Number 0475940804, Model150.0 DYG-15R/158490, 187 KVA, 480 VAC 3-phase, delta output. The output circuit breaker is 225 Amps.

Generator 2 (at the rear of the car) is a KATO Serial Number 8241, 1800 RPM, Model 200-463361111, Type 19567, 200 KW, 250 KVA, 200 Amp, 480 VAC, 3-phase, delta output. The output circuit breaker is 400 Amps.

The voltage regulators are Basler model APR 63-5



Isolation Transformer Interconnection Diagram



Hours meters -	Jan 2014 times	Jan 2015	Jan 2016
Genset 1:	01255.1 Hrs.	01610.	02011
Genset 2:	01120.5 Hrs.	01422	01763

It is recommended that Genset1 be used on odd number days, and Genset 2 be used on even number days. This will help even the wear between the units.

5.0 Electrical

The delta three phase 480 VAC outputs from each of the generators are brought to the Generator Transfer Switch (**there are no fuses or circuit breakers in the transfer switch**). Each generator has a three phase breaker - 225 Amps on Generator 1 and 400 Amps on Generator 2. The source of Train Power output from the panel can be selected as Neutral, Gen 1 or Gen 2. The Train Power cable to the preceding and following cars are three conductor CADILLAC connectors, male at the front and female at the rear - this allows the HEP car to be at either end of the train.

Train Power is also brought to a 15 KVA transformer in the HEP car to provide 120/240 VAC to a breaker box (to the left of the Generator Transfer Switch) for distribution locally. The front (west) end of the car has exterior 120 VAC and 240 VAC receptacles. There are two interior 120 V receptacles - one by the back (east) door and one under the central air plenum on the left (south) side. The one under the plenum provides power for charging the generator's batteries and for charging the batteries in the night (emergency) lights.

The starters for the generators are 24 VDC, and the governors (controllers) for the generators also run on 24 VDC - two 12 V batteries are located under the air plenum on the right (north) side. Each of the night lights has an internal 6 volt ("Emergency Light") battery - their operation does not draw any power from the starter batteries.

The night lights are modified emergency lights. Each has its own internal 6 volt battery so that no residual load is placed on the starter batteries. Normal emergency mode is for the lights to come on when AC power is lost and to remain on until power is recovered - which would drain the batteries every night, in our operation. Solid State relays were added on each light between the internal control relay and the bulbs so that the internal relay has to be in the on position and the solid state relay has to be energized for the bulbs to come on. One of the lights was modified to provide output from the 6 volt battery (through a series resistor) which goes to the two magnetic door switches. When the door opens, the magnetic switch makes contact and provides energizing power to the solid state relays - the solid state relay on the second unit is paralleled to that on the first unit.

Appendix A: Generator Startup/Shutdown Procedures

STARTUP

Photographs are included as Figure references for some steps. They can be found at the end of the Appendix.

1. Determine which of the two generators will be used. Only one should be run at a time. It is good practice to equalize the use of the two generators - unless there are other reasons for selecting a particular generator, use generator 1 on odd number days and generator 2 on even number days.

2. Check the fuel level in the sight glass outside on the under frame of the car. Fig 1. When the bottom half of the sight glass is full, there is enough fuel for two days. When it indicates some fuel (about half of the lower glass), there is enough for one day.

3. Do a visual inspection to look for any obvious leaks such as water or oil on the car floor. This would be an indication of a cooling system leak. Do not start any generator that has a serious leak problem. If during a run, the generator stops and you see water or oil leaking, don't attempt a restart.

4. Check the water level using the wooden dipsticks. Should be at least 3 inches of water showing on the bottom of the dipstick. The ADD line is at this 3-inch level. Fig 2. A supply of coolant, pre-mixed with anti-freeze is kept in the blue water jug. Fill at least to the middle of the tank or all the way to the bottom of the FILL line - do not overfill. Approx. 3/4" per gallon.

5. Check the oil level and add if necessary. Fig 3. A supply of SAE 15-40 oil is kept in the gray cabinet at the end of the car. Approx. 1.5 gallons from LOW to FULL.

6. Set the Generator Transfer Switch to the center NEUTRAL position. Fig 4

NOTE: This switch must always be in the center NEUTRAL position when connecting or disconnecting the power lines between the cars, or when the generator is in idle.

FAILURE TO DO SO COULD CAUSE SERIOUS INJURY TO PERSONNEL OR TRAIN EQUIPMENT.

7. Open (handles in line with the pipes) the fuel shut off valves, both feed and return. Blue for generator 2 and red for generator 1. Fig 5.

8. Set the Manual/Off/Auto/Test switch to Manual. Fig 6

9. Make sure the Emergency Off switch is pulled out. Fig 6

10. Set the idle/run switch to the idle position. In (or down) is idle - Out (or up) is run. Fig 7

11. Start by pushing the Manual Start Button. Should start within a few seconds. Do not crank for more than 30 seconds. At the end of the 30 seconds, if the engine doesn't start, wait 1 to 2

minutes before attempting another start. In cold weather, spraying starter fluid (ether) into the intake filter. If the generator does not start after the third try do not attempt additional starts and notify the conductor. Fig 6.

12. After start, immediately check to make sure there is oil pressure on the Lube Oil Filter Bypass Gauge. Fig 8.

13. Let the generator idle for at least 5 minutes. Then when the water temp has reached 100F, the run/idle switch can be set to run. On cold days, even if the temperature has not reached 100F, the generator can be switched to run after 10 minutes. Fig 10 and Fig 7

14. Check electrical output meters. They must be 480 Volts and 60 cycles respectively. There must be a load on the system for accurate current readings. Cars circuits must be on.
Fig 9.

15. Set the Generator Transfer Switch from the center NEUTRAL position to the running generator. The up position is for the Number 1 generator and the down position is for the Number 2 generator. Fig 4.

NOTE: The Generator Transfer Switch must always be in the center NEUTRAL position when connecting or disconnecting the power lines between the cars, or when the generator is in idle.

FAILURE TO DO SO COULD CAUSE SERIOUS INJURY TO PERSONNEL OR TRAIN EQUIPMENT.

15. Check that engine gauges are in the proper engine running ranges as marked on the gauges. Fig 10.

16. Check that the indicator light on the battery charger is on.

SHUTDOWN

1. **Before setting the generator to idle**, set the Generator Transfer Switch to the center NEUTRAL position. Fig 4

2. Push the idle run switch into (or down to) the idle position. Allow the engine to run at least 5 minutes in idle to allow the engine and turbo to cool properly. Fig. 7

3. Set the Manual/Off/Auto/Test to Off. This will stop the generator. Fig 6

4. Turn the fuel valves to off position (handles at right angles to the pipes) for both feed and return lines. Fig. 5

Figure 1. - Fuel Tank Sight Glass

Figure 2. - Water Level Check

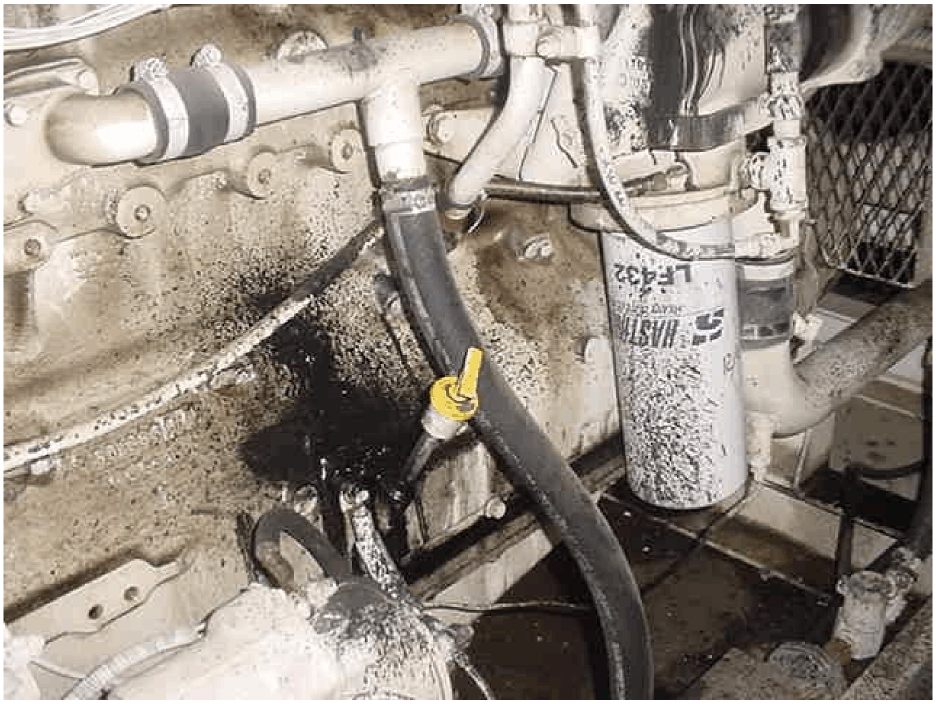


Figure 3. Oil Check

Figure 4. – Generator Transfer Switch

Figure 5. Fuel Shutoff Lines and Valves

Figure 6. Control Panel – Left Side

Figure 7. Idle / Run Switch – Left Side

Figure 8. Lube Oil

Figure 9. Output – Volts / Cycles – Left Side

Figure 10. Operating Gauges – Right Side

Appendix B : Generator Failure Investigation Reports

Initial Installation

When GENTEC replaced the old analog (PID) controllers with new Woodward digital controller units, they had the controllers adjusted such that the throttle(s) were either at idle or at full throttle, often going into overspeed on startup. They apparently told Mike that this was how they were supposed to operate, and that no one should modify their operation. (With the old controllers, we would often hold the control arm in a fixed position to shorten the time for the controller to stabilize.) After several months of this type of operation, it was apparent that long term damage was probably occurring.

A reading of the manual suggested a first problem. Since the analog controller was directly replaced by the digital controller, the digital unit was jumpered to begin RUN (“RATED”) mode as soon as power was applied. The controller interprets the application of power as going into the Engine Start mode, and opens the throttle to FULL ON (sometimes going into overspeed before the controller could correct). This triggered an oscillation which often did not stop. The wiring was corrected to allow the application of power when the engine is started, with independent selection of RUN mode. The idle mode speed control option was jumpered because it malfunctions in cold weather when not all cylinders start at the time.

A second problem was that the controller response to transients was so quick that changing loads (e.g. an air conditioner or a heater cycling on/off) could trigger oscillations. A 100 uF capacitor was added to enable the ramp rate control function, which smoothed out most of the transients.

Other actions taken included changing the ratio on the drive linkage to desensitize the throttle to movement of the actuator, and the lubricate the linkage to reduce hysteresis. (Before these corrections were made, rubber bands were used in various combinations to judge their effect - preload positive or preload negative direction).

First Controller Failure

Approximately nine months after the initial installation, the controller on Gen2 would not stabilize, and soon went to no function. It was still under warranty, so it was removed and sent in for warranty repair. Drake Controls chose not to do the repair and sent the unit to the factory for analysis. The factory concluded that there had been “unauthorized soldering” on the circuit board, and therefore would not honor the warranty. The case had never been opened by either GenTec or us. But because of all of the rough operation initially, it was decided not to dispute the findings, and to swallow the cost of a new unit.

Second Controller Failure

Again almost a year later Gen 2 began “running funny”, and there was a slight “fried electronics” smell. This newest controller was under warranty. This time, Drake Controls performed the repair under warranty and confirmed that the output drive stage had failed. Both controller failures appeared to be heat related (even though our environment is within the operating specifications. External 24 VDC fans were mounted adjacent to air slots in the Woodward controllers to get some air movement, but not (open or) modify the Woodward cases. A later maintenance action added a a suggestion as to why both failures were Gen 2 - Gen 2 was running about 30 - 40 degrees F hotter than Gen 1 (since corrected with through service of the Gen 2 radiator). The hotter ambient air around Gen 2 might have allowed a hot spot to develop in the area of the output drive transistor/FET.

Generator 2 Failure

Near the end of December 2014, Gen 2 went to over 600 VAC (nominal 480 VAC, meter only reads to 600) and. tripped its internal 400 Amp circuit breaker. This overvoltage burned out the voltage meter on the panel (since replaced) and has had intermittent "too low" readings on the frequency meter. Proper operating frequency has been verified with an external meter. On restart, the Bessler voltage regulator
was stressed, was able to adjust the field voltage but does not drop control at low frequency as it should. This means that there is output voltage being generated even though the generator is at idle. The probable cause of the failure was incomplete engagement of one of the contacts in the Generator Transfer Switch. Evidence of arcing supports this theory. Also, the voltage regulator instrument transformer (provides the voltage level feedback) works from just one phase, so loss of that phase could cause the regulator to try to increase the output voltage - explaining the 600+ volt surge.

The contacts in the Generator Transfer Switch were regapped, a cable that could cause some interference with the switch actuator arm was moved, and the contacts were coated with a copper lubricant-antioxident. At the annual training, all crew were reminded to give the Transfer switch an extra shove to make sure that the contacts are seted properly.

HEP Car August 2014 "failure"

On Saturday August 30, 2014, Gen 2 was started and put on line. It remained operational for about two and a half runs, then shut down. The sight glass showed fuel. Gen 1 was started and put on line for about forty five minutes, then it also shut down. Saturday evening, verified (with a stick in case the sight glass was dirty) that the tank was at least one-third full, started each generator and let them run for about 10 or 15 minutes each. Gen 2 was a little more difficult to start, but both ran with no apparent problems. On Sunday, the first run went OK, but during the second run, both generators quit running.

Yes, we had run the tank dry - despite the indication on the dipstick. Removed the sight glass, cleaned it, realigned its indicator stripe with the view windows, changed the water separator filter and the lead fuel filters on each generator .

HEP Car December 2016 failure

The oil level in Gen 1 was noticed to have an "overfill" (oil level above the HIGH mark on the dipstick). No one had recently added oil. By smell, it was suggested that the oil was contaminated with diesel fuel. The oil was drained down to a normal level and the generator was run for a couple of hours - the oil level increased. The generator was taken out of service and a sample of the oil was sent for analysis. The test confirmed the problem - the oil sample was 4% fuel.

September 2017, it was confirmed that one injector was bad and that two others were suspicious. All six injectors were replaced. When the generator was to be put on-line, there was no output. One (of the two) 600 Volt 30 Amp providing voltage feedback to the voltage controller had failed. The fuse was replaced and the generator output was at spec. - no issues with the voltage controller - no cause for the fuse failure was found. As of 10/4/17, the generator has been in operation for eight hours with no problems indicated.

HEP Car July 2017 failure

Gen 2 was difficult to start - it just barely turned over, then caught and ran. A check of the battery voltage showed 18 Volts (should have been at least 24 V). With the generator on-line, the battery charger meter showed 0 Amps charge rate. Connections were check and all were in place. A 10 Amp 24 Volt charger was brought from the shop, clipped onto the terminals and immediately went to max charge rate. During the week, Gen 2 was again difficult to start, so the old battery charger was disconnected (suspecting that the failed unit caused some sneak-circuit discharge path) and the shop unit left clipped in place. Saturday Gen 2 started and ran all day. Some baking soda solution was used to clean the tops of the batteries (again to eliminate a potential source of sneak-circuit discharge). There was no opportunity to check battery water levels. Once the batteries were fully charged, there was a 7 amp draw from the charger (fuel pump, Woodward controller, throttle actuator use 24 V power). At the end of the day, the batteries were measured at about 27 Volts. Sunday morning, the batteries were measured at 27.2 Volts, a fully charged battery - confirming that there were no sneak-circuit discharge paths, and that all cells are operational (there would be about a 2 Volt drop per bad cell).

Caution: Another reason for the batteries to run down (especially if they need water) is having the engine running but the generator off-line. A generator needs to be on-line to provide AC to the charger to recharge the batteries, and to supplement the battery to run the equipment (fuel pump, etc.).