Exhibit E - Part 3

6.3 CV 95 Reverse Trim

Reverse Trim specifies a scale factor by which a voltage drive level should be multiplied, when the controller is driving the unit in the Reverse direction.

Default Value: **128**

CV 95: Reverse Trim Registers

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
D7	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**

- Trim factor preserves the same curve shape as specified in the speed table but allows a simple multiplying factor to scale it larger or smaller for "trimming" its speed behavior in Reverse. This allows making fine adjustments to match the speed of other engines, and to match the engine's Forward speed characteristics.
- The multiplying scale factor is n/128 where "n", the Reverse Trim Factor, can be any number entered into CV 66 from 0 to 255.
- If Reverse Trim Factor is "0", then Reverse Trim is not implemented.
- If Reverse Trim Factor is between 1 and 128 than the voltage applied to the motor is decreased by a multiplying factor that varies from .00775 to .99225.
- If Reverse Trim Factor is between 130 and 255 than the voltage applied to the motor is increased by a multiplying factor that varies from 1.0078 to 1.977.
- CV 95 only applies if the speed tables are activated in CV 29 by setting bit 4 =1.

Appendix I

Sounds Available Under DCC Operation

Steam Sounds

1.1 Automatic Sounds

Steam Chuff: The familiar steam chuff comes from steam exhausted from the steam chest through the smoke stack, which creates a powerful draft to feed the fire. QSI Quantum chuffing produces four distinct chuff sounds per drive wheel set, a rhythm recognized by all steam fans. Our software allows the chuffs to partly overlap to create a more realistic effect; one chuff sounds does not need to terminate before the next one begins.

Articulated Chuff: The Quantum System has two sets of steam chuff sounds that will go gradually in and out of synchrony as the engine moves around the layout. Most prototype articulated locomotives had less weight over the front engine, which resulted in more slippage, causing the two engines to run at slightly different speeds.

Blower or Steam Engine Hiss: The steam from the steam chest venting through the smokestack also draws air through the firebox, keeping the fire healthy. When the engine is sitting still, blowers are often turned on to vent the steam and maintain the draft as well as keep smoke out of the engine cab. The blower sound on Quantum Steam Engines is a continual steam hiss heard in Neutral.

Air Pumps: Air pumps come on whenever air is used. After a Long Air Let-off in Neutral, usually signifying the operation of the power reverse, you will hear the pumps start up at maximum rate to replace the air lost from the reservoir. Once the pressure is up, the pumps only turn on occasionally to maintain pressure.

Air Release: Compressed air is used on engines for the braking system and for operating various appliances like the reversing mechanisms common on large steam engines. When a large steam engine comes to a stop, you will hear a Long Air Let-off released as the power reverse as it is placed in the center Neutral Position.

Brakes: Brake squeal on prototype locomotives is usually most noticeable when the wheels are just about to stop turning. Listen for brake squeal sounds as the Quantum engine slows to a stop.

Steam Pop-off: If there is too much steam in the boiler, special pop-off valves or "safeties" on top of the engine release the excess pressure in a fury of hissing sound. This happens most often when the engine is sitting still, since the fire continues to build up steam that is not used. The Quantum pop-off sound comes on for random lengths, at random times in Neutral.

Steam Water Injector: The water used to make steam is replaced by water injectors at high pressure, to overcome the elevated pressure in the boiler. The sound of rushing water and steam hiss ends with a distinctive valve shut off. This sound comes on for random lengths of time and occurs randomly when the locomotive is in Neutral.

Steam Boiler Blow Down: As water evaporates, minerals and other residues settle to the bottom of the boiler. The fireman opens a valve to vent this material through a large pipe under the side of the cab onto the ground. Quantum's blow down sound occurs completely at random for undetermined lengths of time when the engine is in Neutral.

1.2 Controllable Sounds

Whistle: The whistle has a distinctive start up followed by a steady whistle sound, then enters an ending sound effect immediately after you stop the whistle signal. Use the whistle Function Key to produce any combination of long or short blasts, and the whistle will react properly. Quantum Sound also includes a short hoot that is shorter and more appropriate than using the normal whistle start up followed by the end effect. You can now produce series of short hoots before starting out or for signaling.

Bell: The bell on steam engines may be either hand pulled or pneumatic depending on the size of year of the locomotive. Pull bells have a distinctive ding-dong sound as the bell moves towards and then away from the observer. With pull bells, you can sometimes hear the squeak of the bushings as the bell swings to and fro. Mechanical bells used a pneumatic clapper and produced a very regular striking pattern. The bells on steam engines are loud, because they are mounted high up on the locomotive. In addition, some bells made during World War II were manufactured from steel rather than brass. You can tell the more harsh sound of the steel bell from the more melodic sound from brass bells. Quantum uses a variety of different bell sounds from hand pulled, pneumatic, steel and brass bell types.

Doppler Run-by: Instantly recognizable, the engine sounds get louder as the train approaches, then immediately drop to a much lower pitch and lower volume as the train passes by. With a little practice you can change the pitch exactly when and where you want.

The QSI patented Doppler Run-by responds to the speed of the engine, so the sounds change more dramatically when the engine is running faster. After the Doppler shift has occurred and the whistle is no longer being blown, the locomotive's volume and sound pitch subtly return back to normal.

Flanges or Extended Brakes: When a train enters a curve, the flanges on the wheels tend to ride up on the inside of the rail and squeal. Recreate this squealing effect by pressing and releasing the Brake Sound Function Key button quickly and repeatedly as necessary. Or for slow stops, use the same function key to produce long protracted squealing brake sounds.

Air Brakes: When prototype train brakes are applied, air is released from the brake lines to reduce the pressure. The more the pressure is reduced, the greater the braking. You will hear a continual air release sound from the Steam Locomotive model as braking is continually increased. The longer the air is released, the quicker the locomotive model will slow down. Once all the pressure is released, the engine will continue at maximum braking which can still require a long stopping distance depending on your Load settings.

Dynamic Brakes: Steam Locomotives do not have Dynamic Brakes. When steam engines are operated today, they are often coupled to a diesel to provide dynamic brakes on down grades. If a Quantum Steam Engine is coupled to a Quantum diesel, and Dynamic Brakes are activated, the diesel Dynamic Brake effect will start up and the Steam Engine labored chuffing will reduce at the same time. Since prototype dynamic brakes are relatively ineffective a low speeds, the Dynamic Brakes will shut off automatically below 8 smph and Steam Engine Chuff will return to normal.

Coupler Sounds: There are two types of coupler sounds in Quantum depending on the type of operation. When coupling up to rolling stock, hear the sound of an engine crashing into and pushing a string of cars. When uncoupling, hear the sound of the lift bar and coupler pin after backing up over a magnet to open the couplers. Hear the knuckle opening and the air brakes parting when moving from the uncoupled cars.

Locomotive Shut Down (Extended): The air pumps will turn off, followed by the sounds of Pop Off[118] Operating for about ten seconds and finally the Blower hiss will shut off.

Locomotive Start Up (Extended): The Dynamo will rev up while the Headlight comes on gradually, then the Cab Lights (if available) will turn on, followed by the air pumps, the Steam Blower will turn on and then the locomotive will enter normal operation.

118 Some Steam Engines may not produce a Pop-Off effect during shut down.

Diesel Sounds

2.1 Automatic Sounds

Diesel Motor Rev: Quantum allows Diesel Motors to be operated with all eight notches corresponding to the throttle notches used on the prototype. As the throttle is turned up, the Diesel Motor RPM will increase in fixed increments until the maximum RPM occurs at notch 8. All eight notches are evenly distributed between 0 and the maximum speed step.

Diesel Turbo: QSI diesels have a turbo effect – a very distinctive high whine. Turbo appliances are used to improve the engines horsepower by pumping air into the intake manifold under pressure. The power to activate the turbo motor comes from the engine exhaust pressure. QSI turbo sounds are separate from the Diesel Motor sound, which allows the turbo effect to lag the motor when the Diesel Motor is revving down or revving up, just like the prototype.

Cooling Fans: The enormous Diesel Motors and generators enclosed in the diesel cab need ventilation to stay cool. All diesel locomotives have powerful cooling fans on the roof to draw outside air through louvers on the sides of the locomotive. When cooling fans start, you will also hear the sounds of louvers opening. When cooling fans shut down, you will hear the louvers close.

Air Pumps: When an engine is sitting still, the pumps come on in a steady beat to replace the air lost from the brake air release or any other air operated appliances. Once the pressure is up, the pumps only turn on occasionally to maintain the pressure. Diesel Air Pumps are operated directly from the motor and are quite noticeable when turned on in a non-moving locomotive. In Forward, you will hear the air pumps come on soon after the horn is operated to maintain the air pressure.

Air Release: Compressed air is used on engines for the braking system and operating various appliances.

Brakes: You can hear the brake squeal on prototype locomotives when the engine is moving slowly and can become particularly loud when the wheels are just about to stop turning. Listen at slow speeds for constant brake squeal sound and the final distinctive squealing sounds as the diesel slows to a stop.

Quick Engine Start Up. All diesel engines have a quick start up and shut down effect when an engine is selected. Protracted turn-on effects are available when engines are in Total Shut Down (see Controllable Sounds below).

2.2 Controllable Sounds

Air Horns: The Quantum system uses authentic locomotive sounds whenever possible. The Quantum horn has been recorded from a variety of diesel engines. The number of chimes and the manufacturer usually characterizes air horns. Quantum horns include single chime horns found on early F units, as well as multi-chime horns more common on modern diesels. In addition, all diesels include a special short horn blast. If you blow the horn briefly, you will produce a realistic short horn sound or "hoot".

Bells: Diesels and electric locomotives, as well as larger steam engines, usually have pneumatically operated mechanical bells. Diesel bells can be as distinctive as steam bells. They are characterized by their tone, clapper rep rate and their location in the locomotive. In addition, it often takes time to get the clapper up to speed on the prototype or to shut down. When the Quantum bell is turned on in Neutral, you will hear the wheezy sound of the pneumatic clapper starting up before the bell starts to ring and you will hear the bell fade out with soft rings along with the Short Air Let-off sound associated with turning this appliance off.

Doppler Run-by: The engine sounds get louder as the train approaches, then immediately drop to a much lower pitch and lower volume as the train passes by. With a little practice you can change the pitch exactly when and where you want. Doppler shift is based on the speed of the engine, so the sounds change more dramatically when the engine is running faster. After the Doppler shift has occurred and the horn is no longer being blown, locomotive sounds return to normal.

Flanges or Extended Brakes: When a train enters a curve, the flanges on the wheels tend to ride up on the inside of the rail and squeal. Recreate this squealing effect by pressing and releasing the Brake Sound function key button quickly and repeatedly as necessary. Or for slow stops, use the same function key to produce long protracted squealing brake sounds.

Air Brakes: When prototype train brakes are applied, air is released from the brake lines to reduce the pressure. The more the pressure is reduced, the greater the braking. You will hear a continual air release sound from the diesel locomotive model as braking is continually increased. The longer the air is released, the quicker the locomotive model will slow down. Once all the pressure is released, the engine will continue at maximum braking which can still require a long stopping distance depending on your Load settings.

Dynamic Brakes: Electric motors can act as motors or generators depending on whether they are using power or generating power. When used as generators, the traction motors are disconnected from taking power from the locomotive's prime mover, and instead are connected to large resistor grids in the roof. By increasing the resistive load on the traction motors, the traction

motors become harder to turn and act as brakes for the locomotive. The electric power generated by turning the traction motors is dissipated as heat by the resistor grid. These resistor arrays get quite hot and require cooling. When Dynamic Brakes are turned on in the Quantum equipped diesel locomotive, the Diesel Motor sound drops to notch 1 and the Dynamic Brake cooling fan sounds come on. Since dynamic brakes are relatively ineffective a low speeds, the Dynamic Brakes will shut off automatically below 8 smph.

Coupler Sounds: There are two types of coupler sounds in Quantum depending on the type of operation. When coupling up to rolling stock, hear the sound of an engine crashing into and pushing a string of cars. When uncoupling, hear the sound of the lift bar and coupler pin after backing up over a magnet to open the couplers. Hear the knuckle opening and the air brakes parting when moving from the uncoupled cars.

Low Idle: Low Idle is used on prototype engines to maintain a warm and ready locomotive with a minimum of fuel consumption. The special Low Idle sound has a lower base throb and is less harsh than the normal idle.

Locomotive Shut Down (Extended): The air pumps will turn off, as will the Number Board Lights, followed by the sounds of the cooling fans shutting off, the louvers closing, the Diesel Motors shutting down and finally, the Engineer's door opening and shutting.

Locomotive Start Up (Extended): The engineers door will open and close, then the Number Board Lights will turn on, followed by vents opening, the two Diesel Motors starting up one at a time (if two motor diesel), the air pumps starting up, and the locomotive entering normal operation.

Electric Locomotive Sounds

3.1 Automatic Sounds

Traction Motor Whine: Although both diesels and electric locomotives have traction motors, electric locomotives do not have loud diesel engines drowning out the sounds of the traction motors. You will hear the traction motors when Electrics starts out, especially if the cooling fan volume is turned down to a lower value. Like the prototype, the Quantum traction motor whine pitch increases and decreases with the speed of the engine. It is not affected by track voltage, only the speed.

Cooling Fans: The electric traction motors get quite hot from the enormous current supplied to their circuits. All electric locomotives have powerful cooling fans that can create so much draft the access panel doors cannot be opened when the fans are operating at full power. It is not surprising that these fans can easily be heard in idling and operating engines.

Air Pumps: When an engine is sitting still, the pumps come on in a steady beat to replace the air lost from the brake air release or any other air operated appliances. Once the pressure is up, the pumps only turn on occasionally to maintain the pressure. Air pumps are electrically operated and are quite noticeable if the fans are turned down or off.

Air Release: Compressed air is used on engines for the braking system and operating various appliances.

Brakes: You can hear the brake squeal on prototype locomotives when the engine is moving slowly and can become particularly loud when the wheels are just about to stop turning. Listen at slow speeds for constant brake squeal sound and the final distinctive squealing sounds as the Electric Locomotive slows to a stop.

3.2 Controllable Sounds

Horn: The Quantum system uses authentic locomotive sounds whenever possible. The Quantum horn has been recorded from a prototype single chime GG-1 at a passenger station. All Quantum horns and whistles are engineered by our sound experts to give you the most authentic effects. If you blow the horn briefly, you will produce a realistic short horn sound or "hoot".

Bell: Diesels and electric locomotives, as well as larger steam engines, usually have pneumatically operated mechanical bells. With the Quantum Electric Locomotive bell was recorded from the prototype. When the bell is shut off, you will hear the bell fade out along with the Short Air Let-off sound associated with turning this appliance off.

Doppler Run-by: The engine sounds get louder as the train approaches, then immediately drop to a much lower pitch and lower volume as the train passes by. With a little practice you can change the pitch exactly when and where you want. Doppler shift is based on the speed of the engine, so the sounds change more dramatically when the engine is running faster. After the Doppler shift has occurred and the horn is no longer being blown, locomotive sounds return to normal.

Flanges or Extended Brakes: When a train enters a curve, the flanges on the wheels tend to ride up on the inside of the rail and squeal. Recreate this squealing effect by pressing and releasing the Brake Sound Function Key button quickly and repeatedly as necessary. Or for slow stops, use the same function key to produce long protracted squealing brake sounds.

Air Brakes: When prototype train brakes are applied, air is released from the brake lines to reduce the pressure. The more the pressure is reduced, the greater the braking. You will hear a continual air release sound from the Electric Locomotive model as braking is continually increased. The longer the air is released, the quicker the locomotive model will slow down. Once all the pressure is released, the engine will continue at maximum braking which can still require a long stopping distance depending on your Load settings.

Dynamic Brakes: Electric locomotives do not have Dynamic Brake sounds such as cooling fans. However, the Dynamic Brake function has been included to make the Quantum Electric Locomotive consistent with other Quantum equipped locomotives in a consist. If Dynamic Brakes are activated, the Traction Motor Sound-of-Power will reduce to the lowest setting since It would be inconsistent for an Electric Locomotive to be working at full Sound-of-Power while Dynamic Brakes are being applied to other locomotives within the same consist. When Dynamic Brakes are shut off, the traction motor sounds will return to normal Sound of Power. Since prototype dynamic brakes are relatively ineffective a low speeds, the Dynamic Brakes will shut off automatically below 8 smph.

Coupler: To give you the most authentic coupler sounds, QSI has identified three distinct types of coupler activity. The first is when the coupler is armed where you will hear the clanking sound of the coupler lift bar and coupler pin raising. The next is the coupler opening, with the hiss of the air-lines parting. The third is when the locomotive couples up to its load of cars, and you hear the crash as all the cars bunch together from the impact. DCC only.

Locomotive Shut Down (Extended when using the F9 Shut Down key): The air pumps will turn off, Cab Lights will turn off, followed by the sounds of the louvers being closed and the Engineer's door being opened and shut.

Locomotive Start Up (Extended when using the F6 Start UP key): The engineer's door will open and close, then the Cab Lights will turn on, followed by the air pumps, directional lights, vents opening and then the locomotive will enter normal operation.

Gas Turbine Sounds

4.1 Automatic Sounds

Diesel Motor Rev: The diesel used in the prototype was a Cummings 250 horsepower motor. Under diesel control in RTC or SC throttle mode, the Gas Turbine top speed is limited to 25 smph. Quantum allows the Diesel Motor to be operated over eight notches corresponding to the throttle notches used on most prototype diesels. As the throttle is turned up, the Diesel Motor RPM will increase in fixed increments until the maximum RPM occurs at notch 8. All eight notches are evenly distributed between 0 and the maximum speed step.

Turbine Whoosh: The Gas Turbine produced an almost deafening roar that seemed to drown out all but the horn. It was sometimes referred to as "The Big Blow" since its dominant sound was that of furiously rushing exhaust gas. We have modeled this effect by synthesizing this sound in the Quantum system until it sounded exactly like the prototype turbine. We have coupled this effect to our Sound of Power™ concept to provide labored Turbine Whoosh when the engine is under heavy load.

Turbine Whine: Although some witnesses to the prototype Gas Turbine maintain there is no Turbine Whine, such as the sound that a jet airplane would make. However, other witnesses say that there was a discernable whine as the turbine was revving up that could still be barely heard at idle. We have included a separate whine sound in the Quantum System, which can easily be heard during the transition from diesel to turbine sounds, and which is almost buried in the Turbine Whoosh sound when the turbine is "on the line".

Cooling Fans: The enormous diesel motors and generators enclosed in the Gas Turbine cab need ventilation to stay cool. All diesel locomotives have powerful cooling fans on the roof to draw outside air through louvers on the sides of the locomotive. When cooling fans start, you will also hear the sounds of louvers opening. When cooling fans shut down, you will hear the louvers close.

Air Pumps: When an engine is sitting still, the pumps come on in a steady beat to replace the air lost from the brake air release or any other air operated appliances. Once the pressure is up, the pumps only turn on occasionally to maintain the pressure. Air Pumps are operated directly from the Diesel Motor or from two electric motors when the turbine is "on the line". Air pumps are quite noticeable when turned on in a non-moving locomotive in Diesel Mode.

Air Release: Compressed air is used on engines for the braking system and operating various appliances.

Brakes: You can hear the brake squeal on prototype locomotives when the engine is moving slowly and can become particularly loud when the wheels are just about to stop turning. Listen at slow speeds for constant brake squeal sound and the final distinctive squealing sounds as the Gas Turbine slows to a stop.

Quick Engine Start Up. All diesel engines have a quick start up and shut down effect when an engine is selected. Protracted turn-on effects are available when engines are in Total Shut Down (see Controllable Sounds below).

4.2 Controllable Sounds

Air Horns: The horn used for the Gas Turbine is a single chime horn usually found on early F units. Some commercial videotapes of the Gas Turbine have dubbed a multi-chime horn in for sound effects and do not represent the actual locomotive horn. In addition, the Gas Turbine horn includes a special short horn blast. If you blow the horn briefly, you will produce a realistic short horn sound or "hoot".

Bells: Diesels and electric locomotives, as well as larger steam engines, usually have pneumatically operated mechanical bells. Diesel bells can be as distinctive as steam bells. They are characterized by their tone, clapper rep rate and their location in the locomotive. In addition, it often takes time to get the clapper up to speed on the prototype or to shut down. When the Quantum bell is turned on in Neutral, you will hear the wheezy sound of the pneumatic clapper starting up before the bell starts to ring and you will hear the bell fade out with soft rings along with the Short Air Let-off sound associated with turning this appliance off.

Transition from Diesel to Turbine and Ignition: Starting the gas turbine was a complex procedure which required considerable time for the turbine to be at full power. We have shortened the amount of time to start the turbine in the model but preserved much of the important procedures necessary to bring the turbine "on the line". This includes first ramping up the diesel one notch to start the turbine rotating to the point where it would fire. The firing of the gas turbine model sounds a bit like lighting a large industrial gas furnace. At this point the turbine starts revving up with its distinctive whine coupled with a low level Whoosh. The diesel is then revved up further followed by the turbine whine and whoosh increasing up to the point where the diesel disconnects and returns to idle. Shortly after this, the turbine is ramped up to full power where the Whoosh or roar now dominates the Turbine Whine.

Transition from Turbine to Diesel: Turning off the turbine was almost as complex as turning it on. The diesel is first ramped up to engage the turbine at full RPM. The turbine is dropped down to idle and the turbine throttle is reduced to zero. The Diesel Motor is maintained a full power to allow the turbine to cool over about 40 seconds; during this period, the Turbine Whoosh is first reduced to off while the Turbine Whine is gradually reduced to zero. After the turbine is completely shut down, the Diesel Motor returns to idle.

Doppler Run-by: The engine sounds get louder as the train approaches, then immediately drop to a much lower pitch and lower volume as the train passes by. With a little practice you can change the pitch exactly when and where you want. Doppler shift is based on the speed of the engine, so the sounds change more dramatically when the engine is running faster. After the Doppler shift has occurred and the horn is no longer being blown, locomotive sounds return to normal.

Flanges or Extended Brakes: When a train enters a curve, the flanges on the wheels tend to ride up on the inside of the rail and squeal. Recreate this squealing effect by pressing and releasing the Brake Sound function key button quickly and repeatedly as necessary. Or for slow stops, use the same function key to produce long protracted squealing brake sounds.

Dynamic Brakes: Electric motors can act as motors or generators depending on whether they are using power or generating power. When used as generators, the traction motors are disconnected from taking power from the locomotive's prime mover, and instead are connected to large resistor grids in the roof. By increasing the resistive load on the traction motors, the traction motors become harder to turn and act as brakes for the locomotive. The electric power generated by turning the traction motors is dissipated as heat by the resistor grid. These resistor arrays get quite hot and require cooling. When Dynamic Brakes are turned on under diesel operation, the Diesel Motor sound drops to notch 1 and the Dynamic Brake cooling fan sounds come on. Under Turbine operation, the Turbine sound will drop it its lowest Sound of Power setting but since the Turbine Whoosh stays relatively constant and loud, it may be difficult to hear the Dynamic Brake sounds. Since dynamic brakes are relatively ineffective a low speeds, the Dynamic Brakes will shut off automatically below 8 smph.

Coupler Sounds: There are two types of coupler sounds in Quantum depending on the type of operation. When coupling up to rolling stock, hear the sound of an engine crashing into and pushing a string of cars. When uncoupling, hear the sound of the lift bar and coupler pin after backing up over a magnet to open the couplers. Hear the knuckle opening and the air brakes parting when moving from the uncoupled cars.

Low Idle: Low Idle is used on prototype engines to maintain a warm and ready locomotive with a minimum of fuel consumption. The special Low Idle sound has a lower base throb and is less harsh than the normal idle.

Locomotive Shut Down (Extended): The air pumps will turn off, as will as directional lighting, followed by the sounds of the cooling fans shutting off, the louvers closing, the Diesel Motors shutting down and finally, the Engineer's door opening and shutting.

Locomotive Start Up (Extended): The engineers door will open and close, followed by vents opening, the Diesel Motor starting up, the air pumps starting up, and the locomotive entering normal operation.

Appendix II

Gas Turbine Operation

Prototype Design and Operation

Introduction

The Veranda Gas Turbines were powerful locomotives, developing 4,500 horsepower with 138,000 lbs of tractive effort at start up. As a point of comparison, the N & W J 4-8-4 steam locomotive provided 80,000 lbs and the largest steam locomotive, the UP Big Boy, provided 135,000 lbs of tractive effort. The popular GP series diesels were rated at 2000 hp with a maximum of 65,000 lbs of tractive effort. The gigantic UP DD40AX Centennials come close with 134,000 lbs of tractive effort. Later large two-unit turbines developed over 8,500 horsepower but the Veranda retained its distinction of having the largest internal combustion engine in a single power unit.

The Verandas were designed for freight operation with a top speed of 65 mph.

The advantage of all gas turbines for Union Pacific was their ability to operate on inexpensive heavy oil called "Bunker C" that was readily available on long UP desert lines. The chief disadvantages of gas turbines were their lower efficiency than diesels particularly at low speeds and their tendency towards corrosion. The Bunker C caused both fouling and corrosion of the turbine blades over time and the heavy oil was difficult to handle. Turbines carried their own steam boilers to preheat the Bunker C to 240 degrees to be suitable for combustion in the turbines. These problems combined with the increasing price of Bunker C and competition from new more efficient and powerful diesels, caused the demise of the Gas Turbines. However, the UP Verandas were a success story. They performed well for the UP from 1952 to when they were retired in the early sixties. The more advanced two unit turbines served the UP up to December of 1969 when the last gas turbine was retired.

Design and Description

The Veranda Gas Turbine used two different methods to power the locomotive. A 4500 horsepower gas turbine and a 250 horsepower diesel motor.

Diesel Motor: this was a Cummings Diesel Motor that powered three different machines:

1. **Diesel Generator:** The diesel generator, in turn, had three different functions:
    a) Provide electrical power to change batteries and power for d-c auxiliaries when turbine power was shut down.
    b) To motor one of the main traction generators to crank turbine for starting.
    c) To power two of the eight traction motors low power locomotive movement in the yard (hostling). During hostling, there was no battery charging or air compressor operation.
2. **Diesel Alternator:** This was belt driven from the diesel motor to provide three-phase a-c auxiliary power to run the radiator-fan motors, staring fuel-pump motor, and water booster-pump motor until turbine is up to idling speed.
3. **Air Compressor:** With was also belt driven from the diesel motor to pump up main reservoir air pressure until the two motor driven air compressors take over during battery charging. This is primarily intended for use during hostling and turbine cranking.

The diesel motor was not used to provide additional power during normal operation or when staring the locomotive from a dead stop.

Gas Turbine: This was the main power plant rated at 4,500 horsepower. It is an oil burning, axial flow gas turbine. It delivers power through a single reduction gearbox to drive four traction generators, an auxiliary generator and a turbine alternator.

The traction generators are excited by four amplidyne exciters and furnish power to eight traction motors. Power is controlled in 20 steps by the main handle of the master controller. There are four independent power circuits, each consisting of a traction generator and two traction motors. The following connections are obtained during locomotive operation:

1. Series-connected traction motors, full field.
2. Series-connected traction motors, shunted fields.
3. Parallel-connected traction motors, full field.
4. Parallel-connected traction motors, shunt fields.

Transitions are automatically controlled as a function of locomotive speeds.

While the field current was determined as a function of speed, the series parallel connection of the motors was determined by selection handle. The choices of the selection handle were OFF at the left followed by motor position, M1, motoring position M2, and BRAKE to the right.

The turbine alternator is a three-phase, six–pole machine driven by the turbine and supplies power to the a-c auxiliary system.

The auxiliary generator driven by the turbine furnishes power for d-c auxiliaries and battery charging when turbine is running and “on the line”.

Operation

The Turbine Control Switch, TC, has four positions and along with the Turbine Control Switch Light, controls and monitors diesel-motor and turbine operations.

Starting the Diesel Motor (TC1):

1. Move TC switch to position 1 and all necessary switches and breakers must be closed.
2. Close battery switch BVS.
3. Close breaker TB1 – Turbine generator, Diesel Start.
4. Close breaker TB3 – Coolant pump.
5. Close breaker TB12 – Diesel alternate field (this breaker should normally be left closed). The following sequence will happen:

    - Coolant water pressure switch picks up.
    - Battery charge timing relay, **T-BC**, picks up.
    - Fuel pressure relay, **FPR** picks up.
    - **MF TEMP** lamp lights.
    - **LUB PRS** lamp lights.
    - Sequence relay, **T-SQ**, picks up.
    - Fuel dump solenoid valve**, FDSV,** is energized.

Momentarily depress the engine-start button, **ES**.

a) The diesel crank timing relay, T-DC, picks up and remains closed for 20 seconds. Engine cranks for 20 seconds and fires within this period.
b) Ten seconds later battery charging power is supplied from diesel generator.
c) After battery charging commences, the motor driven train air compressors run to supply main reservoir air. Also the diesel alternator is excited to furnish ac auxiliary power to necessary ac auxiliaries only. At this time, lights can be turned on.

Note: The turbine's diesel did not have an air start. It was also started from the batteries.

The diesel motor can now be used to do hostling of the locomotive. Because of the notoriously inefficient operation of the gas turbine power plant at idle and low speeds, hostling was usually done using the diesel motor. To move the locomotive using the diesel motor:

1) Close propulsion control breaker, TB4.
2) Move reverse handle to FORWARD or REVERSE.
3) Move Selector Handle to M1 position.

    Note: When operating the diesel, the selector handle connects motors in series, M1, or in parallel, M2. Maximum diesel RPM in M2 is 843 rpm.

4) Advance throttle to 1st and then to 2nd notches.
5) To increase speed above 10 mph, move throttle handle to IDLE, then move Selector Handle to motoring position, M2, and again advance throttle handle to notches 1 and then to 2.

    Note: The UP operation manuals do not seem to indicate the top speed in M2. Using the speed ratios for an F7 between series and parallel connections gives a speed ratio of 2.79 independent of gear ratios. I would guess the same holds true for the Turbine diesel. This would give a top speed of about 28 mph.

Note: In the Mighty Turbine video and on independent recordings, there is a high pitch whine when the motor is idling. Since it does not seem likely that the diesel engine would have a turbo and the turbine is not running, this is likely the sound of the gearbox.

Turbine Cranking (TC2)

When Turbine Control Switch, **TCS**, indicating lamp (green) on engineer's instrument panel lights, **TC** Switch can be advanced to **Position 2**, at which time the following occurs in the sequence listed below which takes about 3-5 minutes:

- TCS lamp goes out.
- Battery charging and motor driven air compressors nullified.
- Diesel generator is coupled to traction generators G4 to crank turbine (with diesel engine operating at idling speed).
- When turbine reaches 10-15 percent of speed (about 700 rpm), a limited amount of diesel fuel is admitted to turbine.
- Ignition is turned on.
- Atomizing air is fed to turbine.
- Turbine fires.
- Generator main field is weakened.
- Diesel engine governor is advanced to top speed.
- Turbine accelerates toward top speed.
- Generator G4 uncouples from diesel generator and turbine operates at IDLE speed.
- Diesel engine returns to IDLE speed and diesel generator reconnected for battery charging and air compressor operation.
- Turbine alternator furnishes power to traction motor blower motors, amplidyne drive motors, main lube pump motor.

Fuel Transfer (TC3)

When TCS green indicator lamp again goes on after the above 3-5 minute sequence finishes, TC switch can be moved to position 3. The following then occurs over about one minute:

- Turbine auxiliary generator (dc) takes over battery charging function and supplies control power. Air compressors come on line.
- Fuel transfer mechanism operates progressively to transfer fuel from diesel oil to "Bunker C" within 40 seconds.

Turbine "ON THE LINE"

When **TCS** green indicator lamp relights after the 1-minute sequence above, **TC** Switch can be moved to position 4.

- Diesel motor shuts down.
- Turbine alternator takes over to supply auxiliary ac power to all ac motors.
- Turbine is "on the line" and locomotive is ready for operation.

Setting Turbine Speeds

Under normal conditions, turbine speed is adjusted for idle speed of 5,175 rpm using rheostat R# while having the turbine running in TC4., TH, IDLE, RH OFF and SR OFF. To adjust top speed, install reverse handle, throttle up to notch 13 slowly and adjust rheostat, R14A. Top speed is 6900 plus or minus 70 rpm.

Moving the Locomotive Under Gas Turbine Power

- Move reverse handle to FORWARD or REVERSE, depending on direction desired.
- Move selector handle to MOTORING position **M1** or **M2** position as required.

  Note: The Selector Handle sets the turbine at idle in motor position, M1, or full turbine operation, M2.

- Make sure handbrake is released
- Advance throttle handle as quickly as possible to the position that starts locomotive. Observe limitations of loadmeter and do not permit notching guide pointer to make prolonged indications in the RED band. Reduce throttle position if necessary.
- Operate locomotive according to loadmeter and notching guild limitations.

Stopping the Locomotive

- Move throttle handle to IDLE and apply air brakes.
- If leaving engineers position, move selector and reverse handles to OFF.

Dynamic Brakes

- When Selector Handle is moved to Brake, the turbine goes to idle and dynamic brakes are applied. Resistor grid cooling fans come on automatically.

Reversing the Locomotive

- Bring locomotive to a full stop.
- Move reverse handle to opposite direction.
- Release brakes.
- Continue operation according to *Moving the Locomotive Under Gas Turbine Power* described above.

Shutting Down the Locomotive

- Turn turbine control switch, **TC**, to position 1. Diesel motor automatically starts and gas turbine shuts down in approximately 4½ minutes.

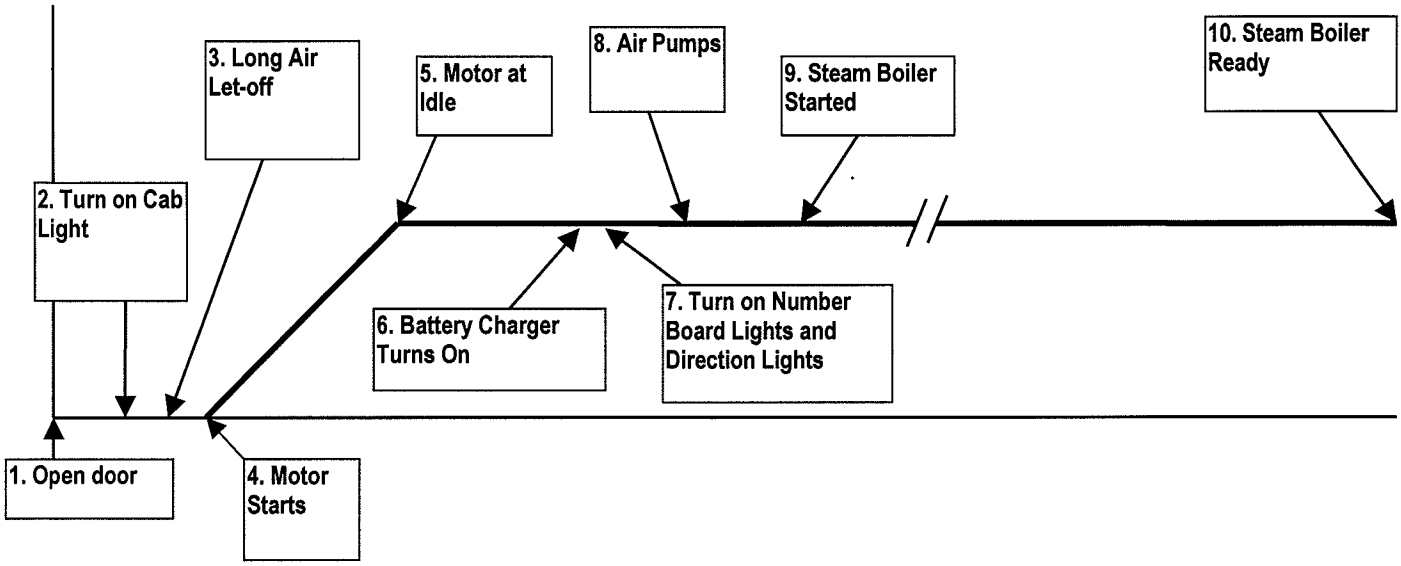
  Note: When fuel was cut to the turbine, without power, it probably took only about thirty seconds to completely stop. However, the diesel was allowed to operate to run the turbine with just air moving through the blades. I understand this was done to prevent heat damage to the blades. Assume that the diesel motor continued at full speed for about forty minutes followed by the diesel shutting down to idle, followed by the turbine winding down to off.

Leaving the Locomotive

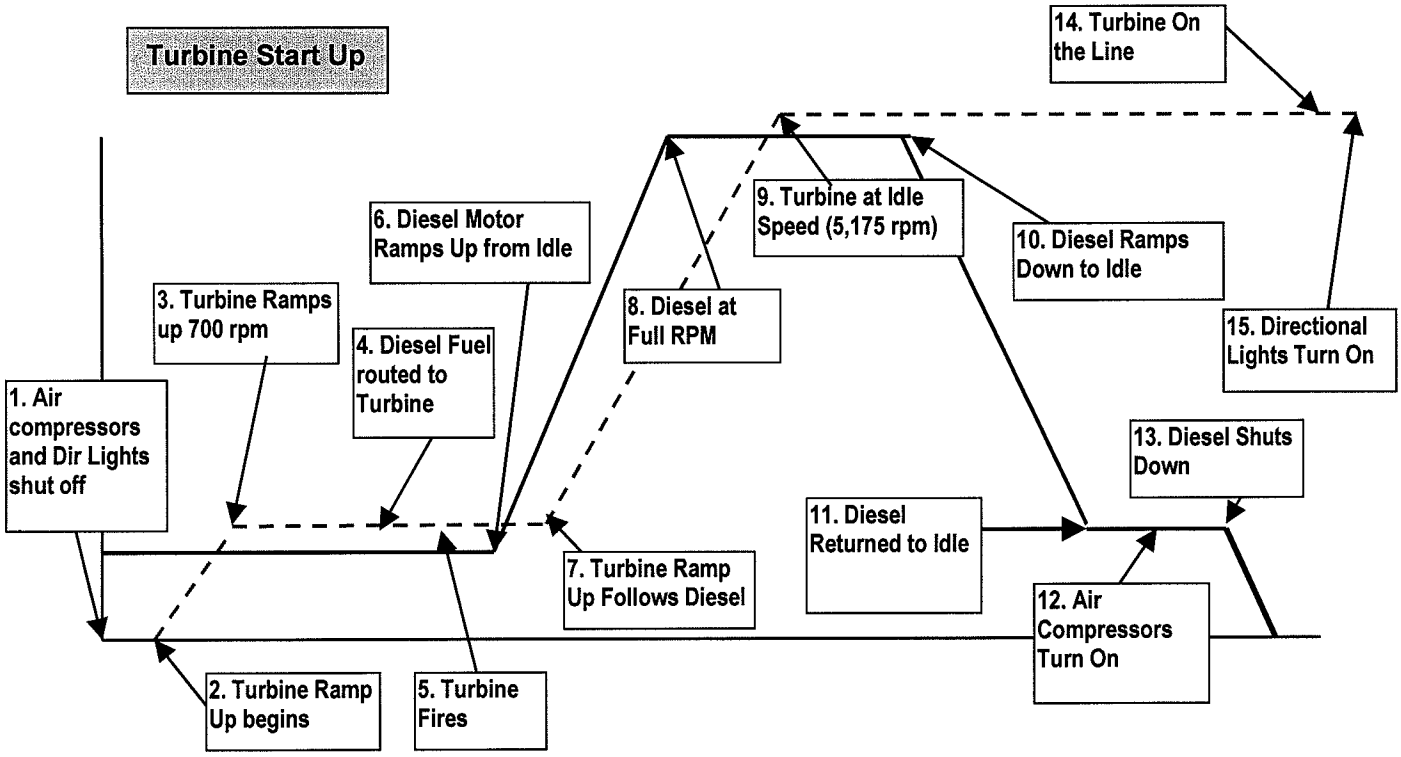
- Set handbrake and close windows and doors.
- Move throttle handle to OFF.
- Move selector handle to OFF.
- Move reverse handle to OFF and remove handle.

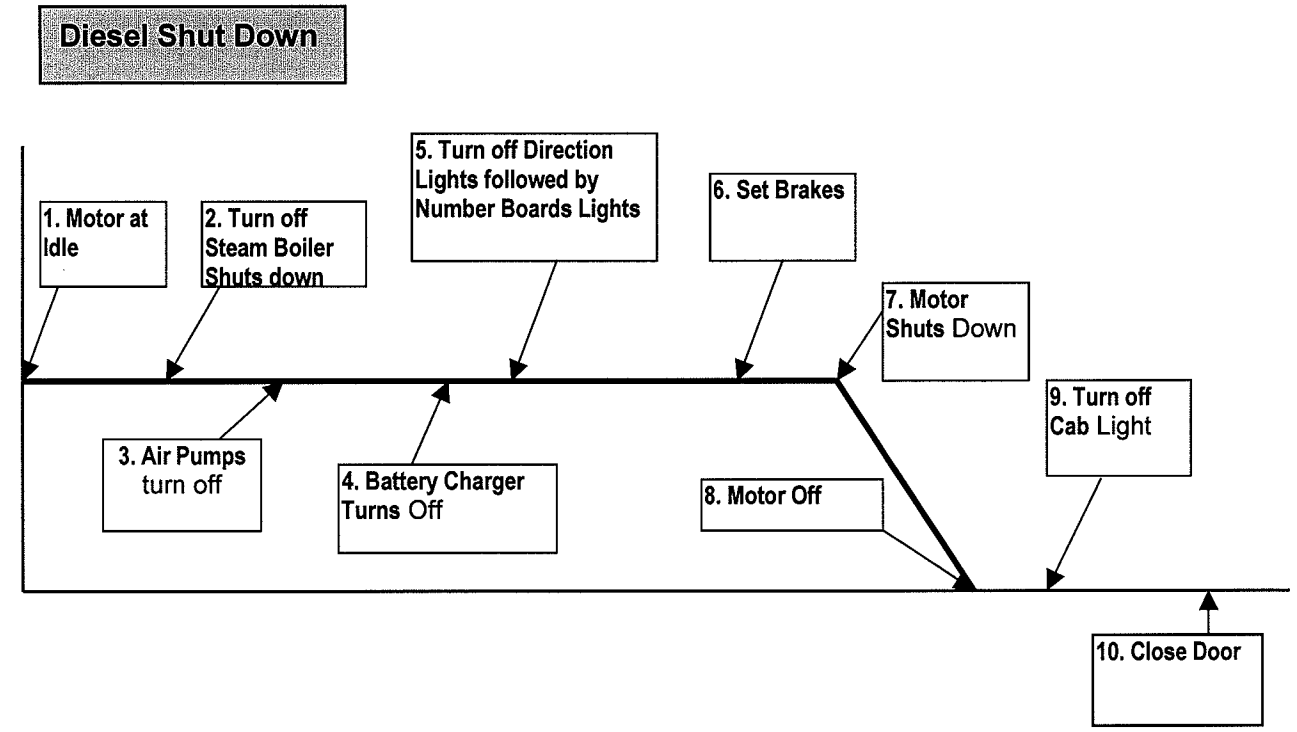
Approximate Prototype Event and Timing Graphs

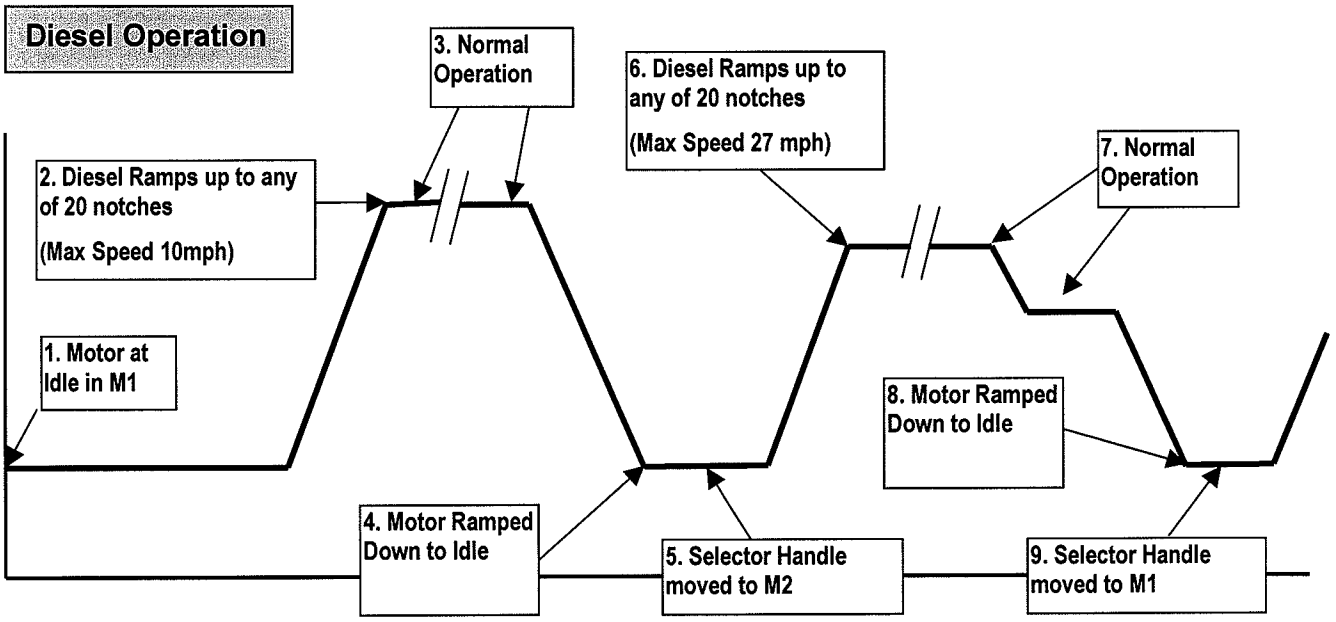
Diesel Start Up

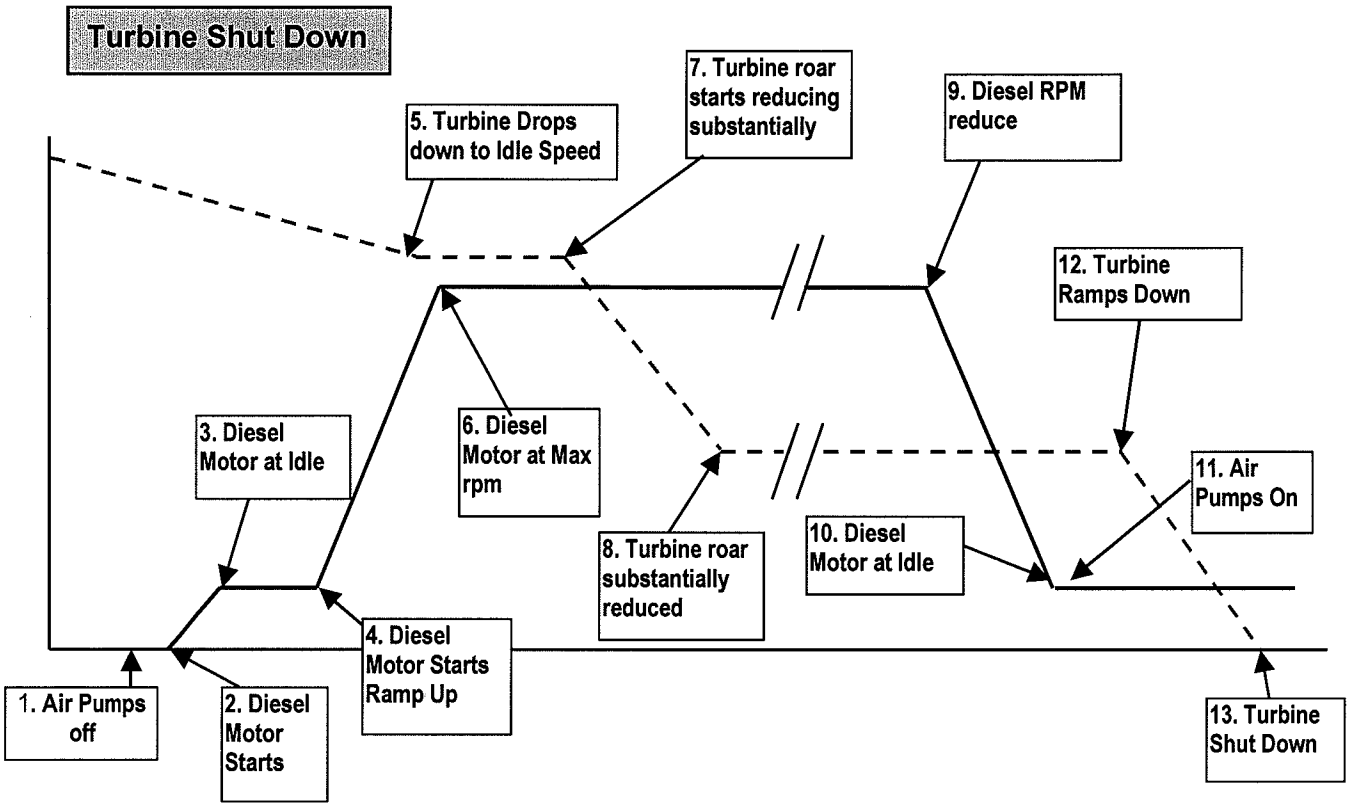


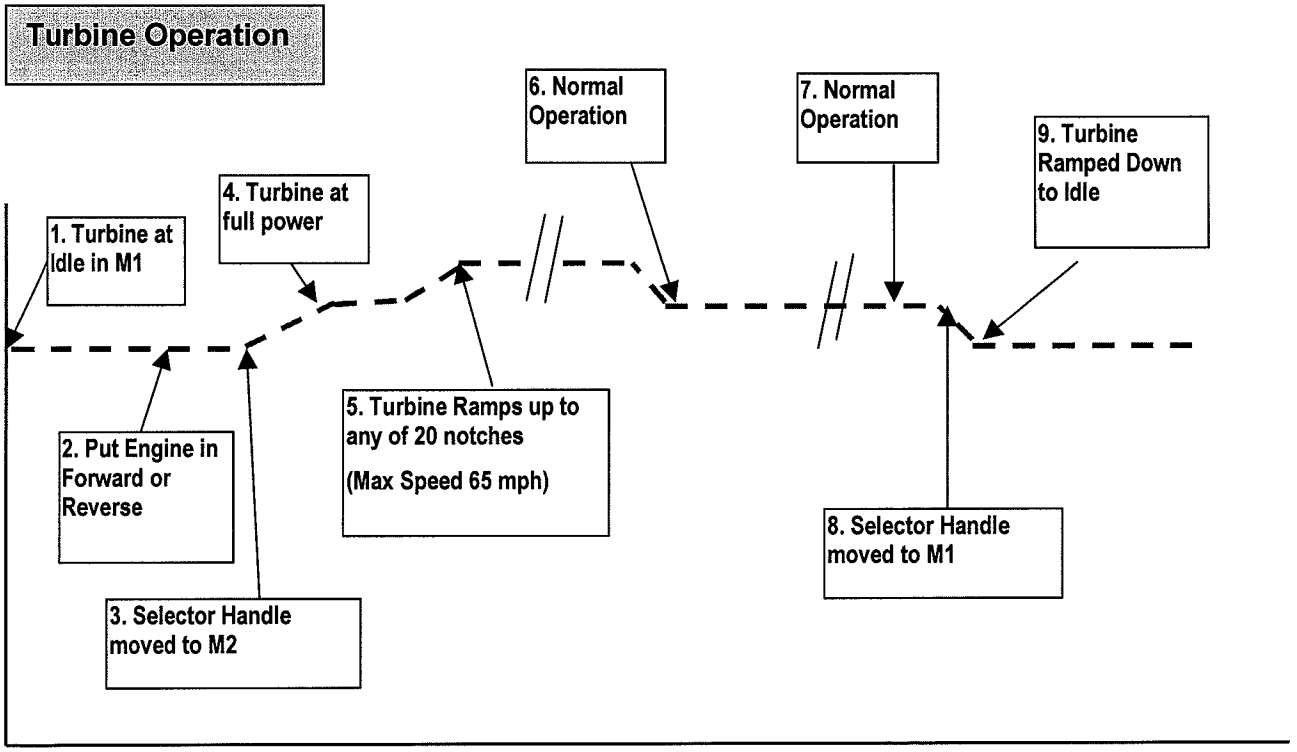
Turbine Start Up




Diesel Shut Down
1. Motor at Idle
2. Turn off Steam Boiler Shuts down
5. Turn off Direction Lights followed by Number Boards Lights
6. Set Brakes
7. Motor Shuts Down
9. Turn off Cab Light
3. Air Pumps turn off
4. Battery Charger Turns Off
8. Motor Off
10. Close Door


Diesel Operation
3. Normal Operation
6. Diesel Ramps up to any of 20 notches
(Max Speed 27 mph)
7. Normal Operation
2. Diesel Ramps up to any of 20 notches
(Max Speed 10mph)
1. Motor at Idle in M1
8. Motor Ramped Down to Idle
4. Motor Ramped Down to Idle
5. Selector Handle moved to M2
9. Selector Handle moved to M1


Turbine Shut Down
5. Turbine Drops down to Idle Speed
7. Turbine roar starts reducing substantially
9. Diesel RPM reduce
12. Turbine Ramps Down
3. Diesel Motor at Idle
6. Diesel Motor at Max rpm
11. Air Pumps On
8. Turbine roar substantially reduced
10. Diesel Motor at Idle
4. Diesel Motor Starts Ramp Up
1. Air Pumps off
2. Diesel Motor Starts
13. Turbine Shut Down


Turbine Operation
6. Normal Operation
7. Normal Operation
9. Turbine Ramped Down to Idle
4. Turbine at full power
1. Turbine at Idle in M1
5. Turbine Ramps up to any of 20 notches
(Max Speed 65 mph)
2. Put Engine in Forward or Reverse
8. Selector Handle moved to M1
3. Selector Handle moved to M2

DCC Operation for Quantum Gas Turbine

Introduction

Because the Gas Turbine model required considerable time to bring the turbine on line or to shut it down, the operation of the transitions between diesel and turbine operation is compressed in time. In the case of shutting down the turbine, twenty minute sequence is reduced to a little less than a minute. In addition, there is some conflicting reports about the turbine sound itself. Some witnesses report that the Big Blow only had the deafening whoosh sound and no turbine whine at all. In some of the tapes we heard, there appeared to be a slight turbine whine, especially at idle. Some maintained that there was a whine sound distinctly heard as the turbine was revved up before ignition. We have left it to the operator to decide how the gas turbine should sound. We have included both a whoosh sound and turbine whine on separate channels which can have their volumes adjusted independently. We have set the defaults of the turbine whine to be easily heard during the start up and shut down sequence. However, on the main, the whoosh clearly dominates especially during Sound-of-Power periods.

The Gas Turbine will initially start and operate as a standard diesel locomotive expect that the speed is limited to 25 smph to model the limited speed of the prototype locomotive when operated with the small 250 hp Cummings diesel.

These steps will allow you to start operating your diesel locomotive immediately using any qualified NMRA command station.

1. Select engine number 3.
2. Set your controller to 128 (preferable) or 28 (acceptable) speed step range.
3. Start your locomotive immediately by pressing the F6 function key to hear the diesel engine Start Up sounds. Number Board Lights will be on. Directional Lighting System (Headlight, Reverse Light, and Mars Light[119]) will be off. Use the FL or F0 key to turn on the Directional Lighting.
4. Slowly turn up the throttle. The locomotive default setting is speed control and will maintain the same speed regardless of varying track voltage, grades or other conditions that would normally affect the speed of an HO model engine. In addition, the engine is pre-calibrated at the factory to move at the speed set by the DCC speed step in scale miles per hour. However, under diesel control, the locomotive will only travel up to 25 smph; any speed setting above this value will not increase speed but will cause the motor sounds to more labored.

When you reduce the throttle to zero, the engine will automatically enter Neutral when the engine stops. You will hear a Short Air Let-off when the engine stops moving and a Long Air Let-off about one second later followed by Air Pumps and other background sounds[120]. The Directional Mars Light will stop pulsing and go dim and Headlight will go off.

The direction of your locomotive will change when you press the direction key.

Although many of the functions for the Gas Turbine are the same as diesels as already described in this reference manual, we have included all functions in this appendix to make it more readable.

Function Keys

The following table lists features that have been pre-assigned to your DCC function keys. Operation of these keys can be different in the Neutral state (locomotive stopped) and the Motive states (locomotive moving in Forward or Reverse). After you have selected your locomotive, simply press any of the function keys listed below to produce the described effects.

Function Key*	Forward and Reverse	Neutral
F0 or FL or Headlight	Directional Lighting on or off	Directional Lighting on or off
F1	Bell on or off	Bell on or off
F2	Horn or horn with Doppler Effect (see below)	Horn on or off
F3	Coupler Crash/Coupler Fire	Coupler Arm or Coupler Fire
F4	Cooling Fans on or off	Cooling Fans on or off
F5	Dynamic Brake function on or off	Dynamic Brake function on or off
F6	Doppler	Start Up
F7	Squealing Brake/Flanges and Air Brakes	Toggle Diesel or Gas Turbine modes
F8	Audio Mute on or off	Audio Mute on or off
F9	Cruise Control on or off	Shut Down
F10	Locomotive's Verbal Speed Readout in SMPH.	Short Air Let-off.
F11	Short Air Let-off.	Short Air Let-off.
F12	Mars Light Off/Dim/Pulsing/Off/Dim/Pulsing/etc.	Mars Light Off/Dim/Pulsing/Off/Dim/Pulsing/etc.

* Quantum supports the new NMRA 0-12 function key standard; the old 0-8 standard is not supported.

If you have a DCC command station that supports only the older 0 to 8 function key standard, you will have no way to initiate Shut Down in Neutral with these pre-assigned feature to function key mappings. There is an interim solution to this problem by changing CV 38 from its

[119] Not all locomotive models have the Mars Light feature.
[120] Neutral sounds also include Cooling Fans with Vents opening and closing that turn on and off randomly.

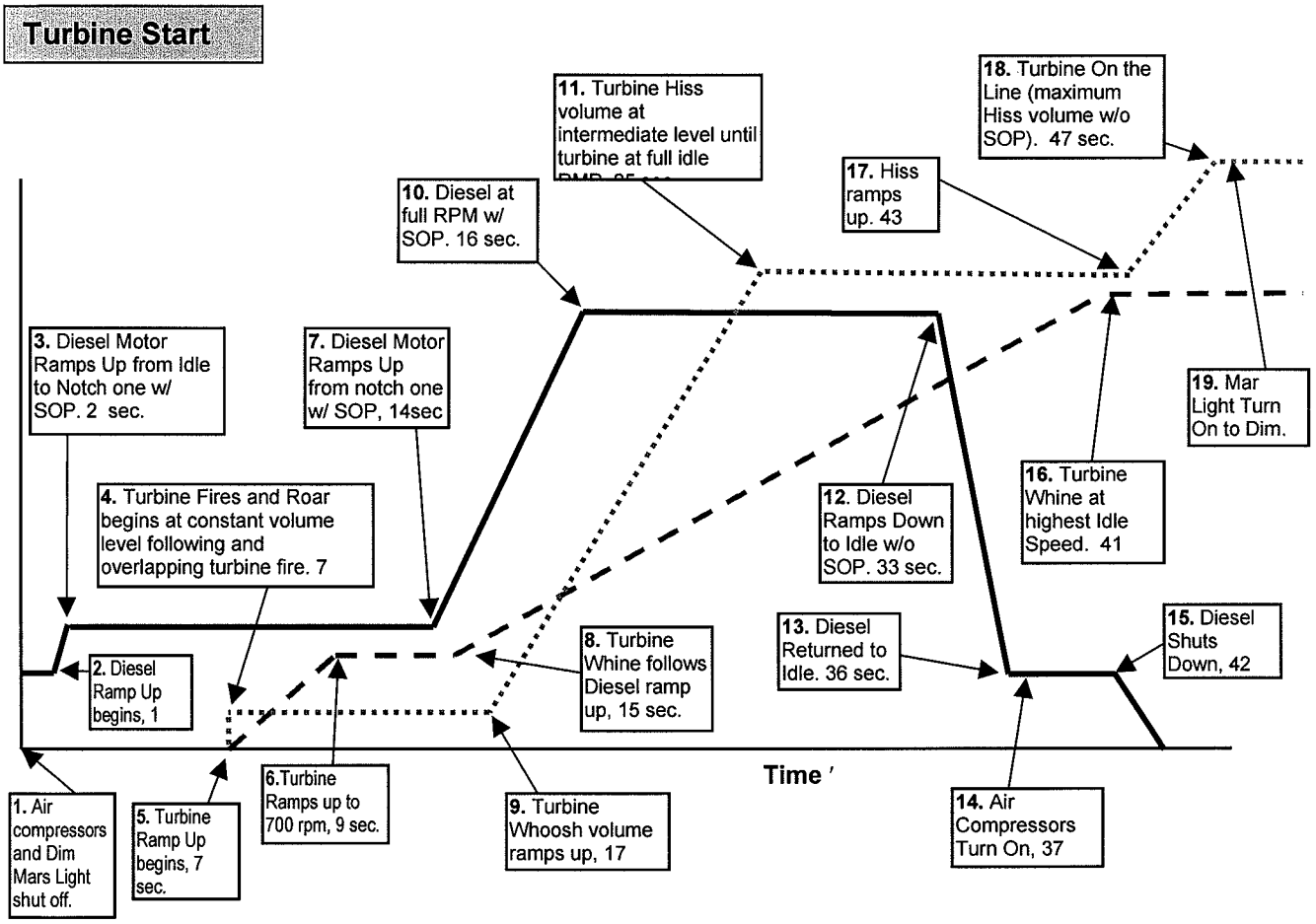
default value of 32 to decimal 128, you can control Shut Down in Neutral and Cruise Control from function F4 (instead of function F9) on your DCC command station. Although Cooling fans cannot be toggled on and off using a function key, they will still have automatic operation in Neutral.

Changing between Diesel and Gas Turbine Mode

Diesel Mode to Turbine Mode: The Gas Turbine locomotive comes from the factory in Diesel Mode. Because of the limited power from the diesel engine in the prototype, the model will be limited to 25 smph in Diesel mode. To achieve full power from your model for mainline operation, you will need to change to Turbine Mode. There are two ways to do this. To change from Diesel Mode to Turbine Mode:

- Press the horn button four times to produce four short horn hoots in Neutral.
- Press the F7 key in Neutral.

The engine will go through a complex Turbine start up scenario as depicted in the graph below. At the start of the transition to Turbine Mode, the Mars Light will change from Dim to Off. When the transition scenario is completed, the Mars light will change from Off back to Dim.



There are three operations shown.

- The solid black lines show the volume and rpm operation of the diesel motor.
- The dotted blue line with large dashes shows the volume and rpm of the Turbine Whine.
- The dotted red line with small dashes shows the volume of the Turbine Whoosh.

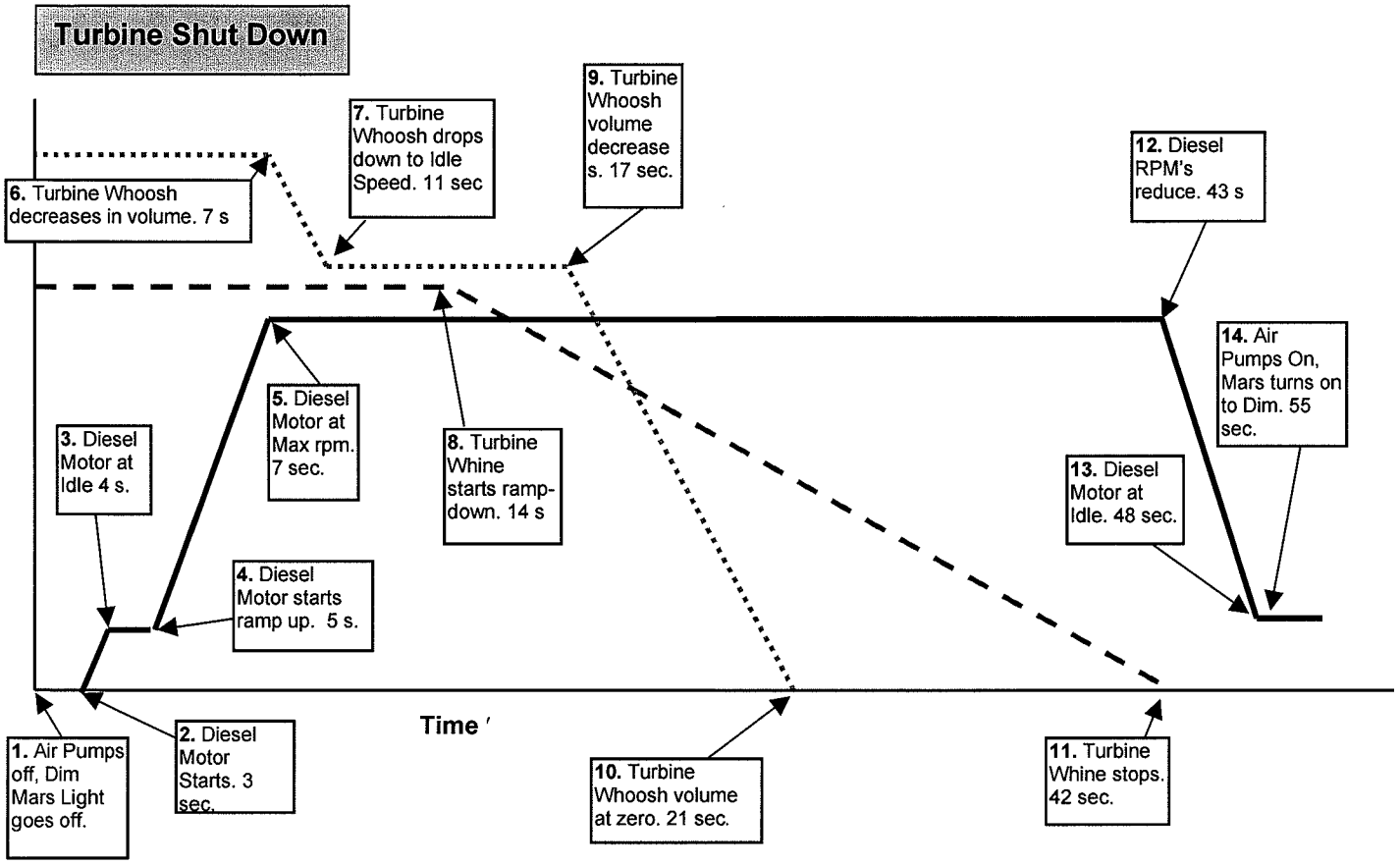
The yellow boxes indicate major events in the transition to Turbine Mode. The timing shown in each box indicates the number of seconds since the transition command was sent to start Turbine Mode.

Note: Turbine fire is a distinctive sound that sounds like a giant gas furnace being ignited.

Turbine to Diesel Mode: There are two ways to return to Diesel Mode from Turbine Mode.

- Press the horn button four times to produce four short horn hoots in Neutral.
- Press the F7 key in Neutral.

The engine will go through a complex Turbine shut down scenario as depicted in the graph below. At the start of the transition to Diesel Mode, the Mars Light will change from Dim to Off. When the transition scenario is completed, the Mars light will change from Off back to Dim.



Notes: The following is a list of operational issues when changing between Diesel and Turbine Mode:

1. After the Turbine whoosh starts reducing, the Diesel motor will continue at maximum RPM for 36 seconds to model the Turbine cool down process.
2. Cooling fans and vent opening sounds only occur in Diesel Mode.
3. Mars Light, Air Pumps, Cooling Fans and other Neutral Sounds will be suspended during transition from Turbine Mode to Diesel Mode or from Diesel Mode to Turbine Mode, like the prototype.
4. If engine is in Turbine Mode or Diesel Mode when power is shut off, the engine will power up in the same Mode when power is reapplied.
5. If engine is at any point in transition from Turbine to Diesel Mode, it will power up in full Diesel Mode when power is reapplied with standard rapid diesel start up sounds.
6. If engine is in Turbine Mode or in transition from Diesel to Turbine Mode when power is shut off, Turbine sounds will sequence through rapid turn on operation instead of artificially and abruptly producing full Turbine sounds when power is reapplied.
7. If the locomotive is in any point in the transition from Diesel Mode to Turbine Mode, and the throttle is turned up to leave Neutral, the locomotive will terminate Diesel/Turbine transition and rapidly enter full Turbine operation in Turbine Mode.
8. If the locomotive is at any point in the transition from Turbine Mode to Diesel Mode, and the throttle is turned up to leave Neutral, engine will terminate Turbine/Diesel transition and enter Diesel Mode.
9. A Software Reset (soft reset) in Analog or DCC will not change from Diesel Mode to Turbine Mode or from Turbine Mode to Diesel Mode. A Hardware Reset using the jumper will always return the locomotive to Diesel Mode.

10. It is disallowed to move back and forth between Turbine and Diesel Mode when the locomotive is in transition between either Mode. The transition process must be completed before another transition can be initiated.
11. Transition from Diesel to Turbine Mode or transition from Turbine to Diesel Mode will only happen in Neutral. Neither the Turbine/Diesel transition by a coded horn (four short horn hoots) or the F7 key will have any affect on changing modes in Forward or Reverse.
12. The coded horn Turbine/Diesel Mode toggle can be disabled in DCC in CV 52.2 bit 1. Enable =1 (default) and Disable =0.

Sound-of-Power™

Your Gas Turbine locomotive will produce labored sounds under acceleration and lighter sounds under deceleration but only if CV 3, or CV 23 and CV 4, or CV 24 are set to non-zero positive values. The level of labored sounds is proportional to the values for these four CV's, and how much the throttle is increased or decreased. Labored sounds will be heard in either Diesel or Turbine Mode.

Diesel Motor RPM: Quantum has eight Diesel Motor throttle "notches" found on most prototype locomotives. As you increase the throttle, you will hear the RPM's increase for every increase in ten speed steps (at 128 speed step setting). Idle is considered Notch 1 and occurs for speed step 0. Notch 2 ranges from 1 to 10, Notch 3 from 11 to 20, Notch 4 from 21 to 30, etc. If your controller has an option to increment or decrement your throttle set setting by ten speed steps, it is very easy and predicable to set your notch value.

Turbine Whine and Whoosh will change with the throttle only slightly over the entire throttle range since the turbine was often run near full RMP at all times. Although the changes in Turbine sound is not as dramatic as changes in diesel RPM's or volume, it is nevertheless quite noticeable.

Directional Lighting Operation (F0 or FL or Headlight)

The FL (or F0, or Headlight) key toggles the Directional Headlight/Reverse/Mars Light System[121] on or off.

The defaults for Headlight/Reverse Light and Mars Directional Lights are off. When toggled on, the Directional Lights[122] come on according to the table below.

Directional Lighting Operation in DCC and Analog with Mars Light Option

	Forward	Neutral from Forward	Reverse	Neutral from Reverse
Headlight	On	Off	Off	Off
Reverse Light	Off	Off	On	Off
Mars Light	Strobing	Dim	Dim	Dim

Note: In Neutral, Mars is set at Dim to conform to general Rail Safety regulation Rule 17. In Forward and Reverse, Mars is pulsing. Mars light can be operated automatically or under "Take Control" Mode in DCC.

Note: Number Board lights and Cab light is on whenever track power is applied and are not under the control of the Quantum System.

Note: Both the tender Reverse Light and locomotive Reverse Light will operate whenever engine is in Reverse. These lamps are wired together when tender is plugged in and are not under separate Quantum control.

Coupler and Coupler Crash Sounds (F3)

There are two ways to use the F3 key.

- As your engine is about to couple up to a string of cars, press the F3 key to trigger the crashing sound of engine coupling. Use the F3 key again as the engine moves out to trigger the same sound as the slack is taken up in the cars.
- Use the F3 key in Neutral to produce uncoupling sounds as you disconnect cars over uncoupler magnets. Press the F3 key once to produce the sound of the lift bar and coupling pin being raised. This also arms the uncoupling sound effect. Press the F3 key again while moving or in Neutral to trigger the sound of the coupler knuckle opening and air-lines parting.

Horn and Bell Buttons (F2, F1)

Some DCC controllers have separate horn and bell buttons along with function keys assigned to horn and bell operation. The horn is usually assigned to F2. The F2 key behaves differently than using the horn button.

- Pressing the F2 key and releasing it will cause the horn command to come on and stay on, until you press F2 again [123].
- Pressing the horn button will send the horn only as long as you are holding it down.

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[121] Explicit lighting control features for Headlight, Reverse Light and Mars Light can be assigned to DCC function outputs. (See QSI DCC Reference Manual, version 3)

[122] Quantum uses constant voltage lighting that is independent of track voltage.

[123] Since the prototype horn uses compressed air, you will hear the Air Pump sounds turn on after the Horn is operated.

Pressing the F1 key and releasing it will cause the Bell to come on and stay on, until you press F1 again. There is no difference in operation between the bell button and its corresponding function key.

Note: The Veranda Gas Turbine uses a single chime horn[124].

Doppler Operation (F6)

With DCC, you can trigger the Doppler effect by quickly interrupting the horn signal in the same way it is described under Analog control. Or you can use the function key dedicated to the Doppler effect.

- Start the Horn and/or Bell by pressing and releasing their function keys[125].
- Press F6 to hear the Doppler shift. A few seconds after the horn button is turned off with the F2 key the engine sounds return to normal [126].

Standard Throttle Control, Speed Control and Regulated Throttle Control

There are three ways your engine can respond to your throttle.

Under **Standard Throttle Control (STC)**, the power to the locomotive is controlled directly by the throttle setting. With STC the speed of the engine will change with loading and variations in track voltage.

Speed Control (SC) uses calibrated internal motor control electronics to maintain the same speed regardless of varying load or track voltage conditions. Under Speed Control, the throttle setting (using 128 speed steps) selects the engine's speed in 1 smph (scale miles per hour) increments. If you set the throttle at 35, the model locomotive will go 35 smph on level track or up hill or down hill. If you use 14 or 28 speed steps, you will need to multiple your settings by 9 and 4.5 respectively to compute your scale speed.

Regulated Throttle Control[127] (RTC) combines the benefits of Standard Throttle Control and Speed Control and is the preferred method when multiple heading Quantum engines together.

Note: All three types of throttle control are available in either Turbine or Diesel Mode.

Note: The 25 smph limit in Diesel Mode is automatically available in SC and RTC but is not available in Standard Throttle Operation.

The default is "Speed Control". If you prefer, change the setting in CV 56.4 (see next section).

Cruise Control (F9)

Quantum Cruise Control behaves in much the same way as cruise control on a modern automobile.

- Press F9 and hear two short toots when Cruise Control is toggled on
- Press F9 and hear one short toot when Cruise Control is toggled off.

When Cruise Control is on, the engine will continue at its present speed regardless of grades, changes in load, or tight curves. Turning the throttle up or down will not affect engine speed, but will cause Sound-of-Power chuffing labor sounds to change in direct proportion to the throttle's movement from the initial setting (where Cruise Control was turned on). You can increase the laboring motor sounds in Cruise Control as a train climbs a grade or decrease the Sound-of-Power effects as the train moves down the grade.

Return the throttle to its initial setting to avoid acceleration or deceleration when Cruise Control is toggled off.

Note: Cruise Control is only available under Regulated Throttle Control or Speed Control.

Note: Cruise Control is automatically turned off when the speed step is reduced to zero or track power is turned off.

Squealing Brake and Flange Sounds (F7)

- Quantum provides automatic brake squeal as an engine slows to a stop. The operator can also control squealing sounds for continuous and variable brake sounds for protracted stops or to simulate the sounds of squealing wheel flanges on curved track.
- Squealing Brakes come on automatically when the speed is reduced from high-speed travel (over 35 smph) to less than 10 smph.
- Pressing the F7 key when the engine is moving at any speed will manually activate Squealing Brake sounds, and repeated pressings while the Squealing Brake sounds are occurring will continue the sounds uninterrupted.

Note: If you slow the engine too quickly, the brake sounds will terminate abruptly when the locomotive stops and enters Neutral.

Note: If you lower your throttle to speed step 0 on a moving locomotive, the F7 key will apply Air Brakes as long as the locomotive continues moving. See next section.

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[124] Some commercial video tapes of the Gas Turbine have dubbed a multi-chime horn in for sound effects and do not represent the actual locomotive horn.

[125] If you do not turn on either Horn or Bell, the Doppler shift will still occur but will be less dramatic.

[126] If the Bell was on, it will shut off prior to sounds returning to normal.

127 RTC maintains engine speed through minor impediments such as misaligned track joints, rough switches, tight curves, etc, but also allows gradual power equalization when engines are used in concert.

Note: The Gas Turbine does not have an Air Brake effect using the F7 key that is standard on later Quantum locomotives.

Dynamic Brakes (F5)

The prototype Gas Turbine locomotive has dynamic brakes that cause the train to slow down by using the traction motors in generator mode. This helps dissipate the energy of a moving train by converting it to electrical power, which is then applied to a large air-cooled resistor load in the locomotive.

- Pressing the F5 key in Forward or Reverse will set the locomotive Diesel Motor or Turbine sound to idle at the lowest Sound of Power setting and turn on the powerful Dynamic Brake cooling fans.
- Pressing the F5 key in Neutral will turn on the Dynamic Brake Fans while Diesel Motor sounds remain at idle.

The Dynamic Brake function automatically turns off when entering or leaving Neutral, or the speed of the locomotive drops below 7 smph[128], or if the throttle is turned up. The Dynamic Brakes cannot be turned on in Forward or Reverse unless the engine is traveling over 8 smph.

Note: Dynamic Brakes do not increase the deceleration rate specified by CV 4 and CV 24.

Note: Dynamic Brakes sounds will be barely audible over the Turbine roar in Turbine Mode.

Automatic Features with "Take Control" Operation

The Quantum System allows the operator to take control of certain automatic features by using their associated function key. Once you "Take Control", the features will no longer have automatic operation and you will control their operation and their state with their function key commands. Automatic and Take Control operations are described in the table below.

Gas Turbine Locomotive "Take Control" Operation

	Automatic Operation			Take Control	
	Forward	**Reverse**	**Neutral**	**Function Key**	**Operation**
Vents & Cooling Fans	Non-operating	Non-operating	On and off at random times	F4	Toggles Vents/Cooling Fans operation between on or off.
Mars Light	Strobing	Dim	Dim	F12	Mars Light Off/Dim/Pulsing/Off/Dim/Pulsing/etc.

- Take Control of Automatic Cooling Fans with the F4 key to stop Automatic Control and select whether the Cooling Fans are on or off.
- Take Control of the Pulsing Mars Light with the F12 key to change the Mars Light state progressively through states of Off, Dim, Pulsing, etc. each time the F12 key is pressed.

Regardless of the state of the automatic fans (on or off), if you press the F4 key, the Cooling Fans will be set to on if the F4 key is "1" and off if the F4 key is "0" and Automatic Control will be disabled. Thereafter, the fans will respond only to the state of the F4 function.

Note: Automatic Control will be restored if the power is shut down and reapplied or if the F6 Start Up key is double pressed in Neutral (see the description of Start Up on the following page).

Note: If Mars Light is under DCC "Take Control" operation, the Mars light will not provide reliable information of the beginning of the Turbine Shut Down operation but will provide information about the beginning of Turbine Start Up operation. Turbine Start Up/Shut Down will reset all "Take Control" features " to "Automatic Operation".

Three Stages of Shut Down: 1. Disconnect, 2. Standby, 3. Total Shut Down (F9)

Engine Shut Down has three distinct stages that you can control. Each stage is entered by double pressing the F9 key[129].

Stage One: Disconnect

- Double press the F9 key in Neutral to enter Disconnect. You will hear a Long Air Let-off.
- To leave Disconnect, either double press the F6 Start Up key described in the Start Up section or double press the F9 key again to reach the next stage of Shut Down, Standby.

If you double press the F9 key in Neutral, the motor drive will be disconnected. Once you hear the Long Air Let-off, the throttle can be moved up and down without the diesel locomotive moving. As the throttle is moved up or down, you will hear the Diesel Motor rev up and down in proportion to the throttle setting.

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[128] Dynamic Brakes on prototype locomotives are less effective and are seldom used at low speeds.

[129] Double pressing ensures that Shut Down stages are not entered or exited accidentally. Double pressing is defined as two F9 commands sent within two seconds. Note that the F9 key may have to be pressed three times, due to the command station and locomotive having different initial states for F9.

Note: All function keys are operable in Disconnect.

Note: You can also turn on the Dynamic Brakes (see description of Dynamic Brakes below) to create Sound–of-Power as the throttle is moved up and down. Engineers on prototype diesels use the Dynamic Brakes to load the diesel motor-generator to test its output and efficiency while the locomotive remains stationary.

Stage Two: Standby

- Double press the F9 key while in Disconnect to enter Standby. You will hear a Long Air Let-off followed by a special "Low Idle" sound. The Directional Lighting and Mars Light will then shut down. The Diesel Motor or Turbine will remain disconnected, while the Air Pumps, automatic Cooling Fan operation, Number Board Lights and Marker Lights will continue to operate. In Standby, the engine will not respond to throttle or function keys[130]. The two exceptions are the F6 Start Up Function Key and the F8 Mu
- te Key (described below).
- To leave Standby, either double press the F6 Start Up Key described in the Start Up section or double press the F9 key again to reach the final stage of Shut Down, Total Shut Down.

Note: Standby is ideal for leaving your engines running on a siding. Besides the Low Idle motor sounds, the engine will not respond to accidentally changing the throttle setting or pressing the function keys.

Note: Diesel Low Idle command will be accepted under DCC in Turbine Mode but low idle sound will not occur until Turbine has shut down completely.

Stage Three: Total Shut Down

- Double press the F9 in Standby to enter Total Shut Down. You will hear a Long Air Let-off.
- To leave Total Shut Down, double press the F6 key.

The Air Pumps will turn off, followed by the Cooling Fans shutting off, the louvers closing and the Diesel Motor shutting down. A few seconds later you will hear the engineer's door open and then shut. In Total Shut Down, the engine will not respond to throttle or function keys. The only exception is the F6 Start Up Function Key (described below).

If power is turned off at any stage of Shut Down (Disconnect, Standby or Total Shut Down) or during a Shut Down procedure, the engine will remember the last Shut Down stage it was at during power down, and will power up in the same stage. If Start Up is initiated during any of the above Shut Down procedures, Shut Down is aborted and the engine returns to normal operation.

Note: Total Shut Down allows the operator to take the engine "off line" (turn off sounds, lights, ignore throttle settings and function commands) independent of the operating session; that is, the engine will still be "off line" when power is reapplied for the next operating session.

Note: If DCC Shut Down commands (F9) are sent while engine is in Turbine Mode in Neutral, Turbine rapid transition to Diesel will first commence followed by one of the three Diesel shut down states, depending on DCC command sent. This will maintain consistency with other Quantum engines in consists.

Start Up (F6)

If your Gas Turbine locomotive is in any stage of Shut Down, you can return your locomotive to normal operation by double pressing the F6 key. Start Up will be different for each stage of Shut Down, but all will start up with a Long Air Let-off and will enter normal operation in Diesel Mode.

Start Up from Disconnect: If you double press the F6 key in Disconnect, the diesel locomotive will produce a Long Air Let-off, Dynamic Brakes will shut off (if on) and the locomotive will enter normal operation.

Start Up from Standby: If you double press the F6 key in Standby, the diesel locomotive will produce a Long Air Let-off, Directional Lighting will turn on (if previously on), the Diesel Motor sound will change from the special Low Idle to regular Idle, and the engine will enter normal operation.

Start Up from Total Shut Down: If you double press the F6 key in Total Shut Down, the diesel locomotive will produce a Long Air Let-off, you will hear the engineer's door opening and closing, Directional Lighting turning on (if previously on), followed by the vents opening, the Diesel Motor starting up, the Air Pumps starting up, and the locomotive entering normal Diesel Mode operation. During the Start Up procedure, none of the function keys are active.

If the throttle is turned up from zero during any of the above Start Up procedures, the Start Up procedure will abort and the engine will enter normal operation in Diesel Mode.

Note: Whenever a Start Up command is sent, regardless of whether the engine is in Shut Down or operating normally, the Quantum System will automatically restore all Automatic Control.

Mute (F8)

The Quantum System allows you to reduce the System Volume to zero or increase it back to its original setting using the F8 function key. This is useful when you need to turn off the sound to engage in a conversation or to answer the phone. Press the F8 key in Neutral or Forward/Reverse to gradually decrease or increase the locomotive's volume.

Note: Mute state is not maintained if power is turned off and back on; the locomotive will return to full volume setting.

Note: The Gas Turbine does not have the mute volume setting that is standard on later Quantum locomotives.

Status (F10)

The Gas Turbine does not have Status Report that is standard on later Quantum locomotives.

Function Key Operation in Neutral

Some function keys used in Forward and Reverse will have different effects in Neutral:

- The F7 key produces Squealing Brake Sounds for a moving engine but activates the transitions between Diesel and Turbine Mode in Neutral.
- Pressing F6 results in Doppler shift for a moving engine but activates Start Up in Neutral.
- Pressing F9 toggles Cruise Control in a moving engine but activates Shut Down in Neutral.

Note: Horn, Bell, Doppler Shift, Squealing Brake and Neutral sounds are described in detail on page 125, in the *Quantum System Sounds* section of this reference manual.

[130] Function keys will only produce a short air let-off.

DCC Programming for the Gas Turbine

Most command stations currently available will program Quantum equipped locomotives in Service of Ops mode. If your command station will not program in Service Mode, check with the manufacturer –some companies will give you a free upgrade.

Changing the System Volume Electronically in CV 51.0

You can change the volume either manually as described in the *Special Operation and Trouble Shooting* section or electronically using QSI **CV 51.0** in DCC[131]. To change volume in Service or Ops Mode, do the following:

- Enter 0 in CV 49[132].
- Enter the system volume in CV 51. The System Volume can be set to any value between 0 (no sound) and 127 (100%). The default Operations Mode Volume is 127.

Note: When you change the System Volume, you will immediately notice the change in volume in Ops Mode.

Enable/Disable Doppler Shift from Whistle Signal Interrupt and Enable/Disable Turbine/Diesel Transition from Coded Horn (CV 51.2)

- Set CV 49 to 2.
- Set CV 51 to the value indicated in the table below. An "X" in the table indicates that the feature will be enabled. The default is 3 (both features are enabled).

Doppler from Horn Signal	Turbine Transition from Coded Horn	Decimal Value	Binary Value	Hex Value
		0	00000000	00
X		1	00000001	01
	X	2	00000010	02
X	X	**3**	**00000011**	**03**

Changing Individual Sound Volumes (CV 52.X[133])

To change the volume of individual sounds listed in the table below do the following:

- Set CV#49 to the Primary Index for the individual sound from the table below.
- Enter Volume level in CV 52 as follows: "0" = No sound, "1 – 15" = Sets volume from the lowest value at "1", the highest volume at "15". The volume levels are in 2db increments.

Primary Index entered into CV 49	Sound	Default
0	Horn	**11**
8	Bell	**11**
10	Diesel Motor	**9**
13	Turbine Whoosh	**12**
15	Turbine Whine	**8**
16	Air Pump	**10**
19	Diesel Motor Cooling Fans and Vents	**8**
21	Long Air Let-off	**11**
22	Short Air Let-off	**11**
24	Squealing Brakes	**11**
28	Dynamic Brakes	**8**
34	Coupler Sounds	**11**

[131] Volume Changes in DCC also apply to Analog.
[132] You will hear the value spoken out in Ops Mode.
[133] 'X' refers to the value in column 1 of the table, the Primary Index number put into CV 49.

Reset All[134] CV's to Factory Default Values (CV 56.128.255)

Note: This does not affect analog settings, except volumes.

- Write 128 to CV 49.
- Write 255 to CV 50.
- Write 113 to CV 56. In Ops mode, you will hear 3 hoots when reset is completed.

Special ID Programming (CV 56.129)

If you cannot program your ID number in Service Mode and your command station prevents you from changing your ID in Ops Mode using CV 1, CV 17 and CV 18, use the following alternative procedure to program your engine ID's.

Procedure for Entering Short (Primary) Address in CV 56.129 in Ops Mode.

- Set CV 49 to 129.
- Set CV 50 to 1.
- Set CV 56 to your short address. Hear the address spoken back.
- Change CV 29, bit 5 to '0' (or set CV 29 to 2 which is factory default) to enable your new primary address.

Procedure for Entering your Long (Extended) Address in CV 56.129 in Ops Mode.

- Determine the value of CV 17 and CV 18 for your Challenger extended address from table below or follow instructions in CV 17 and CV 18 in the *DCC Quantum Reference Manual* to calculate a different ID number.
- Set CV 49 to 129.
- Set CV 50 to 17.
- Enter CV 17 into CV 56. There will be no verbal response.
- Set CV 50 to 18.
- Enter CV 18 into CV 56. Hear the new full address spoken out.
- Change CV 29, bit 5 to "1" (or set CV 29 to 34[135]) to allow operation with your new extended address.

Loco Number	CV 17 (Dec)	CV 18 (Dec)	CV 17 (Hex)	CV 18 (Hex)	CV 17 (Binary)	CV 18 (Binary)
61	192	61	C0	3D	11000000	00111101
64	192	64	C0	40	11000000	01000000
66	192	66	C0	42	11000000	01000010
71	192	71	C0	47	11000000	01000111
73	192	73	C0	49	11000000	01001001
75	192	75	C0	4B	11000000	01001011

Standard Throttle Control, Speed Control and Regulated Throttle Control Options (CV 56.4)

- Set CV 49 to 4.
- Set CV 56 to: 0 for Standard Throttle Control; 1 for Speed Control and 2 for Regulated Throttle Control.

Note: CV 2, CV 5 and speed tables are available for Standard and Regulated Throttle Control[136] but inactive for Speed Control. See DCC Quantum Reference Manual.

Disable/Enable Verbal Announcements (CV 62)

In Ops mode, Quantum will automatically speak out the value of CV you enter.

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[134] Consult the DCC Reference manual to learn how to reset different groups of CV's.
[135] This leaves all settings at factory default, but changes the ID to extended type.
[136] Regardless of the value of CV 2, RTC has a minimum speed of 1 smph at speed step 1.

- To disable set CV 62 to 0, to enable set CV 62 to 1. Default is enabled.

CV Inquiry with Verbal Feedback in Ops Mode (CV 64)[137]

To inquire about the current value of any CV through Verbal Feedback in Ops Mode:

- Enter the CV number in CV 64. Hear the verbal message "CV 'X' equals 'Y'", where 'X' is the CV number and 'Y' is the value.

Note: If the CV has a Primary Index such as QSI CV nn.mm (where nn is the CV number and m is the Primary Index), mm must be entered in CV 49 before you enter the CV number, nn, in CV 64. So if you want to inquire about the contents of CV 56.4, enter 4 into CV 49 and enter 56 into CV 64. You will hear, "CV five six point four equals 'Y' ('Y' is the present value).

Note: If you enter either '17' or '18' in CV 64, you will hear the full extended ID number.

NMRA Configuration Values (CV 29)

Each bit in CV 29 controls some basic operational settings for DCC decoders, including Extended Addressing, Speed Table Enable, Power Source Conversion, Lighting Operation, Locomotive Direction, and others.
The following table provides some of the more common values for CV 29 for the features indicated. Default is 6.

Extended Addressing	Speed Tables	Power Conversion	28/128 speed Steps	Reversal Direction	Decimal Value	Binary Value	Hex Value
			X		2	00000010	0x2
		X	X		**6**	**00000110**	**0x6**
	X		X		18	00010010	0x12
	X	X	X		22	00010110	0x16
X			X		34	00100010	0x22
X		X	X		38	00100110	0x26
X	X		X		50	00110010	0x32
X	X	X	X		54	00110110	0x36
			X	X	3	00000011	3
		X	X	X	7	00000111	7
	X		X	X	19	00010011	13
	X	X	X	X	23	00010111	17
X			X	X	35	00100011	23
X		X	X	X	39	00100111	27
X	X		X	X	51	00110011	33
X	X	X	X	X	55	00110111	37

[137] This option is not disabled by CV 62.