Union Pacific

FEF-3

Developed by Smokebox

for Dovetail Game's Train Simulator™

Issue 2

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).

32- and 64-bit TS

This model is suitable for both versions of TS2021, i.e. in 32- and 64-bit.

Gameplay Modes

"All-in-one"

Previous to the June 2021 updates, the FEF-3 had separate "Advanced" and "HUD" versions which operated differently from each other. However, the updated model **supports all modes of gameplay in every version**.

This means that it can be used in Expert mode as well as in Simple Controls mode, with or without the control panel at the bottom of the screen (the so-called "F4 HUD"), or using mouse and/or keyboard, in either 32- or 64-bit TS. Basically, the model is designed to allow players to run the locomotive using whatever method they prefer.

The models are still marked as "Adv" or "HUD" in order to maintain backwards compatibility with existing scenarios. Nevertheless, the operation of each of those versions is now identical, so it does not matter which one you choose.

Standard TS Automatic Fireman

TS2021 has a "standard" automatic fireman but this model of the FEF-3 has its own scripted "expert" automatic fireman which does a much better job and is enabled by default. It manages the

fire and boiler water, as well as periodically blowing down the water sight glasses and water columns. It can be toggled off at any time to allow the player to fire the locomotive manually.

It is recommended to turn off TS2021's own automatic fireman via the in-game menu:

Main Menu > Settings > Gameplay > Automatic Fireman > Off

If the standard automatic fireman is left enabled, the FEF-3's specialized expert automatic fireman will still be able to do its job. However, please be aware that there are some minor side-effects because of the way Train Simulator is implemented. For example, the boiler pressure will never rise above 299.8 psi (therefore the safety valves may start to lift and feather but will never fully "pop") or go below 195 psi (65% of the maximum) regardless of how badly the locomotive is operated. This behavior is intrinsic to the standard automatic fireman.

F4 HUD

Although the F4 HUD can be used with this loco, there are a few caveats:

1. The water and coal buttons on the F4 HUD have no effect. It is recommended to enable the expert automatic fireman (click on the fireman's seat cushion or press Ctrl Shift A) or to hide the F4 HUD and fire manually.
2. If the live injector water valve has been opened (with the F4 HUD hidden), it will close again as soon as the F4 HUD is enabled. Basically, it's not possible to use the injectors manually with the F4 HUD on-screen, although the expert automatic fireman is able to continue to use the exhaust injector as needed.

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).

Recommended Settings

This is a very detailed model. While a lot depends on the amount of detail there is in the route where the locomotive is used, it's likely to need a computer that at least meets the minimum specifications for Train Simulator.

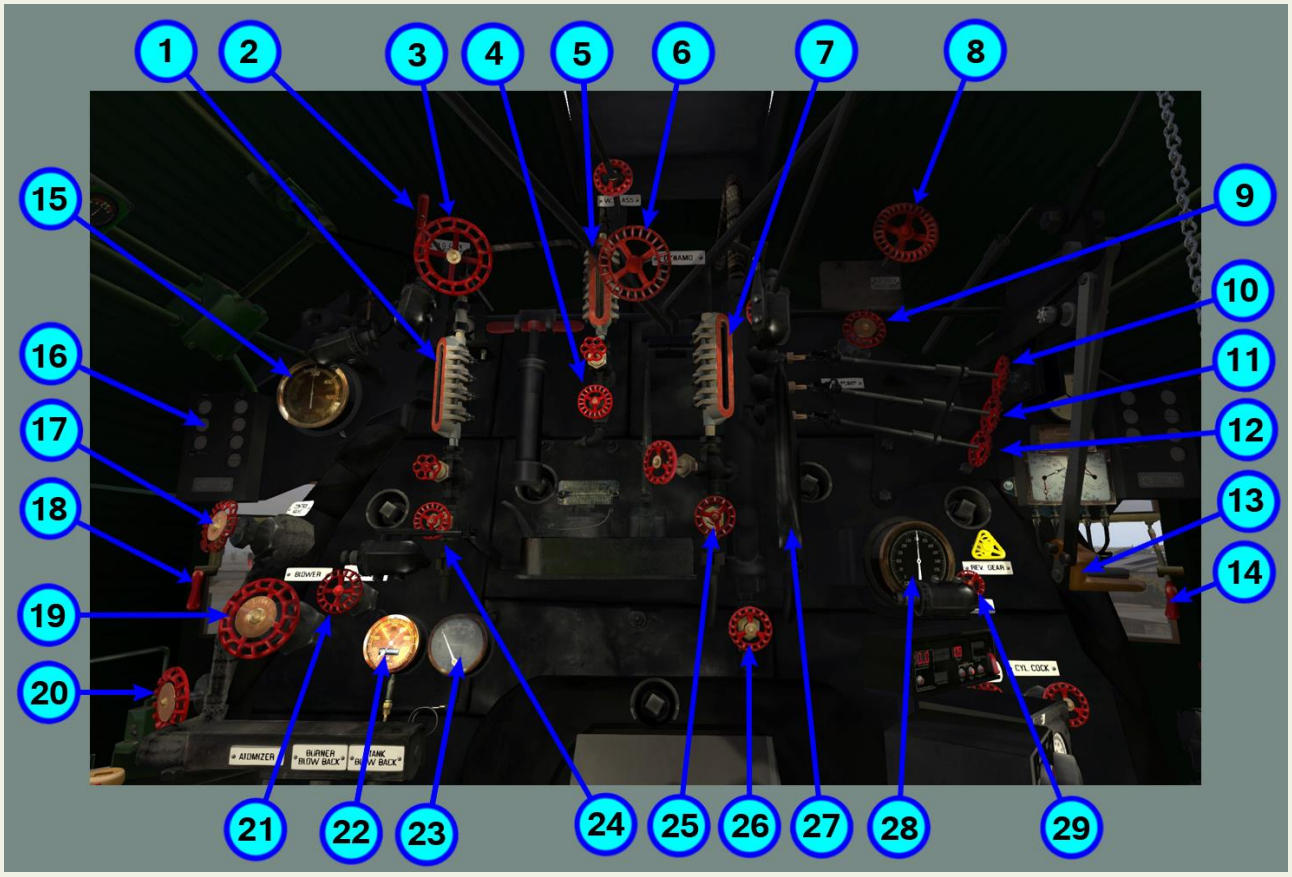
In the event that an increase in frame rates is needed, the recommendation from *Smokebox* is to reduce the amount of work that the CPU has to perform. Therefore, switch off the game's built-in ambient occlusion completely (Ctrl Shift 2), which will also allow small details in the model to be seen more easily, and reduce "View distance", "Shadow quality" and "Water Quality".

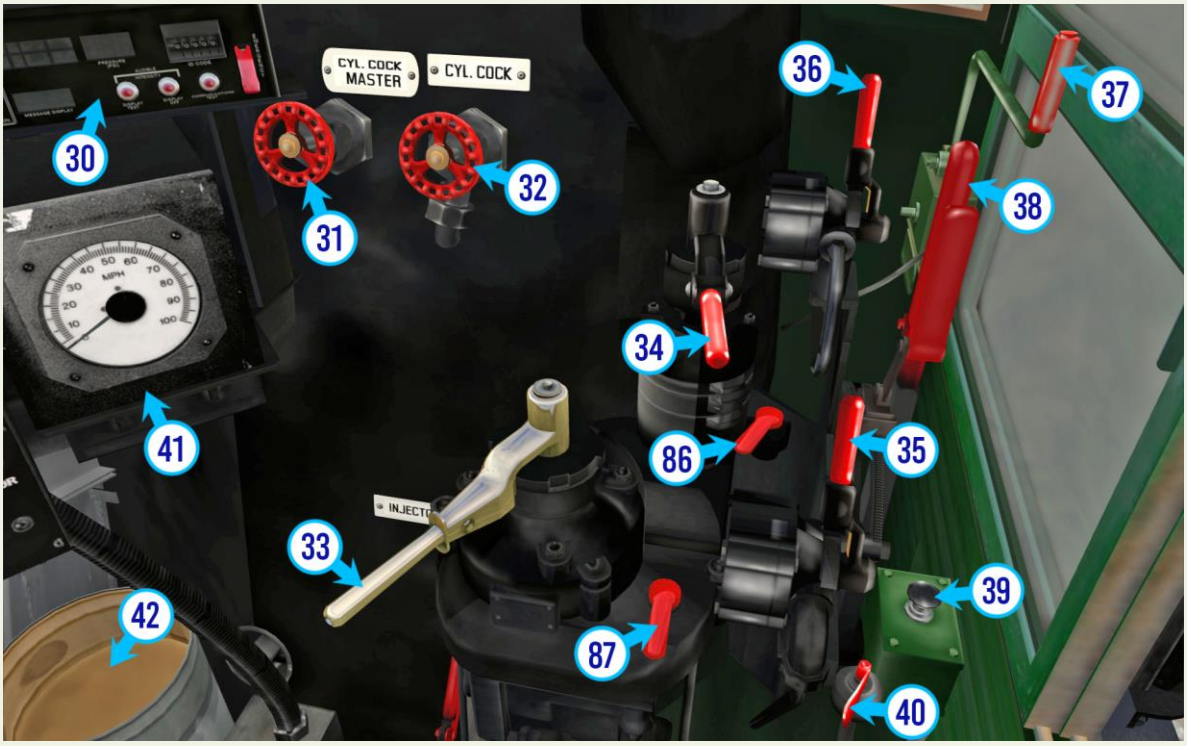
Figure 1: Recommended Graphical Settings

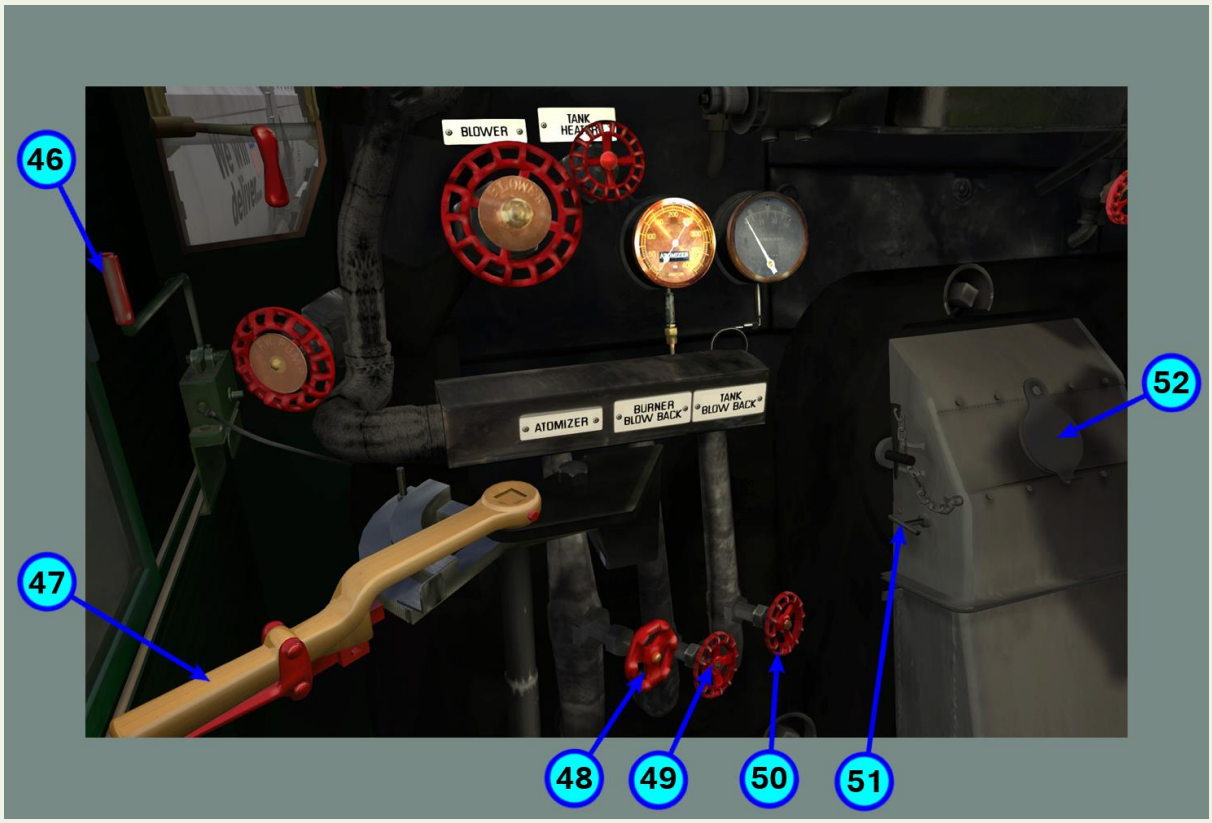
When a scenario is set at night or in poor weather conditions (overcast, rainy, etc.), i.e. when the sun isn't shining strongly, it is recommended to set the shadow quality to the absolute minimum (off).

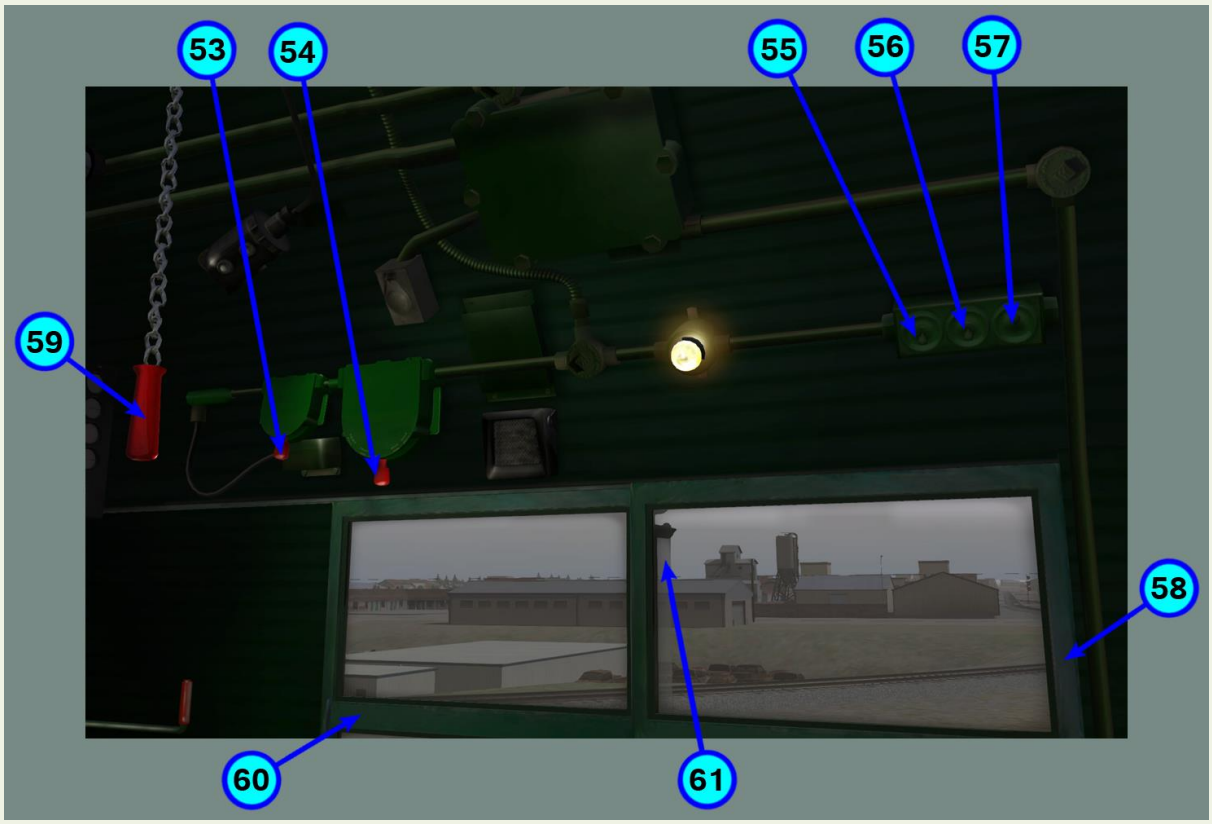
Cab Layout

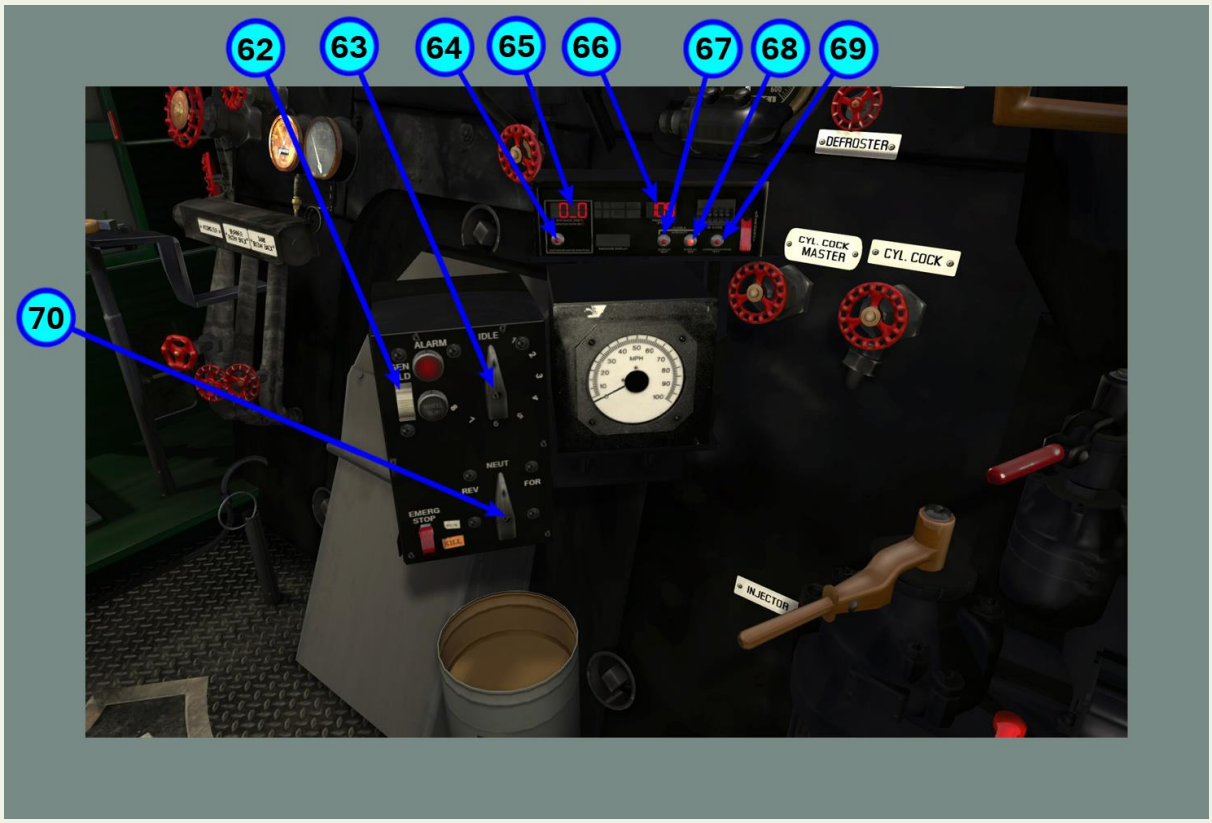
The diagrams below show the positions of the cab controls (all can be operated by dragging or clicking with the mouse) and gauges (or gages, if you prefer).

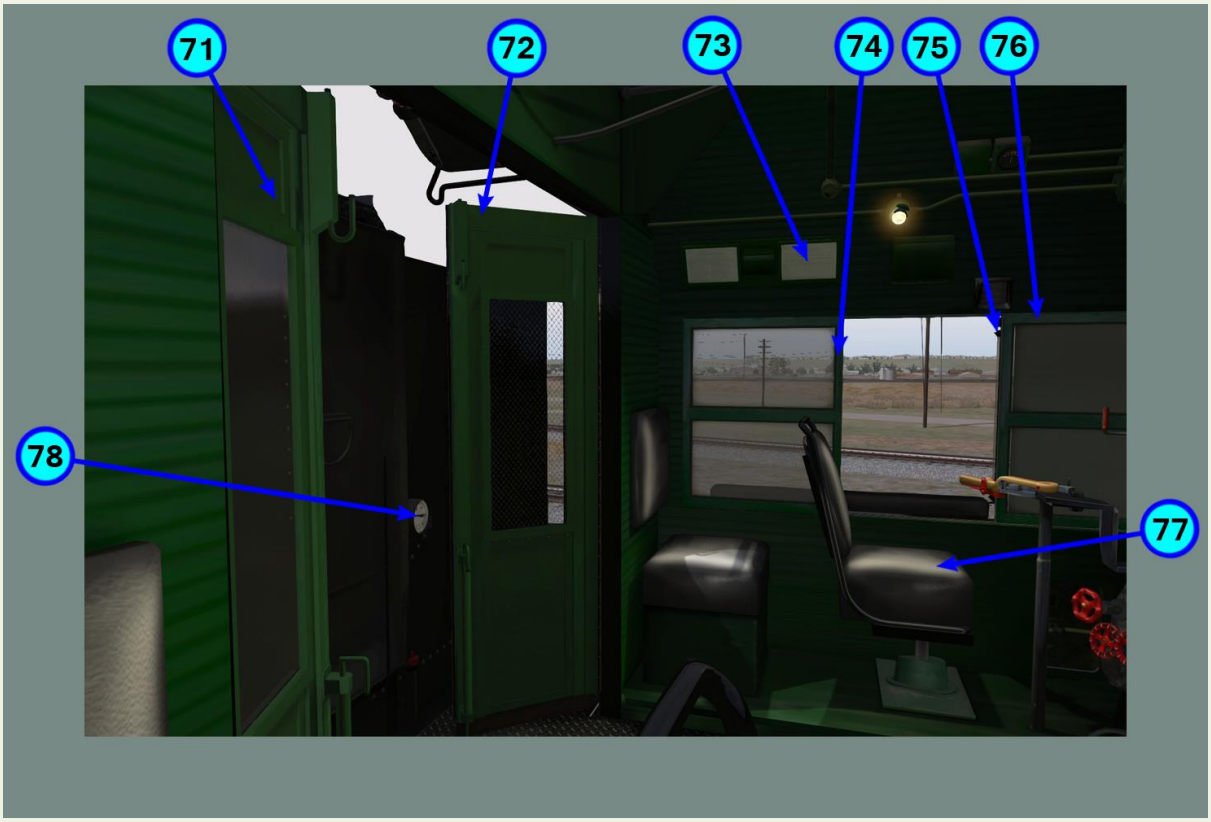


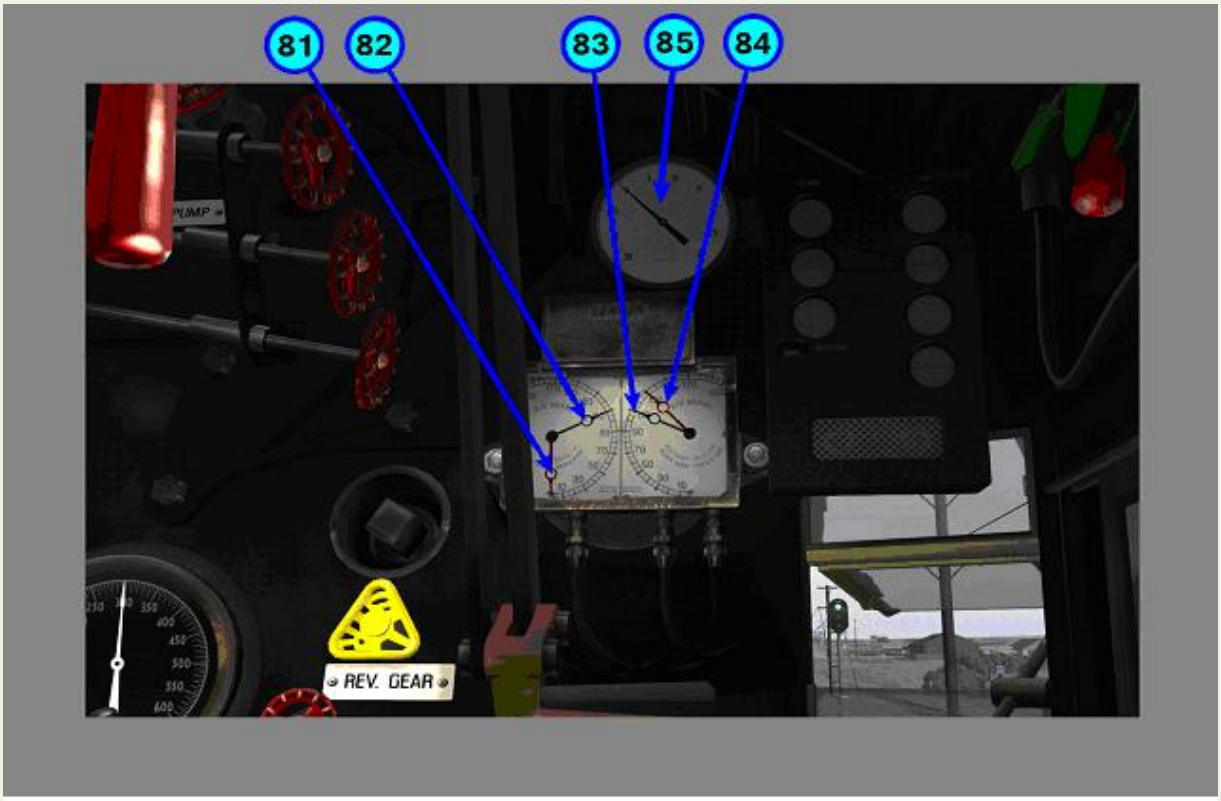












1. Water glass (left)
2. Blowoff cock shut off (left)
3. Feedwater pump shut off
4. Water glass blowdown (middle)
5. Water glass (middle)
6. Dynamo (steam-driven electric DC generators) steam throttle
7. Water glass (right)
8. Blowoff cock shut off (right)
9. Air pump (steam-driven cross-compressors) 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. Injector light switch
56. Running lights switch
57. Back up red 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
85. Back pressure gauge
86. Locomotive Emergency Brake Cylinder Pressure Control
87. First Service Position Cock

Keyboard and Mouse

Item	Key	Action	Remarks
Engineer's controls			
Throttle	A	Increase	The throttle controls the rate at which the steam chest (not the cylinders) is filled with steam.
	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 traveling 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	
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
	Ctrl Shift C	Close	

Item	Key	Action	Remarks
Cylinder Cocks	C	Open	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.
	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.
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 rate at which pre-heated water is pumped into the boiler.
	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	
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	Click	On / off	Toggles the visibility of the optional smoke deflectors (technically called "Wind Wings") on each side of the smoke box.
Firebox flap	Ctrl F	Open	Lift the firebox flap to look at the fire, and before

Item	Key	Action	Remarks
	Ctrl Shift F	Close	throwing in a scoop of sand to clean the flues.
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	
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	

Item	Key	Action	Remarks
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	Rear Dim → Rear Full → Off → Front Full → Front Dim	The corresponding values on the F4 HUD headlight button are as follows: 1 = Rear Dim 2 = Rear Full 3 = Off 4 = Front Full 5 = Front Dim
	Shift H	Opposite direction to H	
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,

Item	Key	Action	Remarks
			off in the SD models.
Injector Light	Click	On / off	The light is under the cab on the right-hand side.
Running Lights	Click	On / off	There are two running lights on each side of the locomotive, beneath the runboards.
Back Up Red Light	Click	On / off	The back up red light is at the rear of the tender, above the taillight.
Train Indicator Lamps	Ctrl Shift N	On / off	There is no switch for the train indicator lamps. In reality they would be turned on and off by disconnecting them or removing the bulbs.
Headlight Beam	Ctrl Shift H	On / off	Toggles the beam of light cast by the "Front Full" headlight. By default, the beam is off, but it's advisable to toggle it on during the hours of darkness.

Item	Key	Action	Remarks
Tender			
Tender Water Tank Lids.	Shift W	Toggle 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.

Item	Key	Action	Remarks
Expert Automatic Engineer	E, or click on the engineer's seat cushion	Enable / disable	The automatic engineer is unique to the FEF-3. It adjusts the throttle and reverser in order to accelerate towards track speed without losing too much boiler pressure. It will try not to exceed the speed limit. However, it does not control the brakes, except to release them as soon as it is activated. Therefore, the player may have to take over manual control when in danger of speeding, such as going downhill, or to bring the train to a stop.
Locomotive Number Selector	Shift 5	Cycle upwards	The locomotive numbers cycle through the series 835 - 844.
	Ctrl 5	Cycle downwards	
Performance Report	Ctrl Shift R, or click the notice board 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	Increase	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. *The track condition is initialized automatically in accordance with the weather and season at the start of each scenario.*
	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!)
Base Smoke Density	Shift 4	Decrease	Allows the base density of the stack smoke to be selected between "Dense", "Normal", "Light" and "Sparse". The default is "Normal".
	Ctrl 4	Increase	

Cab Views and Head-Out Views

Cab Views ("1" key)

The cab is entered by pressing the "1" key. There are multiple cab camera positions. Use the left and right arrow keys to move from one position to another:

These cab views already include head-out views from which you can see the track ahead as well as operating the controls with the mouse (if you turn your virtual head a little bit towards the interior of the cab).

Head-out Views ("Shift 2" key combination)

The two "traditional" left and right head-out views place you at the rear of the cab deck looking forward. Note that, because of the way TS works, the "Shift 2" head-out views give lower frame rates than the "1" key cab views. Therefore, even though they are provided for completeness, it is recommended to avoid using the "Shift 2" views.

Expert Automatic Fireman (EAF)

The standard automatic fireman in Train Simulator™ cannot fire this model of the FEF-3 correctly and so it ought to be disabled (via the game settings menu). The locomotive will still work even if the standard automatic fireman is enabled, but the operation will be less than optimal.

The model includes its own scripted "Expert Automatic Fireman" (EAF) which does a far better job of managing the fireman's controls and will also perform the periodic blow-downs of the sight glasses and water columns.

The EAF is enabled by default but can be toggled on or off at any time simply by mouse-clicking on the fireman's seat cushion or by pressing 'Ctrl Shift A' on the keyboard.

Expert Automatic Engineer (EAE)

Introduction to the Expert Automatic Engineer

This model features an "Expert Automatic Engineer" (EAE).

The EAE is scripted to do what an expert player would do in order to get maximum performance out of the locomotive.

Once every second, the EAE assesses the state of the locomotive - boiler pressure, acceleration, speed, back pressure, steam chest pressure, throttle, reverser, brake system as well as upcoming speed limit changes - and adjusts the controls to get the best performance while maintaining boiler pressure as close as it can to just below 300 psi.

The EAE is disabled by default but can be toggled on and off at any time simply by mouse-clicking on the engineer's seat cushion or by pressing 'E' on the keyboard.

The EAE can be used at the same time as the expert automatic fireman (EAF). It is also possible to enable the EAE and disable the EAF, so that the player can fire manually without needing to worry much about the engineer's tasks.

The EAE gives the player complete freedom to watch the train and enjoy all the different camera angles. The player would need only to turn on the headlights, blow the whistle and ring the bell, all without having to switch off the EAE, but would need to take over control to bring the train to a stop.

Specific Actions Carried Out by the Expert Automatic Engineer

Specifically, the actions the EAE takes, depending on its assessment of the situation, are as follows:

- If the locomotive's driving wheels start to slip, the EAE will apply sand and turn on the rail washers.
- If the boiler pressure is dropping or the locomotive is getting close to the current speed limit or wheel slip is happening despite applying sand, the EAE will reduce the throttle. Otherwise the EAE will gradually open up the throttle.
- If the boiler pressure is dropping or the cylinder back pressure is getting too high, the EAE will gradually shorten the cutoff (reduce the reverser).
- If the boiler pressure is above 296 psi and not dropping, the EAE will gradually increase the cutoff (increase the reverser).
- If there is a risk that foam in the boiler might be starting to clog the water gauges, the EAE will use the sludge removers.
- When the locomotive is at a standstill, the EAE will put the reverser at full (80%) forward cutoff (80% on the F4 HUD panel, 100% on the F5 HUD display).

- If the speed is sufficiently below the current and upcoming speed limits, if any, the EAE will perform partial release of the brakes, i.e. it will move the automatic train brake back and forth between the RUNNING and FIRST SERVICE/LAP positions, eventually leaving it in RUNNING when the equalizing reservoir pressure reaches 110 psi. Otherwise it will be moved to the SERVICE position for one second followed by LAP. Further service applications will be made if necessary but without exceeding a total reduction of 26 psi in the equalizing reservoir pressure, i.e. a full service reduction.
- The engine brakes will be bailed off whenever the brake cylinder pressure exceeds 10 psi.

Immediately after the EAE takes over from the player, it will perform certain additional actions:

- If the Blow Off Cock Shut Off is closed, the EAE will open it.
- If the brakes are set, the EAE will release them by moving the automatic train bake handle to RUNNING and bailing off the engine brakes.
- The First Service Position Cock will be switched to the "OUT" position.
- If the locomotive is at a standstill, the EAE will open the cylinder cocks.

Limitations of the Expert Automatic Engineer

The EAE does not blow the whistle, ring the bell or change the setting of the headlight selector. Those are left to the player to operate.

The EAE is not endowed with complete knowledge of routes. It will attempt to anticipate changes to the speed limits and brake in time but it cannot guarantee that it will avoid speeding. Therefore, the player must still pay attention and be ready to take over manual control.

The EAE will not stop the locomotive. Instead, the player has to take over manual control to bring the train to a halt.

Firing Manually

Overview

The locomotive 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.

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 color of the smoke from the stack, and when it turns a bluish color, reduce the atomizer pressure just enough to change the smoke color 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 Color

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

Ideally, the smoke should be a light grey color.

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

Injectors

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, labeled "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 pump's rate of flow, in gallons per minute. On each stroke of the pump's piston, pre-heated water is forced into the boiler at approximately 600psi (regardless of the boiler pressure). The needle rises and falls on each stroke of the pump.

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. Typically, the 844 would run about 15-25 gallons of water per minute at about 65 MPH on level track at about 15-20% cut-off.

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 pump 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 synchronized 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, 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 synchronizing them with the opening of each exhaust valve. Thus, at low speed, it's possible to see the gauge needle flickering in synch with the chuffs.

Note that the back pressure rises (quickly) only when the exhaust ports are ejecting steam. When the locomotive is at a standstill and you open the throttle, the back pressure needle will remain at zero until the first chuff occurs. A back pressure of zero doesn't mean that the steam chest is empty! If you have the brakes on and open the throttle, the steam chest can easily fill right up before the locomotive even begins to move, so when you do release the brakes, with the reverser fully forward, you are likely to get wheel slip. To avoid that, you can either open the throttle after releasing the brakes or fill the steam chest only partially (by opening the throttle for just a short time) before releasing the brakes. Remember that the "regulator" value seen on the F3/F4/F5 HUDs is actually an indication of how much steam there is in the steam chest.

Brakes

Notable Features of the Advanced Brake Simulation

The operation of the locomotive air brakes is modeled and simulated with the following 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 130 psi. When the MR pressure falls to 120 psi, 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 130 psi again, then it stops.
- 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-hand brake 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.
- “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!

- Brake application and release times depend on the length of the consist (the length of the train brake line) as well as the season (outside temperature). 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 (SLOW APPLICATION or QUICK APPLICATION). Moving the engine brake handle to the RUNNING position does 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" " by holding the engine brake handle in the RELEASE position (against the pressure of the return spring).

- The train brake handle has some additional scripting to simulate the tactile feel of moving the handle in and out of the detents in the brake quadrant, which helps to avoid accidentally moving the handle by more than you intended

  If the train brake handle seems to get stuck as you move it, it is because it has hit one of those detents (you'll also hear a soft "click"). When that happens, stop moving it, wait at least half a second, then continue to move the handle.

  If the handle is moved with the mouse, it's not necessary to release the mouse button. Just stop dragging the mouse to the right for at least half a second.

Automatic Train Brakes

The various positions of the automatic brake handle are shown in the following figure:

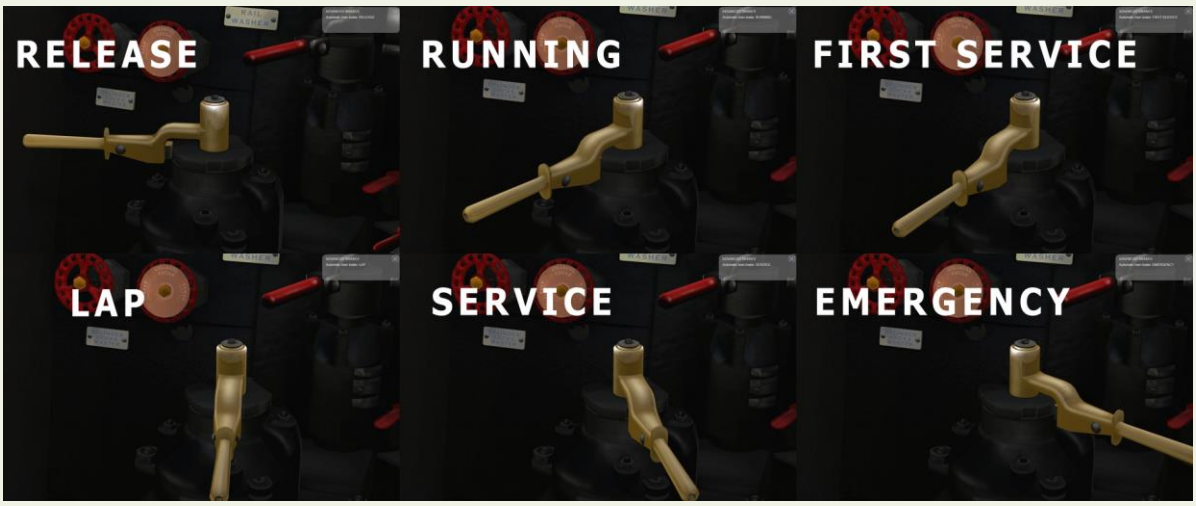


Figure 2: Automatic Train Brake Handle Positions

These positions perform as follows:

- **RELEASE**

  RELEASE connects the brake pipe directly to the main reservoir but holds the locomotive brakes, if set, applied (the brake cylinder pressure shown in the cab gauge stays steady).

  RELEASE should not be used in normal operations, because if left in this position, the brake pipe can become overcharged to more than the 110 psi setting of the feed valve. It should really be used only to recharge an empty brake pipe on a long consist and the handle would have to be moved to RUNNING before the brake pipe pressure gets close to 110 psi.

- **RUNNING**, on the other hand, releases the locomotive brakes as well as the train brakes. In this position, the equalizing reservoir and brake pipe are charged up to 110 psi. This is the normal position for recharging and releasing all brakes, and when running (in order to maintain the brake pipe at 110 psi).

- **FIRST SERVICE**. With the First Service Position Cut-out Cock (see below) set to the "In" position, FIRST SERVICE causes the equalizing reservoir and brake pipe pressures to drop by between 6 to 8 pounds at the regular service rate and then to continue dropping at a reduced rate so as to obtain a total reduction of 20 pounds , i.e. from 110 psi to 90 psi, in approximately 2 minutes. Its purpose is to assist in braking smoothly when stopping a long, heavy train.

- **LAP** stops the equalizing reservoir pressure from reducing, keeping it steady at the current pressure.

- **SERVICE** (or **APPLICATION**) reduces the pressure in the equalizing reservoir - it continues to reduce for as long as you keep the handle in this position. The drop in equalizing reservoir pressure is followed more slowly by the brake pipe pressure as the air in the brake pipe (or "train line") vents through the "small hole" in the locomotive's brake stand. The two pressures (brake pipe and equalizing reservoir) eventually equalize but the time it takes for that to happen depends on the length of the consist.

- **EMERGENCY** gives a rapid reduction of brake pipe pressure and an emergency application of the brakes. You have to wait for the brake pipe pressure to drop to zero before being able to release the brakes.

First Service Position Cut-out Cock

To the right of the automatic train brake handle there is a small red lever called the First Service Position Cut-out Cock. It has two positions, "IN" and "OUT":

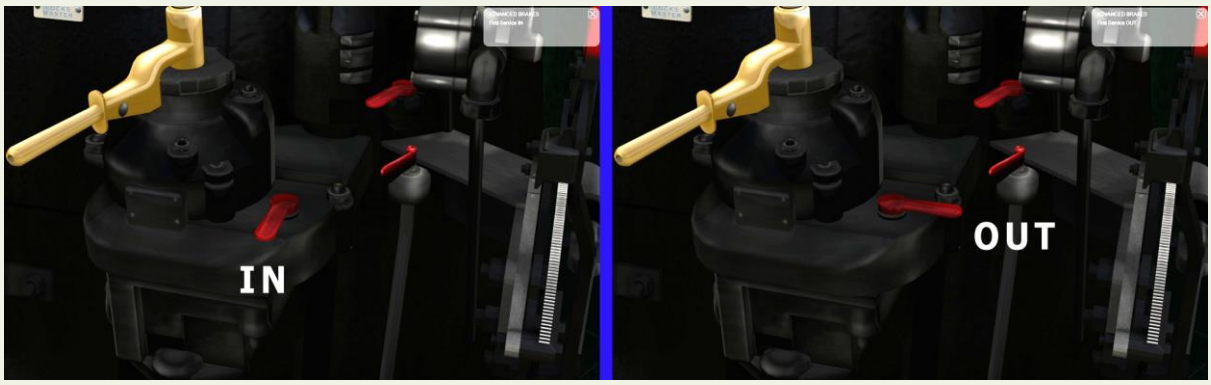


Figure 3: First Service Position Cut-out Cock

When the lever is set to "IN", the FIRST SERVICE position of the train brake handle is indeed FIRST SERVICE, but then the lever is changed to "OUT", the FIRST SERVICE brake handle position instead becomes another LAP position. This allows the engineer to perform a partial release of the train brakes. This is not to be confused with partially releasing the brakes on a railroad car (which isn't possible, because once the brakes on a car start to release, they have to release completely - there is no way to stop it). It actually means allowing the brakes along the train to release, starting with those on the cars nearest to the locomotive (the "head-end" of the train, where the brake pipe pressure rises soonest) but stopping the recharge of the brake pipe before the pressure rises enough to release the brakes on all the cars, leaving those towards the rear of the train with their brakes still on. The extra LAP position is much closer to RUNNING than is the normal LAP, which makes it easy to move the handle swiftly between RUNNING and LAP, releasing more and more of the train's brakes each time the handle is moved to RUNNING.

Engine (Independent) Brakes

The engine brake handle is behind the automatic train brake handle. It has five positions:

Figure 4: Engine Brake Handle Positions

These positions perform as follows:

- **RELEASE** releases (bails off) an automatic application of the engine brakes that occurred as a result of a brake pipe reduction following either a service or emergency application with the automatic train brake handle. This is a spring-loaded position; the handle must be held in position manually (by trying to mouse-drag it towards the left) or it will spring back to the RUNNING position.

- **RUNNING** is the normal position to carry the independent brake valve when running. It releases an independent application of the engine brakes, but not an automatic or emergency application.

- **LAP** holds the current engine brake cylinder pressure steady.

- **SLOW APPLICATION** is the normal position for applying the independent brake and for holding the brake applied when the train or engine is stopped. It produces a smooth but responsive build-up of locomotive brake cylinder pressure.

- **QUICK APPLICATION** produces a rapid increase of engine brake cylinder pressure. This is also a spring-loaded position; the handle must be held in position manually (by trying to mouse-drag it towards the right) or it will spring back to the SLOW APPLICATION position.

Locomotive Emergency Brake Cylinder Pressure Control

To the right of the engine brake handle, there is a small red lever called the " Locomotive Emergency Brake Cylinder Pressure Control" (also known as "Controlled Emergency Cock"). It has two positions, "IN" and "OUT":

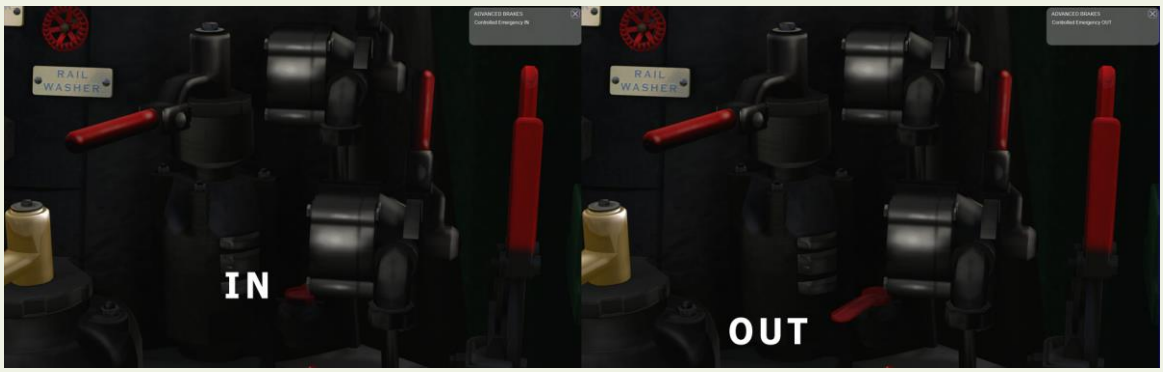


Figure 5: Locomotive Emergency Brake Cylinder Pressure Control

When an emergency brake application is made with the automatic train brake, the resulting rapid drop in brake pipe pressure normally causes a correspondingly rapid increase in locomotive brake cylinder pressure. That can cause the locomotive to brake harder, and decelerate faster, than the cars it is pulling, carrying with it the risk of those cars running into the head end and derailing. To counter that possibility, the IN position results in the rate of increase of locomotive brake cylinder pressure, as the consequence of an emergency brake application, being limited to just over 1 psi per second (much slower than it otherwise would be).

The default position is IN (control), which is required for long, heavy freight consists, whereas OUT (non-control) is typically used on passenger trains, short freight trains and at all times when running light engine.

Engine Brake Bail-off

As already mentioned above, the bail-off position of the engine brake handle has been modeled, along with its spring-loaded action, so that you can 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 white hand, denoting brake pipe pressure, 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 a close approximation and feel of actual bail-off.

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.

When using the F4 HUD, you can still bail-off the engine brakes by using the mouse to click on the "Loco Brake" button and pulling the brake slider downwards. When you let go, the slider will move up and come to rest at about 10%.

Figure 6: Bail-off using F4 HUD Slider - Resting Position after Releasing the Mouse

Pressure Equalization

The brake pipe pressure equalizes first at the head end of the train (that is, at the end of the brake pipe that goes into the equalizing reservoir in the locomotive), taking longer to equalize at the rear end of the train. This means that the train brakes don't apply on every car in the consist at the same time. Instead, it takes longer for them to apply the farther they are from the head end.

Even if the gauge in the cab is showing that the brake pipe pressure has equalized at the desired reduction, the full braking effect won't be felt until the reduction has reached the tail end. The time for that to happen depends on the length of the consist and this is something that you need to take into account when planning your brake applications.

Note: there is no gauge in the cab that shows the brake pipe pressure at the tail end of the train, but if you look at the F5 HUD, the "Brake Cylinder Pressure" shows the average pressure in the cars'

brake cylinders. Therefore, when that pressure reaches a steady value, it's an indication that the tail end brake pipe pressure has equalized.

As the brake pipe pressure reduces, the engine brake cylinder pressure will rise by a corresponding amount, at a ratio of 1:2.5. For example, a 10 psi reduction in head end brake pipe pressure results in a 25 psi increase in engine brake cylinder pressure.

The engine brake cylinder pressure cannot rise above 65psi.

The normal pressure for the fully charged brake pipe and equalizing reservoir is 110 psi. When a reduction is made, the first 6psi reduction in brake pressure (called an "initial reduction") triggers the "quick service" feature of the brake valves on the cars in the consist. Then, instead of the brake pipe air having to travel all the way to the "small hole" in the locomotive brake stand, it vents at the cars themselves, very quickly. In that way, it's possible to get 15psi (2.5 times 6psi) into the cars' brake cylinders very quickly. After the initial reduction, further reductions happen at the normal rate (that is, more slowly) as the air has to travel all the way up the brake pipe to the locomotive.

Train Brake Triple Valves and Auxiliary Reservoirs

Every car in the consist is equipped with an auxiliary reservoir that holds the air used by the brakes in the car, as well as a triple valve that controls three main operations of the brakes:

- Recharging the auxiliary reservoir with air taken from a branch pipe connected to the main brake pipe (or "train line").
- Venting the air accumulated in the car's brake cylinders, so that the brake cylinder pressure falls to zero and the car's brakes release.
- Charging the car's brake cylinders with air from the auxiliary reservoir, so that the car's brakes apply.

As soon as the pressure in the branch pipe is higher than the pressure in the auxiliary reservoir, by at least 1.5 psi, the brake cylinders vent all the air to atmosphere, releasing the brakes, and the auxiliary reservoir begins to recharge (the pressure in the reservoir increases).

There is no partial release per car (brake cylinder retainers are not simulated) and the air is vented very quickly.

However, it's important to understand that the brakes don't release on all of the cars in the consist simultaneously. It takes time for the brake pipe pressure wave to travel down the brake pipe to each car. The brakes release first at the head end, closest to the locomotive, and lastly on the car at the rear end of the train. The "Brake Cylinder Pressure" in the F5 HUD is the average pressure in the

brake cylinders of all cars in the consist, and that average pressure determines the actual braking effort applied to the train by the simulation.

Therefore, if you watch the F5 HUD while releasing the brakes, "Brake Cylinder Pressure" will not change until the brake pipe pressure has risen by 1.5 psi above the current average pressure in the cars' auxiliary reservoirs. Then, "Brake Cylinder Pressure" will rapidly drop to 0 psi, without stopping even if you move the handle to SERVICE, while the brake pipe pressure (shown by the gauge in the cab) continues to rise (at a rate that depends on the length of the consist).

"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 110 psi).

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 110 psi 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”.

Overcharged Brake Pipe

RELEASE connects the brake pipe directly to the main reservoir, circumventing the feed valve. Thus, the brake pipe pressure can continue to rise above 110 psi.

The brake pipe, in turn, recharges the auxiliary reservoirs in the cars, albeit much more slowly (this is because the auxiliary reservoirs recharge off a branch pipe, coming from the main train line, via a narrow feed groove in the triple valves which limits the rate of flow of the air into the reservoir).

If the handle is left in this position for too long, the brake pipe pressure and the auxiliary reservoirs can be charged to more than 110 psi.

When the handle is returned to RUNNING, the brake pipe gradually leaks back down to 110 psi.

However, if the auxiliary reservoirs are also charged at more than 110 psi, that leakage is detected by the cars' triple valves as a reduction, which produces an unintended brake application. The train brakes are, therefore, applied (partially) but the brake pipe is still at its nominal maximum of 110 psi, with the automatic brake handle already in RUNNING, so the brakes cannot be released (brakes are released by raising the pressure in the brake pipe, but in RUNNING, the brake pipe pressure cannot be increased above 110 psi). You can still bail off the engine brakes, but the train brakes are stuck on!

In this condition, if you move the automatic brake handle to RELEASE, the train brakes can be released, but as soon as you move it back to RUNNING, they apply again.

The method for recovering from an overcharged brake pipe is as follows:

- Make an emergency application of the train brakes (move the handle to EMERGENCY)
- Wait for the brake pipe pressure to fall to 0 psi
- Move the handle to RUNNING in order to recharge the equalizing reservoir and brake pipe to 110 psi.

Important Note Concerning the Data Shown in the F5 HUD

The model's scripting does a lot of fancy manipulation of the standard controls and parameters to achieve its high-fidelity simulation of the behavior of things such as the real steam chest, the air

brakes, throttle, etc. That leads to what might look like some strange behavior in the HUD values. This note is intended to explain why you should ignore the HUD (including the F5 HUD).

The "regulator" value that you see in the HUDs is not actually the physical position of the throttle lever in the cab. It's a measure of the amount of steam in the steam chest. The "steam chest" is everything between the throttle valve, basically the dry pipe, and the cylinder admission ports.

Even if you have the throttle only slightly open, the steam chest can eventually fill up (especially if the reverser is in neutral and the cylinder cocks closed, so very little steam is being used up), in which case you see the "regulator" value on the HUDs go up to 100%. If you close the throttle completely, the steam in the steam chest will condense and the "regulator" value will start to fall gradually (meaning less steam in the steam chest).

When you see the "regulator" value going up and down, it's actually the live steam from the boiler filling up and emptying the steam chest on each stroke of each piston as the admission and exhaust ports of the cylinder valves open and close.

The values and names for the brake position that you see in the HUDs are not the position of the physical brake handles either. They actually give you a peek into what the simulation is doing "under the hood" to achieve the extremely realistic behavior of the air brakes, including the way that on a long consist the equalizing reservoir pressure changes more rapidly than the brake pipe pressure (which has to "catch up" because of the speed of propagation of the pressure wave along the brake pipe). The engine (independent) brake also manipulates the standard control values to be able to simulate bail-off. That's why, if you've put it at 0% (bail-off) and let go, it rises back up to 10% - that's the spring-loaded action that returns the handle to the RUNNING position.

The equalizing reservoir pressure shown on the gauge in the cab is controlled entirely by the script, so you have to ignore whatever value is shown in the F5 HUD.

When the brake pipe pressure (as shown by the gauges in the cab) has reached the same level as the equalizing reservoir, the train brake value in the HUD will indicate 62% - that is how the script holds the pressures equal.

When the brake pipe pressure needs to change to catch up with the equalizing reservoir pressure, the script sets the F5 HUD train brake values as needed (depending on the difference between the two pressures), applying and releasing, until the pressures are equalized.

Be aware that the "Brake Cylinder Pressure" shown in the F5 HUD is a representation of the pressure in the train brake cylinders, i.e. the average pressure in the brake cylinders in all the cars in the consist. The gauge in the cab, on the other hand, shows the pressure in the engine brake cylinders.

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.

Note: The valid range of locomotive numbers is 835..844. Any other number can give strange results (such as the number not showing up on the shield beneath the headlight). This is because there were only 10 of the FEF-3 built, starting with UP835.

Genuine Wheelslip/skid

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 behavior, 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 tires 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-pedaling).

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.

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

Headlights, Taillights, Classification, Marker, Cab and Gauge 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-color classification lights. These have to be switched on with the keyboard command (U or shift U). The colors 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.

Headlight Beam

The headlight beam, which illuminates the ground and other objects, can be toggled on and off. By default it is off, which eliminates the unsightly effect of the headlight beam illuminating objects on sunny days. However, the player can toggle the beam on at any time, which is especially useful at night. The beam is also toggled on automatically when the locomotive is in a tunnel.

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 synchronized to the exhaust chuffs. The color 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 tires when wheelslip (wheelspin) or wheelskid occurs.

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

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.

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 Signaling

Functional in-cab signaling 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

Overview

The model 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

Immediately after loading a scenario with the FEF-3, the expert automatic fireman is enabled. Therefore, it's not necessary to perform any initial setup actions related to the fireman's duties. Meanwhile on the engineer's side, the train brakes are released but the engine brakes are applied to about 45 psi. This is to stop the train from rolling away.

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

1. Switch on the headlights (dim or bright, as appropriate).
2. If it's dark, switch on the gauge light and cab light.
3. Open the cylinder cocks (the cylinder cocks master is already open).
4. 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).
5. 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.
6. Turn on the sanders.
7. Turn on the bell, if required, by opening the air valve.
8. Push the Johnson bar (the reverser) forwards.
9. Blow the whistle (two blasts).
10. Release the independent brake (turn it all the way to the left).
11. Open the regulator further to gather speed, but slack off (or reduce the cut-off) if you hear the wheels slipping;

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

13. 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.

14. 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).

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

16. 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.

17. 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).

Save and Resume

Considerable effort has been put into trying to ensure that save and resume (for scenarios) works flawlessly. However, after resuming, it may take a few seconds for the smoke effects to settle down to the way they appeared at the time of the save.

It is inadvisable to save and resume while ascending a steep grade with a heavy consist. This is because the momentum that the train had at the time of the save can be lost immediately, causing the train to slow down and possibly stall, where it would have continued on up the hill without any fuss if the scenario hadn't been interrupted by the save/resume. This is a random occurrence. If it does happen, the advice is to exit the scenario, return to the main menu and from there, re-select

and resume the scenario. Usually it works well the second time, with the momentum correctly restored.

Career 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.

Liveries

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

- Black with white-walled driver tires, 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.

Troubleshooting

Black Steam and Water

In extreme circumstances (such as when running the HD version on a route that is densely populated with assets) an internal error can be triggered that manifests itself as all particle emissions turning completely black because of TS failing to load the associated shaders correctly.

If this happens, quit the scenario and return to the main menu - that will allow the internal state that provoked the error to be reset. Usually everything works correctly after starting the scenario again via the Drive menu. However, if the fault occurs again, consider lowering the graphics settings for scenery detail, shadows, etc. and/or using the SD, instead of HD, version.

Strange Values such as "1.$" in the F5 HUD

If a scenario is played directly after editing it in the Scenario Editor (accessed via the World Editor after clicking on the "Scenario Tools" button), it can sometimes provoke an internal error that corrupts the simulation data. The most obvious symptom is when nonsensical values such as 1.$ appear in the F5 HUD data.

If this fault occurs, proceed as described above for the "Black Steam and Water" fault.

Sounds Vanish in Outside Camera Views

This can happen immediately after resuming a scenario. It can often be solved by pressing '1' to gin to cab view and then returning to the outside view. In some cases, panning the "helicopter" camera view around the locomotive brings the sounds back. If the sounds are still missing, proceed as described above for the "Black Steam and Water" fault.

Locomotive Ran Out of Water

If this occurs soon after switching off the Expert Automatic Engineer, with the Expert Automatic Fireman enabled, try again but this time ensure that the game's default automatic fireman is switched off in the game settings menu.

Train Simulator Crashes in 32-bit Mode

This has occurred in testing but was resolved either by switching to 64-bit mode or, in the case of Quick Drive scenarios, by checking the "Player train only" box so that no AI trains were spawned into the scenario. The FEF-3 itself is perfectly capable of running in 32-bit mode.

Tools Use 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** provided with Train Simulator;
- **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).

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