GE 23 TON SWITCH ENGINE

HISTORY

This switch engine was built in 1941 by General Electric. It passed through many hands, and ended up at a refinery near San Francisco Bay.

Through the years, the switch engine was updated by removing the 1941 Cummins diesel engine and replacing it with a Cummins NHC 250 engine built in 1974. Many modifications were made to the engine to adapt it to the switcher. At some point in its life, due to a poor design, the bell housing cracked, and the engine was idled.

It sat up at the refinery for many years, and in 2016, the engine was donated to the Santa Clara River Valley Railroad Historical Society. Because it had been idle for so long, mud dauber wasps had taken up residence and turned the cab into a mess. The electrical and engine compartments were also a mess with cobwebs and dirt.

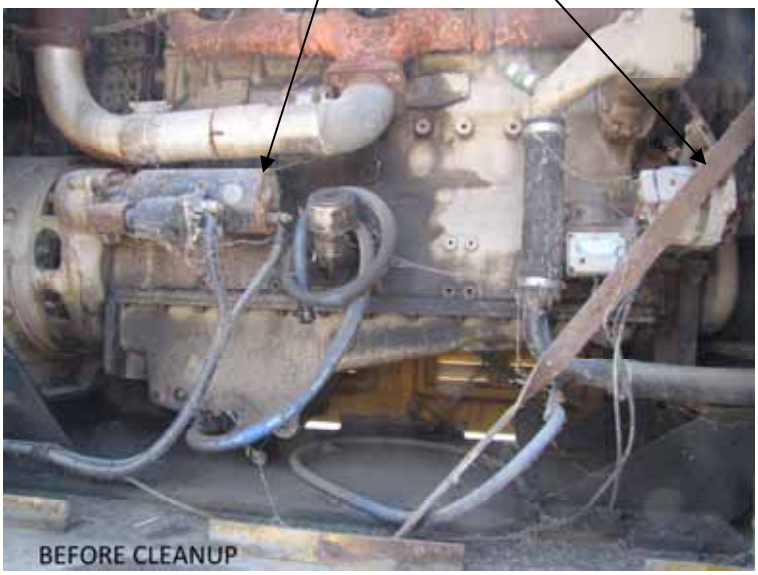
CONTROL PANEL

COMPRESSOR, MAIN SWITCH & GENERATOR

OLD 8 VOLT BATTERIES

LEFT HAND SIDE FILTERS,AIR CLEANER

RIGHT HAND STARTER, ALTERNATOR



We had a work party clean out all the mud dauber nests and remove the rusted floorboards. We also cleaned out a lot of the cobwebs.

DETERMINING THE ENGINE CONDITION

One of our first tasks was to remove the valve covers from the engine and see what shape they were in. Much to our surprise the rocker arms and pushrods were in good shape. We had half expected to see a pile of rust or sludge in there.

We removed the injectors and sent them to be cleaned and adjusted. We also poured some oil and transmission fluid into the cylinders to help loosen them. We also removed the starter and had it overhauled

OVERHAULED STARTER

What we did was all well and good, but we had to face the biggest problem which was the cracked bell housing. Our analysis of the problem was that the diesel engine was supported at the front, but relied on the bell housing to provide support for the rear of the engine. The bell housing was cast iron, and was not designed to handle that kind of stress, and eventually cracked on both sides, rendering the engine inoperable.

We designed an adjustable support for the rear of the engine, and installed it temporarily for a fit check. The results were very encouraging, as the cracks in the bell housing closed up!

We also found a 9/16 inch hole in the back of the engine (arrow) to which we can bolt the brackets. We put a wrench on the back of the generator, and we were able to turn the engine. It did take a bit of effort, but we realized we were not only turning the engine crankshaft, but also the generator rotor!

HAND BRAKE

In the meantime, we attended to another problem brought on by the inactivity of the engine and the close proximity to San Francisco Bay. The hand brake next to the battery box was frozen with rust. We moved the pawl and wire brushed the area around the gear. We then built a dam around the gear with plumber's putty and filled it with penetrating oil. We wire brushed the underside of the shaft and the plate holding the end of the shaft. We also applied penetrating oil at both places. Our plan is to let it soak for a while then try to move the hand brake. We will also try jacking the shaft from the bottom to break it loose. If all else fails, we may have to use a torch.

After dealing with the hand brake, we squirted the door latches on both sides of the engine as well as the electrical cabinet latches with WD-40 to free them up.

AIR BRAAKE SYSTEM

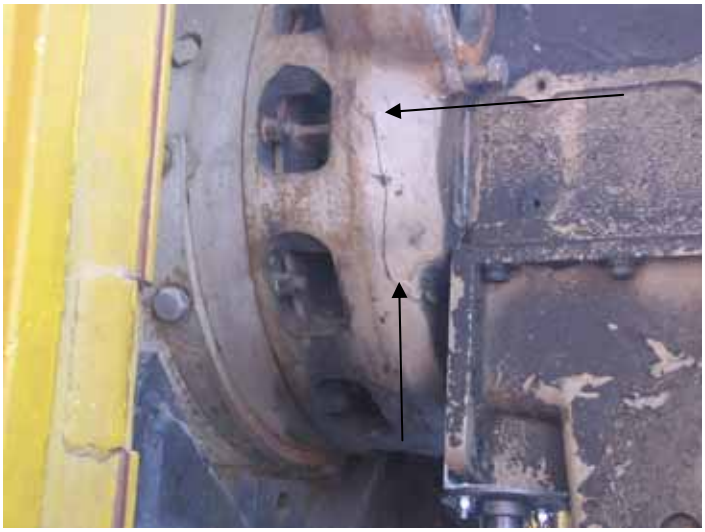
The 14E1 dual brake controller was replaced with two different brake controllers. In place of the 14E1, there is an SA-2 brake controller. This controls the brakes for the switch engine.

There is a panel mounted SA-9 brake controller that controls the air to the other train cars.

The SA indicates a straight air system where the air activates the brakes. In present systems, the air holds the brakes off, and releasing the air activates the brakes.

BELL HOUSING REPAIR

We sent the photos of the bell housing to Lock n Stitch to get a quote on them coming here and making a permanent fix. I received a response from Lock n Stitch requesting the length of the cracks and the material thickness. We made the measurements, sent the data to them.



We received a response that they were worried that someone had welded the bell housing and painted over the welds, and it hardened the cast iron so they could not drill it. They requested that we wire brush the areas to remove the paint and send them photos so they can see if it had been welded.

We wire brushed the areas with a wire wheel and were able to get some good pictures of the bare cracks. We forwarded the pictures to Lock n Stitch for them to give us an estimate.

We got an estimate from Lock n Stitch, but it was so far outside our budget that we could not agree to their estimate.
However, before we do anything we have to secure the rear engine mounts. We will match drill 9/16 holes in the brackets to line up with the holes on the back of the engine. We will then bolt the brackets to the rear of the engine with 9/16 bolts, lock washers, and nuts for a permanent installation

We need another method of securing the cracks before we try to start the diesel engine. I have an idea for a much simpler version of what Lock n Stitch proposed. My proposal, after we get the final installation of the engine rear supports completed is the following:
1. Drill and tap 1/4-20 holes on both sides of the cracks in the bell housing.
2. Install 1/4-20 threaded screw eyes in the holes.
3. Put a 1/2 inch bolt with washers, lock washer, and nut through the screw eye pairs
4. Tighten the bolts to secure the cracks closed.

This is basically what Lock n Stitch would do, but a lot cheaper.
We plan to start on the right side, as the crack is smaller. Because of the thickness of the bell housing, we will have to use plug in electric drills rather than cordless. We downloaded advice on how to drill and tap the cast iron bell housing, and will use plenty of cutting oil both on the drill and the tap. The drilling should go fairly quickly, but tapping the holes will take a lot more time. According to the article I downloaded, we will have to back the tap out frequently to clear the chips.

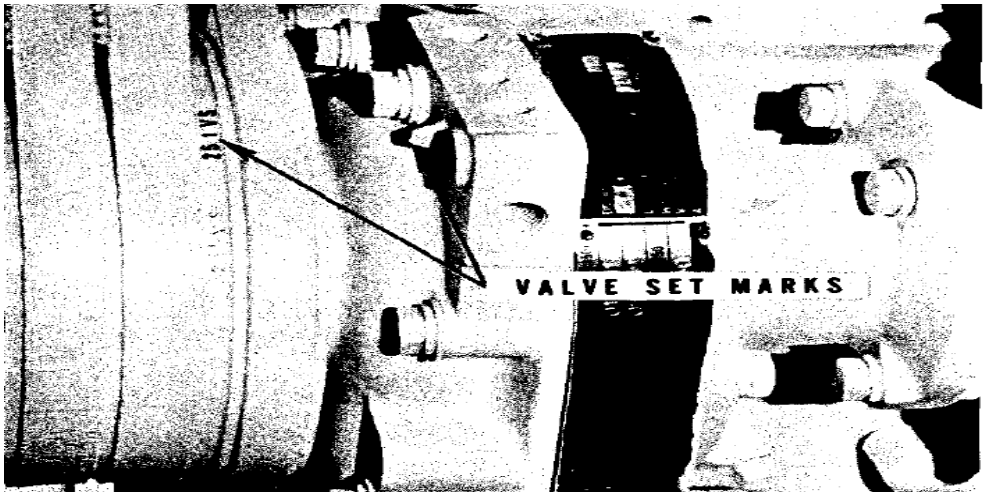
It turned out that the most difficult part was drilling through 3/4 of an inch of cast iron. The actual tapping of the holes was far easier, even using the technique suggested. I believe since the taps were new, they were sharper.
Our next step is to repeat the process on the left side of the engine. Because the crack is longer, we will install 3 sets of eyebolts and 1/2 inch bolts.
Jim brought some high speed metal only drills. That along with using a powered drill made the drilling go faster. The tapping took longer because of the limited access and interference from other parts of the diesel.
We are finally done and we feel the bolts will hold the bell housing securely.

We also made an effort to turn the engine, to make sure there was nothing interfering because of the work we have done.
Below is a picture of Jim and Steve with the smiles of accomplishment.

A couple of people from the Fillmore & Western RR suggested a 50-50 mix of Marvel Mystery Oil and diesel fuel to get the hand brake loose. We will build a bigger dam around the gear and hope this works.

That will be the last thing we need to do before working on the diesel engine. To that end we have bought the following replacement parts:
Oil Filter
Fuel Filter
Air Filter
Fuel/Water Separator
Alternator
Regulator
5 Gals Diesel crankcase oil
Brake air pressure gauge
Ignition switch with keys
Two 12 volt type 31 truck batteries with 1000 cold cranking amps
Two foot long 2-1/4 inch wrench to turn the engine manually

Once we get the engine running, we can then deal with the generator, traction motor, and air compressor and all the relays and controls.
We will need a third battery to operate the relays and controls. We have been assured that the higher voltage is OK.
We also need to get the compressor checked out as well as the control valves. We will have the air gauge calibrated so we can check out the valves. We would like to get the brakes working before trying to move the engine with the generator. We want to have a positive way to stop the engine after we get it going!
GETTING THE ENGINE RUNNING
Today, since it cooled off some, we set about to Install the injectors and push rods. We got that done, but were a little confused as to whether we were missing pushrods for the injectors. We will have to do more research on that.
In the meantime, we had to look for the timing marks on the engine to set the injectors. According to the picture it was supposed to be on a pulley between two of the sheaves. Well after much looking and wire brushing, we found the mark! It was stamped into the edge of the first pulley instead of where the picture shows it. That was only half the battle, however because we had to find the corresponding set mark on the flange. Well instead of it being a pointer, it was a stamp like a maple leaf!



We finally got the injector links back from the overhaul company and installed them. We turned the engine and wire brushed the pulley. The other 2 timing marks were located, so we are good to go to set the injectors, I had to buy a new torque wrench, because the one we had was in foot-pounds, and the injector settings were in inch-pounds. We will also have to set all the valve clearances to specification.
We also bought a push button switch to energize the starter when we are ready. It will give more control that just touching 2 wires together.
We installed the batteries and the starter. We also connected the pushbutton to the starter solenoid. We pushed the button, and the engine turned over easily! SUCCESS!

PUSHBUTTON

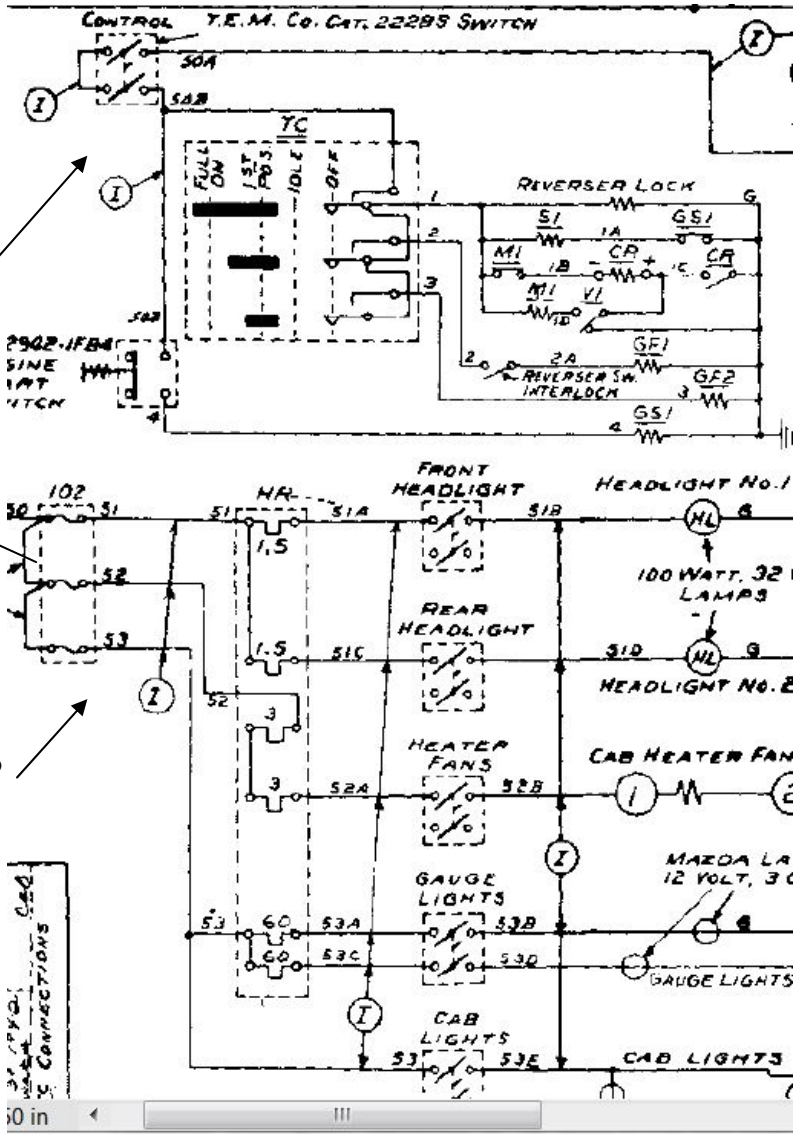
Today was a day of utter frustration. First we replaced the fuel/water filter only to discover that the new filter had different size threads than the old filter. After being unsuccessful in locating adapters, we drained the old filter and reinstalled it. We then took the filter element out of the new filter and put it in the old filter body, which was in good shape.
Next we removed the fuel filter by unscrewing it with the help of a pipe wrench. We tried installing the new filter only to discover that, even though it was the same part number, it was longer. We ended up removing the mounting bracket to screw the new filter in.

In anticipation of getting the engine running, we researched the original wiring diagram, which bears some resemblance to the way the engine is wired now. There is a series of toggle switches on the panel that are unmarked. In looking at the panel of a similar engine, we have figured out what the switch functions are. The first effort was to locate the Control Switch, which supplies power to the relays controlling the direction of the engine.

SWITCH PANEL

GE 2228S DPST SWITCH

10 AMP
FUSES



In further anticipation of getting the engine running, I went out to the electrical cabinet to check some voltages. When I threw the main switch, the voltmeter on the panel read 24 volts, which is what it should have read. I then proceeded to check the voltage on all 6 fuses, and they all read 24 volts. That is a good sign that this part of the wiring matches the diagram in the 1941 manual.

We went out and spun the engine with the starter. It almost sounded like it was ready to start. We got all the injectors adjusted, and reinstalled the air cleaner with a new filter. Surprisingly, the old filter looked in good shape, so we will keep it as a spare.

We temporarily installed a third battery to check out the electrical cabinet. We installed a big knife switch to select either 24 volts to start the engine or 36 volts to power the contactors. If everything checks out, we believe that the alternator will charge the 3 batteries.
Setting the reverser switch in the forward position, we advanced the throttle and heard the contactors operate.

TASKS

1. Install pushrods and injectors DONE
2. Adjust rocker arms to factory specifications DONE
3. Replace rocker arms cover gaskets and reinstall covers DONE
4. Reinstall starter DONE
5. Connect batteries to starter DONE
6. Replace air filter and reinstall air cleaner DONE
7. Replace fuel and fuel/water filters DONE
8. Replace oil filter DONE
9. Inspect all rubber hoses and replace as necessary DONE
10. Drain and refill radiator DONE
11. Drain crankcase and replace with 5 gallons of oil DONE
12. Get 5 gallons of diesel fuel and insert pickup tube into container DONE
13. Cross our fingers and try to start the engine IT STARTED!

We did cross our fingers and started the engine. It ran rough, spewing out all the oil we used to lubricate the cylinders. We also found a few fittings that were not tight enough and leaked some fuel, but we got those fixed.

I believe this is the first time the engine has run in decades. We still have to adjust the idle on the engine to keep it running. In checking the fuel shutoff solenoid, we discovered it had voltage on it, and we had the adjustment screw in the wrong position. We fixed that situation, and hopefully the engine will run next time we try.

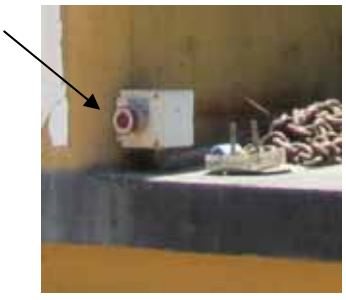
Because we are using 3 batteries that deliver 36 volts, we have to make provisions for powering the control circuits separately. Right now the alternator output and the battery fuse are connected to the main switch terminal. They will have to be rerouted to a switch in the battery box.

This was another day of frustration. After taking forever to drill a 1/2 inch hole through the steel of the cabinet, I tried to loosen the screw in the fuse block, but it is frozen. Jim suggested using WD-40 to loosen it.

All was not lost, however, because we were able to run the #8 wire from near the fuse block all the way to the battery box. It was run under some air piping as protection.

I was successful loosening the screws to the 50 amp and 25 amp fuses. I put a lug on the #8 wire and connected it to the 50 amp fuse. I pulled the on/off switch and the meter read 36 volts. When I tried to energize the contactors, they would not operate. I have a feeling that the batteries, which had been trying to start the engine, and have been sitting for months, lost their charge, so putting any load on them dropped the voltage too low.
I will have to go out and check the charge with a battery charger.
We got out the battery chargers, and found there was still a good charge on the batteries. We set the charger for medium charge of 5 amps and went to lunch to allow the batteries to charge. When we got back, the charge had tapered off.
For lack of anything else, I reconnected the lug that supposedly went to the alternator. It turned out it did not, but energized the contactors.
We then traced the wire from the alternator to the main switch. We disconnected it from the main switch and connected it to the 50 amp fuse block to charge all 3 batteries.
We then tried to start the diesel. It would run momentarily with ether, but then died. We feel there is a problem somewhere in the fuel system and will troubleshoot it next time we are there. We believe we have to bleed all the air out of the fuel lines, which is not that difficult.
We tried to see how voltage was applied to the fuel pump shutoff valve, and traced it as follows;

The -28 volts comes from the main switch (arrow) through a 30 amp fuse to a switch on the control panel labeled “pull to run”. From the other side of the switch, the voltage goes to an emergency switch on the right side of the engine. From there it goes to an emergency switch on the left side of the engine. The voltage then goes to the shutoff switch on the fuel pump



We were not able to find out why there was no voltage, but will have to check the fuse and the switches. In the meantime, there is a knob on the shutoff switch to bypass it, According to the manual, the knob must be turned clockwise to bypass the shutoff switch.

To bleed the lines of air, the fuel line will have to be loosened until fuel flows. The best access is from the right side of the engine as shown above. I disconnected the line from the engine and hooked up a plastic tube to it. That way I could see fuel flowing from the fuel pump as I cranked the engine.. Unfortunately, noting came out. I loosened the other end of the line at the shutoff valve and it was dry. I think the next step is to replace the shutoff valve.

Today was a semi-successful day. We troubleshot the fuel shutoff wiring and discovered that the fuse was blown. We removed the panel switch, and found a third wire going to a run time meter. The meter was shorted, which blew the fuse. Disconnecting the meter solved the problem.

We tried to diagnose the fuel problem. We removed the shutoff switch and verified it was working. Working backwards, we saw there was no fuel at the fuel input to the fuel pump. We tried priming it, and it sucked fuel in. but not enough. By that time we ran out of battery.

I will have to go out and put a 4 hour 8 amp charge on the battery shortly.

I purchased replacement fuses, plus a section of 1/2 ID tubing to prime the pump We also primed the fuel filter, as it was much larger than the same part number that we replaced.

After a 4 hour charge, I turned the engine over and got some fuel in the cup, which told me we had fuel up to the engine. I reconnected the fuel line to the engine and tried to start it. It turned over, but did not start. I think we may need some ether to get it going.

TASKS

1. Install new starter key switch DONE
2. Reinstall cover over engine DONE
3. Reinstall muffler DONE
4. Check for lead based paint DONE
5. Move alternator output wire to 36 volt fuse from 24 volt switch. DONE
6. Connect input to 50 A fuse to a switch in the battery box DONE

7. Charge batteries DONE
8. Bolt 36 volt knife switch to side of battery box DONE
9. Check compressor oil DONE
10. Reinstall compressor belts DONE
11. Replace air pressure gauge DONE
12. Check whistle thread 3/8 NPT DONE
13. Troubleshoot fuel system. DONE
14. Fill up diesel fuel can
15. Try to start engine with ether
16. Adjust engine idle
17. Check throttle response
18. Check oil pressure
19. Set switch in reverse and advance throttle to see if engine will move
20. Check air pressure

Once we verify that the engine will move, that will end our efforts on the switcher. We have spent 2 years and many thousands of dollars getting it to this point. Jim and I had a great deal of fun working on this project together, but Jim's Parkinson's prevents him from working on the engine anymore and I cannot do it alone, if only for safety reasons.

For those reasons we are turning the balance of tasks over to others in the Railroad Society, especially ones younger than my 82 years.

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One of our society members came up with a great idea. Instead of running the switcher over to the Railroad's service pit, We can remove the planking on the turntable rails and use that as a service pit! That way we are on society property and not interfering with the Railroad.

The fuel tank will have to be drained and flushed, and new fuel added.

The chain drive will have to be lubricated, and the chain oilers have to be adjusted. Next, we can see if we can stop the engine with the air brakes. Also the wheel bearings and lubrication will have to be checked.

Once that is done, the Society will have an operational switch engine, capable of running on the main line. Once it gets out of the turntable area, it can be put on the main line. It would be great to take it out and run it east to the town of Piru, some 10 miles.

In the mean time, looking forward to a point after the switcher gets going, we want to deal with the cosmetics of fixing rusted out places and eventually painting the engine. We ran a test on the paint, and unfortunately, it is lead based. However, we found a company named Ecobond that makes a paint that will seal the lead paint. That will certainly be less expensive than trying to remove the paint. I also found that we can fix the rusted out places by welding new pieces in. The Ecobond will encapsulate the lead based paint so the rust can be sanded off.

Cummins ESN 10305171