Union Pacific
FEF-3

Developed for Train Simulator 2015™

by Smokebox

Version 1.0

Contents

Introduction

The model has been built, as far as possible, using Alco's original 1/8th scale drawings, some dated as early as 1944.

There are many, many publications covering the Union Pacific FEF-3 and the most famous member of the class, UP 844, so for further information on the prototype, I recommend reading some of those - in particular, the book "The Mighty 800" by William. W. Kratville, published by Kratville Publications (1st edition 1967) and available from Amazon.com (ASIN: B0007EME4Y).

There will also be some articles available at http:\\www.engine-driver.com.

This is a very complex model. There is a slightly simplified version that can be used with the HUD or Xbox controller, even in Simple mode, but to get the most out of the model, I recommend using the Advanced version in expert mode, and for extra kudos, fire manually. You can even run in tandem with UP8444 (an SD70ACe) and operate 844 and 8444 at the same time from the cab of 844!

Whatever you choose to do, you'll find that it will be somewhat easier if you first read this manual carefully.

Animations

The FEF-3 has a huge number (hundreds, quite literally) of animated parts and **nearly one hundred separate animation sequences**!

- The entire **valve gear and running gear** is animated, with separate animation sequences for when the reverser is in the forward, neutral and reverse positions.
- The animation of the Walschaert's valve gear extends to the links to the **mechanical lubricators** situated near the cylinders - watch the little red handles rotate a bit each time the ratchets on the front of the lubricators are yanked down by the combination levers when the loco is moving.
- The **reversing gear**, from the lever in the cab, through all the linkage, the Alco power reverser cylinder, down the reversing rod to the tumbler shaft and lifting links, and including the movement of the radius bar, valve piston, combination lever and union link. Basically, when you move the Johnson bar, practically everything connected to it that moves in the real loco will move in the model.

- The rods running along the outside of the boiler, connecting the throttle lever in the cab to the **front-end throttle assembly** on the side of the smokebox are animated.
- The **brake rigging and brake pistons** are animated on the engine's driving wheels and also on the trailing truck, as well as on all fourteen wheels of the enormous "Centipede" tender, including its own front articulated truck.
- All four **cab doors**, the **side windows**, **ventilator doors**, **roof hatch**, and **front storm windows**, can be opened, and even the **side windshields** (attached to the cab windows) can be pushed flat or extended.
- On the tender, all of the **toolbox doors** can be opened, as can the **water filler lids** on the top deck.
- The **water level in the tender** is animated - you can see it if you open the filler lids or by looking at the **transparent "sight" pipe** running down the back of the tender (the modern variant, that is - there's also a "clean" variant, called "no MU", without as much paraphernalia on the rear).
- Most of the **cab controls** are animated in both the cab view and the external model, so when you look into the cab from outside, you can see the controls - the firing handle (oil regulator), throttle, reverser, valves, levers - moving just as they do in the internal cab view.

Lights

Note that the lights will not illuminate if the steam-driven electric DC generators (dynamo) are not running and producing 32V.

The locomotive has a headlight with two intensities, dim and bright, which can be selected using the keyboard or the control in the cab. When bright is selected, the headlight beam illuminates well ahead of the loco.

The tender also has a headlight that can be set to dim or bright. Note that the tender headlight is absent from the "clean" (no MU) version.

The locomotive also has two 3-colour classification lights. These have to be switched on with the keyboard command (U or shift U). The colours and their meanings are:

- **White** - an “extra” unscheduled, i.e. not in the timetable, train;
- **Red** - the loco is at the rear of the train; (note: being pedantic, red is actually a "marker" light instead of a "classification" light)

- **Green** - the train is part of a timetabled service that has been split into several consists, or sections, and another section is following behind it.

The Mars light can be activated manually, but is also switched on automatically when the brakes are put into emergency (this also switches off the headlight automatically). When the switch is automatic, the manual selectors stay where they are.

The cab has two main lights, one on each side, and seven gauge lights that focus light on specific parts of the cab. There is also a light outside the cab, above the doors.

Shadows

The two main cab lights and the bright headlight beam can be toggled between casting shadows or not.

By default, the shadows are OFF. Switching shadows ON will probably decrease your frames per second (the impact will depend, obviously, on your particular system), but on a reasonably powerful system, the effect of the shadows is (in my opinion) well worth the cost.

Sanding

The model has been scripted to simulate a limited amount of sand in each sandbox (sand dome), enough for about 2 hours of continuous operation. In addition, the script differentiates between the forward and rear sanders, and the sand helps traction only when traveling in the corresponding direction.

Particle effects

The action of the cylinder cocks steam emitters is scripted to take account of there being two cylinder cocks per cylinder, one for the forward stroke and another for the backward stroke. The script controls the steam emission, alternating between the forward and rear cylinder cocks, synchronized exactly with the piston strokes.

The engine has a double smoke stack, and there are several particle emitters in each stack. Both stacks are synchronised to the exhaust chuffs. The colour of the smoke from the stacks gives a visual indication of how the locomotive is being fired.

In the middle of the stack, there is the air compressors steam exhaust pipe, and attached to the front of the stack cowling is an exhaust for the feedwater heater. The main exhaust of the feedwater heater is just underneath the front of the left-hand cylinder.

The two dynamos have exhaust steam when running.

The Wilson sludge separator gives off a plume of steam when blowing off.

There are three safety pop valves, set to lift at different pressures. Two are muffled and one is un-muffled. At 300psi, the boiler's maximum operational pressure, the first muffled safety valve will be showing some faint wisps of steam.

The oil pan, when it flashes (when the engine is working hard) also gives off a bluish smoke from un-burnt oil.

The sludge spreader gives off a jet of steam when the sludge removers are activated.

The non-pickup injector overflow pipe gives off wisps of steam.

The whistle, when blown, gives off steam - faintly in spring, summer and autumn/fall, but much more in winter.

Sparks fly from the wheel tyres when wheelslip (wheelspin) or wheelskid occurs.

The sanders show particles of sand coming out of the nozzles near the driver tyres.

Other special effects

In cab view, raindrops appear on the window panes when it's raining. These also appear in the outside view after the cab view has been entered at least once.

The water level shown in the water sight glasses (in the cab) sloshes up and down when the locomotive is moving - the amount of sloshing increases with the speed of the engine, but decreases drastically if the sight glasses become clogged with sludge.

"Flashover" flames are visible through the secondary air inlets of the oil pan beneath the firebox, when the engine is working hard - they pulsate in time with the exhaust beats.

Expert mode, Simple mode, HUD and Automatic Fireman

The models are divided into two main groups - "**Advanced**" and "**HUD-enabled**". These are explained in more detail below.

First though, it is extremely important to understand that whichever version is used, and regardless of the driving mode that is selected, the game's **automatic fireman must be disabled** via the in-game menu :

Main Menu > Settings > Gameplay > Automatic Fireman > Off

This is because the model simulates an oil-fired steam locomotive, making it incompatible with TS2015's usual automatic fireman. The model's scripting implements its own specialized "expert" automatic fireman, using all the controls at its disposal.

The differences between "Advanced" and "HUD-enabled" are explained below:

- "**Advanced**" version - if the name of the locomotive contains "**Adv**", it means it is an advanced version.

  The "Advanced" version contains the most amount of scripting for authentic operations (real steam chest, impaired steam generation, etc.) and will not work correctly with the HUDs (this is because the scripts manipulate the HUD controls, such as the regulator/throttle lever and the reverser lever on the HUD, themselves).

  The advanced versions must be operated in Expert driving mode, with or without the expert automatic fireman (toggled on/off using the "Ctrl Shift A" key combination, or by clicking on the fireman's seat cushion).

  A detailed performance report can be obtained at any time by pressing Ctrl Shift R or clicking on the noticeboard on the left cab wall. The report enables you to judge for yourself how well you have been firing and running the locomotive.

- "**HUD-enabled**" version - such models are identified by having "**HUD**" in the name.

  The HUD-enabled versions contain almost as much advanced scripting as the "Advanced" versions, but are less authentic in operation, which allows the player to operate the locomotive using the HUD.

  The HUD-enabled versions can be operated in either Simple or Expert driving mode (the script detects which mode you are using and adapts itself accordingly).

  The HUD-enabled version also performs several actions autonomously at the start, such as turning on the dynamo, air compressors, cylinder cocks master, feedwater pump shut-off

(for the exhaust injector), etc., so that the player can immediately begin using the HUD without the need to initialize any of those controls using the keyboard or mouse.

The HUD-enabled version has the expert automatic fireman enabled permanently (it cannot be toggled off) - this is because the HUD does not have the appropriate controls for an oil-fired steam locomotive. Therefore, with the HUD-enabled version, the player assumes the role of locomotive engineer and leaves the model's scripted expert automatic fireman to take care of maintaining pressure and looking after that side of things.

High Detail (HD) and Standard Detail (SD)

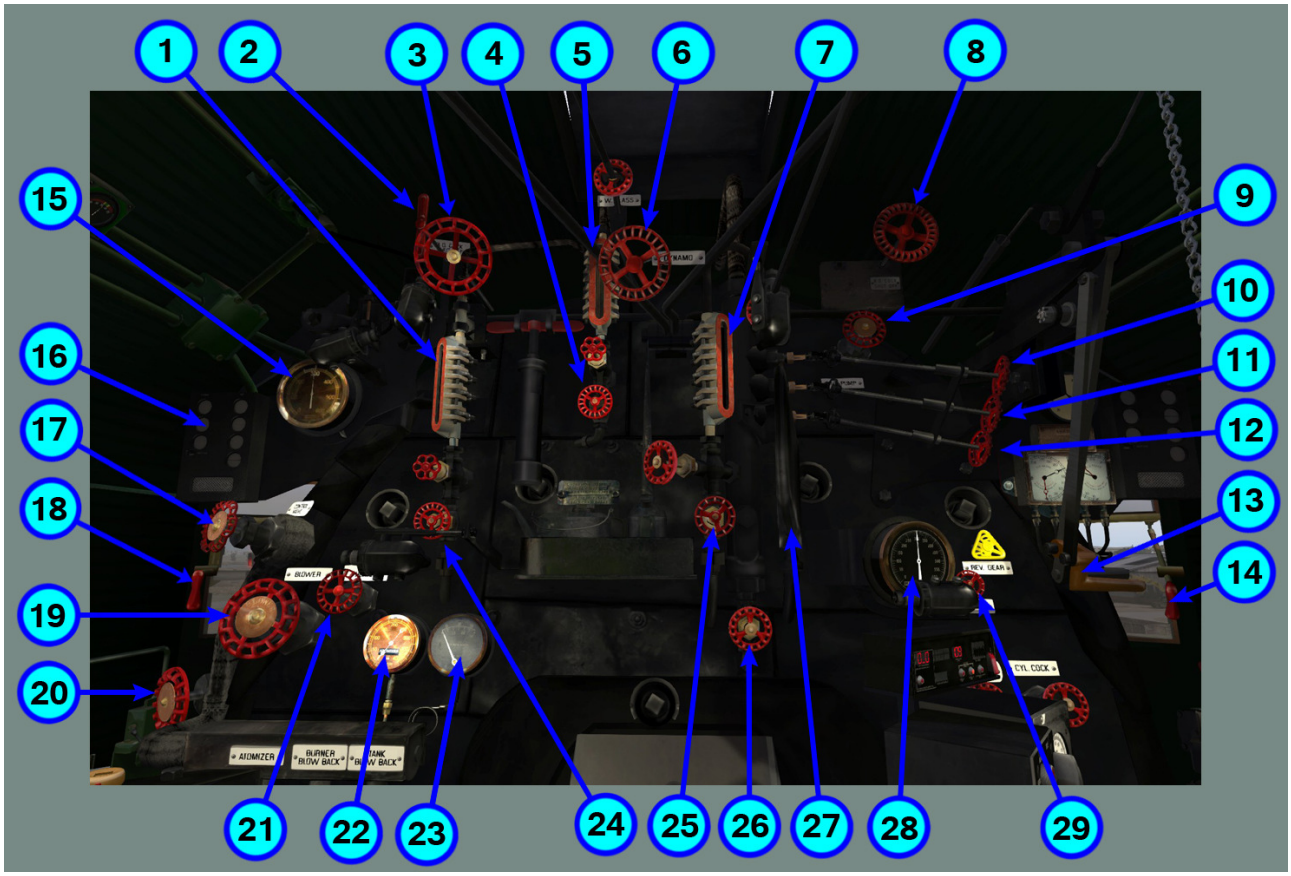
For each model, whether it be Adv or HUD, there is both a "High Detail" ("HD") and "Standard Detail" ("SD") version.

HD models have everything, including all the nuts, bolts, rivets and other small details.

SD models leave out most of the nuts, bolts, rivets and other small details, including gauge lights and oil cans in the cab, and they substitute some of the exterior textures for compressed versions - the difference in quality is not noticeable until you get close to the locomotive (which is why the cab interior keeps the uncompressed textures).

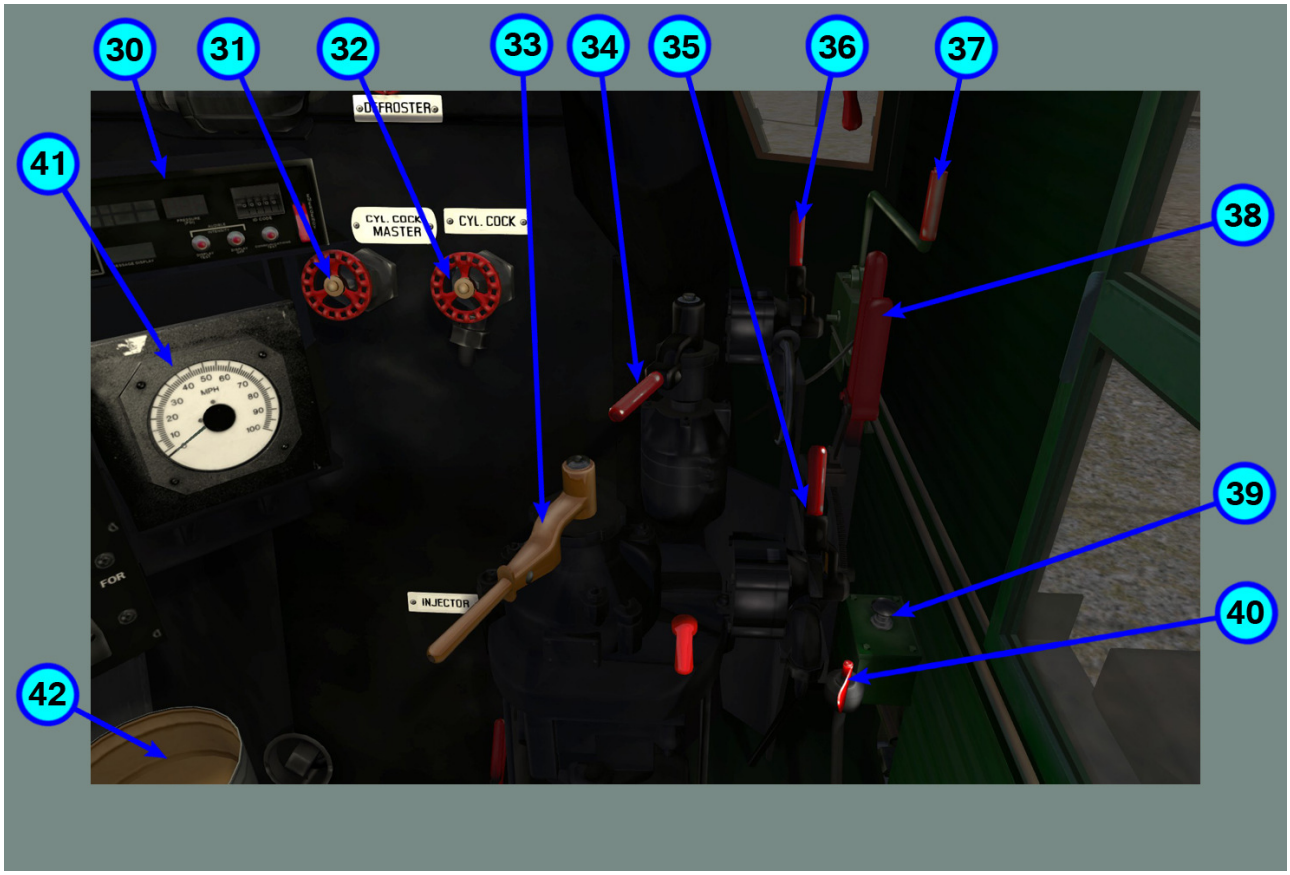
Positions of the controls and gauges in the cab

The diagrams below show the positions of the cab controls (all can be operated by dragging or clicking with the mouse) and gauges (or gages, if you prefer).



1. Water glass (left)
2. Blowoff cock shut off (left)
3. Feedwater pump shut off
4. Water glass blowdown (middle)
5. Water glass (middle)
6. Dynamo (steam-driven electric DC generators) steam throttle
7. Water glass (right)
8. Blowoff cock shut off (right)
9. Air pump (steam-driven cross-compressors) valve

10. Gauge cock (upper)
11. Gauge cock (middle)
12. Gauge cock (lower)
13. Throttle
14. Storm window (right)
15. Boiler pressure gauge (left)
16. Cab signal indicator (left)
17. Control valve (for the steam manifold)
18. Storm window (left)
19. Blower
20. Feedwater pump control
21. Tank heater
22. Atomizer pressure gauge
23. Feedwater pump pressure gauge
24. Water glass blowdown (left)
25. Water glass blowdown (right)
26. Water column blowdown
27. Water column
28. Boiler pressure gauge (right)
29. Defroster air



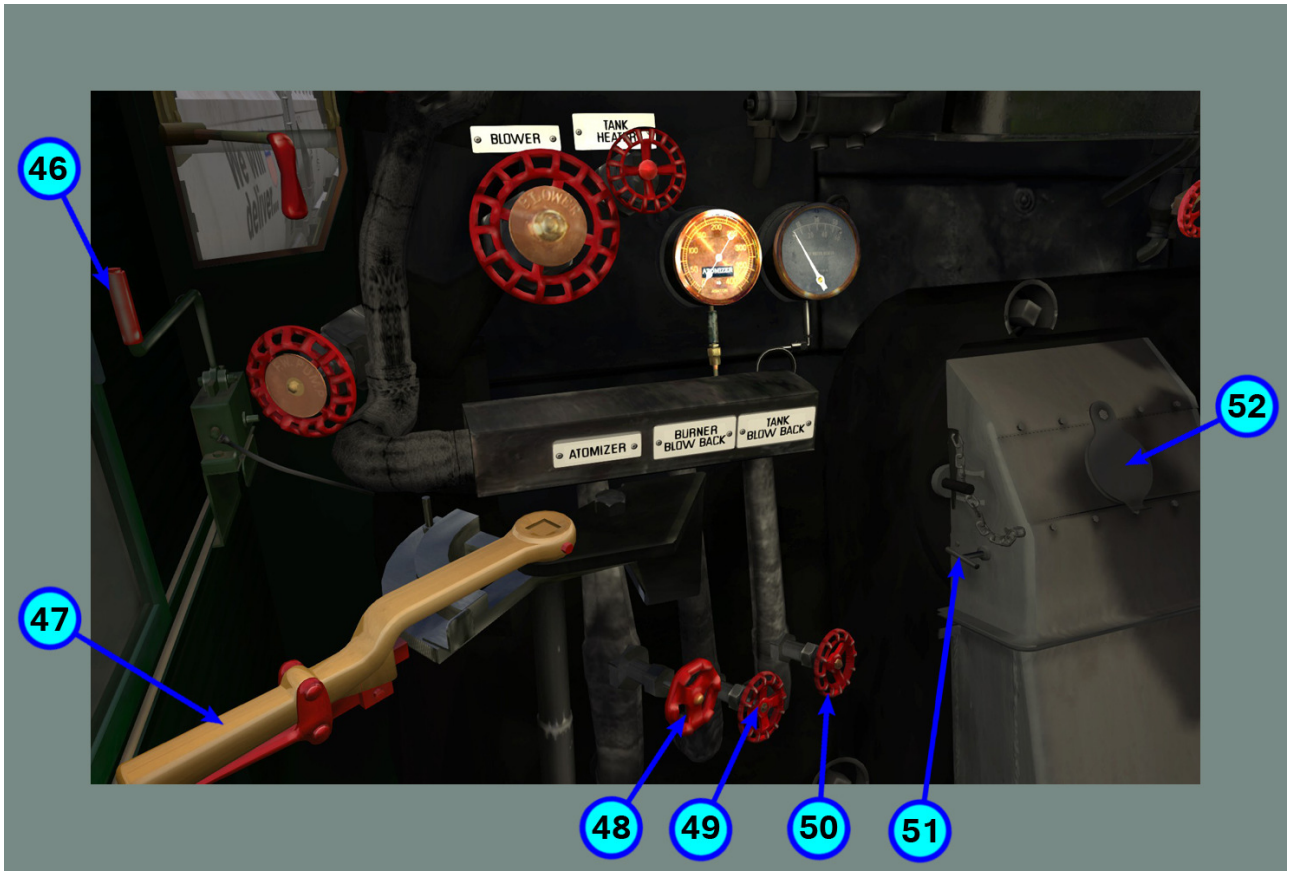
30. Head-of-train (HOT) device (a.k.a. "Wilma")
31. Cylinder cocks master (steam)
32. Cylinder cocks operating (air)
33. Automatic (train) brake
34. Engine (independent) brake
35. Sander valve (forward)
36. Sander valve (rear)
37. Sludge remover (right)
38. Reverse lever (a.k.a Johnson bar)
39. Acknowledge button
40. Bell ringer
41. Speed recorder

42. Sand for clearing the boiler flues

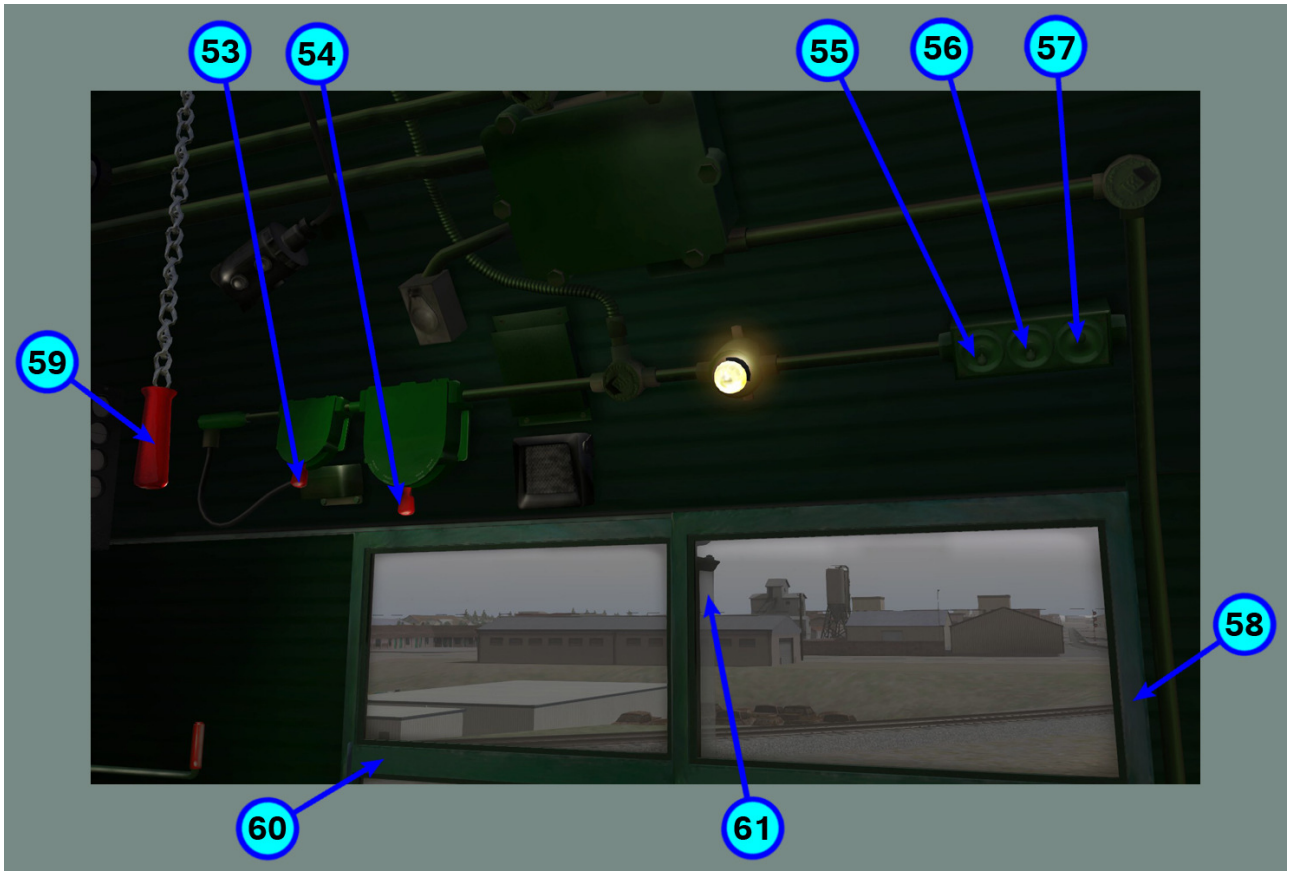
43. Multiple Unit control box

44. Live, non-pickup injector control lever

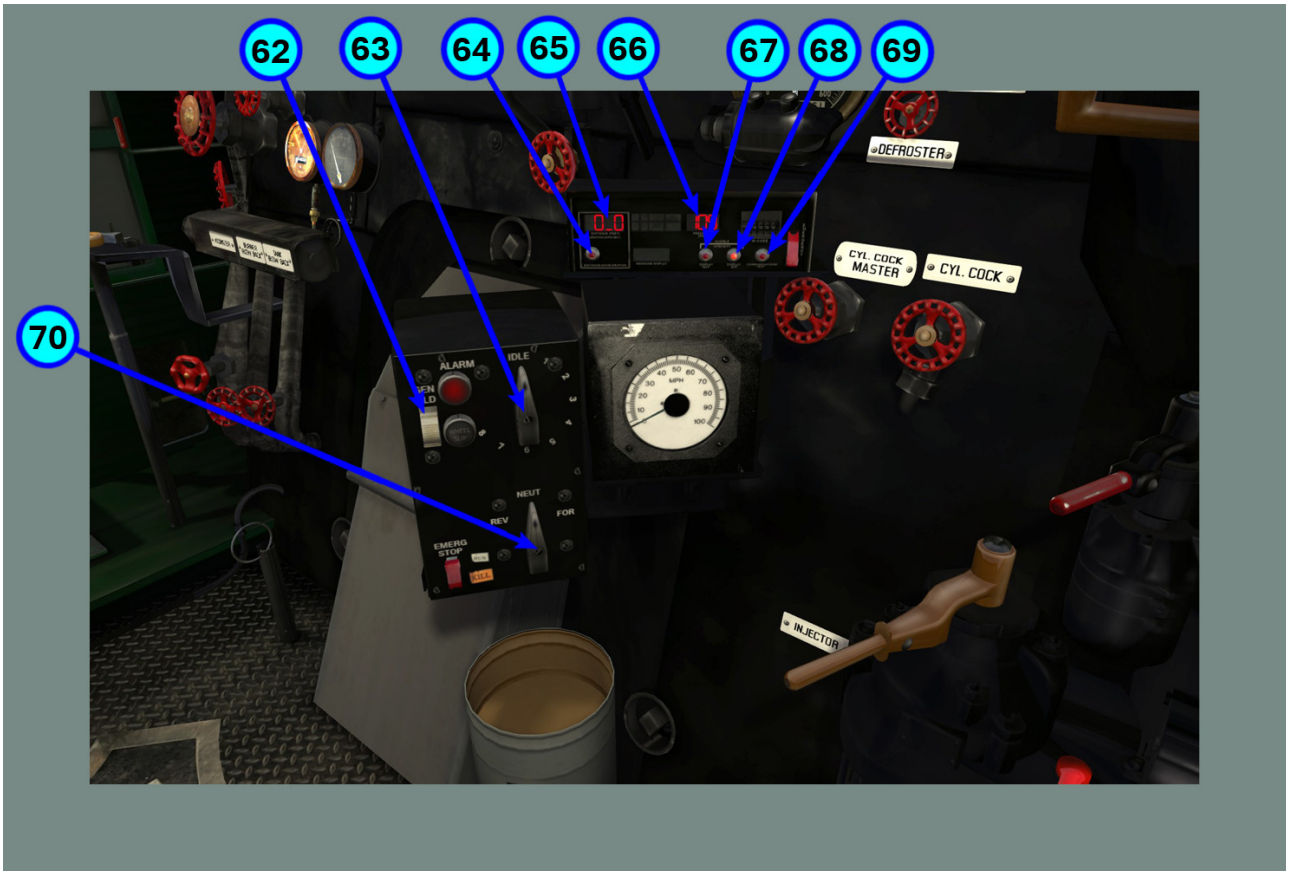
45. Live, non-pickup water feed regulator



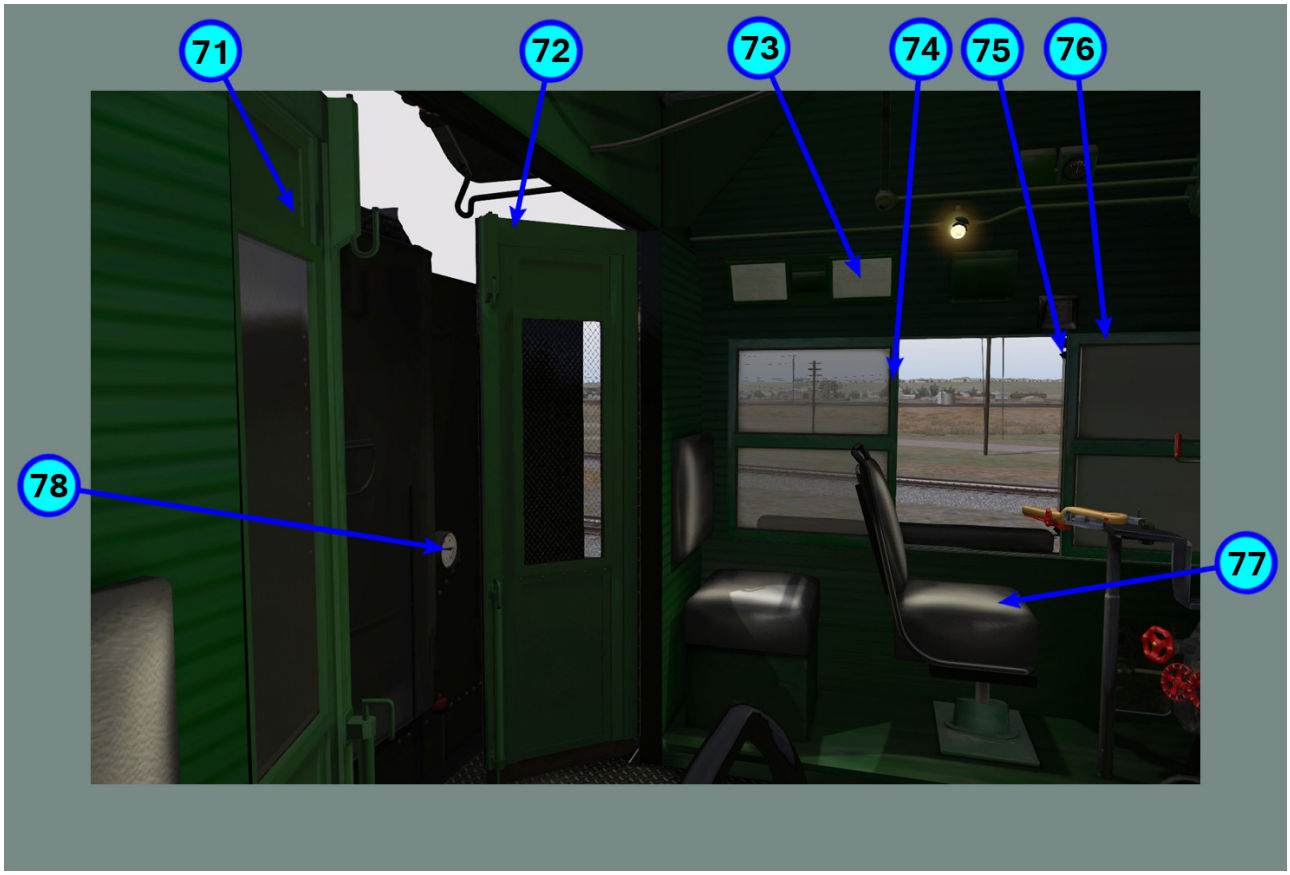
46. Sludge remover (left)
47. Oil regulator (a.k.a. Firing handle)
48. Atomizer
49. Burner blow back
50. Tank blow back
51. Draft hood damper
52. Firedoor peep hole



53. Mars light position selector switch
54. Headlight and tail light positions selector switch
55. Cab lights switch
56. Gauge lights switch
57. Cab rear outside light switch
58. Sliding window (rear right)
59. Whistle pull
60. Sliding window (front right)
61. Folding windshield (right)



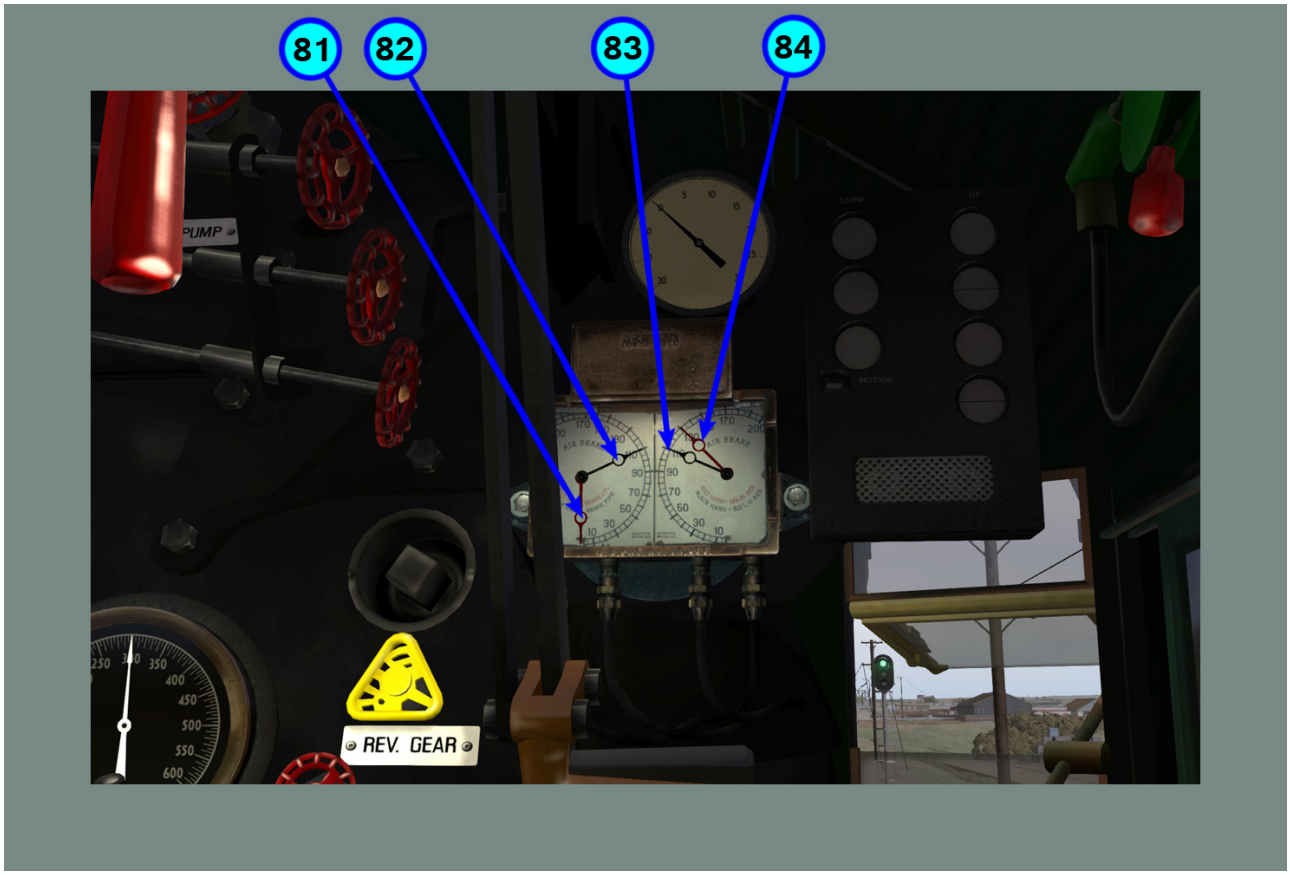
62. MU generator field switch
63. MU notch selector
64. HOT distance/acceleration toggle button
65. HOT distance/acceleration display
66. HOT train line pressure display (psi)
67. HOT display test button
68. HOT display on/off button
69. HOT communications test button
70. MU direction selector



71. Cab doors (right)
72. Cab doors (left)
73. Performance report
74. Sliding window (rear left)
75. Folding windshield (left)
76. Sliding window (front left)
77. Expert automatic fireman toggle on/off
78. Oil fuel tank thermometer (degrees Fahrenheit)

79. DC voltmeter

80. Roof ventilator hatch



81. Engine brake cylinder pressure
82. Brake pipe pressure
83. Equalizing reservoir pressure
84. Main reservoir pressure

Key assignments

Item	Key	Action	Remarks
Engineer's controls			
Throttle	A	Increase	In the advanced version, the throttle controls the rate at which the steam chest (not the cylinders) is filled with steam. In the HUD version, it works just like the usual regulator in a standard model.
	D	Decrease	
Reverser (Johnson Bar)	W	Forwards	The reverser controls the cut-off, i.e. for how long steam is admitted to the cylinders on each piston stroke, as well as the direction of travel (although it is possible, in the right circumstances, to be travelling forwards with the reverser in reverse, and vice-versa).
	S	Reverse (“Hook up”)	
Engine (Independent) Air Brake	Right square bracket ( ])	Increase	Note: to perform a quick application, continue pressing] when the handle is all the way to the right, otherwise it will automatically spring back to the "slow application" position.
	Left square bracket ([ )	Decrease	Bail-off - holding down the [key (or using the mouse to drag the engine brake lever to the left continually) will bail off the pressure in the engine brake cylinders. The lever is spring-loaded, so when [(or the mouse) is released, the lever springs back to the "release/ running" position.
Train Air Brake	Apostrophe	Increase	Four positions: Release, Hold (Running), Apply and Emergency.
Instant emergency brake application	Backspace	Initiates	Once an emergency brake application has been initiated using the backspace key, or the "hand palm" icon on the HUD, the train brake cannot be moved again until the locomotive has come to a complete stop.
Live Injector Water Valve	L	Open	Admits water from the tender into the live injector.
	Shift-L	Close	
Live Injector Lever	O	Toggles Open/Closed	When opened, allows the live injector to ram water into the top of the boiler.
Forward sander	X	Open	
	Shift X	Close	
Rear sander	Ctrl X	Open	
	Ctrl Shift X	Close	
Whistle	Spacebar	Pull handle	
	Spacebar Return	Quill the whistle	

Item	Key	Action	Remarks
Bell	B	Toggle on/off	The standard way to operate the bell from the keyboard.
Cylinder Cocks Master	Ctrl C	Open	Steam will be expelled from the cylinder cocks only when they are open AND the regulator is not fully closed AND the master cock is open. There will be a catastrophic failure if the cylinder cocks are not used after the loco has been stationary for some time, as a result of steam condensing in the cylinders.
	Ctrl Shift C	Close	
Cylinder Cocks	C	Open	
	Shift C	Close	
Reverse Gear Steam	Mouse	Open / close	The yellow triangular knob controls the emergency steam supply to the power reverser (*not implemented*)
Blow off shut-off (engineer's side)	Mouse	Open / close	Opening a blow off shut off valve allows the sludge separator in the turret just ahead of the cab to operate when the sludge remover lever is tapped.
Sludge Remover (Engineer's side)	Shift F8	Open (to close, release button)	Removes sludge from the boiler water jacket surrounding the firebox. They are also used by the crew to signal to each other, when the cab gets noisy, as an alternative to shouting!
Defroster	Mouse	Open / close	The defroster uses air to clear the small windows in the front of the cab.
Head-of-train device (HTD/HOT/Wilma)			
Distance / Acceleration button	Mouse	Push button	The leftmost display on the HTD shows either the distance (in feet) to the rear of the train, or the acceleration (mph per second).
Display test	Mouse	Push and hold button	Tests the LED numerical displays
Display off	Mouse	Push button	The HTD is switched on and off using this button. Note: the dynamo has to be running, otherwise there is no power to the HTD
Communications test	Mouse	Push button	Tests the radio communications between the HTD and EOT device (FRED). A "beep" means the comms are working.
MU Controller visibility	Ctrl Shift M	Toggle on/off	This key combination allows the entire MU controller to be made invisible (useful if you want to simulate a cab that is not fitted with the controller). Note, however, that even if the controller is invisible, the controls are actually still there, so if you move the mouse over the place where the controls are, even if you can't see them, the mouse-over label will pop up.

Item	Key	Action	Remarks
Head Of Train device visibility	Ctrl Shift W	Toggle on/off	This key combination allows the entire HTD/HOT/Wilma to be made invisible (useful if you want simulate a cab that is not fitted with the device). Note, however, that even if the device is invisible, the controls are actually still there, so if you move the mouse over the place where the controls are, even if you can't see them, the mouse-over label will pop up.

Item	Key	Action	Remarks
Fireman's controls			
Firing valve (oil regulator)	R	Increase	Controls the amount of fuel that the atomizer will spray into the firebox.
	Shift R	Decrease	
Atomizer	Shift A	Increase	The force of the fuel atomizer has to be increased as the draft through the flues to the smokebox increases (pulling the fire away from the back of the firebox, reducing the effectiveness of the fire). However, if the atomizer is too forceful, it will lead to un-burnt oil dripping into the pan, and bluish smoke from the stack.
	Shift D	Decrease	
Steam-driven Cross Compound Air Compressor, Steam Throttle	V	Open	Opening the steam throttle starts the compressor and closing the throttle stops it.
	Shift V	Close	
Feedwater Pump shut-off (Exhaust Injector Steam Throttle	I	Open	Allows steam into the feedwater pump. If the pump is shut off, the exhaust injector will not re-fill the boiler.
	Shift I	Close	
Feedwater Pump	K	Open	Regulates the pressure of steam supplied to the feedwater pump. When the pressure is higher than boiler pressure, the boiler is refilled with pre-heated water.
	Shift-K	Close	
Control Valve	E	Open	Controls the supply of steam to the atomizer and to the burner and tank blowback valves.
	Shift E	Close	
Blower	N	Increase	Increasing the blower helps to generate steam more quickly, although it also uses steam.
	Shift N	Decrease	
Damper	M	Open	The damper door is opened, feeding more air to the fire, when the lever on the draft hood is rotated upwards. Open corresponds to “On” in the F5 HUD.
	Shift M	Close	

Item	Key	Action	Remarks
Burner blow back	Mouse	Open / close	If the burner becomes obstructed (no flames seen through the firedoor peephole), open the firing valve and burner blow back valve all the way. Wait until the obstruction is cleared (flames reappear), then close the burner blow back valve and re-adjust the firing valve as needed.
Tank blow back	Mouse	Open / close	
Firebox flap	Ctrl F	Open	Lift the firebox flap to look at the fire, and before throwing in a scoop of sand to clean the flues.
	Ctrl Shift F	Close	
Tank Heater	Mouse	Open / close	The fuel oil in the tender has to be heated, especially in winter, to maintain the required viscosity. Otherwise, there is an increased chance of an obstruction in the burner, caused by un-atomized oil. The ideal temperature is 98 degrees Fahrenheit.
Blow off shut-off (fireman's side)	Mouse	Open / close	Opening a blow off shut off valve allows the sludge separator in the turret just ahead of the cab to operate when the sludge remover lever is tapped.
Sludge Remover (Fireman's side)	Shift F7	Open (to close, release button)	Removes sludge from the boiler water jacket surrounding the firebox. They are also used by the crew to signal to each other, when the cab gets noisy, as an alternative to shouting!

Item	Key	Action	Remarks
Other controls			
Water sight glasses blow-down	Mouse	Open / close	The water sight glasses should be "blown down" at the beginning of every run, and hourly after that, to prevent clogging that will cause them to give false readings. An indication of clogging is that the amount of sloshing, at speed, is greatly reduced.
Water column blowdown	Mouse	Open / close	The water column, to the right of the water sight glass on the engineer's side, also has to be blown down every hour to prevent clogging.
Pyle National Electric DC Generator, Steam Throttle	Mouse	Open / close	The generator (dynamo) supplies electricity to all the lights. So, if the generator is stopped, the lights will be extinguished.

Item	Key	Action	Remarks
Doors and windows			
Cab Window (front left)	comma	Open	The key commands slide the windows nearest to the front of the cab, but all of them can be moved separately with the mouse.
	Shift comma	Close	
Cab Window (front right)	period	Open	
	Shift period	Close	

Item	Key	Action	Remarks
Roof ventilator hatch	Ctrl T	Close	The ventilator hatch is open by default
	Shift T	Open	
Cab Doors (left)	Home	Open	
	Shift Home	Close	
Cab Doors (right)	End	Open	
	Shift End	Close	
Cabside windshield (left)	Ctrl comma	Toggle flat/extended	The narrow windshields attached to the cab windows can be pushed flat or extended.
Cabside windshield (right)	Ctrl period	Toggle flat/extended	
Storm Window (left)	Pg Up	Open	The storm window affords the engineer a clearer view ahead when it's raining.
	Shift Pg Up	Close	
Storm Window (right)	Pg Dn	Open	The storm window affords the fireman a clearer view ahead when it's raining.
	Shift Pg Dn	Close	
Side Vent (left)	Mouse	Open / close	
Side Vent (right)	Mouse	Open / close	

Item	Key	Action	Remarks
Lights			
Classification Lights	U	Off → White → Red → Green	There is no corresponding cab control. That is because in the real loco, the light was controlled by a lever under its casing.
	Shift U	Green → Red → White → Off	
Headlight selector switch	H	<u>HUD version:</u> Rear Full → Off → Front Full <u>Adv version:</u> Rear Full → Rear Dim → Off → Front Dim → Front Full	The headlight selector begins a scenario in the Off position. Note that if the Mars light is activated automatically as a result of putting the train brakes into emergency, the headlight will be extinguished regardless of the position of the manual selector.
	Shift H	Opposite direction to H	

Item	Key	Action	Remarks
Mars light manual selector switch	Mouse	Oscillating ↔ Steady ↔ Off	The Mars light has a manual switch selector as well as being activated automatically when the brakes are put in emergency (regardless of the position of the manual selector).
Cab Lights	minus	On	The shadows they cast can be toggled on/off with Ctrl Shift S.
	Shift minus	Off	
Gauge Lights	=	On	There are several small lights to illuminate various gauges.
	Shift =	Off	
Shadows cast by lights	Ctrl Shift S	Toggle on/off	Switching off the shadows cast by the cab lights can be useful as a means of gaining some extra fps when needed. By default, shadows are on in the HD models, off in the SD models.

Item	Key	Action	Remarks
Tender			
Tender water tank lids.	Shift W	Open / Close	
Tender toolboxes (right-hand side)	Ctrl Shift period	Toggle open/close	
Tender toolboxes (left-hand side)	Ctrl Shift comma	Toggle open/close	
Tender toolbox (front)	shift forward slash	Toggle open/close	

Item	Key	Action	Remarks
Miscellaneous simulation control commands			
Expert Automatic Fireman	Ctrl Shift A, or click the fireman's seat cushion	Toggle on/off	This automatic fireman is specific to the FEF-3. For it to work properly, the usual automatic fireman accessed through the game menu must be disabled. The FEF-3's automatic fireman attempts to keep the boiler pressure between 297 and 299 psi without the safety pop valves lifting, and the water level in the boiler at 0.8. This toggle is for the "Advanced" (non-HUD) version only. The expert automatic fireman is enabled permanently in the HUD version.

Item	Key	Action	Remarks
Performance Report	Ctrl Shift R, or click the noticeboard in the cab	Toggle On/Off	Enables a pop-up message giving summary information on various aspects of operating the locomotive, such as for how long it has been emitting black smoke, total duration of wheelslip and wheelskid, time spent firing manually, etc. If you do particularly well firing manually, you might like to post a screenshot of this report.
Track conditions	Shift 3	Increases	The track conditions are selectable . It starts off as "dry" (practically impossible to induce wheelslip), but the slipperiness can be increased progressively through "rain", "snow" and "wet leaves" (very easy to slip). Ctrl 3 progressively decreases the slipperiness.
	Ctrl 3	Decrease	
Pilot coupling hood	Ctrl Shift P	Toggle on/off	The hood should be removed before coupling up at the front of the locomotive (it looks better that way!)

Auto-numbering

In addition to the locomotive number, the model also features auto-numbering on the train consist boards mounted on the smokebox. These accept digits from 0..9 as well as "X" and "-".

The auto-numbering code that you enter into the locomotive when creating a scenario is composed of 11 characters, as illustrated with the following examples:

Example 1:

XXX-844844X

XXXX-844844X Commemorative plate is removed

XXXX-844844X Smoke deflectors (a.k.a "elephant ears" or "wind wings") are removed

XXX-844844X Train code is set to "X-844"

XXX-844844X Locomotive number is set to "844" and the special embossed shield on the cab floor is visible.

XXX-844844X Mars light is removed

Example 2:

##--27-843#

##--27-843# Commemorative plate is placed on the top of the front cowling

##--27-843# Smoke deflectors appear

##--27-843# Train code is set to "--27-"

###--27-843# Locomotive number is set to "843" and there is no shield on the cab floor (only 844 has the cab floor shield)

##--27-843# Mars light appears

The auto-numbering does something extra special when the locomotive number is 840 or 844:

- When 840 or 844 is chosen, the shield on the smokebox door is rendered in full 3D, including the lettering and numbers.
- When 844 is chosen, an embossed shield appears on the cab floor.

Genuine wheelslip/wheelskid

The model features extremely realistic wheelslip and wheelskid physics, using a method pioneered by Smokebox.

The motion of the eight driving wheels and all of the connected rods, cranks, links and valve gear, even the linkage to the mechanical lubricator, are governed by LUA scripting (the forwards backwards motion of the locomotive, as well as the rotation of the pilot, trailing and tender wheels is still controlled through the core code). This allows the model to exhibit true wheelslip/skid behaviour, in different track conditions that can be selected (via key presses) by the player. When the locomotive loses traction, you will see the driving wheels slip. When the brakes are applied and stop the wheels from rotating, if the loco is still moving forwards (or backwards), you'll see them skid (and you might even see sparks fly!).

The LUA scripting contains some quite complicated calculations for wheel inertia, momentum and adhesion, taking account of the locomotive's instantaneous tractive effort, the weight on the driving wheels (allowing for the current mass of water in the boiler), sanding and the coefficient of friction between the driver tyres and the rails (or brake shoes, if applied).

The friction can be changed "on the fly" through a keystroke combination, even to the extremely slippery condition of "leaves on the track" (leaves produce a resinous black goo so slippery that not even sanding will help).

It's possible to induce wheelslip even when running "light engine" (in fact, the weight of the consist pulled by the locomotive is not a direct factor in determining wheelslip - it only affects how much power is needed to overcome the inertia of the consist and get it rolling) and, furthermore, the power reverser can be used to slow down the engine, and then when traction is lost, the wheels will spin in the opposite sense to the direction of travel of the locomotive.

Once wheelslip occurs, if it's not corrected promptly, the wheels will continue to spin faster and faster until "something bad happens" to your locomotive.

Example: If you close the throttle and put the reverser into the opposite direction, then open the throttle again, the driving wheels will slow down (losing their rotational momentum as the pistons act like brakes) and eventually rotate in the opposite direction (back-pedalling).

Note: when the reverser is put into reverse, the radius rod will be lifted into the reverse position even though the locomotive is still going forwards, and if the reverser is put into forward, the radius rod will be dropped into the forward position even though the locomotive is still going backwards.

Note: In the Advanced version, when wheelslip occurs, the engine script sets the reverser control to zero, in order to prevent the locomotive from accelerating (the core code, which controls the backwards/forwards movement of the entire locomotive, doesn't know that the drivers are slipping). As soon as the wheels regain traction, the reverser returns to where it was before the wheelslip.

Firing manually

The Advanced version can be fired manually by toggling off the expert automatic fireman (Ctrl Shift A, or alternatively, mouse click on the fireman's seat cushion).

However, manually firing the FEF-3 is quite complicated - there's a lot more to do than in a standard model of a steam locomotive in Train Simulator, so you'll need to read this section thoroughly.

The main controls you will use, as fireman, to manage the boiler pressure are as follows:

- Oil regulator (also called a "firing valve").
- Atomizer
- Blower
- Firebox front damper
- Feedwater pump

At the start of each scenario, there is a certain amount of preparation for the fireman to perform, involving these controls:

- Steam manifold control valve
- Feedwater pump shut-off
- Tank heater
- Blowdown valves for the three water sight glasses and the water column (situated next to the right-hand sight glass)
- Dynamo throttle

In addition, as fireman, from time-to-time you will need to use the following controls:

- Burner blow-back
- Tank blow-back
- Firebox door peep-hole and sand bucket

Managing the boiler pressure

Responsiveness

First of all, you must understand that the boiler reacts to oil-firing much more quickly than in a coal-fired (or wood-fired) steam locomotive. This makes it much easier to maintain the optimum boiler pressure, because the pressure can be raised very quickly. However, in order to keep the pressure high but without causing the safety pop valves to lift, the fireman also has to adjust the firing controls before the engineer makes adjustments to the throttle or reverser, to avoid sudden changes in boiler pressure that will occur when the steam demand changes. This is one of the reasons why, in real life, the engineer doesn't generally make sudden, large adjustments to those controls, and in any case always warns the fireman, verbally or by a quick nudge on the sludge remover (which makes a loud hiss), that he is about to increase or decrease the steam consumption.

Oil Regulator

The fire is fed with viscous fuel oil (stored in a tank in the tender) through a valve that is opened and closed using the oil regulator (firing valve) control just in front of the fireman's seat. To increase the amount of fuel in the firebox, push the oil regulator further forward.

Take care not to leave the oil regulator in the fully closed position for long, because the fuel already in the firebox will quickly be used up and the fire could be extinguished (game over!). To try to prevent this from happening accidentally, even in manual firing mode, the expert automatic fireman keeps an eye on the fire mass and takes action autonomously to increase the fuel flow to prevent the fire from going out (so in manual mode, there is still a chance you might see the oil regulator move a little bit by itself).

Atomizer

After going through the oil regulator, the fuel reaches the atomizer, where it is mixed with high-pressure steam to turn it into fine droplets and then spray it into the firebox, where it will mix with air and burn. The droplets confer two benefits - one is that the droplets increase the surface area for the oil to mix with air, and the second is that the droplets are suspended in air as they burn, spreading the heat of the fire evenly around the heating surface of the firebox.

However, the vacuum in the smokebox, created by the effect of the high-pressure exhaust gases, as well as the blower steam, if any, that draws the hot air from the firebox, through the flues to heat the water in the boiler, also draws the atomized fuel away from the back of the firebox. That tends to reduce the heating effect and impairs the steam generation. To counteract that effect, the atomizer has to be set to a pressure that will be high enough to force the spray of fuel towards the back of the firebox, against the opposite force of the vacuum. On the other hand, if you set the atomizer pressure higher than it needs to be to counteract the vacuum, the fire doesn't get any hotter but it will lead to an excess of fuel that drips down into the oil pan and can cause the burner to get obstructed. It also causes soot to build up in the boiler flues. A visible symptom of this is that the smoke from the stack gets much blacker. Note that all of this is simulated in the Advanced version with manual firing selected.

So, the ideal setting for the atomizer is where it balances the vacuum created by the exhaust and the blower. The way to do this is to set the atomizer pressure (there is a gauge, above the steam manifold, showing atomizer pressure) to 25psi first of all (enough to produce a spray), then increase it slowly, observing the colour of the smoke from the stack, and when it turns a bluish colour, reduce the atomizer pressure just enough to change the smoke colour to grey. When the engine is working hard, creating a lot of exhaust, and burning a lot of fuel, the atomizer will need to be opened considerably more.

Note that the atomizer is fed with steam at boiler pressure, so the reading on the atomizer gauge also depends on the boiler pressure. If the atomizer is opened fully, the atomizer will be reading will be the same as the boiler pressure.

Finding the optimum setting for the atomizer pressure can be a bit tricky. It depends on the exhaust and the boiler pressure. While learning the ropes, you can use the "steam chest pressure" value in the F5 HUD (keeping in mind that it is actually not showing the pressure in the steam chest) to judge the optimum setting for the atomizer pressure. Simply set the atomizer pressure to the steam chest pressure plus 25psi.

Firedoor hood damper

There are two dampers to control the flow of air into the firebox (air mixes with the atomized fuel in the firebox where the mixture is burnt). One is at the front of the firebox and is opened and closed using a chain that sticks out of a pipe in the cab floor, near to the fireman's seat. In normal operations, this damper is usually kept closed all the time. For that reason, its operation is not simulated. The other damper is in the firebox door and controls the flow of air being drawn up (by the vacuum from the smokebox, through the flues) from below the cab. The operation of this damper is simulated - it is opened and closed using the handle on the left side of the firebox door hood.

The operation of the firebox door damper is very important for correct firing. The right amount of air has to be allowed into the firebox, to create the optimum mixture of vaporized fuel and air for combustion. If there is not enough air, some fuel will not be burnt, instead dripping into the oil pan (where it can cause an obstruction of the burner) or being sucked out by the vacuum - this turns the smoke black. If there is too much air, it reduces the heat efficiency of the boiler and cools the firebox.

The ideal setting for the damper is when it matches the setting of the oil regulator. So, as you open the oil regulator further, also open the damper further, and vice versa. If the damper is not open at the correct position, the smoke will get blacker.

Blower

The blower shouldn't be used above 4MPH. It's purpose is to provide a draft for the firebox when there are no exhaust gases to create a vacuum from the smokebox through the flues to the firebox.

Using the blower when the locomotive is at a standstill, you might be able to control the steam generation more easily than with the oil regulator alone. If you enable the expert automatic fireman, you'll be able to see that happening.

Smoke Colour

As you can see by now, the smoke colour is a very good indication of whether the locomotive is being fired correctly.

Ideally, the smoke should be a light grey colour.

If it is fired badly, it will usually turn black, meaning too much oil in the firebox, or the atomizer on too strong, or the wrong amount of air flowing past the damper. However, if it turns whiter than normal, with a faint bluish tinge, that is an indication that there is not enough fuel for the amount of draft through the boiler flues. It could also indicate that the oil burner is obstructed.

Fire Mass

If you look at the F5 HUD, you will see that the "fire mass" is a very low value (compared to what you might be used to in other steam locomotives). In fact, it's ideal value (for maximum heat and maximum steam generation) is 150lbs. When the locomotive is idling, using only around 5,200 lbs/hr of steam to run the auxiliary equipment, the fire mass should be less than 7lbs. It is this small value, representing the atomized oil droplets suspended in air inside the firebox, that give the boiler its fast response time.

Managing the boiler water level

There are two injectors:

- On the fireman's side, the **Worthington SA feedwater heater** - this is the exhaust injector
- On the engineer's side, the **Nathan non-lifting injector** - this is the live injector

Worthington SA feedwater heater

The Worthington SA feedwater heater has three main parts:

- **Cold Water Pump** - water from the tender is delivered to the cold water pump located under the left side of the cab.
- **Heater** - water is piped from the cold water pump to the feedwater heater in the top of the smokebox (what you see right at the top of the smokebox is the top of the heater - the rest of it is on a pedestal inside the smokebox). The cold water is heated by exhaust steam. There is a vent to the track, with its nozzle just below and in front of the left-hand cylinder, for the exhausted feedwater heater steam.
- **Hot Water Pump** - water from the feedwater heater is piped back down to the hot water pump situated under the runboard on the left side of the engine.

The fireman manually controls the feed rate by varying the speed of the hot water pump with a valve, labelled "FW Pump", in the cab. The feedwater heater puts out 170 U.S. gallons (141.6 Imperial gallons) of water per minute at maximum feed rate.

The feedwater gauge, to the right of the atomizer gauge, indicates the feedwater heater pressure, in tens of psi. When the boiler pressure is at 300psi, the maximum feedwater heater pressure is 525psi, which shows on the gauge as 52.5.

With practice, it's possible to set the rate, using the FW Pump valve, to match the rate of water consumption, thereby maintaining the water level in the boiler.

The feedwater heater pump will not work if the feedwater cock shut-off is closed.

The expert automatic fireman, if enabled, will operate the feedwater heater for you, maintaining the level at approximately 0.8.

Nathan non-lifting injector

This injector has two controls near the engineer's cab seat:

- Just to the left of the seat, there is a notched lever to control the live steam to the injector, i.e. to activate the injector. This has a latch, to seat the lever in a notch when at rest. In the model, the latch lever is squeezed automatically as soon as you start moving the injector lever, and released when the injector lever stops moving - as with the reverser, it simulates the "squeeze and move" being a combined, fluid action (it avoids obliging the player to press a key unnecessarily).
- Behind the engineer's seat is the control for the water to the live injector. This can be turned to set the desired amount of water.

The non-lifting injector delivers water to the boiler at a maximum rate of 216 U.S. gallons (179.9 Imperial gallons) per minute.

Oil pan flashes

The oil pan, at the bottom of the firebox, has holes cut in the sides for secondary air. These holes have sheet metal covers but when the locomotive is working hard, there are frequent flashes, or gouts of flame, from the oil pan. In the model, these flashes are scripted to occur when the exhaust exceeds a certain threshold, and they are synchronised with the exhaust beats.

Power reverser

The reverser lever in the cab operates a power reverser situated under the runboard on the right hand side of the locomotive. The power reverser is a cylinder and piston powered with compressed air from the main reservoir (a large tank in the middle of the engine frame).

The reverser lever in the cab (the "Johnson bar") has a latch mechanism to hold it in place in a notch. There is no need for you, the player, to use a separate key to release the latch. In real life, the engineer would release the latch and move the lever all in a single, fluid movement. In the simulation, it's assumed that if you move the lever, you're also squeezing the latch handle at the same time, so the animation portrays that (holding the latch lever closed while the reverser lever moves, releasing it when the lever stops). Note that there are 100 notches for the reverser (a lot more than the few notches you find on other locomotives).

Also, because the reverser is powered, and dampened by the power reverser cylinder and piston, there is no "backlash" from moving the reverser lever in the cab while the throttle is still open.

Real steam chest with individual valve events

In expert mode, using the non-HUD-enabled version, the throttle is not connected directly to the cylinders but instead there is a complex, scripted simulation of the way that the throttle actually fills up the steam chest (everything between the regulator ports, through which high-pressure steam enters from the boiler, and the valve admission ports, including the superheater tubes in-between). It can be thought of as a reservoir of steam that is emptied when the valve gear opens the admission ports to let steam into the cylinders to move the pistons and turn the wheels. The simulation fills this reservoir when the throttle is opened and empties it each time the admission ports are opened (and by an amount that depends on the cut-off and the speed of the pistons). It accounts for losses in pressure caused by condensation in the steam chest, the effect of "wire-drawing" when the valve pistons are moving fast, and the loss of pressure through the cylinder drain cocks when they are open.

If you watch the back pressure gauge (see below) while the pistons are reciprocating at slow speed, you should be able to see the needle moving up and down slightly as the cylinders fill and empty on each stroke. The effect is even more noticeable when the admission phase is longer (long cut-off).

Back pressure gauge

The FEF-3 does not have a steam chest pressure gauge (even though it simulates, internally in the scripting, a "real" steam chest).

Instead, it has a back pressure gauge.

Back pressure is produced by the exhaust steam that remains in the end of the cylinder towards which the piston is moving. To an experienced engineer, it gives a very good indication of how efficiently the cylinders are working, and when to reduce the cut-off ("hook up" the Johnson bar) or to increase it, and when the throttle needs to be adjusted to keep the right amount of steam pressure in the steam chest and for the admission segment of each piston stroke. Basically, if you want to maintain a certain back pressure, but see that it's falling, it means the steam chest is being emptied faster than it's being filled, so you would need to open the throttle a bit more to keep the filling and emptying balanced. Some engineers prefer to keep the throttle wide open and regulate the power using the reverser most of the time.

In addition to showing positive back pressure, the gauge has a range for negative values. These correspond to vacuum in the cylinders, which happens when there is no steam in the cylinder and the movement of the piston generates a vacuum as the volume on the "behind" half (the part of the cylinder that the piston is moving away from) increases. This happens, for example, when the steam chest is emptied (indicating that, perhaps, the throttle needs to be opened further to maintain the mass of steam in the steam chest) or the cut-off is reduced to the minimum (the Johnson bar is hooked up to neutral).

The script calculates back pressure and vacuum on each stroke of each piston - basically synchronising them with the opening of each live steam admission valve. Thus, at low speed, it's possible to see the gauge needle flickering in synch with the chuffs.

Brakes

The operation of the locomotive air brakes is modelled and simulated with the following enhanced features:

- When the train brakes are applied, air from the main reservoir is used to raise the pressure in the brake pipe (train line). This causes a drop in the main reservoir (MR) pressure, which starts at 130psi. When the MR pressure falls to 125psi, the steam-driven air compressor is switched on (in real life by a single-head governor) and you can hear it cycling (pumping) as it raises the MR pressure up to 130psi again, then it stops.

- In the "Advanced" version, when the train brakes are applied (or "set"), the equalizing reservoir pressure drops, followed more slowly by the brake pipe pressure (remember that the black hand on the left-handbrake gauge shows the pressure at the *head end* of the brake pipe) . The two pressures eventually equalize. The time taken for the brake pipe and equalizing reservoir pressures to equalize depends on the length of the consist.

- The compressor throttle has to be opened for the compressor to work. If you forget to open it, you'll see the MR pressure falling below 125psi, as you repeatedly apply the brakes, and eventually you'll have no brakes!

  Note: In the HUD-enabled version, the compressor throttle is opened automatically at the start of a scenario.

- "Peeing away your air"! This is a term used to describe what happens when a novice engineer applies and releases the brakes rapidly several times in succession, such as when going down a hill, causing the air in the auxiliary reservoirs under each car to become depleted (this makes it harder and harder to apply the brakes, and when they do come on, they do so with less and less force). It is simulated in this model. Try it!

- In the "Advanced" version, brake application and release times depend on the length of the consist (the length of the train brake line). For example, a 32-car consist will take approximately four times longer to apply or release the brakes as an 8-car consist. You'll need to allow for this extra time when running a long train and anticipate your use of the brakes accordingly.

- Bailing off the engine brakes. The automatic brakes, i.e. the train brakes, also affect the engine brakes (in diesels, these are called "independent" brakes). In other words, when you apply the automatic brakes, the engine brakes are also applied (even if the engine brake handle is not in any "application" position. Moving the engine brake handle to the "release" position will not release the engine brakes unless the train brakes are released first. The only way to release the engine brakes while keeping the train brakes set is to "bail-off". This has never been simulated in Train Simulator - until now.

- The train brake handle has some additional scripting to prevent an accidental emergency brake application. The handle can be brought up to the full application position, at which point it will move no further until the player has stopped trying to move it for at least one second. After that time, the handle can be moved all the way to the emergency position. If the handle is moved with the mouse, it's not necessary to release the mouse button, but just stop dragging the mouse to the right for one second.

- In the "Advanced" version, when the emergency brakes are applied, the brake system automatically switches on the Mars light (in oscillating mode) and switches off the headlight. You will also need to wait for the brake pipe pressure to drop to zero before

being able to release the brakes (before that time, putting the automatic brake handle in the release position will not release the brakes).

- The system will make a service application (not an emergency application) of the train brakes if the alerter acknowledge button is not pressed within 6 seconds of the in-cab signal display changing to a more restrictive signal.

Let's look at some of these points in more detail:

"Peeing away your air"

To understand this, you must first understand that the brakes are applied by lowering the pressure in the train's brake pipe (in simple terms, by letting air out of the pipe through a hole in the brake control stand) and the brakes are released by pumping compressed air into the train's brake pipe (again, via the train brake control in the cab) until the pressure in the brake pipe is higher than in the auxiliary air brake reservoirs under each car (these are normally pressurized to 90psi).

When the brakes are applied, the brake pipe (train line) pressure drops. When it falls below the pressure in the auxiliary air brake reservoirs of each car, the brakes are applied on the cars by means of pressurized air (from those auxiliary reservoirs) going into the cars' brake cylinders. However, that in turn means that the pressure in the auxiliary reservoirs drops.

The cars´ auxiliary reservoirs are recharged with air from the brake pipe (which comes from the locomotive) when the train brake handle is in the running or release position, but it takes time, especially on a long train. If the engineer has not left the handle in running or release for sufficient time before again applying the brakes (making a "service application"), the auxiliary reservoirs might not yet have recharged to their nominal 90psi pressure. That leads to two effects: first, the brake pipe pressure has to drop even further before it is lower than the pressure in the auxiliary reservoirs, so it takes longer for the brakes to come on, and secondly, when the brakes do come on, they do so with less force because the pressure in the brake cylinders, which comes from the auxiliary reservoirs, is lower.

The more often the engineer does this, without giving the auxiliary reservoirs a chance to recharge, the worse it gets, until eventually there is hardly enough pressure left in the reservoirs to feed the brake cylinders and apply the brakes. At that point, the engineer has "pi**ed away his air" and could have a runaway train on his hands.

Fortunately, he might still be able to stop with the emergency brakes, using air from the emergency air reservoirs under each car.

The lesson is, try to avoid applying, releasing, applying, releasing the brakes rapidly, and after releasing the brakes, leave the handle in the "running" position, to keep recharging the brake line. A good way to release the brakes smoothly (and slowly) is to put the handle in "running" rather than "release".

Engine brake bail-off

The bail-off position of the engine brake handle has been modelled, along with its spring-loaded action, so that you can now release the engine (independent) brakes while the train brakes are still applied - when you push the engine brake handle all the way to the left, holding it there against the pressure of the spring (holding down the [key or using the mouse to drag the engine brake lever to the left continually), the engine brake cylinder pressure drops (look at the red hand on the left-hand side of the dual brake gauge in the cab) and the engine brake pistons and shoes move, but the train brakes stay on (the black hand on the left-hand side of the dual brake gauge will stay put).

Although it's still not simulated 100% (because if the train brakes are set, the locomotive, as well as the consist, is in fact still being slowed down), this implementation gives the closest approximation and feel of actual bail-off that has ever been achieved in Train Simulator up to now.

It's quite easy to apply too much pressure to the engine brakes (which are very effective) when applying the train brakes. If you do hear screeching when you apply the train brakes, it'll be because the driving wheels have locked up, so you should immediately bail-off the engine brakes (the quickest way is to hold down the [key) until the engine brake pressure falls to zero.

In particular, if you hit the emergency brakes (backspace key), be prepared to bail off the engine brakes immediately to prevent a wheel slide.

Note that the opposite end of the range of travel of the engine brake handle is "quick application", used to apply the engine brakes more quickly than in the "slow application" position, but the "quick application" is also spring-loaded, so it has to be held there either by using the mouse to drag the handle to the right continuously or by holding down the right square bracket ( ]) key.

Bail off and quick application work in both the Advanced and HUD versions. With the HUD, you can bail-off the engine brakes by using the mouse to pull the brake handle icon downwards. When you let go, the icon will move up and come to rest at about 10%.

Steam-driven Cross Compressors

The two cross compressors at the front of the locomotive (slightly hidden behind the smoke deflectors) recharge the main air reservoir when the pressure falls below 125psi, to keep the main air reservoir pressure at 130psi.

Compressed air is used up when various equipment is operated:

- Train and engine brakes

- Power Reverser
- Sanders
- Cylinder cocks
- Bell
- Sludge removers

The compressors will work only when the Air Pump valve is open.

When the compressors are running, a plume of white exhaust steam can be seen coming from the exhaust pipe between the two smoke stacks.

In-cab signalling

Functional in-cab signalling equipment is included, on both sides of the cab. Each display shows the 4-aspect Coded Cab Signal (CCS) system, on the right of the display, for UP territory.

The C&NW 3-aspect Automatic Train Control (ATC) system signals are on the left side of each display but are non-functional.

The CCS displays show the aspect of the most recent signal that the locomotive has passed, i.e. the signal that applies to the block that the train currently occupies. It's important to understand that it does not show the aspect for the signal ahead. Instead, it is a reminder to the crew of the state of the current block. For example, if it shows green, the crew know that they don't have to slow to less than the maximum line speed, but it doesn't necessarily mean that the next signal is also going to be green.

The indications are detailed below (from left to right, less restrictive to more restrictive):

Clear **Approach Limited** **Approach Medium** **Approach** **Restricted**

The UP CCS requires an acknowledgment by the engineer within 6 seconds of a more restrictive signal change - clear to advance approach, or approach to restricting - or else the system will put the train into a penalty brake application at a service rate.

When the change to a more restrictive signal occurs, there is an audible warning (two beeps).

Speedometer

The speedometer, next to the engineer's seat, has a range that goes up to 100MPH, as in the real 844. However, as I know that most, if not all, players will want to see just how fast they can go with the locomotive (I'm no exception), I've created a speedometer that morphs instantly into one that goes up to 200MPH when the speed exceeds 100MPH. In that way, you have the genuine speedometer for as long as the speed is below 100MPH, but a more useful speedo when you go faster than that.

Diesel Multiple-Unit (MU) Control

To the left of the speedometer is the MU Controller. This equipment allows the engineer to control a diesel running in tandem behind the steam locomotive.

The MU box has four controls:

1. "Gen. Fld" - in the simulation, this switch is used to connect the controller to the diesel.

2. Notch selector (Idle, 1 .. 8)

3. Direction selector (Reverse, Neutral, Forward)

4. Emergency "kill" switch (non-functional)

In order for the MU Controller to work, a special modified version of the SD70ACe, in Union Pacific livery and with the number 8444, has been included in the package.

It is possible to run other diesels behind the FEF-3, but the MU controller will not work correctly. Instead of hearing the rpm for the notch selected on the MU controller, the diesel's rpm would be governed directly by the amount of steam in the FEF-3's "real" steam chest! The scripting and audio control in the special UP SD70ACe no. 8444 is designed to overcome that problem, so that the rpm of the diesel engine is governed by the MU controller's notch selector. Even though it is designed primarily to run in tandem with 844, no. 8444 can also be run on its own. That way, it's possible to have 8444 bring up a consist, couple-up behind 844, and for both locomotives then to double-head the consist.

Note: When 8444 is m.u.'ed with a HUD version of the FEF-3, it's not always possible to move the FEF-3's reverser unless the throttle is closed. The Adv version doesn't exhibit that problem.

Head Of Train (HOT) electronics

The cab also includes a Head Of Train ("Wilma") device that displays radio telemetry received from the rear of the train - brake line pressure, distance and acceleration. It can also be used to apply the brakes more rapidly in an emergency, simulating the EOT ("FRED") dumping air from the rear of the train.

The HOT will not work until the generator is turned on and the voltage has risen.

There is a button to turn the display on and off, another for changing the left-most readout between distance (length of the consist, in feet) and acceleration (in MPH per second), and two test buttons - one for testing the digital displays (it displays an "8" in each position) and another to test the radio communications (it beeps if the communications are OK).

Note that the brake line pressure readout is the pressure at the rear of the train. The propagation of the air pressure wave is simulated, so that the pressure readout on the HOT changes a short time after the air brake pressure hand on the brake gauges changes. The amount of time for the delay depends on the length of the consist, considering a propagation speed of 600 feet per second.

Blow-off (sludge separation)

Situated approximately in the middle of the steam turret, just forward of the top of the cab, there is the Wilson sludge remover that separates water from steam, by a swirling action in a chamber above the boiler. This can be activated by opening either of the two blow off shut-off cocks in the cab (above the backhead) and tapping the corresponding "sludge remover" lever in the cab (they're placed up against the window guides). Pull those down (by clicking on them and holding down the left mouse button). Doing so will expel the sludge out of the spreader located under the cab on the engineer's side and create a plume of steam from the separator.

To see the effect from outside, perform the operation in the cab but without releasing the mouse button until you are in the outside view. When you are back in the cab, click on the sludge remover lever again to release it.

Impaired operation

The Advanced version simulates several ways in which things can go wrong:

- Damage to the cylinders when they aren't properly drained of condensation
- Obstructions in the firebox burner caused by incorrect setting of the atomizer and/or damper, or because the fuel oil in the tender is too cool (and therefore too viscous)
- Clogging of the sight gauges, because of frothing and impurities in the water, which cause them to give false readings
- Damage resulting from the mechanical stresses of overspeeding (including wheelslip at high revolutions)
- Problems caused by overfilling the boiler

All of these are in addition to the "standard" failures such as running out of water, dousing the fire, derailments ...

Cylinder damage

When the locomotive is left standing for some time, with the cylinder cocks closed, condensation builds up in them. Water, unlike steam, cannot be compressed, so if the water is left in the cylinders when the pistons start to move, it can reach a point where the pistons are pushing up against the water. If they keep on pushing, something has to give, and it's usually the cylinder caps, or sometimes it can be worse and result in damage to the pistons and rods. To prevent that from happening, the cylinder cocks should be opened before the locomotive starts to move, so that on each piston stroke, water will be expelled from the drain cocks beneath the cylinders. After a few revolutions, the cylinder cocks can be closed - doing so means that steam pressure isn't lost through the drain cocks and it also helps to preserve the lubrication in the cylinders.

Obstructions in the burner

There is a random possibility of an obstruction in the burner. When it happens, the oil regulator becomes ineffective (it won't add more fuel to the fire) and no flames will be visible through the firebox door peephole (however, a residual amount of fuel will remain in the fire, so that it won't be extinguished completely).

The probability of a blockage in the burner starts at 1 in 10,000 per second (in other words, very low) but increases if the oil in the tender tank is below 98 degrees Fahrenheit, or if the atomizer is closed while the oil regulator is open.

With regard to the oil temperature, the probability of a blockage in the burner increases in proportion to the difference in temperature between 98°F and the temperature of the oil in the tank, when the oil is colder than 98°F. The starting temperature of the oil depends on the season (spring 48°F, summer 72°F, fall 50°F, winter 26°F - these are approximately the average seasonal temperatures in Nebraska, USA). For every 10 degrees below 98°F, the chance of blockage increases by 0.005% per second. There's a working temperature gauge on the front of the tender (you can see it from the cab). Turning on the tank heater in the cab raises the temperature by 3°F per minute, if opened fully, less if it's partially open. Keep an eye on the temperature and try to maintain it at about 98°F.

To clear any blockage in the burner, open the oil regulator fully, then open the burner blow back fully for a few seconds, then return the oil regulator to where it was before.

Note: The expert automatic fireman, if enabled, will operate the tank heater.

Note: If the oil is too hot, it becomes more volatile and the temperature of the fire is more difficult to control. A visible symptom of this is that blue smoke (unburnt gases) will appear from the draft openings in the oil pan, accompanying the flashes that occur in the oil pan when the draft from the front end is strong.

Clogging of the water sight gauges and water column

There is a random chance of clogging in the sight gauges or water column (each one is handled separately, so one or more could be clogged while the remainder are still working fine).

When a sight gauge is clogged, there are two visible symptoms:

- The amplitude of the sloshing that occurs at speed is greatly reduced - in other words, the level will still go up and down, but not by as much as it normally does.
- The average level indicated by the sight gauge won't change. You'll notice it if you compare the level shown on the two lower sight gauges (one facing the fireman, the other facing the engineer).

You can also use the three water gauge cocks that protrude at a downward angle from the right-hand side of the water column, starting at the top. If the water level in the column is below the gauge cock, it will make a hissing sound when you open it, otherwise you'll hear the sound of trickling water.

To clear the clogging, you have to open the corresponding blowdown valve at the very bottom of the sight gauge or column, and close it after all the water has drained away - it takes just a few seconds. In fact, as the probability of clogging increases if the sight glass or water column has not been blown down, that procedure should be followed systematically at the beginning of each journey, as a preventative measure, and once every hour thereafter.

Also note that the chance of clogging increases considerably if the boiler is kept nearly full (more than 0.9 on the F5 HUD) because of foam spilling over from the boiler, but that too can be reduced by using the sludge remover levers to do a "blow off" regularly (once every 15 minutes).

Overspeeding

When the rotational speed of the driving wheels exceeds the equivalent of 140 MPH (note that this can happen during extreme wheelslip, even if the actual speed of the locomotive is very low), damage starts to accrue in the motion and valve gear. Eventually, there will be a catastrophic failure (which will end the scenario).

Overfilling the boiler

Care has to be taken to avoid overfilling the boiler - keep watch on the sight glasses, and especially the upper, middle one. If water starts to appear in the middle sight glass, it's a sign that the boiler is overfilling.

When the boiler is too full, two things happen. First, when the level is at around 1.23 (the value you would see on the F5 HUD), water spills over into the front end throttle valve and the throttle gets stuck. You won't be able to move it again until the water level drops below 1.00. If the water level continues to rise and reaches 1.25, water from the boiler enters the cylinders - game over!

What to do to after entering the cab for the first time

Advanced, manually-fired

Before setting off down the track, there are several things to do. Note that valves are opened by turning them anti-clockwise. Here’s the checklist (the order doesn't have to be followed strictly - you'll soon get the idea):

1. **At the start of each scenario, the train brakes are automatically moved to the 85% position (“apply”). This is to stop the train from rolling away. You’ll hear the hissing of the train brakes**

being applied. You should immediately move the train brake lever to the "hold" position (about 35%, where the hissing sound stops).

2. Open the control valve for the steam manifold;
3. Open the feedwater pump shut-off;
4. Open the tank heater;
5. Open the oil regulator slightly;
6. Open the firebox damper (turning the handle clockwise) slightly - note that the damper should normally be opened by the same percentage as the oil regulator;
7. Turn on the blower a little bit, to maintain a draft from the firebox through to the smokebox while the loco is stationary;
8. Open the atomizer gradually until the smoke turns blue, then reduce it slightly until the smoke turns grey (it might take a few seconds);
9. Open the doors, windows, roof ventilator hatch and side ventilator flaps;
10. Open the air compressors shut-off valve and check that you have 130psi in the main reservoir;
11. Start the electric DC generators (dynamos) and check that the reading on the voltmeter settles at around 32V;
12. Select the color of the classification lights, as appropriate (press U or Shift-U as many times as needed);
13. Switch on the headlights (dim or bright, as appropriate);
14. If it's dark, switch on the gauge light and cab light;
15. Open the cylinder cocks master valve;
16. Open the cylinder cocks;
17. Crack open the regulator slightly – you should now see steam coming out of the cylinder cocks (this helps to warm the cylinders and to expel any water that might have condensed in them while the locomotive was stationary) ;
18. Open the blow-down valve for each of the three sight glasses and the water column, keeping them open for one to two seconds - this is to ensure that they are not clogged (afterwards, this procedure has to be repeated approximately every hour - or half an hour if the boiler water level is high - to avoid clogging);
19. Open both blow-off shut-off valves ;

20. Tap each of the sludge remover levers - a lot of steam will erupt from the separator in the steam turret just ahead of the cab and from the sludge spreader under the right-hand side of the cab. To "tap" a lever, click on it and hold the mouse button down to keep the lever pulled down - releasing the mouse button will release the lever;

21. Turn on the sanders;

22. Turn on the bell, if required, by opening the air valve;

23. Push the Johnson bar (the reverser) forwards;

24. Blow the whistle (two blasts);

25. Release the independent brake (turn it all the way to the left) - this will bail-off the engine brakes while the train brakes remain set;

26. Once the locomotive has started moving, release the train brake and then put it in the “running” position (where it doesn’t make any sound, or just a faint hiss);

27. Open the regulator further to gather speed, but slack off (or reduce the cut-off) if you hear the wheels slipping;

28. Close the cylinder cocks after about twenty seconds or three full revolutions of the driving wheels (12 chuffs);

29. As the back pressure rises, pull the Johnson bar a bit closer to you (this is like changing gear in a car before you redline the revs, to be able to go faster), to reduce the back pressure to close to zero

30. If the back pressure goes negative, indicating a vacuum in the cylinders because the steam chest is empty and the pistons are moving, open the throttle a bit further in order to give the steam chest and the cylinders more steam (the back pressure will go to zero and then positive again);

31. Turn off the sanders (unless you still need sand because of conditions);

32. Once out of the station area, turn off the bell. Rules and regulations require that the bell be sounded before a locomotive begins to move, as well as in congested areas, like yards, that have no public crossing. The bell is also used when approaching an area where there are likely to be members of the public or other employees around the tracks, like stations or industrial spurs. Trains passing other standing trains on sidings will also use the bell to let any workers on the ground know that the train is continuing on the main. In addition, there are a lot of traditional uses for the bell, like a courtesy signal when a train on the main is passing a rail yard or large industry;

33. If there's been black smoke coming out of the stack, the boiler flues could be fouled with soot, which will impair the heat transfer and steam generation - if so, open the firebox peephole and click on the drum of sand to the right of the firebox cover, in order to sand the flues (this will result in more black smoke, temporarily, as the sand does it's job and dislodges the soot, which gets sucked out the stack);

34. Keep watch on the fire - if it goes out, clear the obstruction in the burner by putting the oil regulator fully forward and opening the burner blow-back valve for a few seconds. Try to keep the fuel oil temperature at about 97 degrees Fahrenheit.

Scenarios

The package includes three Career scenarios for the Sherman Hill route (available on Steam as separate DLC).

- **UP Employee Excursion, Pt. 1 [HUD]**

  With renowned FEF-3 4-8-4 No. 844, Union Pacific is operating an employee appreciation excursion from Cheyenne to Laramie via Sherman Hill. You are the engineer of UP 844, readying for departure from Cheyenne with a consist of 16 UP streamlined passengers cars. Ahead awaits grades of up to 1.5 percent and the opportunity to run at speeds up to 70 mph, so you will need to use throttle and reverser (cut-off) well to maintain steam pressure for the entire run.

- **UP Employee Excursion, Pt. 2 [HUD]**

  You are the engineer of Union Pacific FEF-3 844 leading a UP employee excursion from Cheyenne to Laramie. In Part 1 of this journey, you made the climb from Cheyenne to Dale, where you are presently stopped awaiting an eastbound perishables train to clear. In short order, you'll be starting the remainder of your trip to Laramie. During the majority of the run on the west slope of Sherman Hill, you will be descending a 0.8 percent grade and you'll need to utilize your train and engine air brakes well to maintain but not exceed track speed.

- **UP 844 Excursion from Denver [Adv]**

  The Union Pacific is operating an excursion from Denver to Laramie with FEF-3 844 and its diesel "sister" SD70ACe 8444, as power. You are the engineer of the 20-car train which has made a momentary stop at Speer, where the line from Denver joins Sherman Hill's Track 3. You'll shortly resume the westbound run, using the Borie Cutoff to reach Track 2 for the climb over Sherman Hill.

Note that when the scenario uses a loco made to be run in expert mode without the HUD or Xbox controller, in order to have access to the complete set of controls, it is identified by “[Adv]”, otherwise by “[HUD]”.

Liveries

In the editor, the models belong to the provider called “Smokebox”. Two variations of black livery are included:

- Black with white-walled driver tyres, chrome finish on some parts, silver gray striping along the edge of the runboards, and gold painted cab front window frames.
- All black.

Keep an eye on the Marketplace for additional liveries.

What I used to build the model

- **3DCrafter Pro version 9.2.2** to create the model geometry and animations;
- **Photoshop** to produce the source textures;
- The **Asset Editor** of TS2015;
- **Power Sound Editor Free** and **Creative Wave Studio 7** to create the sounds*;
- **HxD** (freeware hex editor) to edit the cab view exported geometry, changing the material name of the window textures to enable rain effects. The geometry file is too large to be compiled by the serz.exe application.

* A few sounds, such as switch and button clicks, were made using samples from http://www.freesound.org, distributed under a Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0/legalcode).

Special thanks

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Mike Rennie

Perth and Kinross, Scotland, October 2014

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