Boeing Super Stearman IB75A

MSFS 2020 for PC and Xbox

*** Compatible with MSFS 2024 ***
***see Index page 5**

Pilot's Operating Handbook v 6.0

Introduction

Thank you for purchasing this virtual replication of the **Boeing Super Stearman IB75A**.
The Boeing Stearman Model 75 is an American biplane formerly used as a military trainer aircraft, of which at least 10,626 were built in the United States during the 1930s and 1940s. Stearman Aircraft became a subsidiary of Boeing in 1934.
Widely known as the Stearman, Boeing Stearman, or **Kaydet**, it served as a primary trainer for the United States Army Air Forces, the United States Navy (as the NS and N2S), and with the Royal Canadian Air Force as the Kaydet throughout World War II.
After the conflict was over, thousands of surplus aircraft were sold on the civilian market. In the immediate postwar years, they became popular as crop dusters and sports planes, and for aerobatic and wing walking use in air shows.

Post-war usage

After World War II, thousands of surplus PT-17s were auctioned off to civilians and former military pilots. Many were modified for crop-dusting use, with a hopper for pesticide or fertilizer fitted in place of the front cockpit. Additional equipment included pumps, spray bars, and nozzles mounted below the lower wings. A popular approved modification to increase the maximum takeoff weight and climb performance involved fitting a larger Pratt & Whitney R-985 Wasp Junior engine and a constant-speed propeller.
This add-on is intended to be the most faithful of this aircraft modified after the war for acrobatic use and ensure presentations during air shows.
Despite the limitations imposed by the simulator, some basic features that are not present in MSFS 2020 have been implemented to try to best represent this iconic aircraft.

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System Requirements

Microsoft Flight Simulator 2020
1.5 GB Free hard drive space
This add-on is not compatible with Flight Simulator X or Prepar3D

Support

If you are having problems using this aircraft, please email at
goldenagesimulationstech@gmail.com.
Please try to describe the problem as best you can and also include which simulator you are using and the operating system.

Problems with downloading the package should be directed to the retailer as they are responsible for delivery of the downloads

Installation

This aircraft is designed for Microsoft's Flight Simulator 2020 (including the Steam version).
The aircraft is compatible with MSFS 2024 as a "Legacy" aircraft in Free Flight Mode Only.
It is not compatible with Flight Simulator X or Lockheed Martin's Prepar3D. Installation is handled by an installer program which attempts to place the files into the Community folder.
Confirm the location of your Community folder before beginning the installation.
The Community folder is where all 3rd party add-ons should be installed.

The Community folder can be difficult to find. The location will depend on the version installed (MS Store or Steam) or if the user has set a custom location. The installer will attempt to find your Community folder location. If it cannot find the Community folder, you will need to manually browse to your Community folder.

By default, the Community folder could be in any of these locations:

Windows Store default
C:\Users\"*userame*"\AppData\Local\Packages\
Microsoft.FlightSimulator_8wekyb3d8bbwe\LocalCache\Packages\Community

Steam default
C:\Users\" *userame*"\AppData\Local\Packages\
Microsoft.FlightDashboard_8wekyb3d8bbwe\LocalCache\Packages\Community or C:\Users\" *userame*"\AppData\Roaming\Microsoft Flight Simulator\Packages
\Community

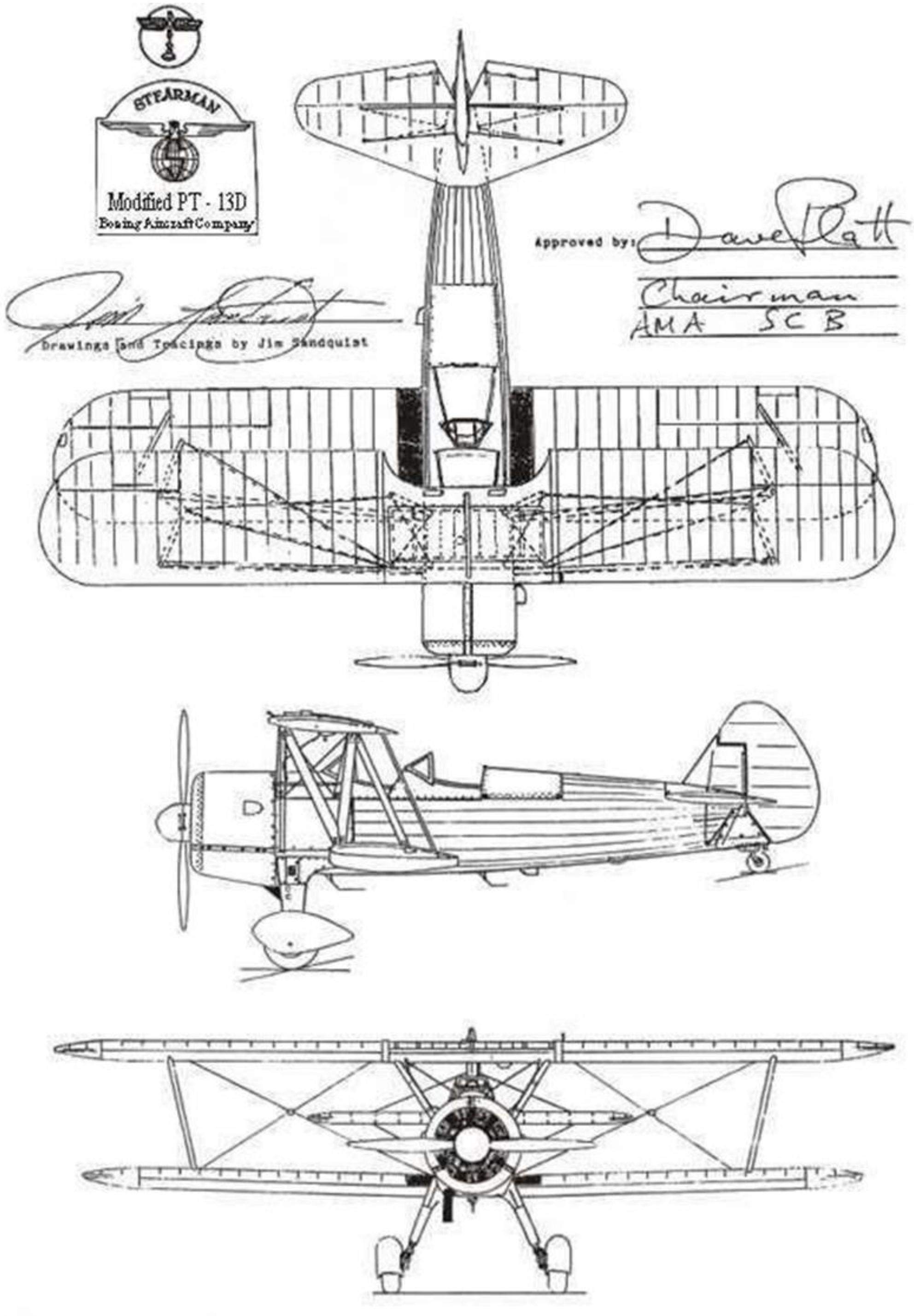
Ensure that the last folder in the install location is "Community".

If you accidentally install it to the incorrect location, you can manually move the installed folders into the Community folder. There are no links to the installed folders so manually moving them will not cause any issues.

MSFS 2024 NOTAM

This aircraft is compatible with MSFS 2024 as a "Legacy" aircraft. This means that it is designed for use in 2020 and functions in 2024 with the following limitations. I may only be used in Free Flight Mode. Upon loading the flight your viewpoint will be outside the aircraft. Keystroke Shift+C to enter the VC cockpit. At that point the model will share all functions associated with the MSFS 2020. **Technical support is not available for issues encountered in 2024**.

Pilot Avatars – MSFS 2024
MSFS 2024 does not provide for use of avatars used in MSFS 2020 and as such if the model is flown in MSFS 2024 there will be no pilot/passenger figures in the exterior model. Asobo/MS are working on a "fix" and testing is in progress
https://forums.flightsimulator.com/t/fs2020-aircraft-in-community-are-showing-the-co-pilot-avatar-in-place-of-pilot/700680


STEARMAN
Modified PT - 13D
Boeing Aircraft Company
Approved by: Dave Platt
Chairman
AMA SCB
Drawings and Tracings by Jim Sandquist

Xbox Console Operations

Before flight set "Show White Dot Cursor in Freelook" to OFF using the **General Options – Accessibility** This ensures proper throttle operation using the "A" and "B" game pad buttons to manage throttle settings. White dot cursor may be reactivated in cockpit by depressing the LEFT game pad analogue stick, allowing for operation of all other cockpit elements.

All Preflight operations: Walk Around: This is managed using the "Instruments" option of the Internal Cockpit Camera Menu. Scrolling down will present the users with the 7 preflight stations.

If opting for the "Quick Flight" Please see page 8 for proper operation and note that while this will remove all security options, the engine must be properly warmed before flight as described on page 13

Failure to assure proper fuel/oil levels and battery voltage >24 volts will prevent engine starting. Parameters may be reset as described on page 16

Presentation

This add-on is not a simple evolution of the previous add-on Stearman PT-x & A75L300, it is an airplane equipped with a completely different engine: the famous Pratt & Whitney R-985 Wasp.

The aircraft is supplied in three variants:

- Standard,
- Racing
- Air Show with Wing Walker and Mast on Upper Wing

Each aircraft can be customized using the various. It is particularly distinguished by the way in which the engine is simulated. Indeed, a lot of code have been added to handle functions that are not supported by default by Asobo/Microsoft such as:

- Complete fuel and oil systems : refill tanks, weight of fuel and oil on board affecting the mass of the aircraft, oil and fuel consumptions, oil leaks,

- Advance engine parameters including wear and performance degradation of the engine when used to the limit of its capabilities or outside the operating ranges defined by the manufacturer,

- Custom made component failures,

- Persistent parameters so that you have a more realistic

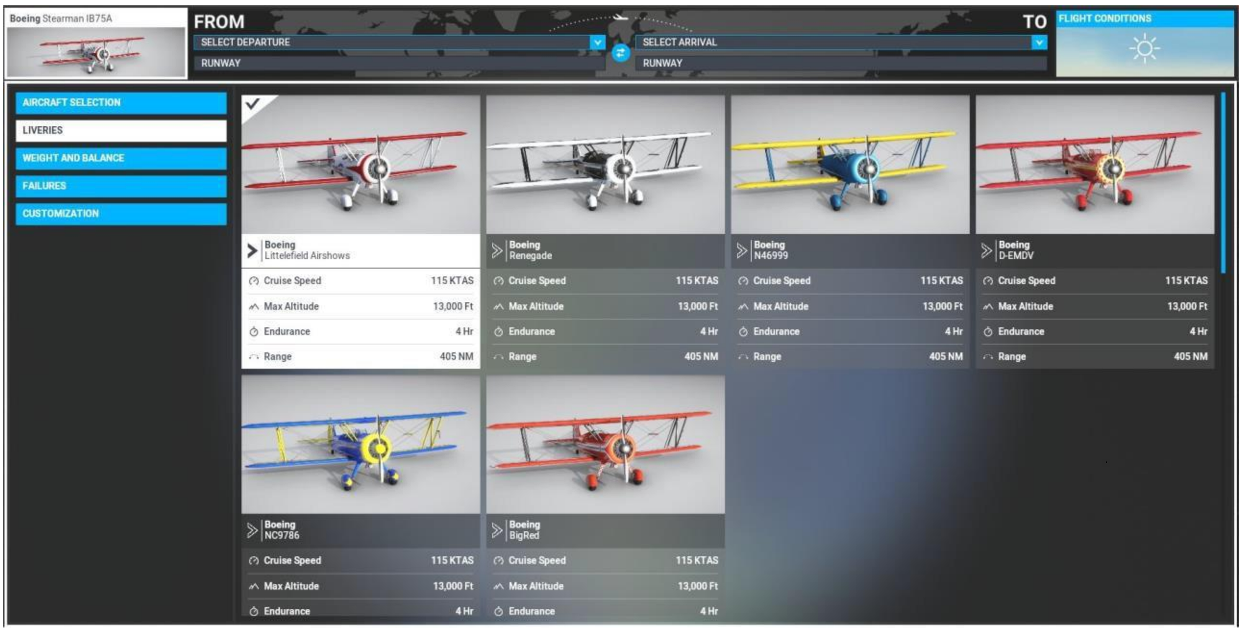
All these elements contribute to creating a more immersive add-on to try to meet the expectations of users.

-NOTAM -

This aircraft has only one mode of operation: Enhanced mode. There is no easy mode. There are consequences for failing to follow procedures and checklists. For the best user experience consult the Aircraft Monitoring and Maintenance Panel before flying. Details found on page 10 of this document.

Aircraft Selection

The Super Stearman will appear in the Aircraft Selection screen under "Boeing Aircraft Company " Stearman Model IB75A.
Clicking on the LIVERIES tab will allow you to select from the various repaints.



Quick overview

WARNING

While the "Super Stearman" is a simple aircraft to fly it's also a very old aircraft (it's was produced between 1930 and 1940) so please read the following quick tips which highlight some point you should take in account to fly with this "old lady".

Super Stearman Virtual Rear Cockpit

This aircraft can be configured/configured in several ways :

Using options

Several options and animations are offered to the user using the available basic cameras (in interior view) and during Pre-flight Inspection using the Aircraft Monitoring and Maintenance Panel interface. Options are selected using a left mouse click:

- remove or keep wheel covers and blades spinner,
- remove or keep the engine cover,
- remove or keep the faired gears,
- be able to display the Wing Walker Girl and Mat on the upper wing of the aircraft ,
- to refuel via an external barrel and its manual pump,
- make a supplement of oil for the engine.

The aircraft can be configured in the following manner:

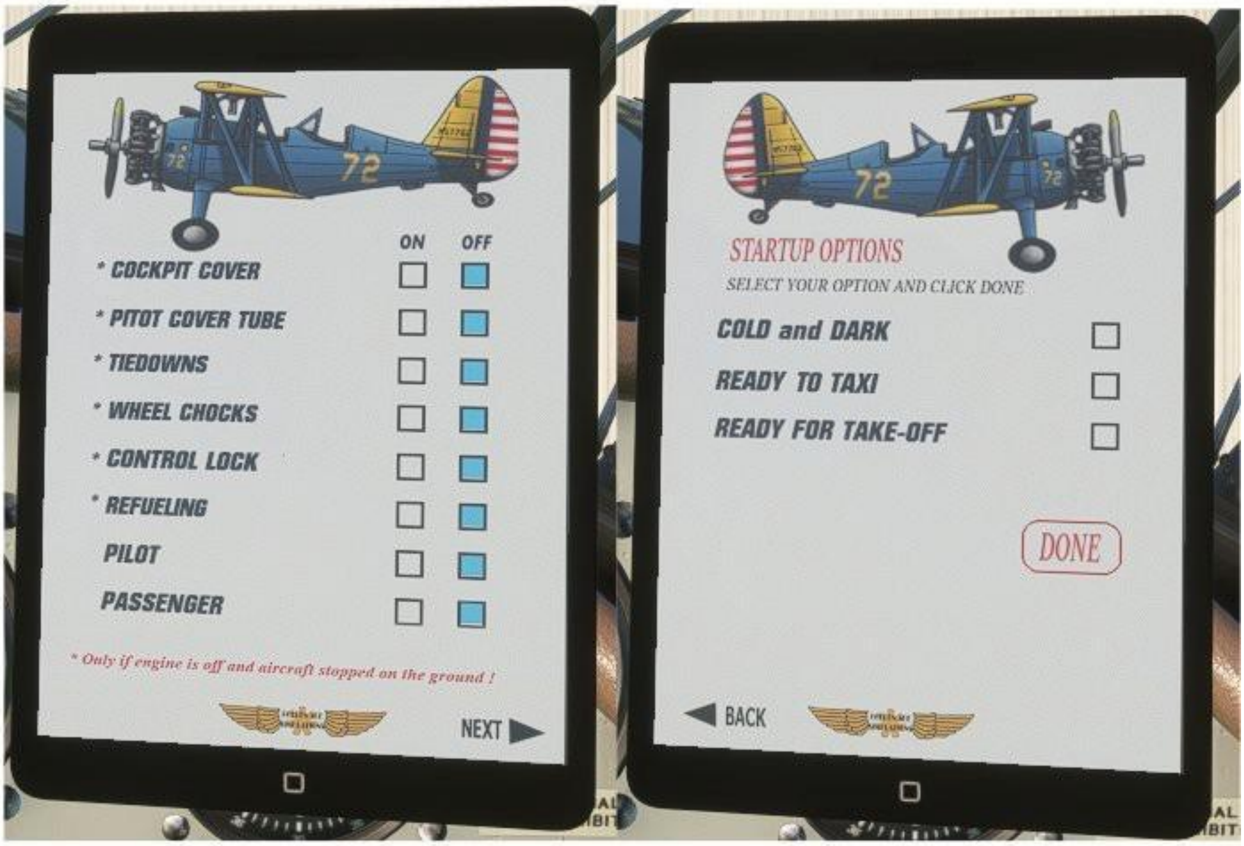
- a Standard version with two cockpits with/without faired gears and engine cover,
- a Racing version with one cockpit and its streamlined windshield with/without faired gears and engine cover,
- An Air Show version with Mast and a Wing Walker.

THE EFB

A tablet can be displayed by clicking on the compass correction card mounted to the panel in the rear cockpit (see previous screenshot above).

The first page of the Tablet can be used to set various user preferences (display of some security parts and/or pilot/co-pilot).
The second page allows you to pre-configure certain situations to assist engine starting (cold & dark, ready to park, ready to take-off).

The location of this tablet is fixed so you cannot move it within the cockpit.



By clicking on the edge (bottom which corresponds to the on/off button) of the tablet, it disappears from the display.

NOTAM:
a) Should the pre-flight interface freeze and refuses to allow the user to click on "C", click on any one of the numbered steps and after return to "C" to unlock the interface.

b) When the engine is running, you should not use the Y shortcut to slew the aircraft!!!
When the engine is running, a lot of extra computations are made, and the Slew operation disturbs the TIME variable which leads to erroneous calculations in the advanced engine management module. For this reason, it is advisable to use this function BEFORE starting the engine but absolutely NEVER during its operation.

Using the Aircraft Monitoring and Maintenance Panel interface.

In addition to the EFB, an interface available via the MSFS toolbar allows access to other functions such as:

- be able to fold the aircraft's checklists,
- select different options via mouse click,
- conduct a pre-flight visit by passing through the pre-determined points of passage to test the flight rules and ensure their proper functioning,
- be able to consult the values of some local variables used for the management of the add-on.

You can access to this interface via this icon on the center of the MSFS toolbar (top of the screen)

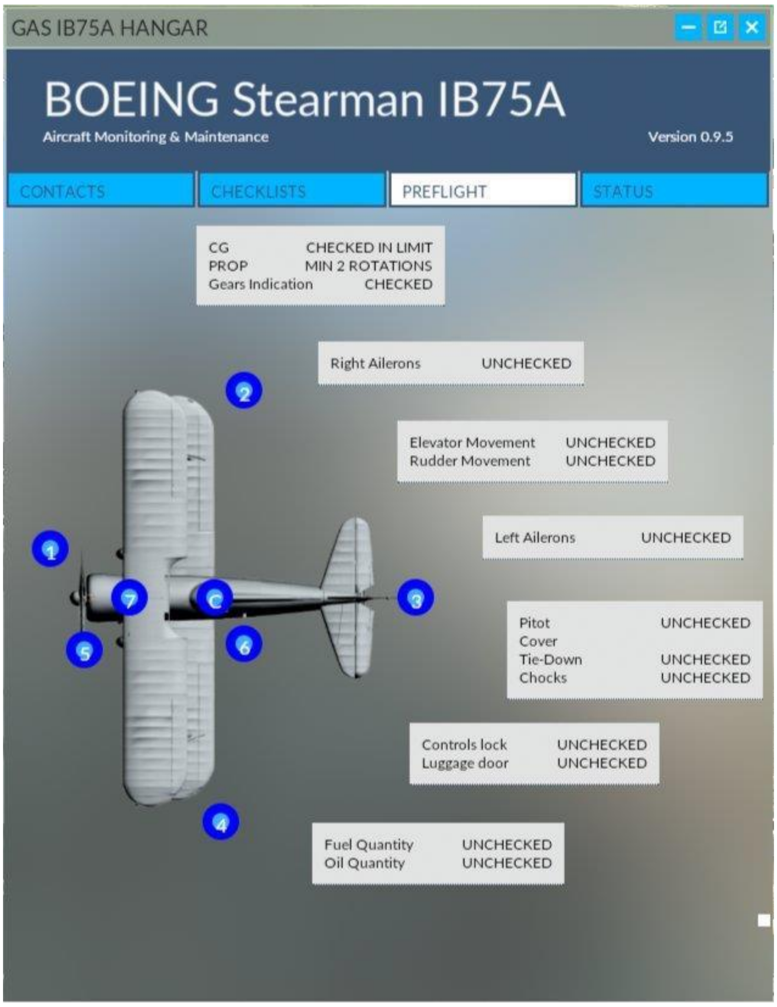
1. *Contact: Presentation and several links to web site and supports,*
2. *Checklists: To access quickly to the main information,*
3. *Preflight:*
4. *Status: Values of several parameters to manage the health and damage of the aircraft.*

Focus on the Checklist tab:

Focus on the Preflight tab:

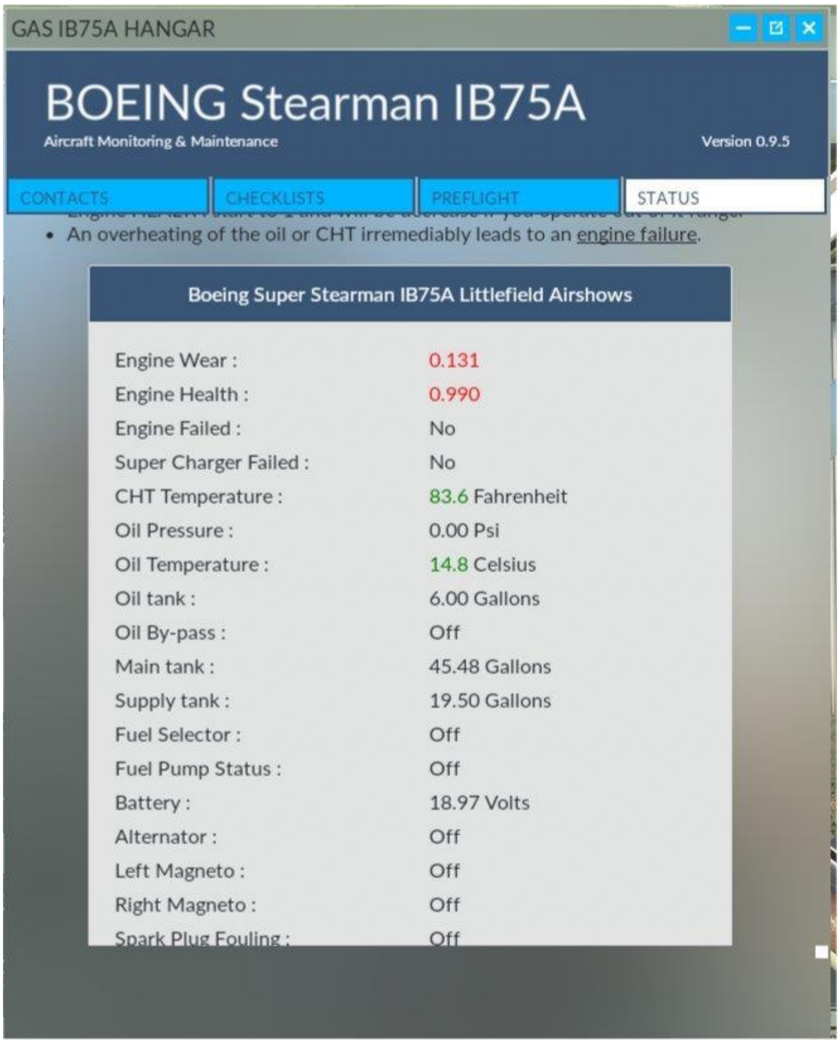
This graphical interface uses shortcuts presented around an aircraft top view to quickly access pre-programmed views around the aircraft and make the necessary checks before starting the aircraft.
On the right side, summary tables are updated following each flight and safety check controls. Security elements e.g. chocks, tie downs, and pitot tube covers as well as wheel-pants/farings, engine cowl, and prop hub can be manipulated during the preflight review.

CAUTION:* *Before the Preflight Inspection, ALWAYS set the CONTROL LOCK to OFF in order to unlock the flight controls.
How to unlock the flight surfaces control lever by keyboard or joystick:
The variable (A:TAILHOOK POSITION, Bool) can be used to unlock/lock the flight surfaces control lever. By assigning a keyboard shortcut or a key from your joystick to this control(tailhook position), you can lock/unlock the red lever on the left cockpit console.



Focus on the Status tab:

This module management records the aircraft's status every second and the data are refreshed to a period of 10 seconds.
This tab provides the user with data collected by the simulator reflecting key elements of performance. It may be monitored in real time during flight.



Tool tips

*For first flights, **it is strongly recommended** to validate in the **MSFS General Options**, and more precisely in the menu **User Interface** the option "**Menu Tooltips**" in order to be able to display the right information needed to start the engine: the number propeller blade pull-throughs and amount of prime to use.*

These messages take into account all the parameters (ambient temperature , engine hot or cold), then calculate and display in live the exact number of actions that remain to be performed in each case.

Failure to complete the required "pull through" operation will simulate hydraulic lock, also known as hydrolock or hydrostatic lock resulting in catastrophic engine failure of start-up

Number of strokes to be applied on the primer:

*You can also access text messages about the oil parameters (pressure, temperature and CHT) by hovering over the associated dial (bottom left). **Failure to allow engine oil temp to achieve 40 degrees C before applying full power will damage engine and degrade performance resulting in an off-airport landing***

Main conditions to observe when using this aircraft

Compared to a basic aircraft supplied in MSFS, whose operation is simulated in a simplistic way, the Pratt & Whitney of the "Super Stearman" takes into account additional parameters to make it closer to reality.
Therefore, its start-up, ground and flight operation and finally its shutdown require special precautions, specific procedures that other aircraft do not need.

WARNING
If you do not follow these procedures, you may damage the engine and therefore be forced to completely restart the flight by going through the interface of the MSFS world map.

1. Due to its large engine, the "Super Stearman" will not be able to be started by hand propping; it therefore needs the use of an electrical starter to power on the engine. However, prior to activating some procedures are required in in order to start the engine without risk of engine failure:
   - This engine has 9 cylinders arranged in star. When not in use, the lubricating oil can accumulate by gravity in the lower cylinders, so before each start, its therefore necessary to ensure that this oil is evenly distributed throughout the lubrication circuit and prevent hydrostatic cylinder lock.
2. For this the "**pull through**" procedure which consists in turning manually the propeller around its axis on one or more times will set in motion the internal engine components and the oil pump which will therefore distribute the excess oil throughout the engine. The number of revolutions required is function of two parameters: ambient temperature, which is also that of the lubricating oil, and cylinder temperature. The lower these temperatures are, the more you will have to turn the propeller manually (**Note A Page 14**).

3. If this mixing is not done, the engine can start but depending on the amount of oil remaining in the combustion chambers, **excessive compression could** occur leading to engine failure.
4. The fuel system shall be primed according to the **internal temperature of the engine** for this it is necessary to unlock the primer lever and then press as many times as necessary on the control to prime the circuit (**Note B Page 14**).

2. If you want **to get flying quickly** then using the Auto-Start key command **CTRL+E** will start the engine without needing to follow the full start procedure).
3. The user also has the possibility via the second page of the tablet to choose a "**Cold &**Dark" procedure.

After starting, the user must raise the oil temperature to 38°C ~ 40°C using the throttle lever to slow down between 800 and 1000 RPM. If this idle is lower, the engine cannot run in nominal mode and the spark plugs will get dirty which may cause engine power losses. The switch OIL BYPASS allows cutting the circuit bringing oil to the radiator which allows a much faster heating: **on the ground to go from 15° C to 40°C using this switch (30 secs. to 1 min) is required**.

When working on runways, do not increase engine speed excessively.

For take-off, it is advisable to use the manifold at the edge of the red zone for less than one minute. This allows you to have all the power needed to take off. If you take off using the **engine in the red zone you can damage your engine irreparably**.

In flight, do not operate the engine while holding the RPM needle in red area excessively. If this happens, the **engine will be damaged and may fail completely**.

Stopping the engine

The recommended method for stopping the engine is to turn both magnetos off. The mixture control cannot be moved into a cutoff position and turning off the fuel means the engine can keep running for up to a minute as it uses the fuel remaining in the fuel lines.

Technical notes

If the engine cylinder temperature (CHT) is above the ambient temperature by **more than 50 units**, the **engine is considered to be hot** (It has operated before and therefore does not require as much care for a re-start).

Note A :
A cold engine will require:

1, Propeller rotation for an ambient temperature of more than 20°C, = 1

2, Propeller rotations for an ambient temperature between 20° C and 5° C = ,

5, Propeller rotations for an ambient temperature of less than 5° C.

A hot engine that has just been running before **will not require any propeller rotation** because the oil did not have time to stagnate in the bottom cylinders.

Note B :
A cold engine will require **3 strokes to prime** the fuel circuit.

A hot engine will require **1 stroke to prime** the fuel circuit.

Pre-flight, Start Sequence and Take-Off Demo Video
https://youtu.be/zPlQXYk9r60

Advanced functionalities

The main novelty of MSFS simulator was its innovative graphic model that attracted a lot of people. On the other hand, the physical simulation aspect despite many evolutions has in comparison very little evolved.

By making this add-on, we wanted to offer the user a more immersive and attractive model by increasing the realism of the simulation.
For this, we have tried to supplement some aspects not foreseen basic by deepening some physical phenomena not addressed:

- Since fuel management is already taken into account, we opted for similar **engine oil management**. This allows, among other things, to have one or more oil tanks that can be filled, the amount of oil on board the aircraft influences the total weight, depending on the temperature of the oil and the mode of operation of the engine (compliance or not with the authorized zones) can lead to leaks in the lubrication circuit which can cause engine failures.
- Radial engines were widely used during the first 50 years of aviation, they brought many advantages but also constraints including the requirement to rotate the propeller by hand in order to force the oil that settles in the lower cylinders during periods on disuse, to be distributed throughout the lubrication system. These **pull through operations** are modeled.
- Similarly, **priming operations** before engine start and **use of boost pump** are modeled and coded to increase realism.
- **Heat phenomena in engine oil or cylinder heads** were the most frequent sources of engine failure, in this perspective a number of scripts have been added to simulate these problems which allows a greater realism of this add-on.
- This type of air-cooled engine requires special attention when starting and warm-up, prolonged operation at low rpm clogs the spark plugs and can be **detrimental to the engine. This is called spark plug fouling** and it has been simulated modeled in this add-on.
- All these physical parameters that evolve during a flight are accumulated over time and due to the "persistence" function, be reflected on the next flight. Thus, two important parameters that reflect the wear and health of the engine were introduced to characterize the life of the engine.
- The model is coded to use what we call "Persistent Data Function". This instructs the simulator to store a number of local variables: engine wear, health, oil and fuel consumption and battery charge at the end of a flight, which are be used to set baseline level for subsequent flights. Additional variables stored are: priming, pull through operations, boost pump to help during take-off operations, heating effects (engine oil and cylinders head temperatures), and spark plug fouling

Enhanced Engine Reset

In some situations, it is possible to reset a number of parameters to known nominal values that allow scripts to function normally.
To reset these parameters, it is **imperative** that:
The aircraft is on the ground and the engine and battery are off.
Reset process:

1. to open the "DATACASE" by a mouse click on the top of this box,
2. Activate switch for a few seconds on the "Reset switch" located inside the box and on the right.

This procedure does not apply to ALL parameters, some of which are not user-addressable and calculated in automatic mode; for example, if the engine oil reaches extreme temperatures, it will take a time defined by MSFS (several minutes) to return to ambient values and the user cannot act on this.
If the action on the Reset switch does not allow reactivating the aircraft in operation, it will be necessary:

1. to exit the flight,
2. return to the MSFS interface with the World Map and
3. reset the flight.

In the event that the cockpit switch does not clear the data saved, an alternative solution may be implemented:

1. to exit the flight,
2. return to the MSFS interface with the World Map and
3. manually the "state.cfg" file which will be re-established upon loading next flight:
C:\Users\"username"\AppData\Local\Packages
\Microsoft.FlightSimulator_8wekyb3d8bbwe\ LocalCache\SimObjects
\Airplanes\gas-aircraft-stearman-ib75a\state.cfg

- **username** is the label of your Windows account
- **state.cfg** is an ASCII file where persistent data are stored.
- if your **installation PATH** is different (D:\ or X:\), you should adapt this process based on your installation directory.

Persistent Data

All persistent data are stored in a file named **state.cfg** file which is stored on your disk.
The user may want to revert the aircraft to its "factory fresh" state. To do so, **the user can simply delete this state.cfg file**.
This file will be re-created automatically when MSFS is restarted.
The location of this file depends on the installation that was made by the user and the software provider. In the vast majority of cases, this file is located:

```
STEAM: C:\Users\<USERNAME>\AppData\Roaming\Microsoft Flight
Simulator\SimObjects\<AIRCRAFT_NAME>\state.cfg

MS STORE:
C:\Users\<USERNAME>\AppData\Local\Packages\Microsoft.FlightSimulator_8wekyb3
d8bbwe\LocalCache\SimObjects\<AIRCRAFT_NAME>\state.cfg
```

Persistent fuel and oil
Fuel and oil levels are "*persistent data*", that means that they are saved after a flight which **has ended normally** and reload them on the next flight.

<u>A flight is considered ending normally when:</u>

1. landing is OK,
2. engine is OFF,
3. all switches are OFF and
4. the user returns to the World Map!

CAUTION: Do not use the "X" (Close Window) icon to end flight as data will not be saved.

FLIGHT SIM NOTE

Persistent fuel and oil levels will be loaded a few seconds after the flight has loaded.

Any changes made in "weight and balance" pre-flight will be overwritten by the persistent settings. You should therefore only set the fuel and oil quantities after loading flight.

Oil Consumption
The **Pratt & Whitney R-985 AN3** oil tank holds a total of 8 Gallons of which 1.5 was reserved and necessary for operations on the constant-speed propeller, so the oil level cannot drop under 1.5 Gallons.
This engine consumes roughly **4.6 quarts/hour of oil** (1.148 Gallon/Hr.).

The oil level may be adjusted using the MSFS fuel window (see page 12).

<u>Warnings:</u>
If the oil level drops below 50%, expect oil pressure to start to drop.
If the oil level drops below 20% the engine will fail.

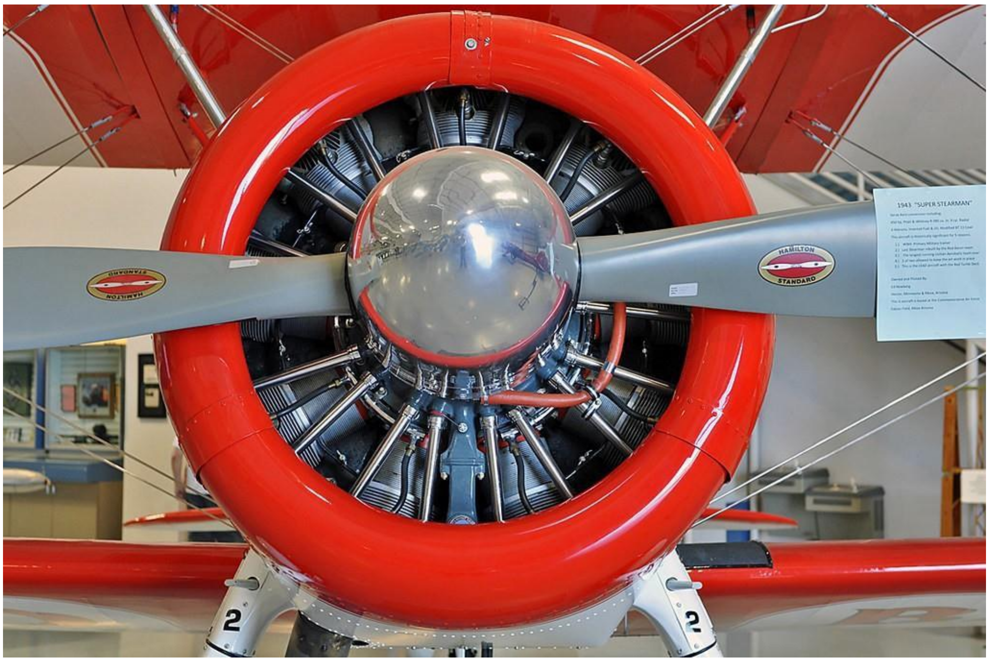
Engine Overheating
Since air-cooled engines are more sensitive to cooling problems, the user must monitor the CHT and Oil temps carefully when:

- Taxing and taking off,
- Operating in environments of extreme heat.
- On approach and landing.

Failure to monitor and prevent overheating may result in engine failure despite the engine's reputation for great reliability.

Spark plug Fouling
<u>If the engine is operated for 1 minute at below 1000 RPM</u>, carbon will start to build-up on the spark plugs, and this will quickly cause the engine to stop.

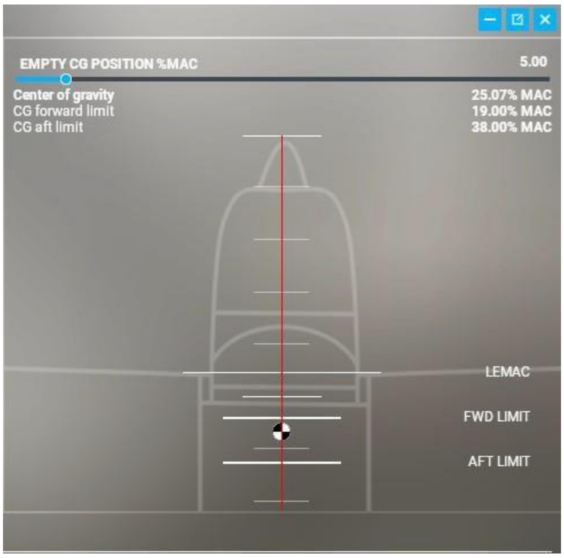
Running the engine between 800 – 1000 RPM will burn off the carbon build-up.



Weight and balance

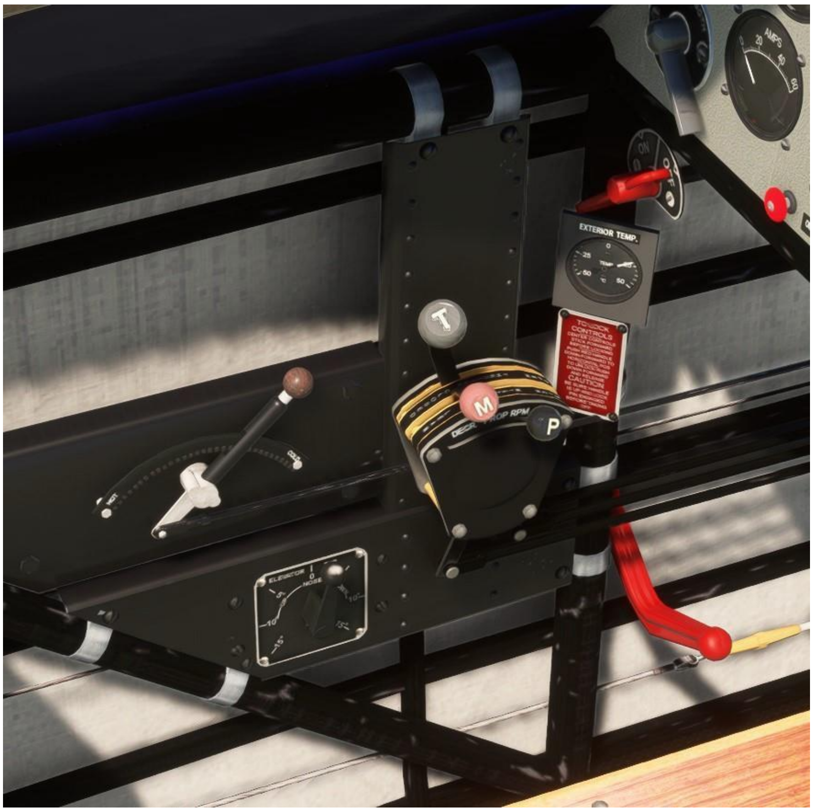
Weight and balance is the imaginary point t which all the weight is concentrated. To provide the necessary balance between longitudinal stability and elevator control, the CG is usually located slightly forward of the center of lift.

Before starting a flight is advised to watch "weight and balance" menu and confirm that the center of gravity is within limits.
Avoid heavy weights on baggage stations as they are aft of the center of lift and will effect pitch stability which may result in loss of aircraft control.



Elevator trim

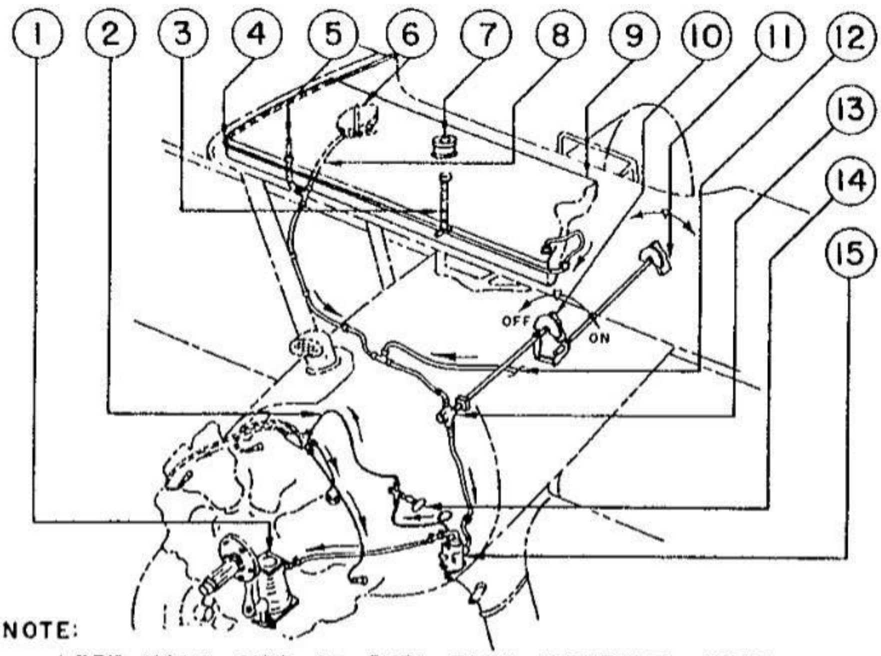
The elevator trim is located on the left side of the cockpit, just behind the "throttle/mixture/propeller rpm" levers and below the carburetor lever. The tab control is fitted with a dial that indicates in degrees the displacement of the tab with respect to the elevator. The control is moved aft to correct for a nose heavy condition and pushed forward to correct for tail heavy condition.



Fuel System

The Enhanced Mod provided with this add-on now uses the MSFS2020 advanced modern "Fuel system". This aircraft has its fuel system, located in the upper wing (diagram below).

The fuel tank is located in the center section of the upper wing and has a capacity of 46 U.S. Gallons (38.23 Imp. gallons) with an expansion space of 1.4 U.S. Gallons (1-1/4 Imp. Gallons). The fuel system is of the gravity feed type. In the post war conversions owners, the higher horse power Lycoming and Pratt power plants opted for a greater full capacity. An FAA approved modification for the IB75A provides for a 66-gallon capacity utilizing a 20-gallon header tank in line with the main center wing tank of 46 gallons. There is a single fuel valve control mounted below and to the left of the instrument panel.



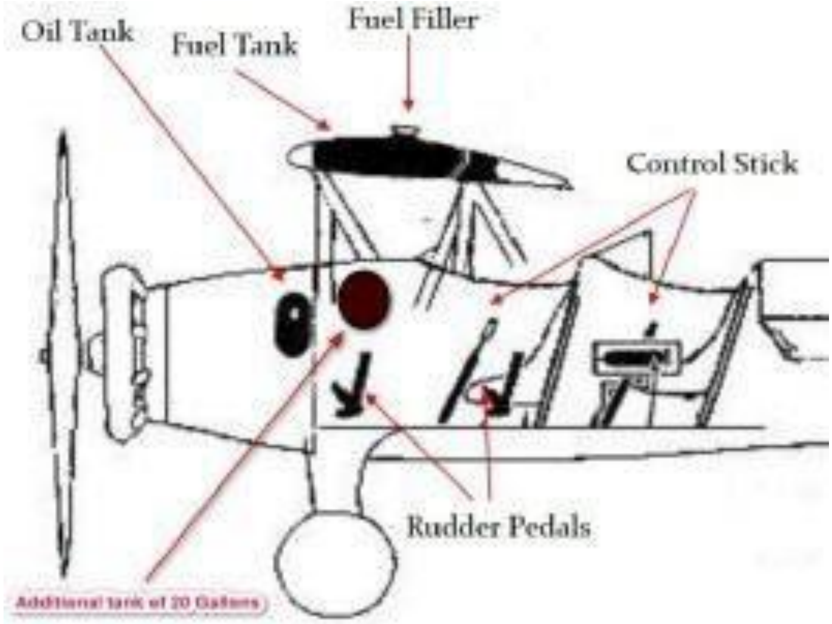
NOTE:
LEFT HAND SIDE OF FUEL TANK IDENTICAL WITH RIGHT HAND SIDE

1. CARBURETOR
2. PRIMER LINE TO ENGINE
3. FUEL GAGE
4. VENT LINE
5. OUTLET LINE
6. SUMP
7. FILLER NECK
8. FUEL LINE FROM TANK
9. FUEL TANK-46 GALS.
10. FUEL VALVE CONTROL FRONT COCKPIT
11. FUEL VALVE CONTROL REAR COCKPIT
12. LINE FROM LEFT OUTLET & SUMP
13. FUEL VALVE
14. PRIMER
15. FUEL STRAINER

REFERENCE DRAWING A75NI-3100

Picture from PILOT'S HANDBOOK for Model N2S-4

Based on a real modification (i.e. nota) which has received **FAA field approval**, an additional 20 **gallons** tank has been added. Per his, the tank was physically located in the fuselage ahead of the front cockpit in order to not modify the “load repartition” of the aircraft.



Note:
This modification is based on the work which has been executed on a real Stearman powered by a 275 HP Jacobs and reported by our GAS Flight Dynamics Expert).

The fuel system was plumbed such that plane was fueled via the wing tank with the fuel gravity feeding down into the header tank.
In operation:

1. fuel gravity feeds from the wing tank to the header tank,
2. through the fuel pump,
3. the fuel valve and
4. from there to the engine.

The only selector valve was between the header tank and the carburetor. Strangely, the FAA specifically mandated that there was to be **no fuel quantity gauge** for the header tank.

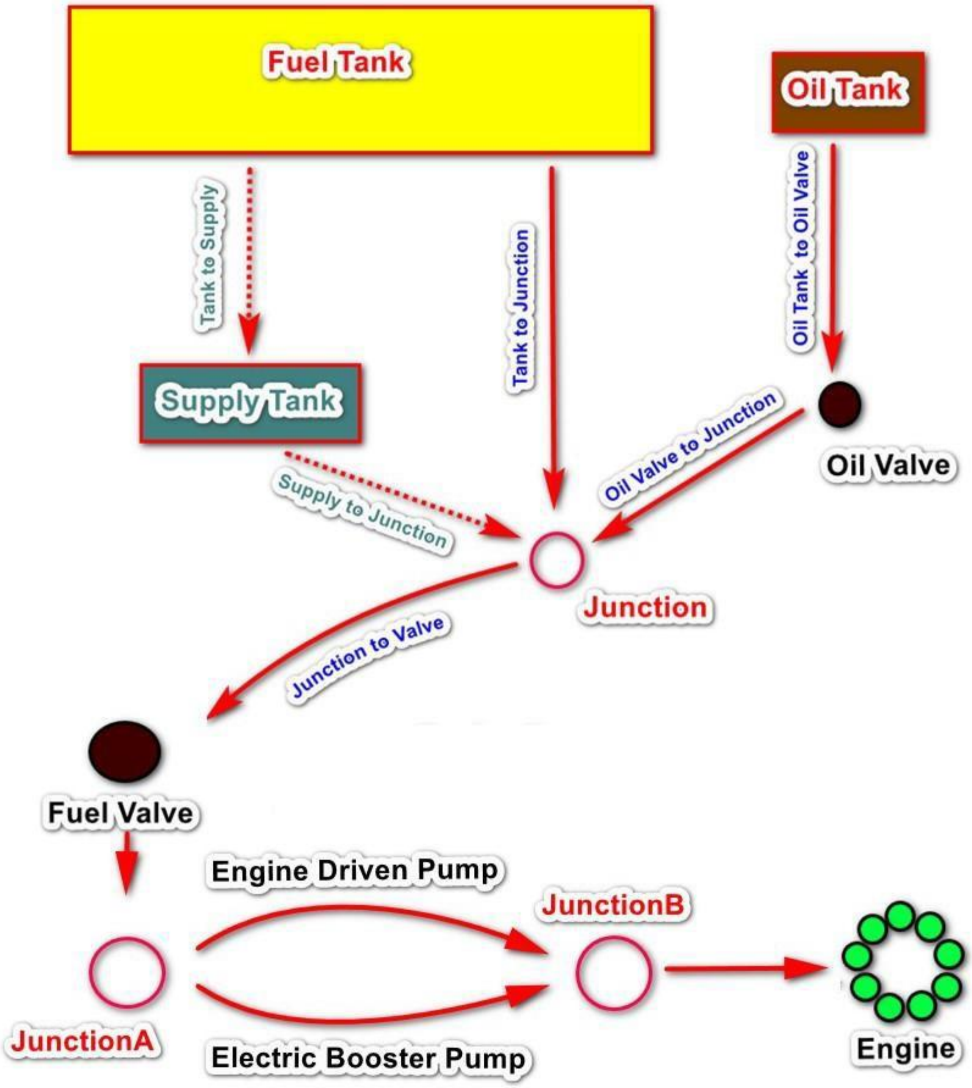
From a pilot's point of view, this means flight planning so one knows roughly when the main tank gauge will show empty, after which one knows there is between 50 minutes and 67 minutes' fuel remaining, depending on how much power he is pulling.

The good news is that this adaptation extends one's range by roughly 115 miles; the bad news is one must pay close attention to how his fuel burn, lest he actually reach the point of burning his reserve fuel.

FAA required reserve fuel is 30 minutes during the day and :45 minutes at night, so effectively, **when the main tank reads empty, one is into his reserve fuel.**

Supply Tank

In order to implement this new **Supply Tank** here is the new schema of the **FUEL SYSTEM** management:



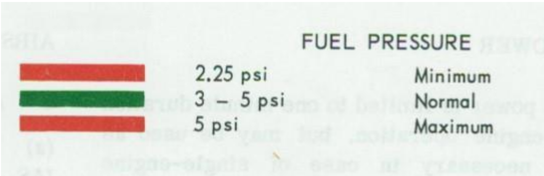
Fuel Pumps

In the "Super Stearman" the fuel pump is an **engine driven pump**.

Important: Pratt & Whitney R-985 engine require 3-5 PSI of fuel pressure for combustion.

The Super Stearman has an inverted fuel system that allows it to fly upside down. This system includes a header tank, a check valve, and a fuel booster pump

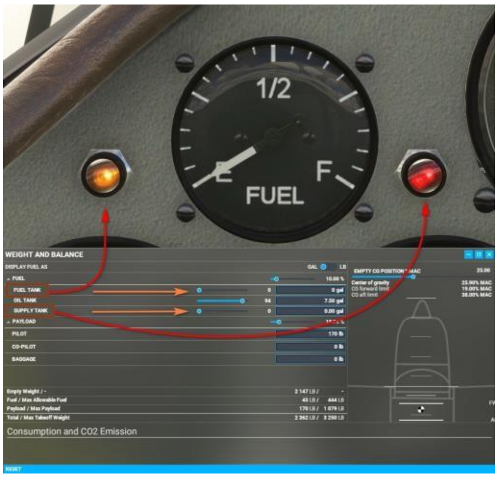
Source: Pratt & Whitney R-985 Manual



Fuel quantity indicator gauge, and Fuel warning lights

Two lights are provided near the fuel indicator gauge : When tanks in use is almost empty, due to low fuel or pressure drop (below 2.5 PSI), the corresponding light will illuminate warning the pilot to find a suitable landing location. **The default fuel quantity is set at 55% when the a/c loads in the sim. Additional fuel can be added in the weight and balance menu or during pre-flight walk around and inspection**

An **Orange light** (at the left side) which illuminates when the main fuel tank is empty (0.5 Gallon)



a **Red light** (at the right side) which indicates that volume in the supply tank is less than 1.5 Gallons

Tip:

If the tooltip messages are enabled in the general interface of MSFS, when the user leaves the mouse above theses LED, a tooltip appears which will indicate the fuel remained in the main or supply tank.

- The use of the electric fuel booster pump is required for engine start, ground operations, and landing where low idle settings could lead to engine stop if only engine driven pump is used.
- During takeoff, its use is advised to prevent engine shutdown due to engine pump failure.
- This electric fuel booster pump is also used during acrobatic tricks to have a safety in the fuel supply of the engine.
- This pump can also be used in a punctual way to enrich the mixture which has as consequence of better cooling the cylinder heads, elements subjected to heat as well as oil system.

Oil System

While default MSFS SDK only allows oil temperature and pressure and these are computed after engine calculations and therefore they don't have a direct effect on performance, with this new system oil is treated as something with substance that exists in aircraft and impacts on how plane behaves, not only mechanically but also how it flies.

In order to use an add-on with more realism, a set of scripts have been created to simply model the oil consumption of the engine:

- Oil quantity is persistent between flights: you need to check and fill the oil tank, as required prior to any flight.
- The location of the oil tank and volume affected the weight and balance and should be considered in calculations prior to flight.
- Oil temperature and pressure that not only derives from engine calculations but also contribute to.
- Oil consumption that match Pratt & Whitney engine real numbers crossing all range of engine operation and is influenced by engine wear.
- Oil leaks.
- Virtually all instruments present in the real-world aircraft to manage the lubrication system are presented in this simulation: oil bypass and oil shutoff switches are simulated using bespoke XML coding.

Oil system overview.

This oil is used for engine lubrication and propeller operations. Oil path starts on oil tank. From there oil is supplied to engine through gravity and then it returns to the oil tank passing through the oil cooler.

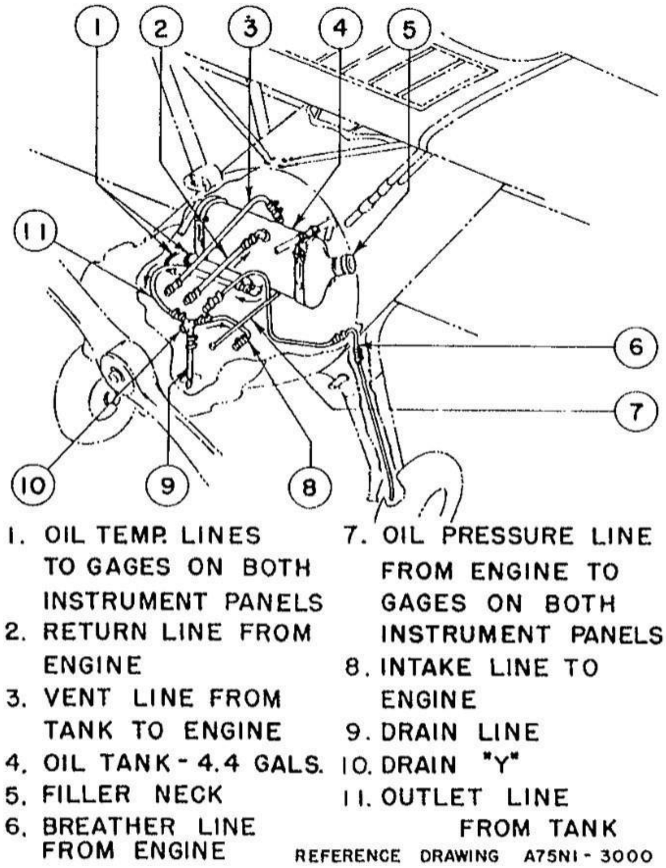
Oil quantity is confirmed using the "Weight and Balance" menu (*) under "Oil tank" but its load is locked by the simulator at the maximum capacity (7.5 gallons).

Oil tank.

The unique tank is located between the passenger/co-pilot cockpit and just behind the engine. This tank has a capacity of 8 gallons with 6.5 gallons are for engine and 1.5 gallons are for constant-speed propeller operations.

Minimum oil quantity: 4.7 gallons.
According to Pratt &Whitney, R-985 engine require 3.2 oil gallons to normal operation. Adding 1.5 gallons to propeller operation, we get 4.7 gallons minimum. If oil quantity gets below this value, oil pressure starts to decrease, and engine starts to overheat. This lead to engine wear and could lead to engine failure.

Max oil quantity: 7.5 gallons.
Although there is room for 3 gallons for expansion in oil system, real pilots report that oil quantity shouldn't be more than 7.5 gallons in oil tank. More than this could lead to increase in oil pressure and consequently to oil leaks.



Picture from PILOT'S HANDBOOK for Model N2S-4

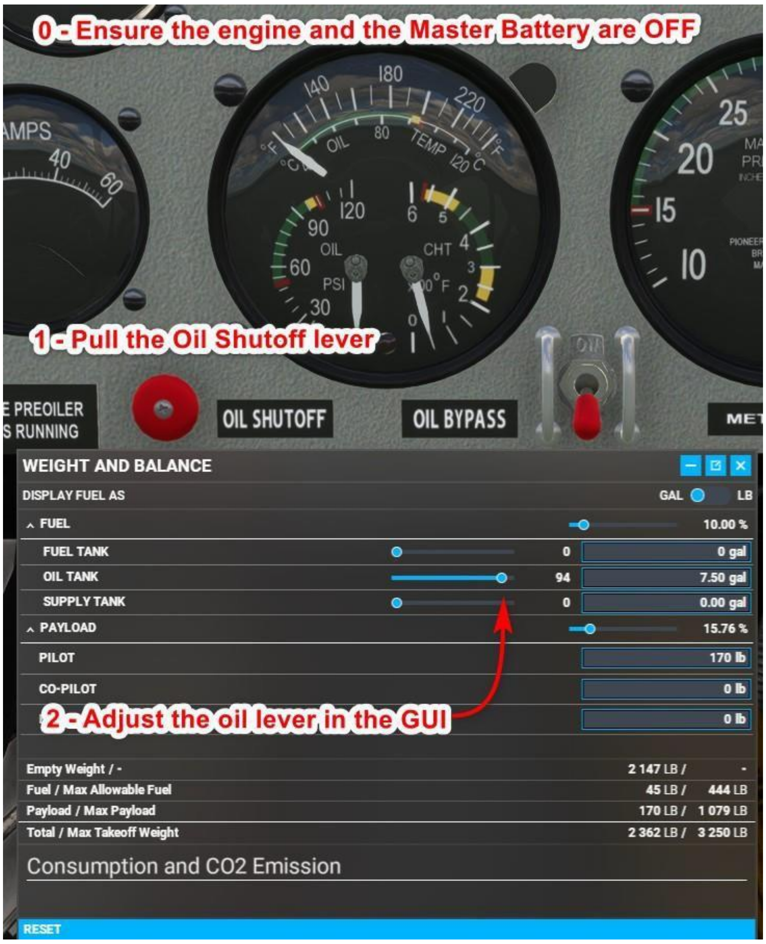
(*) Important:

To check oil quantity, you must access "weight and balance" through upper menu inside cockpit. Accessing "Weight and Balance" via the "World map" will not work.

How to fill oil tanks

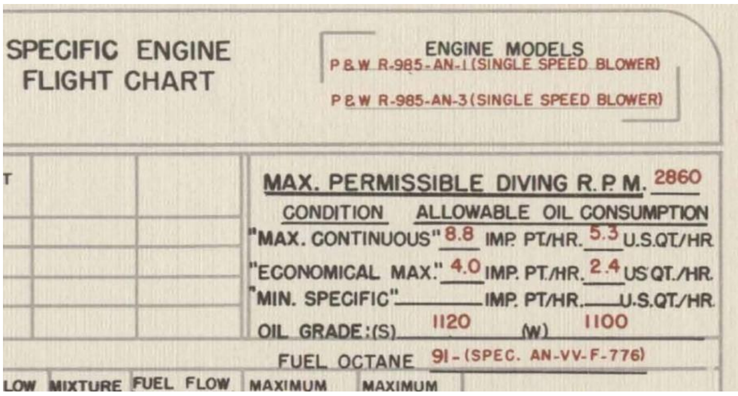
Like in real aviation, checking oil quantity should be part of your pre-flight check list. To replenish oil volume the following process is used: (see image page 26)

1. **With the engine OFF and battery OFF and aircraft on the ground,**
2. Pull Oil Shutoff switch,
3. Adjust oil tank slider using the Weight and balance menu
4. Push OIL SHUTOFF switch in to set desired volume.



Oil consumption

According to Pratt & Whitney, R-985 engines use around 1.14 gallons of oil per hour at max continuous power and around 0.6 gallons at max cruise power. At all other power settings oil usage is proportional to these values. In this mod, oil consumption increase with engine wears.



For every 2 percent of engine wear there's a 1% increase of oil consumption.

Oil Quantity Persistence

To increase the reality aspect of this add-on, in addition to the fact that the oil consumption was modeled by additional scripts, it is also possible to keep the amount of fuel and oil remaining at the end of a flight for the next flight. This function provided by Asobo/Microsoft is named "Data Persistence." This means that at the beginning of flight aircraft oil tanks will have the same amount of oil that was at the end of previous flight.

But this can only be used if you start your flight parked with engine off. If you start your flight on runway or flying, oil tanks will have the maximum correct oil quantity: 7.5 gallons. This is for those people who just want a fast flight and don't want to spend time with complex engine systems.

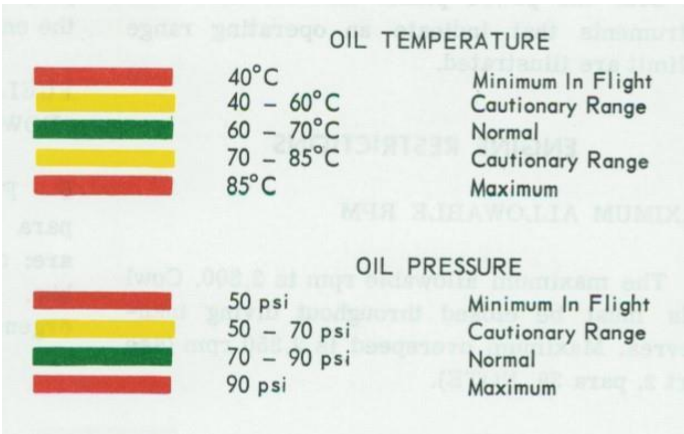
At the end of flight, if you want oil quantity to be saved for your next flight you must:
Stop the aircraft park the aircraft,
Switch off the engine
Turn off the battery, return to the main menu via the MSFS GUI (not clicking on the X "close window icon" of the MSFS windows).
Only in these conditions, oil and fuel will be saved.
If these conditions are not met, then saved oil quantity will revert to that which was the volume at the beginning of the flight

Oil temperature

Radial piston engines are very sensitive to oil temperature.

Never operate the engines with RPM above 1100 when the oil temperatures below 40ºC (red line on oil gauge).

The viscosity of the oil depends on the temperature and below 40ºC the oil does not have the correct viscosity for proper engine lubrication.



Source: Pratt & Whitney R-985 Manual

Increasing RPM above 1100 with oil temperatures below 40ºc will increase engine wear and will result in a rapid rise in cylinders temps due to low lubrication and the MP needle will oscillate wildly due to low lubrication of engine. Engine power is compromised, and total engine failure is a possibility

Tips:

If the tooltip messages are validated in the general interface of MSFS, when the user leaves the mouse above the 3 gauges related to oil and cylinders heads temperature, a tooltip appears which will indicate the numerical values of these gauges (a tooltip for each gauge).

Oil System Instrumentation/Controls

There are two controls used to manage the oil system flow and oil temperatures:

Oil bypass switch

Use oil bypass button, to warm oil temperature during startup in cold weather operations. Use this with caution and monitor oil temps closer.

It is advised to turn off the bypass switch when the oil temperature reaches required values. CHT (cylinders head temperatures) must be also be monitored to prevent overheating. Oil temperature will never be higher than CHT.

The rate by which oil temperature rises is proportional to the difference in temperature between CHT and oil temp. This means than oil heating will slow as oil temperatures gets near CHT.

Oil shutoff button.

Used when replenishing oil volume or when aircraft is parked reducing oil pooling in lower cylinders.

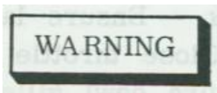
Oil Loss

Oil loss is modeled in this system, and they are a result of a probability calculation. The probability of oil leak occurring depends on the combination place of two engine factors:

Engine management during flight

- Over boosting engine with manifold pressure over 36.5 In/Hg
- Oil pressure above 90 PSI
- Operating the engine above max continuous power will result in an increase in oil and CHT temperature resulting in leaks due to high pressures.
- Starting an engine with outside temperatures below freezing (0ºC or 32ºF). The oil radiator has small diameter pipes that are very prone to clogging due to ice particles in oil. For this reason, if external temperature is below freezing you should always put oil bypass switch ON prior to engine start and keep it until oil temperatures go above 40º.

Engine Wear



Management of oil loss/leaking

When an oil loss occurs, it will continue until oil is completely depleted from tank.

The quantity of oil that is leaking during an oil leak is proportional to oil pressure so lowering engine power output is a method to slow down oil leak.

During an oil leak, until the quantity of oil in tank is lower than 4.7 gallons, engines will keep running without any degradation of performance or changes in oil pressure. For that reason, if you notice a decrease of oil pressure or increase in cylinders temperature, it means that oil is already below minimum => rapid actions are required.

Land as soon as possible.

If you are on a descent and within 10 to 20 minutes away from a valid runway, reduce power setting from engine so you can decrease oil pressure in the engine and land as soon as possible.

If you are far away from a possible runway, shut down the engine and seek a suitable off-runway landing location.

Electric System

Electrical power is supplied by a 28-volt 100-amp, engine driven generator and supplemented by a 24-volt battery.

Alternator / Generator

Alternator has a master switch in cockpit. It is located on the right side of the rear cockpit. With engine running above 1200 RPM, if ammeter needle is parked at zero position, than that means that generator has failed. You will need to perform maintenance on it.

Battery

Battery have persistent voltage, meaning that its voltage is saved at the end of flight and is restored for next flight (if all conditions needed are OK).

With temperatures below freezing it is normal to observe these battery behaviors: - Their voltage doesn't top at 24 volts.
They deplete faster than with cold weather.
They take more time to recharge.

Ammeter

This aircraft has one ammeter on left side of front panel.

Engine settings (RPM and manifold pressure gauges)

Even if you use engine settings below red line, there is a limited time in which you can use high power settings. Both these settings are modeled in this mod and using them more than restricted time would lead to engine wear and high CHT temperatures.

Takeoff power, **red line** (around 1 minute).
Climb power, **yellow band** (around 30 min).Altitude restrictions are also modeled

Take-OFF Power		
	5000 ft. Sea level	*450 HP - 36.5 in Hg. at*
		2300 RPM - Limit one minute
METO Power		
	Sea level	*400 HP - 34.5 in Hg. at 2200 RPM*
	5000 ft.	*400 HP - 33.5 in Hg. at 2200 RPM*

Over boost

Although R-985 engine is rated at 36.5 inHg of Manifold pressure (red line in MP gauge), it can deliver more at low altitudes. In ideal conditions it can be run over 41 inHg for short periods of time.

Never use more than 36.5 inHg, meaning at low altitudes using full power.

By doing so you are increasing engine wear and cylinder temps, using very high MP can damage or even ruin your engine in just a few seconds.

Mixture

Fuel needs to be mixed with air in order to ignite. The ratio between this two shouldn't be too high towards to fuel side, otherwise it will not ignite and consequently flood the engine with unburned fuel; and shouldn't be to lean or too much air because there isn't enough fuel to keep combustion and engine will stop.

To adjust fuel-air ratio, there is one mixture levers on each throttle quadrant. Full forward position is the full rich position, and it gets lean towards rear position. Setting lever full aft will cut fuel from engine stopping the combustion.

Mixture can affect three main parameters in the engine: power output, fuel consumption and temperatures, both EGT and CHT.

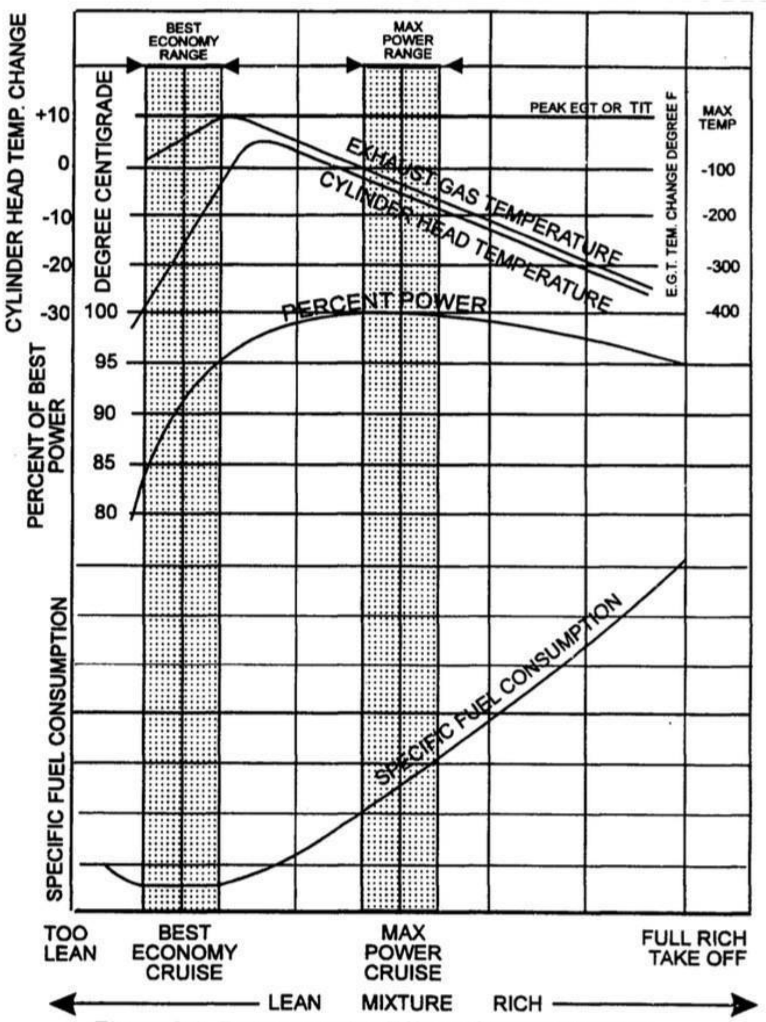


Figure 3-1. Representative Effect of Fuel/Air Ratio

Generic graph showing relation between mixture, fuel consumption, power and temperatures on piston engines

Power output

The power-mixture relations are documented for Pratt & Whitney radial engines.

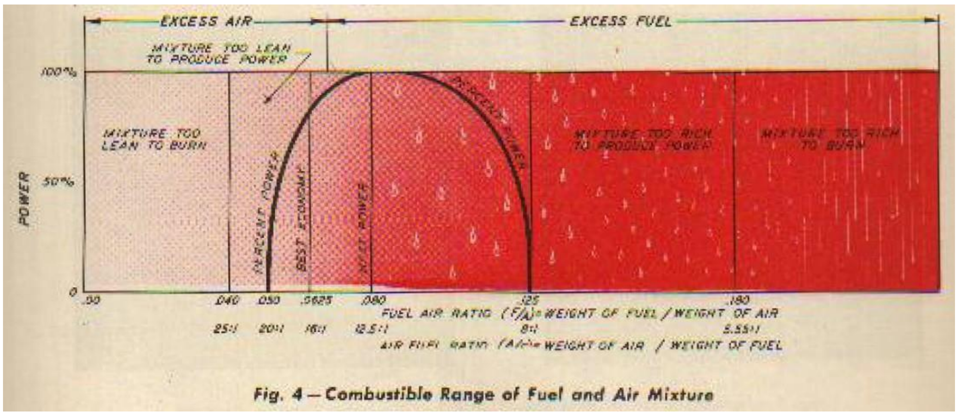


Fig. 4 — Combustible Range of Fuel and Air Mixture

Image Source: "The aircraft engine and its operation", 1955 by Pratt & Whitney.

Temperatures

Cylinder head temperature: Mixture is one of the tools to control the cylinders head temperatures. With full rich mixture, the excessive fuel in cylinders will act as a coolant and because of this cylinder's temperature will be lower. It's advised to use full rich during initial climb to keep CHT under control.

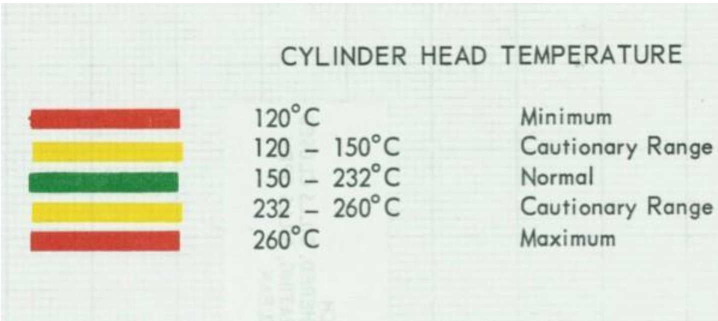


Image Source: Pratt & Whitney R-985 Manual

A lean setting, although with less fuel, will also give a low temperature combustion inside chamber and for this reason will also decrease CHT. All ranges between full rich and lean will follow the curve on previous page.

Detonation

Under normal conditions, fuel ignition should occur in a smooth orderly fashion starting at the spark plugs, starting at the spark plugs and progressing across the combustion chamber until it is quenched upon reaching the cylinder walls and piston crown when air-fuel charge has been completely consumed and there's nothing more to burn.
The combustion event takes a significant period of time – 6 milliseconds or 90° of crankshaft rotation give or take.
But if the combustion process moves too fast and the pressure peak occur too early, the result can be excessive pressure, excessive temperature and unstable pressure pulses known as "detonation" phenomenon.
Detonation causes
There are various reasons for detonation to occur. Although they are separate their contribution to detonation can overlap and there for increased level of detonation. Light detonation is not very dangerous. It can occur for continuous amount of time.
Although it will not break your engine, it increases its wear and reduces engine efficiency there for engine power.

This phenomenon is perfectly described in the PDF file that you can find in the "Documentation" folder is provided with this add-on.

High CHT: high temperatures inside cylinder chamber can disrupt fuel ignition and lead to detonation. Usually, only high temperatures can contribute to detonation, above 260ºC or 500ºF.

Manifold pressure/RPM ratio. High manifold pressures require fast moving cylinders to cope with that pressure levels. If there is high pressure inside cylinder and the cylinders aren't moving fast enough, this could as well lead to detonation. For this reason, when changing power RPM should always stay above MP. When reducing power, first reduce throttle and then propeller pitch and when increasing power, first increase RPM with propeller pitch and then increase throttle.

Excessive leaning. Fuel needs to be mixed with air in order to ignite. The ratio between this two shouldn't be too high towards to fuel side, otherwise it will not ignite and consequently flood the engine with unburned fuel; and shouldn't be to lean or too much air because there isn't enough fuel to keep combustion and engine will stop. But before this extreme low fuel ratio is reached, there is a point where combustion still occur but not as it should but as detonation. In reality this is the main cause of detonation damage in engines. In this situation, slightly increase or carb. temps. can help reduce detonation.

High carburetor temperatures, above 15ºC or red line also lead to detonation. During hot weather there is the possibility that carburetor temperatures are above this threshold no matter what. In this situation avoid high power settings as much as possible in order to help reduce detonation. Additional factors contribute to detonation:
manifold pressure.
engine wear.

How to detect Detonation and detonation consequences.
There are four direct ways of detecting detonation.

- high CHT.
- low EGT.
- loss of power
- rough running engine.

Unfortunately, under light detonation, engine doesn't show any signs of roughness and other symptoms are practically imperceptible. Only pilot experience and knowledge of aircraft and correct procedures can help avoid detonation.
The good news is that light detonation hardly damage the engine and lead to any serious problem. It will increase wear over time and decrease its efficiency .

Moderate detonation aggravate the symptoms and rough running engine can also be observed, so it will be more obvious that fuel is detonating but at the same time aggravate the wear, the efficiency and after some time can lead to more serious problems like engine damage. In this situation rapid actions are required in order to stop detonation.
Increase mixture
Reduce carburetor temperature if possible.
Reduce RPM/manifold pressure.
Reduce manifold pressure .
Severe detonation
lead to pre-ignition and this will result in engine failure is seconds.
Never let the engine reach levels of severe detonation.

Spark plug Fouling
If the pilot performs his warm up has less than 1000 RPM, this leads to clogging the spark plugs after 3 minutes. To avoid this, it is advisable to idle the engine at more than 1400 RPM. If the spark plugs are fouled it can drive the engine to stop.
To clean the spark plugs the pilot may:
operate the engine for more than 8 s at more than 1400 RPM
Navigate to front of the engine and with the mouse scroll on the cylinders in order to clean the spark plugs.
Fouled spark plugs can result in as much as 60%loss engine power negatively effecting take-off performance.

Final notes on detonation

Detonation also aggravate with time. Light detonation level can lead to a more serious situation over time, even if the pre-conditions stay the same.

Like all other calculations, detonation is dynamic and progressive calculated. There isn't an on/off state. Everything is direct consequence of engine and ambient parameters and as so their calculation is also progressive. Its relation to engine wear is also proportional to detonation levels.

Engine wear

- Every time you are operating aircraft out of its normal engine operating ranges, you are increasing engine wear.
- Engines wear is inevitable, even if you do everything right, there is always some minimal wear like in real life. This continuous value increase engine wear 10% for every 100 hours of working engines.
- Engine wear range from 100% (new engine)to 0%
- From 95% and below there is a loss of engine performance proportional to the wear value.
- Engine wear is persistent between flights, but you have to save it (yet explained).
- Engine wear is irreversible: there is nothing you can do other than resetting that can make engine wear decrease.

Engine damage

- Engine damage is not persistent between flights.
- You can't watch engine damages any other way than normal using aircraft gauges and behavior (MSFS rendering engine don't permit this).
- You can reset engine damage the same way as engine wear.
- Each system has its own damage associated, like CHT, manifold pressure, etc. You can damage or destroy an engine with almost no wear.
- Every time you operate an engine you are also wearing it.
- There are 4 types of engine damage simulated:
    1. Catastrophic engine events => engine stop irreparably
    2. Partial engine damage event => loss of performance (irreversible)
    3. Decrease if capacity to resist over-stressing operating range.
    4. Oil leaks .

Oil and cylinders temperatures

Ranges of temperatures in which you should use your engine are defined in this table (Pratt & Whitney R-985 Manual):

Oil temperature		
Minimum allowable	*40 °C*	*104 °F*
Maximum allowable	*93 °C*	*200 °F*
Cylinders temperatures		
Minimum for Take-OFF	*106 °C*	*225 °C*
Maximum allowable	*260 °C*	*500 °F*
Carburetor Mixture Thermometer		
Icing Danger Region	*-10° - 3°C*	*14° - 37 °F*

Oil temperatures

Below 38°C ~ 40° C, Oil cannot act completely and using an engine in this value range is equivalent to a poorly lubricated engine therefore damages.

Over 93º C adds to engine wear and at very high temperatures could lead to engine catastrophic events.

Cylinder head temperatures:

Using an engine with CHT (cylinder head temperatures) above 260 ºC or 500 ºF could lead to engine wear or even to engine damage.

Remember that at very high temperatures, near or above the red line, engine damage or problems can occur in a few seconds.

To control an elevated cylinder head temperature (CHT), a pilot can perform one or all of the following:
Reduce power (better solution),
Adjust mixture,
Activate fuel boost pump.

Notes :

Boost pump usage causes an enrichment of the mixture and thus allows to cool the engine; however, it also increases fuel consumption.

Carburetor temperature

These parameters are determined by the Asobo/Microsoft's algorithms. **To prevent carburetor icing activate carburetor heat when RPM are below 1500**

Checklists

Before engine start

All payload adjustments, fuel, oil and cargo must be performed with upper menu already inside cockpit. Perform walk-around preflight inspection.

- Check fuel quantity and fill as needed,
- Check oil quantity and fill as needed (oil shut off and then go to weight & balance),
- Check and adjust center of gravity,
- Verify that all switches are OFF,
- Parking brake on,
- Tail wheel lock,
- Battery ON to check battery voltage,
- Pull Through the propeller depending on the ambient temperature.

Engine Start

Priming is required prior to engine start.

- Propeller and mixture levers full forward (with airfields above 5000 ft some mixture leaning may be required),
- Throttle lever at 20% forward,
- Tank selector ON,
- Oil bypass - as require (Switch ON for cold weather and monitor oil temperature after, switch OFF once oil temperature exceeds 40º C),
- Fuel Boost Pump ON,
- Magnetos ON,
- Prime the engine as may be necessary: 0 or 2 pulls on prime knob depending on the ambient temperature,
- Starter selector ON,
- Use throttle lever to keep RPM between 800 and 1000 rpm,
- Switch ON Navigation lights.

Warm Up

- Lean mixture to max RPM (keep this setting for ground operations until entering runway,
- Monitor engine RPM and adjust, using throttle, to keep below 1000 until oil temp =40º C,
- Use oil bypass switch to speed up oil temperature increase,
- Turn ON engine Generator, but they don't load the battery under 1200 RPM.
- Don't turn ON any electric system other than minimally required (like NAV lights) until our Generator is on-line (Doing so will deplete battery charge),
- Adjust elevator trim according to center of gravity (3.1° advised),

Taxi

- Increase engine RPM to around 1300 and check generator is online (ammeter comes alive).
- Adjust mixture to max. RPM.
- Turn ON master instruments switch.
- Turn ON transponder.
- Set all frequencies, GPS and any navigation instrument as required.
- Turn ON Navigation lights
- Request taxi clearance
- Parking brakes OFF
- Unlock tail wheel (due to MSFS 2020 limitation on free castoring wheel, you can use tail wheel lock during taxi to keep aircraft centered).

Tip: Use of tail wheel lock. The tail wheel lock is engaged for take-off and landings . Unlock when needed to taxi about the airstrip to and from parking.

Before take-off pre-flight check

- Engine at IDLE speed. Check 8 00/1000 RPM.
- Advance engine to warm-up RPM.
- Check magnetos by turning them off one at a time. No more than 100 RPM drop should be observed.
- Advance engine to 1950 RPM, manifold pressure gage should indicate your airfield barometric pressure plus or minus 1 inch Hg.
- Check oil temperature and pressure as required
- Check CHT
- Check elevator trim.
- Check oil bypass switch - CLOSED.
- Check Fuel Boost Pump is ON.

Take-off

- Check Oil bypass switch - CLOSED.
- Navigation lights ON.
- Tail wheel locked
- Elevator trim set
- Pitot heat ON
- Mixture full rich (below 5000 ft). Adjust for runways at altitudes above 5000 ft.
- Propeller pitch - FULL FOWARD.
- With crosswind adjust rudder trim as required.
- Slowly increase throttle and don't exceed 36.6 manifold pressure.
- Until tail is raised, use differential power or differential toe brakes to steer.
- Tail wheel should lift at around 40 knots. Be prepared to react with rudder to keep on centerline.
- Use positive input to rotate at around 70 kn.
- Apply wheel brakes to stop wheel rotation.

Climb

- Keep Max. power until all obstacles are cleared.
- Switch OFF fuel pump above 2000ft.
- Adjust elevator trim to climb.
- Reduce to max. continuous power or climb power.
- Keep full rich mixture to help on high CHT. Once CHT is controlled you can start the leaning procedure as required. Keep adjusting during the climb.

Cruise

- Fuel Boost Pump OFF,
- Adjust mixture to cruise.
- Check oil and fuel temperatures and don't forget pressure.

Descent

- Fuel Boost Pump ON,
- Adjust mixture to descent. Given that altitude is decreasing it is better to adjust for richer settings in order to avoid detonation. Below 5000 ft full rich setting can be used.
- Set power to descent (be careful to avoid over speed).
- Unnecessary interior lights OFF.

Final

- Check tail wheel lock is engaged
- Mixture full rich.
- Propeller pitch - High RPM, from 2000 to 2300 RPM.
- Elevator trim for neutral pitch input as required.
- Throttle target for 70 kt on last stage of "final".

Landing

- Propeller pitch full forward.
- Throttle - Idle over runway.
- Touch down at 60 kts IAS.

Taxi

- Fuel Boost Pump OFF,
- Tail wheel unlocked.
- Mixture lean to max. RPM.
- Tube pitot heat OFF
- Nav. lights on.

Shut Down

Parking brakes set.
Panel lights OFF
Instruments master OFF
COM2 radio and transponder OFF.
Fuel pump OFF
Engine for above 1200 RPM for 30 seconds to 1 minute.
Check alternators are off-line.
Shut down the engine with mixture.
Magnetos OFF
Throttle and propeller pitch levers full back.
Tank selector OFF
All lights OFF
Battery OFF (This will trigger persistent variables to save for next flight, don't forget to quit MSFS via the GUI).

References

Super Stearman Model IB75N Fuel Consumption P&W R-985 AN1/3
Pratt & Whitney-R985-Series-Aircraft-Engines-Operating-Instructions-March-1-1943.pd

SECTION III
SPECIFIC OPERATING INSTRUCTIONS

ENGINE: R-985-25, -27, -AN1 and -AN-3

DATE:

CONDITION	FUEL PRESSURE LB/IN.²	OIL PRESSURE LB/IN.²	OIL TEMP °C	COOLANT TEMP °C
DESIRED	3-4	75-90	50-70	
MAXIMUM		100	95	
MINIMUM		60		
IDLING		15		

MAX PERMISSIBLE ENGINE OVER SPEED: 2760 RPM

MAX ALLOWABLE OIL CONSUMPTION AT:
NORMAL RATED POWER ____ QT /HR
MAXIMUM CRUISING 4.6 QT /HR
MINIMUM SPECIFIC FUEL FLOW ____ QT /HR

FUEL GRADE 87 OCTANE

⊕ OPERATING CONDITION	HORSE POWER	RPM	MANIF PRESS. (IN. HG)	PRESSURE ALTITUDE (IN FEET)	BLOWER CONTROL POSITION	USE LOW BLOWER BELOW	MIXTURE CONTROL POSITION	MINM F/A RATIO	FUEL FLOW GAL/HR	MAX CYL HD TEMP °C	REMARKS
TAKE-OFF	450	2300	38.5				"Full Rich"	.092	50	260	5 Minute Limit
MILITARY RATED POWER											
⊙ NORMAL RATED POWER (100%)	450	2300	37.5	1000			"Full Rich"	.092	50	260	
MAX CRUISING (75%)	350	2000	33.0	3500			"Full Rich" to "Smooth" Operation	.084	31	235	
DESIRED CRUISE (67%)	330	2000	31.0	5000			"Best Power"	.075	27	235	
DESIRED CRUISE (60%)	310	1940	29.5	6000			"Best Power"	.073	23	235	

NOTE: The data on this chart are the result of dynamometer tests and are adaptable for flight purposes in the absence of the Pilot's Handbook of Operating Instructions.

⊕ REFER TO T.O. NO. 00-10 FOR DEFINITION OF EACH OPERATING CONDITION ⊙ MAXIMUM PERMISSIBLE CONTINUOUS HORSE POWER REVISED 12-1-41