Franklin Engine Oil Cooling

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Technical Report

Unlimited distribution

Summary

The Franklin 6A350-C1R aircraft engine chronically suffers from high oil temperature. This document details my efforts to determine why this engine runs hot, and how the problem can be addressed.

As early as 1999, and perhaps earlier, pilots using the engine in tractor and pusher configurations have expressed issues with high oil temperatures. As of this date, there is no obvious commercial solution to the problem. In this paper, data from multiple flights will detail the operating parameters of a Franklin Engine.

The conclusion is that the design of the oil cooling loop in the Franklin does not provide a sufficient rate of oil thermal mass through the cooler for heat rejection to maintain cooler oil temperatures.

The recommendation is to implement a cooling loop that provides a rate of oil thermal mass through the cooler that lowers the oil temperatures to the temperature limits as recommended by SAE-J1966 specification for piston motor oil, and the Aeroshell performance specifications. The solution maintains proper engine temperatures and pressures to satisfy the limits of engine operation for oil pressure, and the temperature limits for oil. The oil temperatures are high enough to drive out water from combustion, but low enough to prevent varnish buildup and oil break down (oxidation).

Introduction

The history of the Franklin engine is plagued with high oil temperature problems. There are various anecdotal solutions to solve the problem, but there is no evidence showing that the solutions are effective. Presented data will show the effects of the common mitigating approaches, and why they are unsuccessful, and even detrimental.

Details are presented, showing the characteristics of the engine, which others can use for sound engineering decisions when faced with high oil temperatures of their own.

This document is the result of research into the cooling loop, and the oil bypass plate which are the core of oil cooling management of the engine. Oil cooler design, and mass airflow issues are not discussed. Many Internet articles outline approaches to air inlet and air exhaust for the purposes of cylinder fin cooling and oil cooler cooling. This document does not address issues related to aerodynamics or mass-air flow. For comparison of results, oil cooler performance specifications will be used for heat rejection calculations at a constant mass airflow.

Background

The platform used to carry out these tests is a Velocity Standard Elite, Fixed Gear (SEFG). It is a pusher airplane, with the engine in the rear of the plane. Pusher configurations are more difficult to cool because of a lack of direct airflow, in contrast to a tractor configuration.

Drawing 1: A Velocity Factory SEFG.

The Franklin is historically a difficult engine to cool[1], and many attempts at modifying oil cooler air inlets and oil cooler exhaust have been tried[2,3].

Rick Lavoie, a Franklin owner, and previous editor of the Velocity Views newsletter detailed his experience attempting to solve Franklin high oil temperature problems, and shared his correspondence with the PZL factory in Poland which manufactures the Franklin[4]. Lavoie's correspondence with the PZL factory focused mostly on the proper temperature and pressure locations for sensing.

Franklin 6A-350-C1R

The Franklin is an aircraft engine, certified for flight under FAA Type Certificate Data Sheet E9EA[5].

1 http://www.hangar9aeroworks.com/108TweedieF-220.html
2 http://maulepilots.org/forums/viewtopic.php?p=19697&sid=b2335543d547ef5a8754b1c53160d972
3 http://saginawwings.com/monty-answerman/frank.htm
4 http://www.velocityaircraft.com/views/v37.pdf
5 http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgMakeModel.nsf/0/e3cf7a8ecb36bb5886256f5e00472065/$FILE/E9EA.pdf

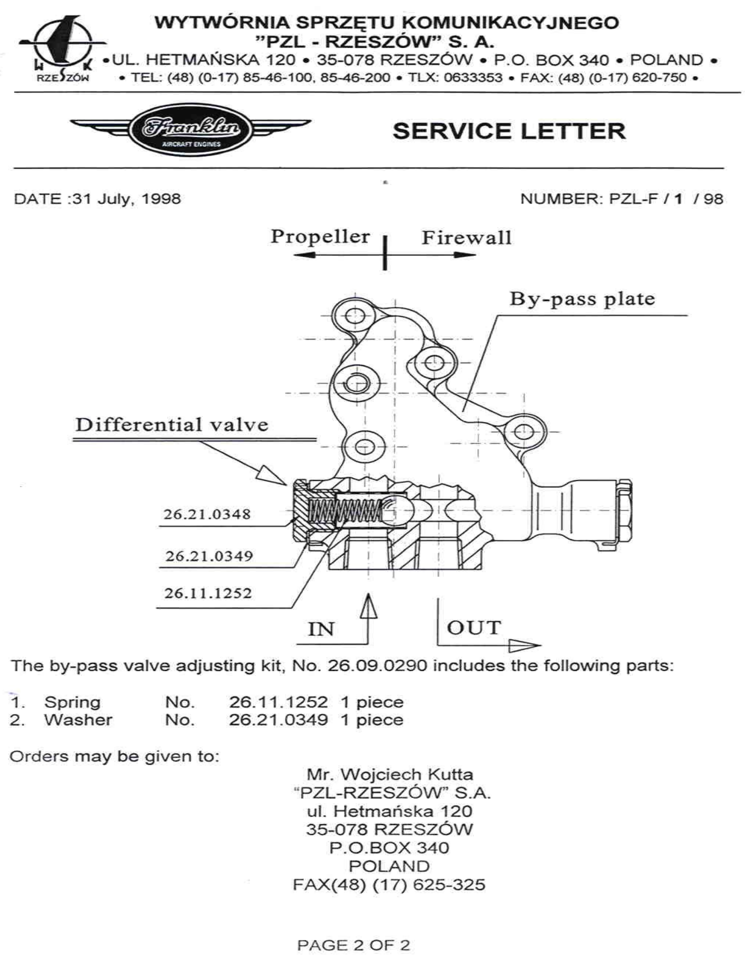
This document states among other limits, the oil pressures and oil temperatures for flight.

1. Oil inlet temperature: 235F
2. Oil pressure at engine inlet: 25 PSI idle, 55-80 PSI normal, with a note that 50 PSI is the minimum when using an external oil filter.

Oil Bypass Plate

The stock oil bypass plate, is depicted in a PZL service letter (Figure 1) detailing how to install a “by-pass valve adjusting kit”. The bypass plate is the core of the oil system, maintaining pressure to enable oil to flow through the cooler, and ensuring that excessive oil pressures are not applied to the engine. It allows the oil to take three routes from the oil pump:

1. Relieved through the relief valve directly to the sump.
2. Bypassed through the differential valve directly to the engine internals.
3. Cooling loop route where the oil flows through the filter and cooler, and then to the engine.


WYTWÓRNIA SPRZĘTU KOMUNIKACYJNEGO
”PZL - RZESZÓW” S. A.
•UL. HETMAŃSKA 120 • 35-078 RZESZÓW • P.O. BOX 340 • POLAND •
• TEL: (48) (0-17) 85-46-100, 85-46-200 • TLX: 0633353 • FAX: (48) (0-17) 620-750 •

SERVICE LETTER

DATE :31 July, 1998 NUMBER: PZL-F / 1 / 98

The by-pass valve adjusting kit, No. 26.09.0290 includes the following parts:

1. Spring No. 26.11.1252 1 piece
2. Washer No. 26.21.0349 1 piece

Orders may be given to:

Mr. Wojciech Kutta
“PZL-RZESZÓW” S.A.
ul. Hetmańska 120
35-078 RZESZÓW
P.O.BOX 340
POLAND
FAX(48) (17) 625-325

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Figure 1: Oil Bypass Plate

The bypass plate removed from N4PE, is shown in Figure 2. The bottom face is annotated with arrows to show the function of each galley hole. A marked line outlines the internal galleys that move oil to and from the valves. The pump hole has a marked line leading to the center of the housing where the bypass and relief valve face each other. The oil can take one of three paths from this point: 1) relieved to sump, 2) bypassed to the engine, or 3) sent to the cooling loop.

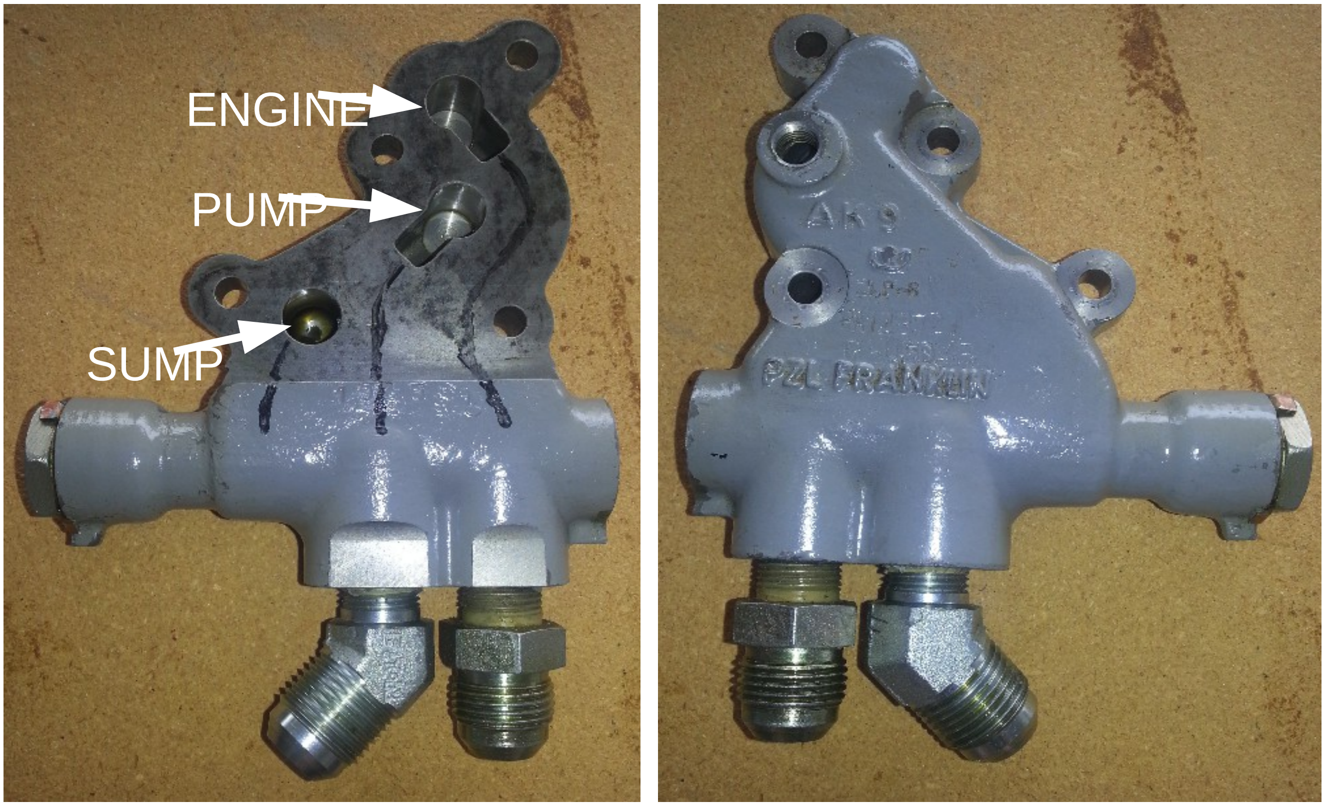

Figure 2: Bypass plate removed from N4PE

A notional view of the valve configuration is in Figure 3. To determine pressure settings, the components were removed and inspected. Air pressure was used to determine that the relief valve is nominally set to 78 PSI. Spring forces were measured and a spring constant calculated for the bypass valve so that opening pressures could be calculated for any spring compression distance. The stock PZL spring was found to have a spring constant of 2.83 lb/in as shown in the worksheet in Figure 4.

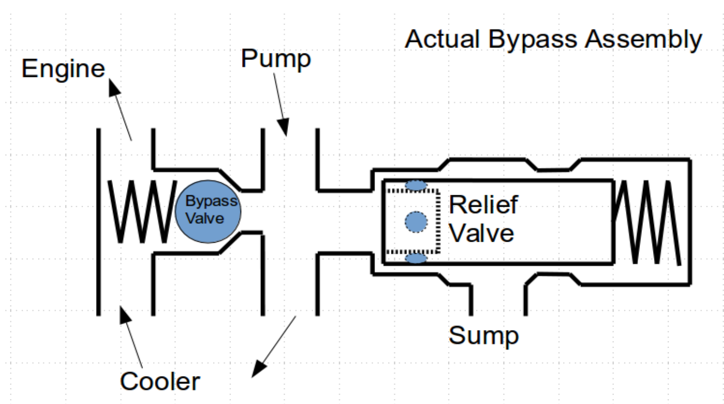

Figure 3: Notional view of the bypass plate

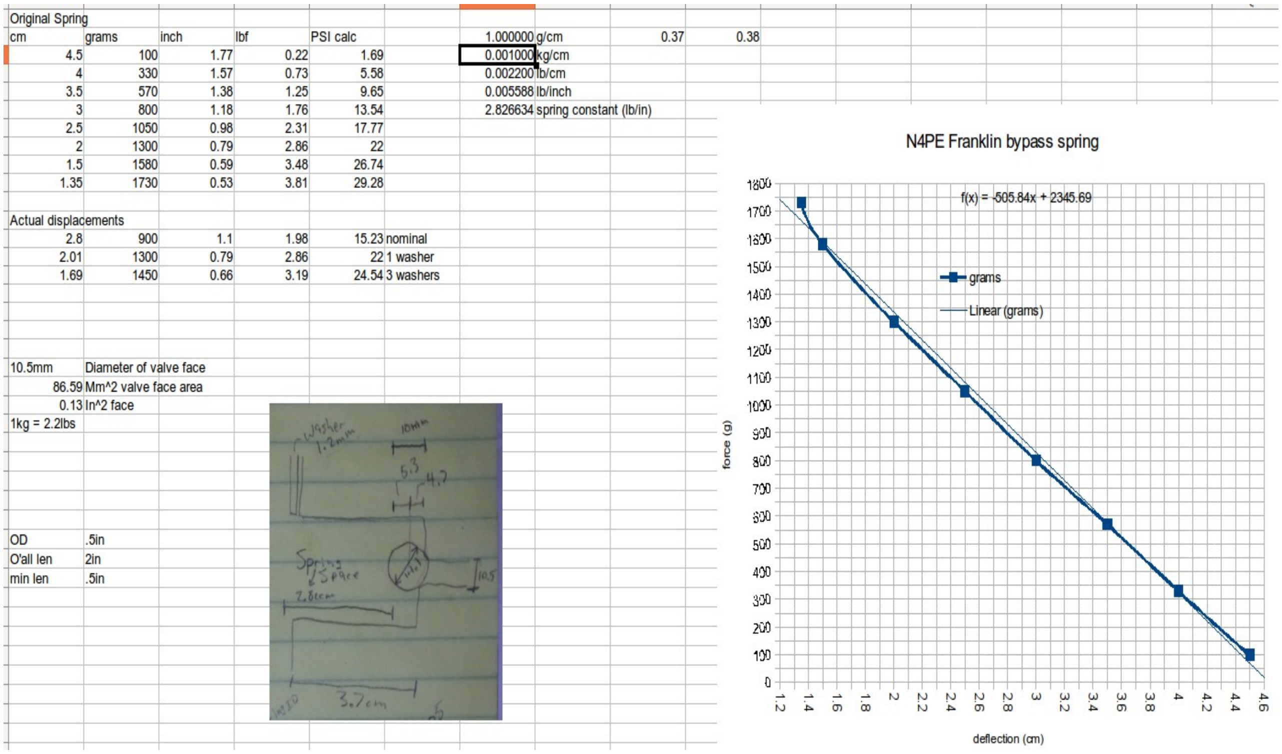

Figure 4: Worksheet for spring constant calculation

From the spring constant, the bypass pressure can be calculated, and is shown in in Table 1.

Configuration	Spring Length (in)	Calculated Pressure(PSI)	Actual Pressure(PSI)
Stock	1.1	15.2	16
One washer(5/16)	0.79	22	21
Three Washers(7/16)	0.66	24.5	24

Table 1: Bypass pressure for various spring lengths

This author believes that Franklin engine installations run hotter than most pilots would prefer, which is to say that the engine runs consistently near red-line temperatures, and flight profiles must be modified in order to keep oil temperature below the allowed limit.

Methods, assumptions and procedures

The method chosen to obtain the information used to make the claim of insufficient oil flow assumes that the oil flow parameters can be reasonably characterized through the use of:

1. Temperature sensors which show the effectiveness of oil cooling
2. Pressure sensors which show the action of valve configuration, and resistance to flow in the cooling loop
3. Oil flow meter which shows the flow rate of oil through the oil cooler and oil filter.

The procedures used to modify the parameters have been applied through multiple flights covering the following modifications:

1. Stock valve configuration
2. 5/16 inch (8mm) spacer pre-loading the spring
3. 7/16 inch (11mm) spacer pre-loading the spring
4. 7/16 inch spacer with no filter or cooler in the loop
5. 7/16 inch spacer using 30 weight automotive oil

Temperature sensor placement

Figure 5: Westberg temperature probe

For N4PE, temperature probes are placed in the oil bypass plate, and the engine case. In Figure 1 above, part number 26.21.0348 is a captivating plug that holds the bypass spring. This plug was modified by the author to house a 1/8” NPT temperature sensor (Figure 5).


Figure 6: Placement of the logged oil temperature sensor

This sensor is in a location such that it should be measuring the bypassed and cooled oil, and it drives a panel mounted gauge which is used during flight operation. The second sensor is logged by computer, and provides the measurements in all graphs in this paper. This sensor as shown in Figure 6, reads lower than the panel mounted gauge, because of the thermal mass of the engine case, and the absence of oil flow at this location. Even though this sensor does not accurately reflect true oil temperature, it is effective to document the behavior of the oil cooling configurations.

PZL specifies in Figure 7 where the oil temperature probe is to be mounted. This author believes that this sensor placement does not accurately account for the temperature of the oil that has bypassed the cooling loop. Therefore, the oil temperature readings at this position are lower than the actual temperature of oil entering the engine, and could lead to a dangerous oil temperature reading. You will see graphs showing that the nominal oil flow rate through the engine is three gallons per minute (GPM). Oil flowing through the cooler at 3 GPM will be excessively cooled, which aggravates the problem by becoming more viscous, therefore causing the bypass valve to open. In this scenario, the oil temperature probe reports very cool oil temperatures while the engine is ingesting oil that has not been through the cooling loop.

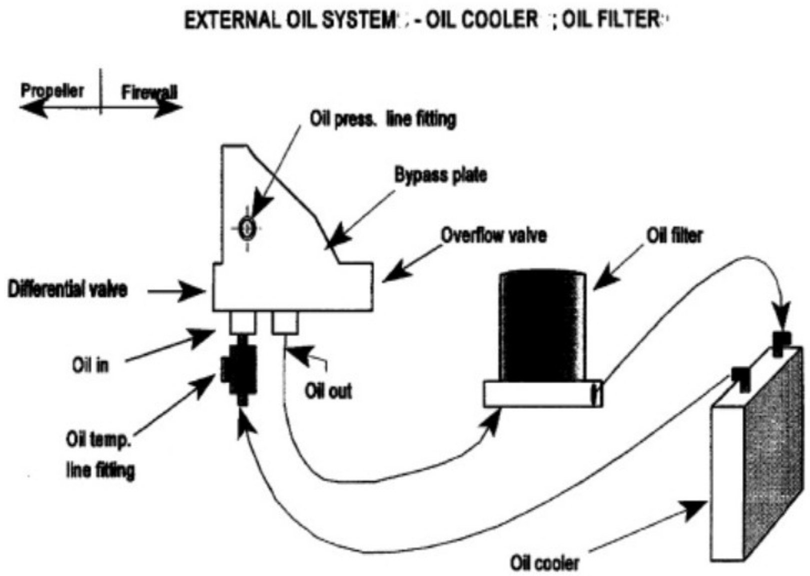

Figure 7: PZL instructions for temperature sensor placement

Figure 8: VDO Pressure sensor

Pressure Sensor Placement

The pressure sensor is a 150 PSI VDO pressure sensor similar to Figure 8. It is mounted via a vibration isolating flexible hose to a point on the bypass plate as depicted in Figure 7. In this position it reports the oil pressure at the point where the oil enters the engine for lubrication.

Flow Meter

The oil flow meter is mounted in the nose of the airplane in the oil cooling loop. It is an Omega FPR-200 paddle wheel

Figure 9: Oil Flow Meter

flow meter, and is ported for 3/4” fittings with a flow range of 1.5 to 50 GPM. A picture of it mounted in N4PE is Figure 9.

Acquisition

The acquisition system is built using Silicon Laboratories 8051F330 8 bit micro controller. The author designed a daisy-chain system for all modules to communicate to a Linux computer over SMBUS. Data is stored on the computer and is uploaded to the a server for later analysis. A sensor I/O base board is shown in Figure 10.

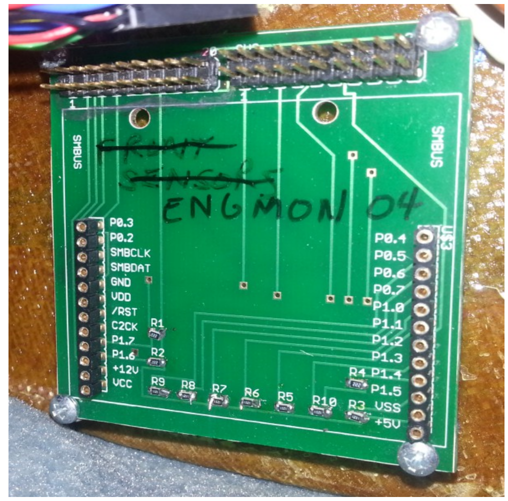

Figure 10: Engine Monitor acquisition board installed in N4PE.

Oil Pump

The oil pump capacity must be known in order to solve the amount of oil flowing through the bypass valve. The flow meter measures the cooling loop, and with a known pump flow, the bypass flow can be calculated. The pump flow capacity was determined by turning the prop through 20 revolutions, and measuring the weight of oil pumped out of the sump without any pressure restriction. The result is that .033lbs of oil is moved by the pump for each revolution of the crankshaft. Therefore, at 1,000RPM, the pump moves 4.4 gallons of oil per minute without any pressure restriction. The gear pump is considered a positive displacement pump, but it is not leak-proof. The nominal flow is 4.4 GPM, but the actual flow varies based on oil viscosity, head pressure and pump wear. Flight data shows that with a running engine at 1,000 RPM, and warm oil, one can expect about 3 gallons per minute of oil to flow out of the oil pump.

Results

The acquisition system logged flight data beginning in 2012. The flight data for these results was collected in November of 2013 through February 2014 out of the Taylor airport at 650 foot elevation. For each flight, the data was summarized and results are shown when normal operating temperatures and stable conditions had been achieved. These results are presented with oil pressure measured at both the outlet of the bypass plate and at the inlet to the engine. The difference between the two is the *bias pressure.* If the bias pressure exceeds the opening pressure of the bypass valve, then oil will flow through the valve, bypassing the cooling loop. Oil temperature is reported in Celsius as *coolant temp*, and is obtained from the case mounted temperature probe. RPM and oil flow in gallons per minute are also reported.

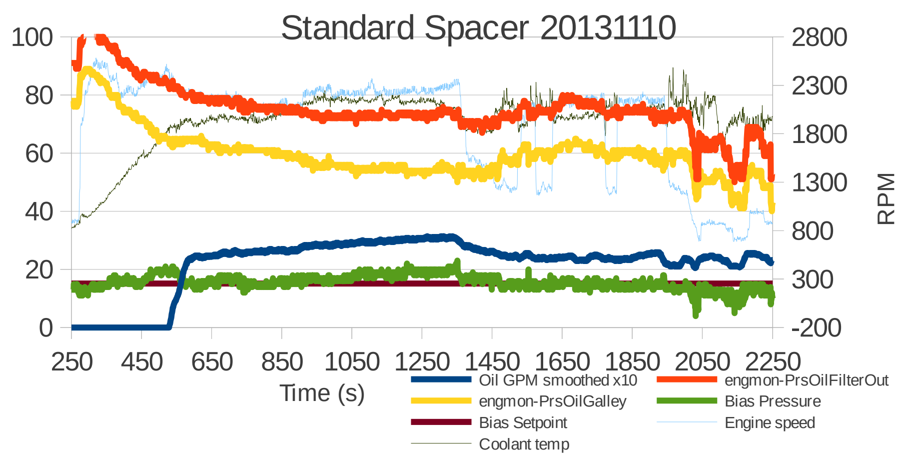

Figure 11: Data with the stock configuration. (72° F ambient)

The first chart(Figure 11) shows the behavior of the stock spring configuration. Note that the bias pressure remains close to the calculated bias set point. As the engine heats up, the cooled oil flow rate tends to increase, but nominally remains at 3 gallons per minute. The bypass valve is open for almost the entire flight, allowing uncooled and unfiltered oil directly into the engine. At about the 500 second mark, the flow meter begins to register oil flow. The meter doesn't work below 1.5 GPM.

The next chart(Figure 12) shows the oil behavior using a single washer which compresses the spring by 5/16" compared to the stock configuration. Here, oil flow has increased to four gallons per minute as the bypass valve maintains the setpoint pressure of 22 PSI. It is interesting to note that the relief valve also appears to maintain its setpoint right at 78 PSI beginning shortly after the 1,000 second mark. When the RPM drops at the 1800 mark, the pressure out of the pump falls well below its setpoint, and the galley pressure falls into the 40 PSI range. This flight test was terminated at about the 1300 second mark due to high oil temperature indications on the panel gauge (oil inlet temperature) which were at or above the redline temperature of 235° F. The case temperature is at about 167° F (75° C).

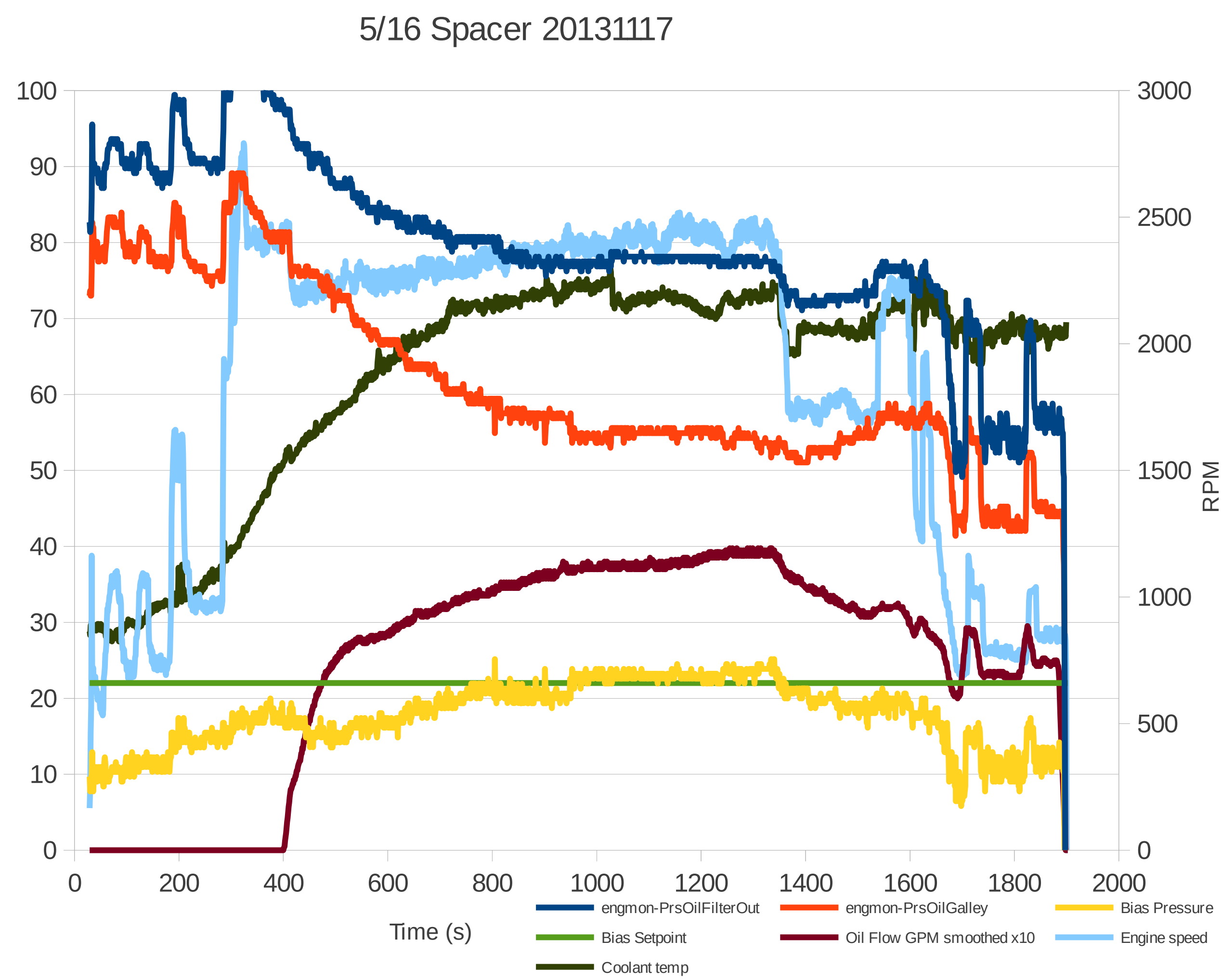

Figure 12: Flight data with the 5/16" spacer (82° F ambient)

The next chart (Figure 13) shows a flight with the 7/16” spacer on the bypass spring. The bypass pressure has increased to 22.5 PSI, but through all phases of flight the oil flow never exceeds 4 GPM, even though the bias pressure is higher. There are many interesting artifacts in this chart:

1. At the end of the flight at idle RPM, the oil pressure drops into the 30's.

2. The oil pump pressure remains below its 78 PSI set point for a significant period of time. At

around the 1500 second mark, the relief valve would have been closed and the bypass valve would have been open.

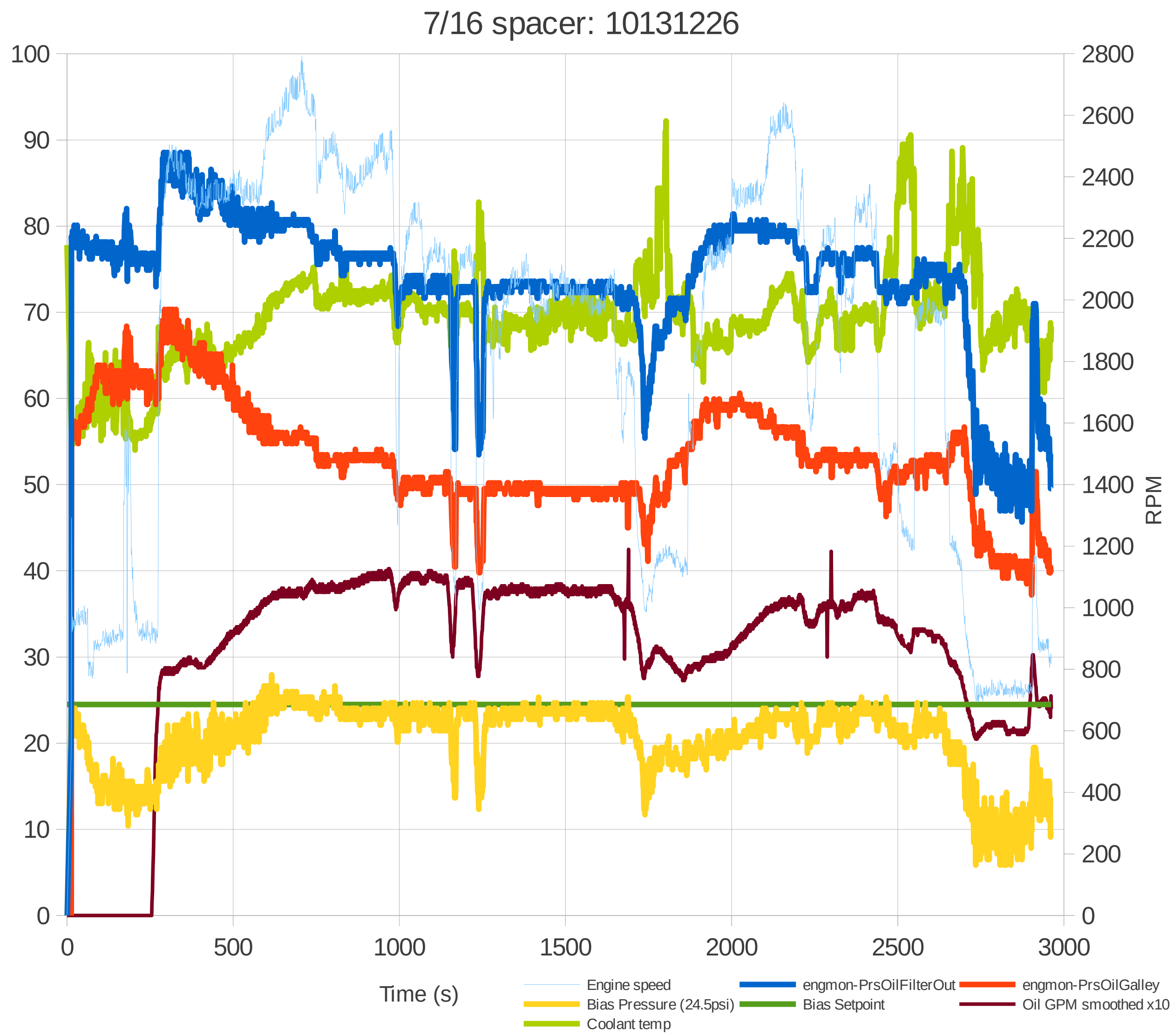

Figure 13: Flight Data With the 7/16" Spacer (68° F)

3. After the engine is hot, a reduction in RPM causes the temperature to spike, and at one point the oil temperature reaches 200° F (93° C). This is for a sensor reading cooled oil at the engine case, which reads lower than actual.

Summarizing all three flights using all RPM ranges with oil temperatures above 158° F (70° C), results in a scatter plot of Figure 14. Using this chart, which includes data points for a closed bypass valve, and an open bypass valve shows that in order to increase oil flow by 1 GPM, one must increase pressure by 6.25 PSI. A much better estimation of the pressure required is to analyze data for when the bypass valve is closed as in Figure 15.

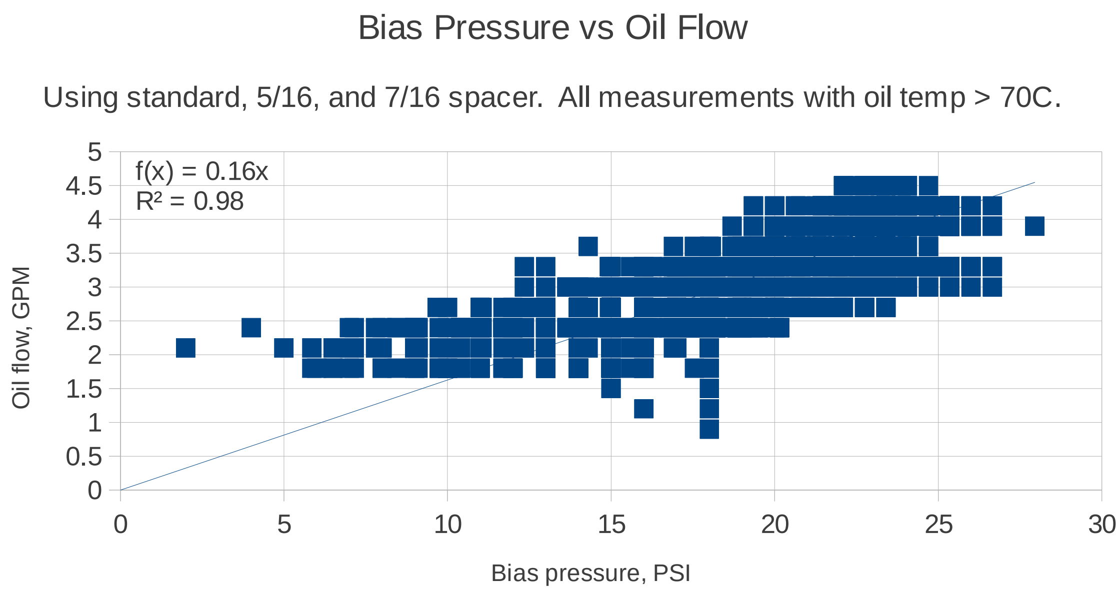

Figure 14: Summarized pressure vs flow

Two flights were made with the 7/16" spacer and 30 weight automotive oil. A data acquisition problem prevented collection of pressure data, but in this configuration temperatures are reduced by 18° F(10° C), and oil flow is increased to 5 GPM. Flying with automotive oil in a leaded fuel aircraft engine is not a recommended practice because automotive oils lack the lead scavenging compounds that keep spark plugs clean to prevent pre-ignition.

Discussion

In general, increasing spring tension appears to accomplish very little. It tends to lower the galley pressure in the engine while slightly increasing the oil temperature and oil flow. The charts plotting bias pressure against oil flow show that modification of spring stiffness is useless as a tool to increase oil flow, because at some point, increasing bypass spring pressure will cease to increase oil flow through the cooler.

Oil Flow

Recalling the available routes for oil to flow, we can characterize the flow rates through the engines as:

Frp = Frs + Fre

where

Frp is the flow rate from the pump

Frs is the flow rate to the sump

Fre is the flow rate to the engine

Furthermore, the flow rate to the engine can be defined by:

Fre = Frc + Frb

where

Frc is the flow rate through the cooling loop

Frb is the flow rate through the bypass valve

Since the bypass valve can be observed through the bias pressure, we know that at bias pressures below its set point that it is closed and no oil is flowing across the valve. In this case, Frb=0, and the equation becomes Fre = Frc, meaning that all oil into the engine has passed through the cooling loop when the bias pressure is below the bias set point. When the 7/16”

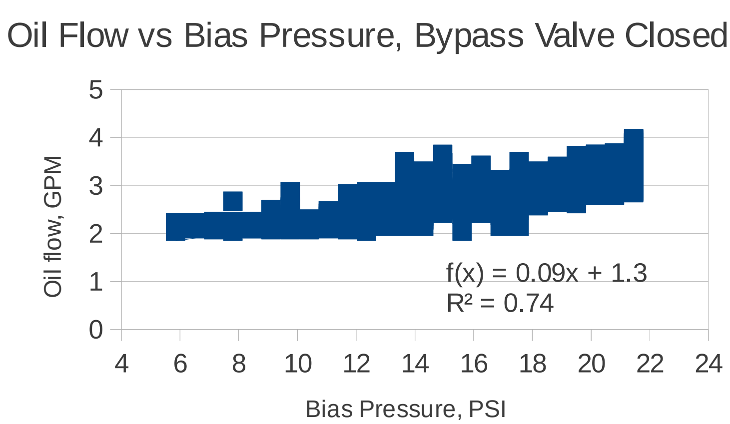

Figure 15: Oil flow characteristics with bias valve closed.

spacers are used on N4PE, the pressure set point is such that the portions of flight with low RPM settings cause the bias valve to close. If we analyze that data, and only consider those readings where the oil temperature is over 70° C where the bypass valve is closed, then we get the results in Figure 15. The slope of the line is 0.09, meaning that in order to get one GPM additional oil flow requires an increase of 11.1 PSI in bias pressure. Remember, that Fre=Frc+Frb. The problem is that we need to cool the engine, therefore we need to have the bypass valve closed. In that case Fre=Frc, and in normal operating conditions the Franklin engine will not use more than four gallons (three nominal) per minute of oil for lubrication. Therefore a maximum of four gallons per minute will ever go through the oil cooler, and that is an optimistic assumption!

Given that the positive displacement oil pump generates an actual 3 gallons per minute at 1,000 RPM at hot temperatures, then it follows that it generates about 8.4 GPM at 2800 RPM. This means that in stock configuration and at maximum RPM, three gallons per minute are delivered to the engine. The remaining 5.4 gallons per minute are returned to the sump without having been cooled or filtered. In addition to that, of the three gallons going into the engine, the bypass valve allows some of that to bypass the cooling loop. Approximately 75% of the oil circulation is never filtered or cooled.

Instrumentation

The PZL instructions call for the oil temperature sensor to be placed in the cooling loop, before joining the bypassed oil leading to the engine inlet. This sensor reads the coldest portion of the oil anywhere in the system, which is the most optimistic reading and the least conservative.

Table 2 shows what happens to Aeroshell W100 at various temperatures, with the temperature numbers referenced to the oil inlet port. Using that information, a desirable operating range can be established. The oil needs to be hot enough to drive out water from fuel combustion, but cool enough to not leave varnish deposits or oxidize.

Effects of Oil Temperatures on the Engine	
Oil Temperature in the Engine	Effects
100° F to 150° F	Minimum limit (white line) on oil temperature gauge.
Below 170° F	Causes wear on internal engine components. Moisture will not evaporate in the oil. Low temperatures are just as harmful as high temperatures due to the buildup of water and acids within the oil system, which cause rust and corrosion of internal engine components.
180° F to 200° F	Ideal operating range.
210° F	An oil cooler is required when the oil is operating over this temperature in the engine.
212° F	Somewhere in the oil circulation of the engine, the oil temperature must be above this temperature in order for evaporation of water from the engine to occur. 180° F to 190° F gauge temperature.
Above 220° F	Oil rapidly loses its ability to lubricate and cool, causing accelerated fatigue and premature component failure. In other words, this reduces the engine life.
240° F	Varnish forms (burning the oil onto the engine's internal parts).
240° F to 245° F	Maximum limit (red line) on oil temperature gauge.
260° F to 295° F	Seals harden.
315° F	Seals burn out.
350° F	Bearing material softens.
450° F to 620° F	Bearing material melts.
500° F	Flashpoint of Aeroshell W100 50w oil.

Table 2: Effects of Oil Temperatures on the Engine[6]

Lycoming says that when the ambient air temperature is above 80° F, then the normal operating range for their engines at the oil inlet is 180° F (82° C) to 245° F (118° C)[7]. The Franklin maximum temperature is 235° F, however the PZL instructions call for the sensor to be mounted such that an optimistic cool oil temperature is measured, and not the more realistic engine oil inlet temperature. A new set of operating parameters should be used when operating the Franklin to ensure that excessive oil temperatures do not occur in the engine.

6 Kitplanes, June 2009

7 Lycoming Operators Manual, O-360 and associated models, Section 3, operating instructions, pp. 3-11

Conclusions

Analysis of the Franklin design shows that 100% of oil that flows through the cooler must go into the engine oil inlet port. Since the engine uses about 3 GPM nominal, then there is no facility to increase the flow of oil through the cooler, and increasing the bias pressure does not significantly increase oil flow.

N4PE has two NDM 20004A coolers plumbed in parallel. Bill Genevro from Airflow Systems, the company that now makes this cooler, provided the specifications to the Stewart Warner 10599R cooler,

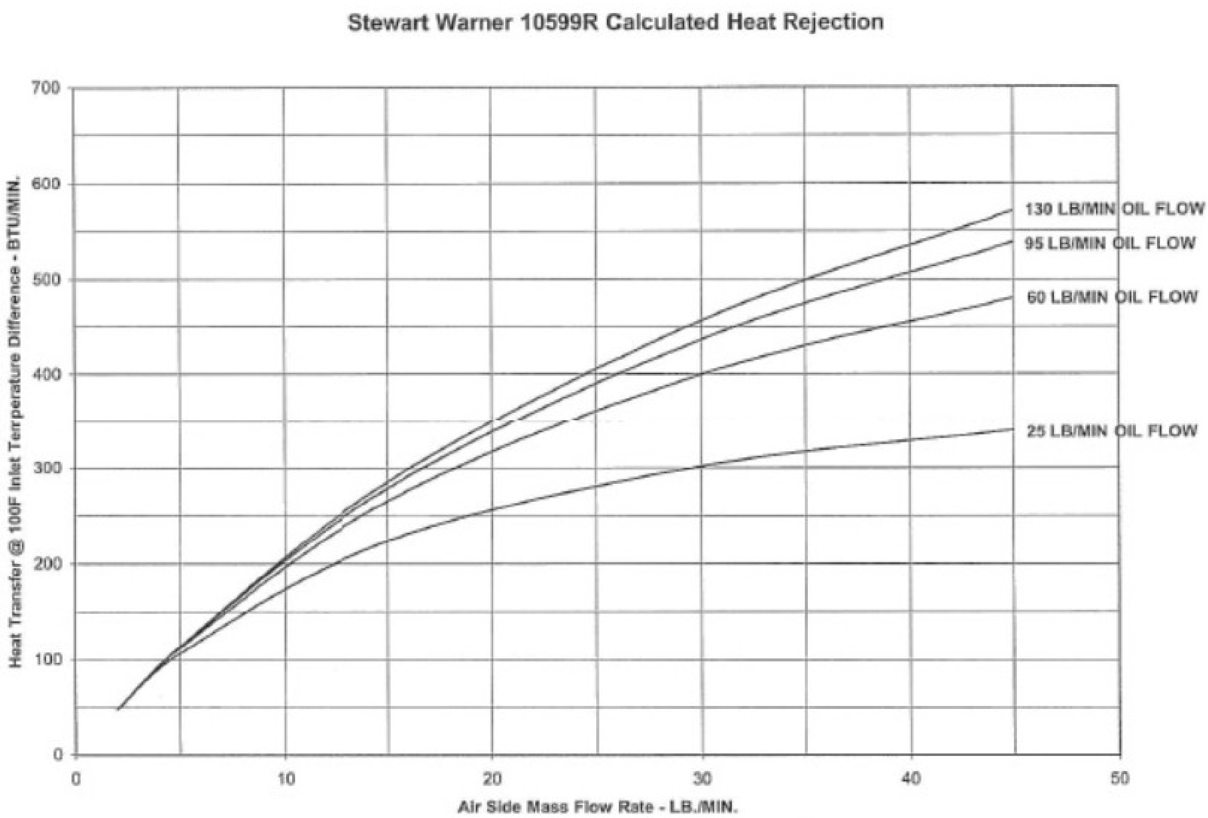

Figure 16: Performance specifications for the NDM 20004A oil cooler

which is the same basic design. As seen in Figure 16, the nominal Franklin engine oil flow of 3 gallons per minute (equivalent to 22.5 lb/min) is below their minimum oil flow line of 25lb/min.

This indicates that the Franklin design is flawed, and results in high oil temperatures and low oil pressures.

Compare the results in this paper with an excerpt from a Lycoming IO-360-A1B6D manual:

> "Provision is made for use of a full flow oil cooler with this engine. Oil flow through the cooler system will be approximately 7 gallons per minute and heat rejection will not exceed 750 Btu per minute. Note: The oil cooler must be capable of withstanding continuous pressure of 150 psi. A thermostatic oil cooler bypass valve is supplied as standard equipment. It limits pressure drop between cooler connection to 75±15 psi and closes at 185° F oil temperature to put all engine oil flow thru the cooler." [8]

With this information, we can infer that the Lycoming bypass valve is set to 75PSI and the relief valve is also set to 75PSI. This flow rate is equivalent to 52.5 lb/min through the cooler, and that is well into the performance curves for this cooler. A Franklin design should be able to maintain similar mass-oil flow rates.

Recommendations

Instrumentation

PZL recommends the oil temperature probe be mounted to measure the coolest oil in the system, and not the more realistic inlet temperature. This author tentatively recommends instrumentation that shows the true temperatures and pressures for nominal operation. The new locations and temperature limits are in line with the oil manufacturer and the PZL temperature limits.

Oil Limits (tentative, pending flight results)			
	Nominal	Idle	Maximum limit
Engine inlet temperature (after the bypass valve)	180° F to 200° F		235° F
Pump outlet temperature	210° F to 220° F		
Engine inlet pressure	78 PSI	25 PSI	55-90 PSI
Pump outlet pressure	Less than 150 PSI		200 PSI

Table 3: Author suggested operating limits for the Franklin

The inlet temperature must be sensed after the bypass valve so that both bypass and cooled oil are mixed and indicated to the pilot, as opposed to the current configuration of displaying cooled oil temperature.

8 Kitplanes, June 2009

Oil Flow

A permanent solution to the chronic high oil temperatures endemic to the Franklin requires a re-routing of the oil flow. The desired diagram is depicted in Figure 17. A solution can be had that is a bolt-on replacement for the stock Franklin bypass plate. This was designed and fabricated by the author, and flight tests have proven the effectiveness of the new bypass plate, seen in Figure 18 and Figure 19.

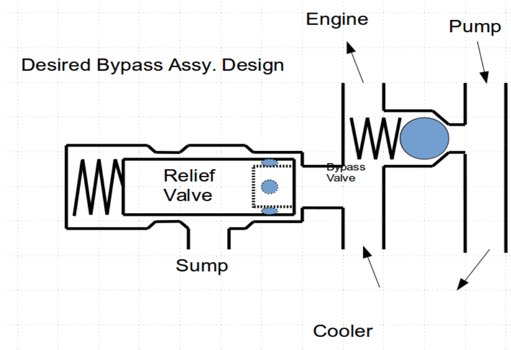

Figure 17: Desired Oil Schematic

New Bypass Plate

The new bypass plate contains two adjustable valves, one for setting the relief pressure, and another for setting the bias pressure. The current design is one inch thick, and provides two 1/2" NPT threaded ports in the same location as the stock bypass plate. However, since the stock design is difficult to attach fittings to because of physical interference, a second return port is provided which is a -10AN O-Ring boss. There are four sense points: 1) oil inlet temperature, 2) oil pump outlet temperature, 3) pump pressure and 4) galley pressure. All sense points are 1/8"NPT, and can be plugged if desired. The plate is machined out of a solid 6061-T6 aluminum billet.

Figure 18: Picture of the second iteration bypass plate.

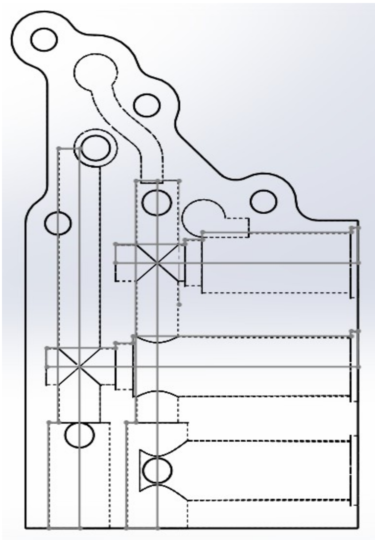

Figure 19: Drawing of the replacement bypass plate

Initial static ground test data

The initial runs with the new bypass plate are used to calibrate the settings and provide the stock pressures as specified in the operating manual. In Figure 20, three runs were made to lower the galley pressure to about 65PSI. These tests were made at idle RPM, and even at idle, the new oil route is performing with a nominal oil flow of almost 4 GPM. Bias pressure starts at almost 60PSI, and as the oil warms, comes down to about 25PSI, while maintaining a steady galley pressure just above 65PSI.

Once the relief valve pressure was set, several tests were made at different bias pressure settings. The metric for setting the pressure is to count the number of threads showing past the adjustment valve jam nut. As the number of threads showing decreases, bias pressure increases (Figures 21,22,23,24).

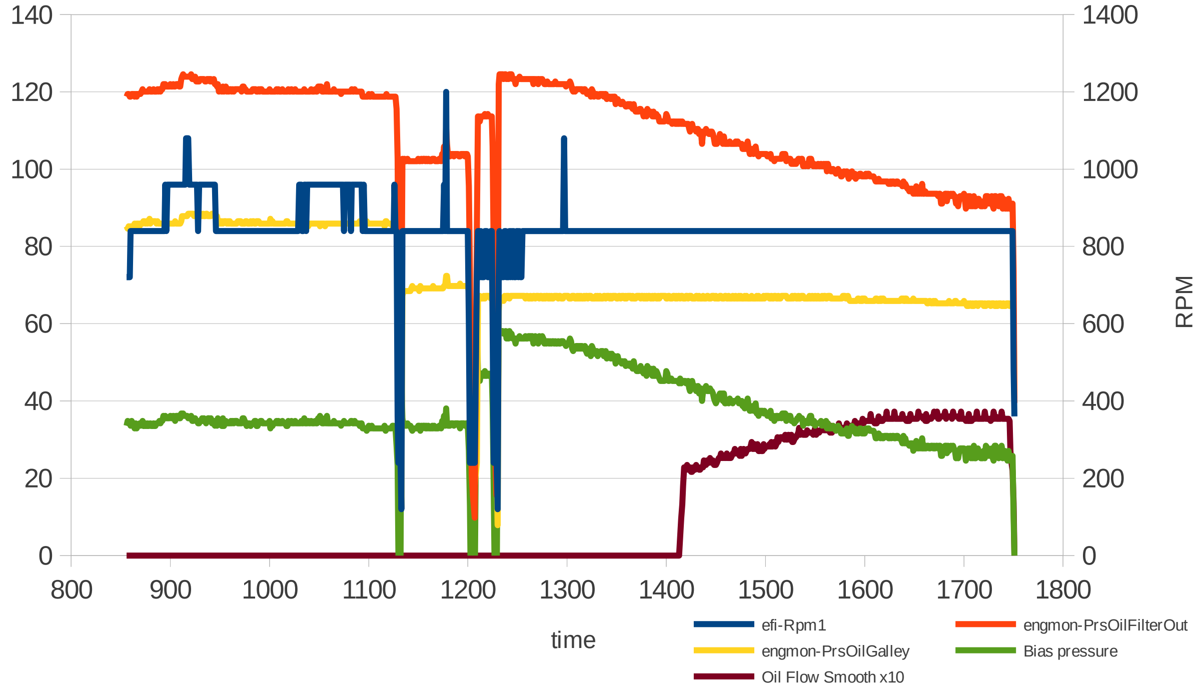

Figure 20: Three engine runs to set the relief pressure

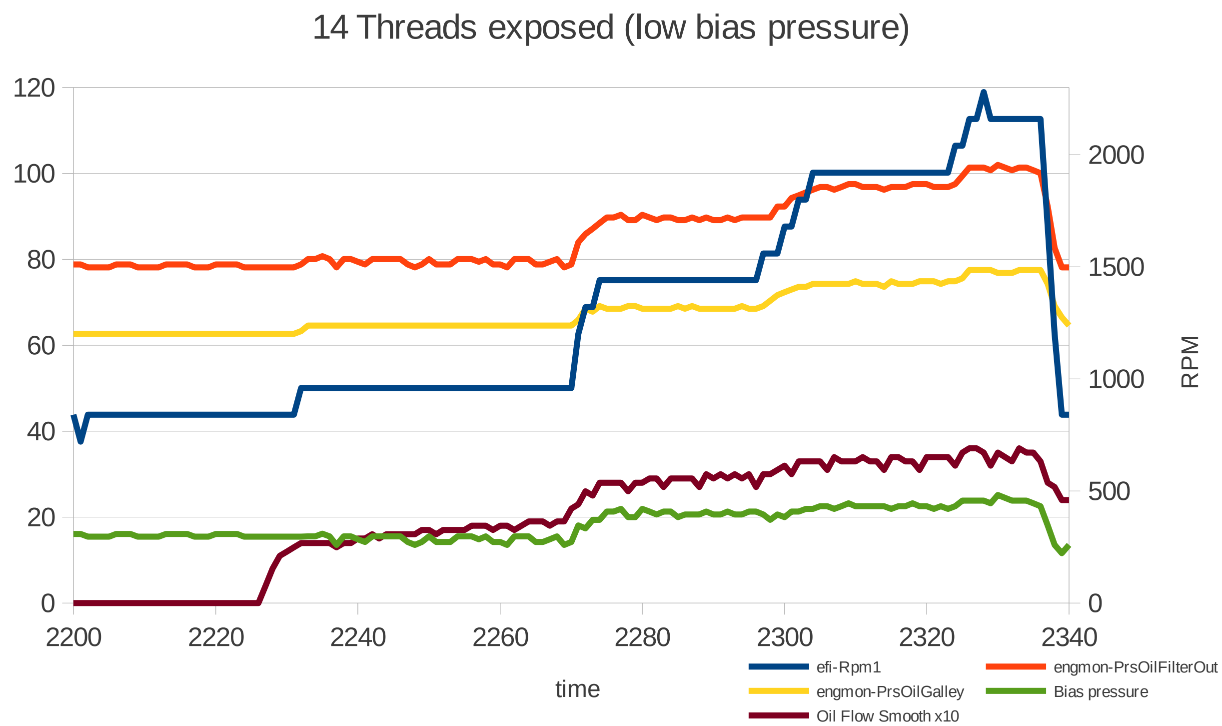

Figure 21: 14 Threads Showing (Low Bias Pressure)

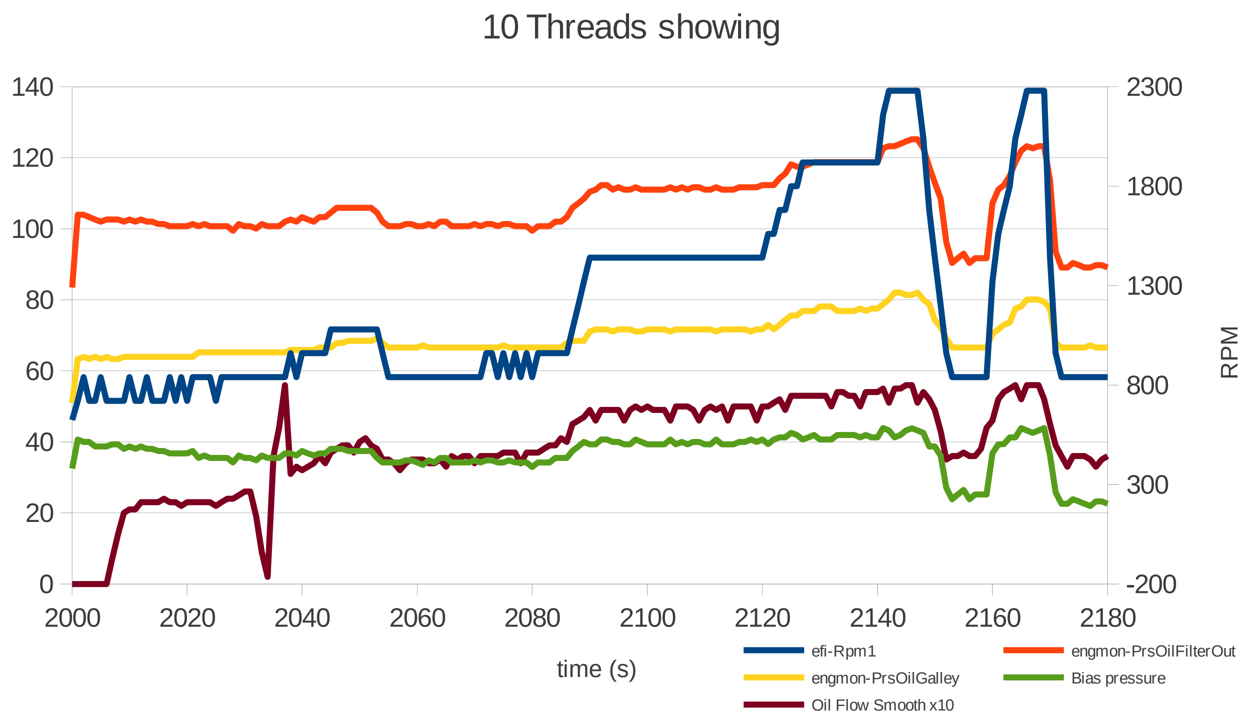

Figure 22: Ten Threads Showing

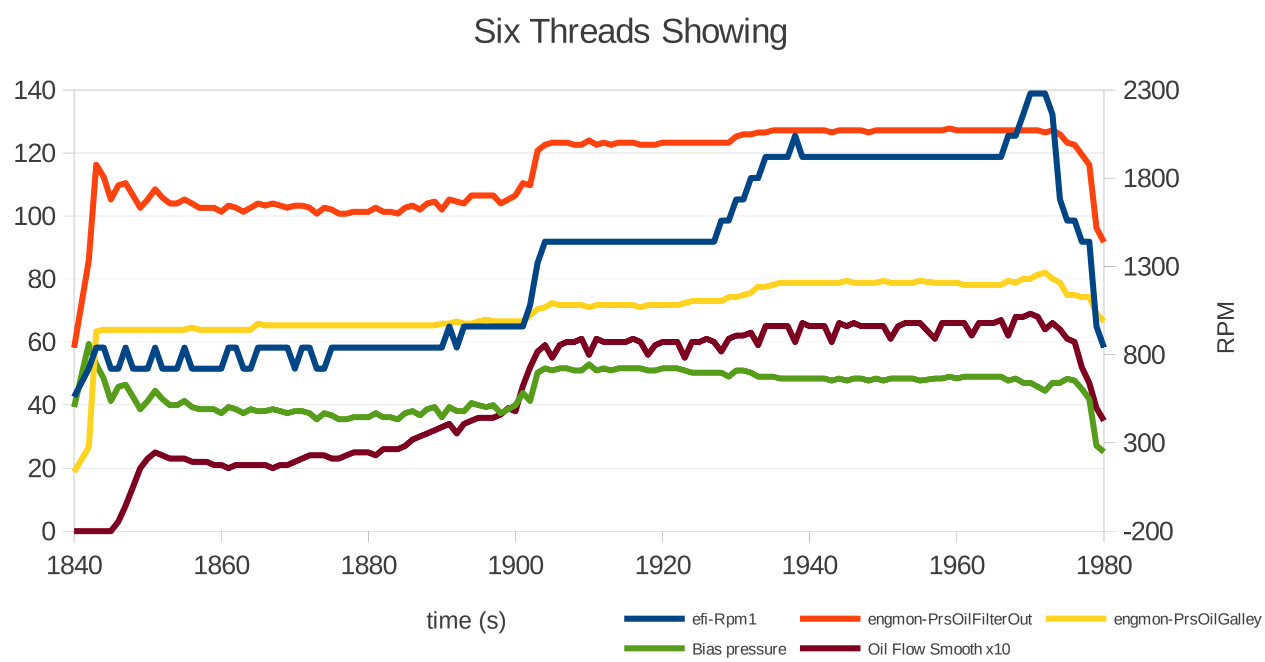

Figure 23: Six Threads Showing

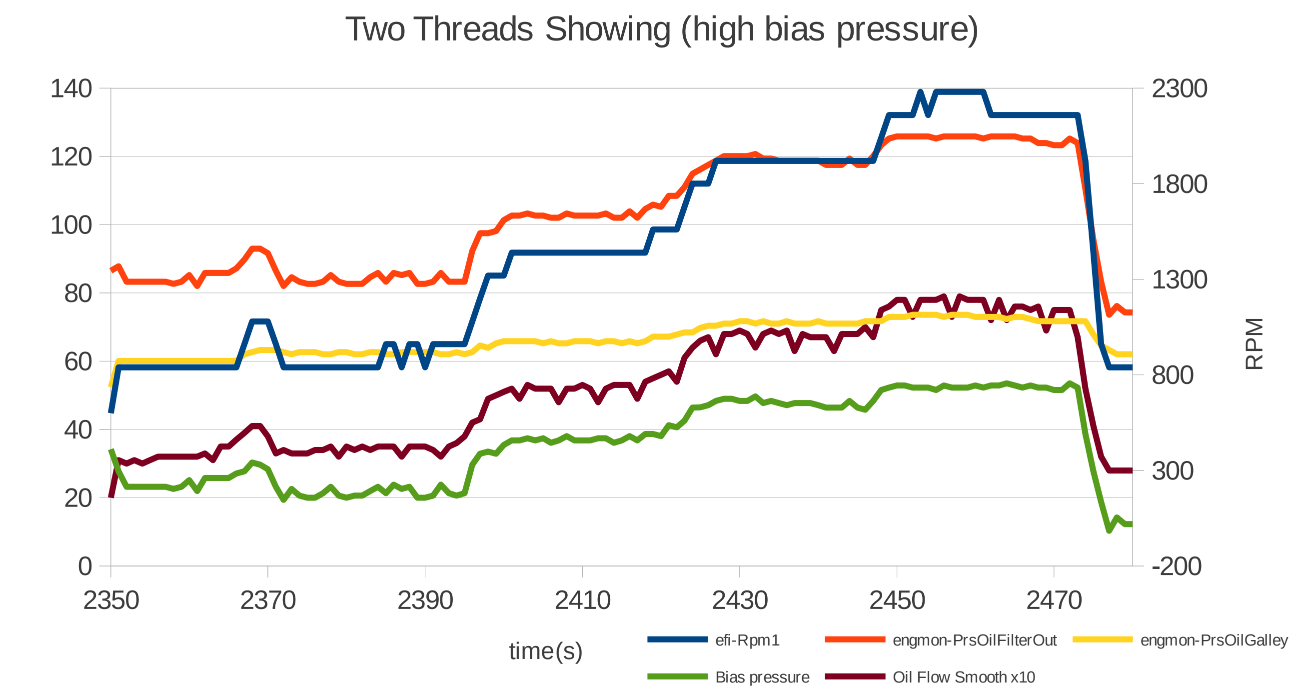

Figure 24: Two Threads Showing (High Bias Pressure)

Flight Test Data

The data from a 30 minute flight is presented in Figure 25. Compare this data to the stock configuration data in Figure 11. Differences to note:

	Ground Air Temp	Nominal engine pressure	Minimum engine pressure	Nominal Oil Flow	Nominal Case Temperature
Stock	72° F	55 PSI	45 PSI	3 GPM	172° F
Modified	95° F	75 PSI	60 PSI	8 GPM	149° F

Table 4: Comparison of stock vs modified oil bypass plate

On the *modified* flight test day, the ground temperature was 23° F hotter than the *stock* flight day. Despite this, the case temperature is 23° F cooler on the *modified* flight, and in all parameters measured, the modified oil bypass plate exceeds the performance of the stock bypass plate.

The panel mounted oil temperature gauge which is not logged, indicated a temperature of 225° F nominal, which is below the red-line limit of 235° F. On previous flights, oil temperature required management as it exceeded the 235° F limit. Since the new configuration measures bypass and cooled oil (as opposed to cooled only), it was expected that the indicated temperature would be hotter than the stock configuration. However, this did not occur. It should be possible to reduce the temperatures further to achieve the 200° F target by reducing the galley pressure (increasing bias pressure increases flow), and address any disruptions to air flow through the cooler.

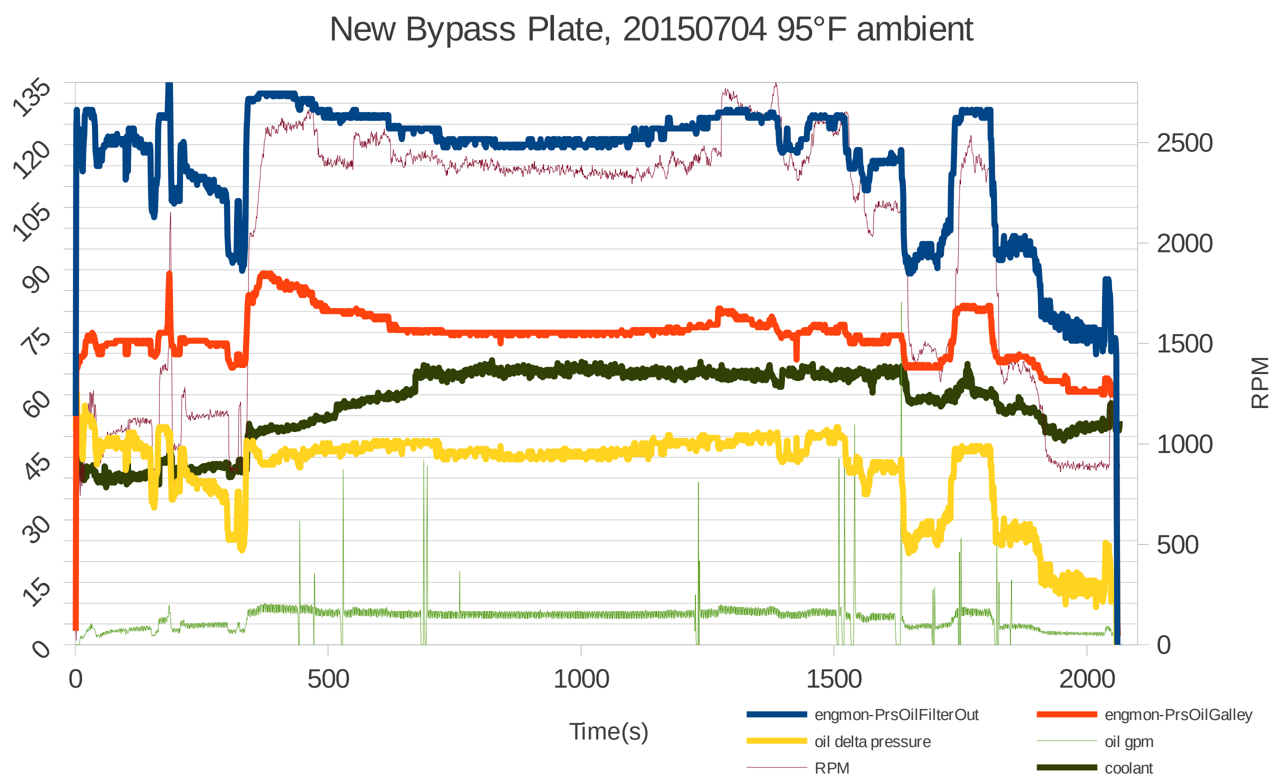

Figure 25: Test Flight with the new Bypass Plate (95° F ambient)

Installation Instructions

1. To install the new bypass plate, one must first remove the existing plate.
2. Replace the gasket material if necessary and install the new bypass plate. Note that the lower left ¼-20 cap screw must have a sealing washer placed under the head. This bolt hole intersects with the return oil galley and requires a seal. Next, re-attach the oil hoses, and the pressure, and

temperature sensors.

3. Set the relief valve such that ten threads are showing.
4. Set the bypass valve such that eight threads are showing.
5. Do not start the engine without first taking precautions, as a bad oil pressure setting will rupture your oil cooler!
    1. With the magnetos off, and preferably one set of plugs removed, pull the prop through at least 20 revolutions while a helper reads the galley oil pressure on the instrument panel. If the pressure goes over 50 PSI, unscrew the relief valve set screw two turns. Repeat until the pressure is below 50 PSI.
    2. Again, with the magnetos off, crank the engine with the starter, which should be about 300 RPM. Ensure that the panel pressure does not exceed 50 PSI.
    3. Now start the engine, being careful not to place too much pressure on the oil cooler. If the pressure is above or below 65 PSI, adjust the relief valve set screw until 65 +/-5PSI is obtained at idle with cold oil. You may need to increase this pressure after gaining some experience with the new bypass.
6. The bypass pressure should not need adjustment, but in the absence of flow data, one can use temperature measurements to make small adjustments. Generally, if the oil temperature is too hot, turning the bias valve set screw clockwise will cause more oil to flow through the loop and increase cooling.