



# The Bend High Desert Flyer of Chapter 1345

WEBSITE: <http://www.eaa1345.org/>

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## **PREZ SEZ:**

Our August meeting, 6pm at Tony's hangar, the 2<sup>nd</sup> from the south end of Bend Muni, facing Powell Butte Hwy, will feature a presentation by Ken Couch, our local Lawn-Chair-and-Balloons celebrity. Ken will describe the design of his air vehicle, his preparations for the flight, and the flight itself. Ken's adventure has taken the world by storm and we are lucky and grateful that Ken accepted our invitation to talk to us. This looks to be a really good meeting, so be sure you turn out.

In news that is less fun to report, Bill Blackwood has resigned as Vice-President and he will "no longer participate in the Chapter activities", according to the letter he sent me. I've tried several times to call Bill to learn why he resigned, to no avail. If any of you know Bill better than I do, contact him and find out why he resigned. Then let me know.

If you were at the BBQ, you heard that Jerry Rozelle was giving up his portion of the hangar where we used to meet. Tony Partain is negotiating to get a large twin in there to help cover the rent costs. If he is successful, then we'll be able to have the hangar as a regular location for our Chapter meetings and a place to work on the PJ-260 and monitor Tony's progress on his Kitfox.

As a last thought for this month, I flew up to the Arlington Airshow on Saturday, July 14th and returned on the 15th. I saw Bruce Hoisington there; he'd flown up in his great-looking Kitfox. In my opinion, the Arlington show was less well-attended than the last time I visited three years ago, and it seemed like there were fewer vendors. The food choices were more limited, too, with none of the food vendors doing breakfast on Sunday morning. Most of the planes that were there vanished Saturday afternoon. I thought maybe they had a weather forecast that I didn't have and were trying to beat some IMC conditions. As it turned out, though, Sunday's weather was pretty good and we got back to Bend on schedule.

Fly Safe. And in this fire season, don't believe the "base" of the smoke layer that you see; you will continue to descend and that "base" will always appear just a bit lower. Ask me how I know this.

*Dennis Douglas*

## **Schedule of Meetings & Events**

<u>Meetings:</u>	<u>Breakfast</u>
August 8	August 18
September 12	September 15
October 10	October 20
November 14	November 17
December 12	December 15

## **July 11<sup>th</sup>, 2007 Meeting**

Well it wasn't really a meeting, so there are no minutes ... It was our annual chapter barbecue, enjoyed by all. Thanks to Dennis for the cooking duties and to Tony and Jerry for the use of their hangar for the event ...

Dennis presented the PJ-260 project prior to the food, but I arrived after his presentation ... sorry 'bout that!

*Mike Bond*

### **RENO RESERVATIONS**

Several from the chapter have made our reservations for the Reno Air Races this September 11th through the 16<sup>th</sup>. Have you made yours?

## ***The Anderson-Greenwood AG-14.***

If Dave Powell has one complaint about flying his Anderson-Greenwood AG-14, it is that it doesn't have much of a front reference point to line up his landings with.

The AG-14 is a twin tail boom, pusher configuration single with the cabin—Powell calls it a pod, not a fuselage—placed well in front of the wing. The result is almost unrestricted visibility, up, down, and all around. And with the engine in the back, the cabin is exceptionally quiet.



Powell's 1953 plane is the fifth and last AG-14 produced. Four of them still exist, though only one other is in flying condition.

His interest in finding and restoring the plane came from a very personal connection. Powell's father, Walter, worked for Anderson-Greenwood, though not directly on the AG-14 program. But through that connection Dave Powell met both principals for whom the company and the airplane are named, Ben Anderson and Marvin Greenwood.

"My brother and I started looking around to see what happened to [the AG-14s]," Powell said. "We found this one in a warehouse in Texas in parts and pieces. Actually, it was scattered among many different locations.

"I flew out [from Arkansas to Oregon] with my 9-year-old-son," Powell said. "I rented the largest Ryder truck I could, spent 12 hours loading it up and drove back. That's been very helpful [with the project] and I've been able to help a couple of the other owners as well."

Anderson, Greenwood, and Lomis Slaughter, all engineers for Boeing during WWII, took on the project as an exercise in creating the perfect light plane. In their eyes, "perfect" included making the plane as much like an automobile as possible, an attempt to ease the transition from driver to pilot. So unusual features like nosewheel steering connected to the control yoke, a bench seat, a single brake pedal and a starter pedal are part of the design.

Power comes from a 90-hp Continental engine mounted on the back of the pod. The engine, with its ground-adjustable prop, gets the little plane off the ground in about 700 feet. Typical cruise is 115 mph.

Powell's restoration includes all of the original instruments. The only addition is a cylinder head temperature gauge he added after hearing that the rear-mounted engine installations were known to have some engine cooling problems. To date he has not seen any unusual temperatures.

One special experience for Powell was a visit he made to Anderson shortly before the restoration was complete.

"I brought some pictures of the plane as it was coming together," Powell said. "He's pretty much confined to a wheel chair now and it was exciting to be able to share this with him. He actually had a model of the plane sitting on his credenza."

Ultimately, Anderson-Greenwood found success as a defense contractor and in manufacturing pressure relief valves for the oil industry. Financing for manufacturing airplanes was difficult to come by and AG-14 production ceased. They did re-enter the airplane business in the 1970s with the development of a model known as the Aries T250. Although it was a good performer, only two of examples of the plane were built.

## ***New Glastar in town:***

Thought you might want a picture of our new GlaStar. Although we purchased it three months ago I had no tail dragger time so had to go to Arlington, WA for 10 hours of training. I flew the plane back last week from Jupiter, Florida. Total flying time was 25 hours. Plane is now stored on the ramp at Sunriver. Plane has 360 total hours. The Lycoming 320 160HP has the same as does the constant speed prop.



Looking forward to soon good flying and interesting experiences.

*Ken Day*

# Lycoming O-320-B and –D Series Power

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*The Lycoming Operator's Manual for the O-320-B and –D series engines provides outdated power curves for these engines, "as they are manufactured and tested today". This article provides the corrected data and develops a simple mathematical approach for calculating power tables for those flying an O-320-B or –D series engine with a constant-speed propeller.*

**Background.** About six months before my "first flight", I started preparing drawings and data sheets for the Pilot's Operating Handbook (POH) that would be specific for my GlaStar, N9103D. My starting point for this was the GlaStar Owner's Manual, of course, but I've made numerous additions, deletions and changes to various pages, as those are indicated by the specifics of my airplane. The additions included schematics of the electrical system, checklist items, procedures, airspeed correction tables, and a new "Performance" section.

For the "Performance" section in the POH, I wanted to include tables of engine power, fuel consumption, and endurance as a function of manifold pressure, RPM, and altitude. These tables are commonly found in the POH for other aircraft I've flown and they are useful for flight planning as well as an in-flight aid for power and fuel management. To get the information I needed, I went to the Lycoming Operator's Manual for the O-320 engine series. This is a small, ring binder-type book, with a Textron Lycoming Publication number 60297-16.

The Sea Level and Altitude Performance charts for the O-320-B and –D series engines are found in Figure 3-6 of the Lycoming Owner's Manual. This figure shows two tiny, complicated graphs that allow the reader to scale off engine horsepower from manifold pressure, RPM, altitude and OAT. The combined graph is labeled "Curve No. 11260-A".

I got out my magnifying glass and started scaling off numbers. After an hour or two of frequently jumping a line on the graph and thus getting incorrect numbers, I called Lycoming and asked them if they had a larger version of the data in Figure 3-6. "Sure", they said, and they sent me a supplementary publication, No. 2283-H dated February 28, 2000, entitled "Detailed Specifications for Engine, Aircraft: Model O-320-D1A, -D2A, -D1B, -D2B, -D1C, -D3C, -D2G, -D3G 160 Horsepower Direct Drive". The power chart for the O-320-B and –D series engines in 2283-H is labeled "Curve 13381".

A problem arose when I compared Curve 11260-A with Curve 13381: For a given RPM and manifold pressure, the horsepower values were significantly different—typically by about 5 HP or about 3% in percent power. The fuel consumption rates were different also—by several GPH.

**Discussion.** I called Lycoming to find out which of the two pairs of curves were correct: 11260-A shown in the Operator's Manual or 13381 shown in the Detailed Specification document. After a time I got an answer: "The performance data on curve no.13381 is representative of the O-320-B and –D as they are manufactured and tested today"<sup>1</sup>. For those of us who are trying to define the operating parameters of our airplane with the same care we used building the airplane, this says that the horsepower data shown in the Operator's Manual is out-of-date and needs updating. Curve 13381 is the correct one to use.

**Horsepower.** Curve 13381 is a hand-annotated, rough-drawn chart. I scaled the data from the curve, entered the values into an Excel™ spreadsheet, and used regression methods to develop a set of curves that represent Curve 13381 in a more readable form. After changing the axis title to show the altitude data as a function of density altitude (to automatically compensate pressure altitude for deviations from the standard altitude-temperature relationship)<sup>2</sup>, the results are shown in Figure 1.

This power chart, then, is a corrected power chart applicable to the O-320-B and –D series engines and should be used instead of Chart 11260-A in the Operator's Manual.

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<sup>1</sup> Private communication: email to D. Douglas from Mike Day (Lycoming), 12/21/2004.

<sup>2</sup> Curve 13381 uses pressure altitude as the x-axis and includes another curve for corrections of the altitude data for deviations from a standard temperature-pressure profile. In my opinion, this unnecessarily complicates use of Curve 13381 since the correction merely represents density altitude. Since density altitude is easy to calculate, I've chosen to present Figure 1 and the succeeding materials in terms of density altitude. Besides that, my EFIS computes density altitude directly.

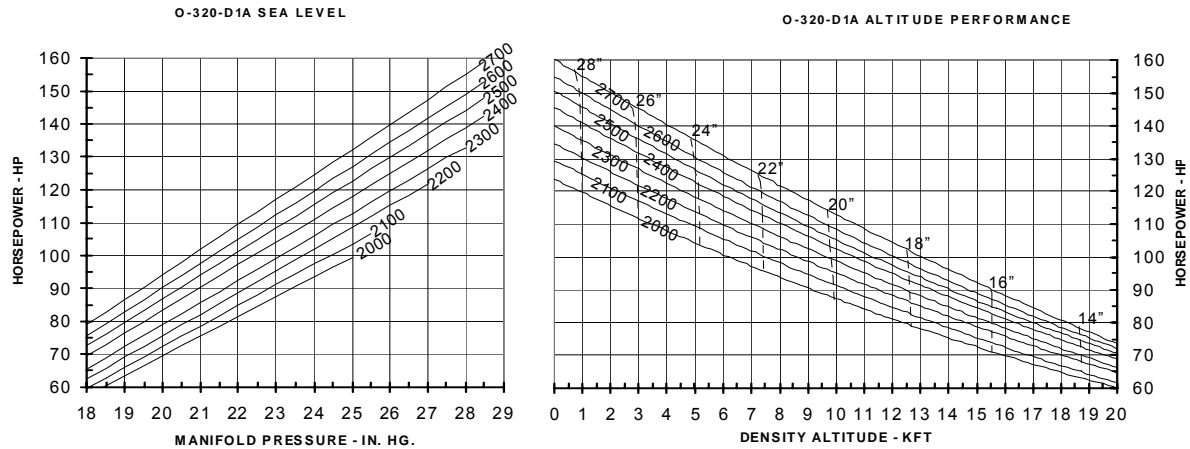


Figure 1. Power Chart for Lycoming O-320-B and -D Series Engines.

**Horsepower At Sea Level.** For the sea level data—the family of lines on the left side of Figure 1—the horsepower curves were calculated by finding simultaneous linear relationships from the data in Curve 13381, as described above. The relationship developed for the sea level data shown in Figure 1 is:

$$HP_{SL} \approx (0.0022 \cdot RPM) \cdot MP + (1.6733 \cdot MP) - (0.0081 \cdot RPM) - 36.176, \quad [1]$$

where RPM is the engine RPM, MP is the manifold pressure in inches, and the dot (·) indicates a product. This equation allows us to calculate horsepower for arbitrary RPM and manifold pressure values.

I first saw this approach used in the work of Lowry [Ref 1], who developed his equations following a thorough review of engine theory. Although equation [1] differs slightly from the expression Lowry obtained<sup>3</sup>, it is based on the data I measured using Curve 13381. The differences are minor and you could use either equation with no significant loss of accuracy.

You will note that the sea level data shown in Figure 1 does not extend over the full range of manifold pressure for all RPM values. This is a result of using the “limiting maximum manifold pressure for continuous operation” described in Chart 11260-A, and applying it to the data of Figure 1. Thus, Figure 1 shows the limiting “over square” power settings (evidently) permitted by Lycoming for the O-320-B and -D engines. For example, while 2300 RPM and 28” of manifold pressure is permissible, a maximum of 25” is permitted for 2000 RPM for this engine.

**Horsepower at Altitude.** While we could use equation [1] to generate a table of horsepower as a function of manifold pressure and RPM, it would represent only the sea level values. This is because horsepower increases with altitude for a constant manifold pressure and RPM. This power increase with altitude is due to the reduced exhaust backpressure as altitude increases [Ref 1, 2]. The reduced backpressure increases the thermal efficiency of the engine, thus yielding additional power. So, to obtain the horsepower at altitude, we must use the right side of Figure 1.

Although correct, the data of Figure 1 remains awkward to use. To calculate a power, we enter a manifold pressure and RPM on the sea level chart and draw a straight horizontal line to a preliminary power value on the right side of the sea level chart. Then we locate the manifold pressure and RPM on the altitude chart and draw a straight line from there to the same preliminary power value on the left vertical axis of the altitude chart. On this second line, we locate the density altitude and draw a horizontal line from there to obtain the actual power value.

Using a similar simultaneous equation approach as used for the sea level data, we can infer the relationship for the power gain with altitude. Lowry [op. cite.] shows that, for the O-320 engines, the horsepower increases by about 2.36 HP/1000 ft near sea level and by about 1.87 HP/1000 ft near 10,000 feet. Making a linear estimate of this change in horsepower with density altitude gives us a relationship for the actual horsepower:

$$HP_{DA} \approx HP_{SL} + DA \cdot (-0.049 \cdot DA + 2.36), \quad [2]$$

<sup>3</sup> Lowry’s expression is:  $HP(RPM,MP) \approx (0.002277 \cdot RPM) \cdot MP + (1.4670 \cdot MP) - (0.01036 \cdot RPM) - 30.4$

where DA is the density altitude in 1000's of feet and  $HP_{SL}$  is the horsepower scaled from Figure 1 or calculated from equation [1]. The use of equation [2] allows the development of power tables for arbitrary altitudes through simple spreadsheet calculations. This is illustrated later.

**Fuel Consumption.** As for the power charts, the fuel consumption data shown in Curve 11260-A of the Lycoming Operator's Manual may overestimate the actual fuel burn rate. Curve 13380 in Lycoming's publication No. 2283-H provides more recent information. This consumption curve is shown in Figure 2, below<sup>4</sup>.

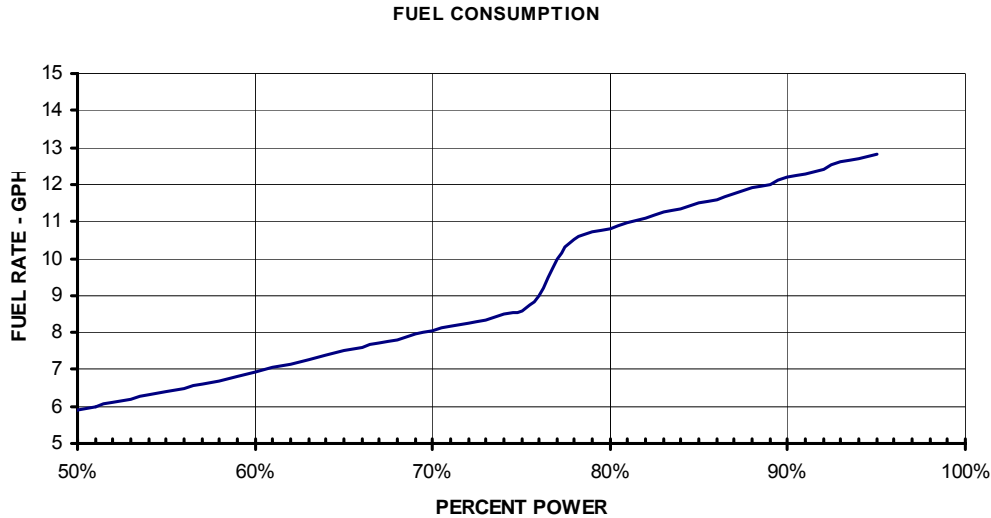


Figure 2. Fuel Consumption for O-320-B and -D Series Engines (Ref: Curve 13380).

As described by Lycoming<sup>1</sup>, this data "...portrays the MINIMUM fuel consumption of these engines with the mixture manually leaned to best economy below 75% power and best power above 79% power." Fuel consumption rates for best power are about 1.5 GPH greater than shown in Figure 2. (The Operator's Manual shows that "best economy is obtained from max leaned EGT to about -75 °F lean of peak, and best power is -100 °F to -150 °F rich of peak.)

**Power Tables.** Using the information from equation [2], the fuel flow data from Figure 2, and some fuel tank volume data, we can put together tables of horsepower, percent horsepower, fuel flow, and endurance as a function of manifold pressure and RPM for any altitude. One such table is illustrated in Figure 3, which shows these parameters for a (density) altitude of 5,500 feet.

(Note that the fuel flow rates shown in Figure 3 are greater than the data shown in Figure 2 by 1.5 GPH. I did this to be conservative in the endurance estimates to reduce the risk of running out of fuel because I usually lean to best power instead of best economy.)

All that's left is to fly the airplane and gather some airspeed data to complete the table.

Using the equations above, one can create tables of O-320-B and -D engine performance for arbitrary altitudes. These tables can be printed and inserted into the POH and used for flight planning and enroute monitoring.

**Summary.** This article has examined the performance of the Lycoming O-320-B and -D series engines using recent information provided by

5,500 FEET  
CRUISE POWER CHART -- BEST POWER LEAN

RPM	M.P. (in)	HP	% PWR	TAS (kts)	FUEL RATE <sup>1</sup> (gal/hr)	MAIN ENDR. (hr)	MN + AUX ENDR. (hr)
2200	19.0	81.3	51%		7.4	3.9	6.5
	20.0	87.8	55%		7.8	3.7	6.2
	21.0	94.3	59%		8.2	3.5	5.9
	22.0	100.8	63%		8.7	3.4	5.5
	23.0	107.3	67%		9.2	3.2	5.2
2300	24.0	113.8	71%		9.7	3.0	5.0
	19.0	84.6	53%		7.6	3.8	6.3
	20.0	91.4	57%		8.1	3.6	5.9
	21.0	98.1	61%		8.6	3.4	5.6
	22.0	104.8	66%		9.0	3.2	5.3
2400	23.0	111.6	70%		9.5	3.1	5.1
	24.0	118.3	74%		9.9	2.9	4.9
	19.0	88.0	55%		7.8	3.7	6.2
	20.0	94.9	59%		8.3	3.5	5.8
	21.0	101.9	64%		8.8	3.3	5.5
2500	22.0	108.9	68%		9.3	3.1	5.2
	23.0	115.8	72%		9.8	3.0	4.9
	24.0	122.8	77%		10.5	2.8	4.6
	19.0	91.4	57%		8.1	3.6	5.9
	20.0	98.5	62%		8.6	3.4	5.6
2600	21.0	105.7	66%		9.1	3.2	5.3
	22.0	112.9	71%		9.6	3.0	5.0
	23.0	120.1	75%		10.1	2.9	4.8
	24.0	127.2	80%		12.2	2.4	3.9
	19.0	94.7	59%		8.3	3.5	5.8
2700	20.0	102.1	64%		8.8	3.3	5.5
	21.0	109.5	68%		9.3	3.1	5.2
	22.0	116.9	73%		9.9	2.9	4.9
	23.0	124.3	78%		11.5	2.5	4.2
	24.0	131.7	82%		12.6	2.3	3.8

<sup>1</sup> REF: Lycoming Curve 13380; minimum consumption leaned to best economy for power <75% and best power for power >79% PLUS 1.5 GPH.

Figure 3. Power Table for O-320 at 5,500 feet Density Altitude.

<sup>4</sup> The "jiggles" in the data of Figure 2 are a result of round-off error in scaling the data from the plot in the Lycoming graph.

Lycoming, and it develops a simple arithmetic approach for calculating horsepower and fuel flow for any specified manifold pressure, RPM, and (density) altitude for these engines. The approach described here can be applied to any normally aspirated engine. The values will differ, of course, but the approach remains the same.

The actual horsepower generated by an installed engine may differ from the calculated values because of induction and exhaust differences, the general condition of the engine, and because of high humidity or other factors.

**References**

1. John T. Lowry, *Performance of Light Aircraft*, ISBN 1-56347-330-5, American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191 (1999).
2. John Schwaner, *Sky Ranch Engineering Manual*, 2<sup>nd</sup> Edition, Sacramento Sky Ranch, Inc., 6622 Freeport Blvd., Sacramento, CA 95822 (1991).

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***ED NOTE:***

Dennis provided this great article several months ago, but this kind of info never ages, so I saved it for 'light' month, meaning I received no other inputs for this month's newsletter, other than about Ken's new Glastar.

Dennis's full article is not included in the snail-mail version, due to it's size, but I'm sure can be provided to any members interested in having a printed copy. Remember, if any charts are difficult to read, they can be magnified in both Word and PDF versions of the emailed newsletter.

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