Pilot's Guide

Fuel Scan
FS-460

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J.P.INSTRUMENTS

Information: P. O. Box 7033
Huntington Beach, CA 92646

Factory: 3185B Airway
Costa Mesa, CA 92626

(714) 557-5434 Fax (714) 557-9840

www.jpinstruments.com

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Table of Contents

Section 1 - Introduction

Product Features

- Fuel quantity measured in gallons, liters, or pounds
- Low fuel quantity alarm
- Low fuel time alarm
- GPS interface—bi-directional serial interface
- Solid-state pulse generating rotor fuel flow transducers
- Instantaneous fuel flow rate
- Total amount of fuel consumed
- Fuel consumed by each engine
- Total fuel remaining
- Time to empty at the current fuel flow rate
- Fuel required to next waypoint
- Fuel reserve at next waypoint
- Nautical miles per gallon

Fuel Management

Without a means of measuring fuel flow, you must rely on the aircraft fuel gauges or total time of flight. Aircraft fuel gauges are notoriously inaccurate (they are only required by the FAA to read accurately when displaying empty). And measuring time of flight is only an approximation, and assumes a constant fuel flow rate for each phase of flight.

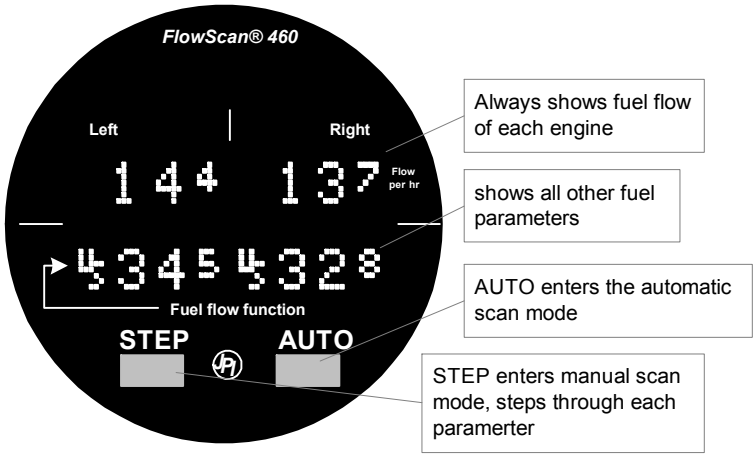
The FS-460 Fuel Scan uses small turbine transducers that measure the fuel flowing into each engine. Higher fuel flow causes the transducer turbine to rotate faster which generates a faster pulse rate. Because the transducer turbine generates thousands of pulses per gallon of fuel, it can measure with high resolution the amount of fuel that the engines have consumed. Prior to engine start you inform the FS-460 Fuel Scan of the known quantity of fuel aboard, and it will keep track of all fuel used.

For fuel calculations to be accurate, it is imperative that you inform the FS-460 of the correct amount of fuel aboard the aircraft. Do not rely on fuel flow instruments to determine fuel levels in tanks. Refer to original fuel flow instrumentation for primary information.

Section 2 - Displays and Controls

The FS-460 helps you manage your fuel. There are two components of the user interface:

- Digital display for numeric readouts and messages: top display is fuel flow per hour and the lower display for all other parameters.
- Two front panel operating buttons: STEP and AUTO



Two operating buttons control all functions of the FS-460.

The term **tap** will be used to denote pressing a button momentarily. The term **hold** will be used to denote pressing and holding a button for five seconds or longer.

STEP Button

Located on the lower left side near the instrument face.

- Tapping the STEP button will stop Automatic Indexing and change to the Manual indexing mode. Then each tap

of the STEP button will display the next parameter in the sequence.

- Holding the STEP button will display the previous parameters in the sequence (rapidly backwards).
- In the programming procedures, described on page 8, tapping the STEP button will advance to the next item in the list.
- When an alarm is displayed, tapping the STEP button will temporarily delete that alarm from appearing for the next ten minutes.
- When an alarm is displayed, holding the STEP button until the word OFF appears will delete that alarm from appearing for the remainder of the flight.

AUTO button

Located on the lower right side near the instrument face.

- The AUTO button will begin the Automatic Indexing Mode.
- In the pilot programming procedure, holding or tapping the AUTO button is used to increment or decrement parameter values and toggle between yes and no answers to questions.

STEP and AUTO buttons

- Holding both the STEP and AUTO buttons simultaneously for five seconds changes to the pilot programming procedure.

Section 3 - Modes and Alarms

Modes

There are two standard operating modes of the FS-460: **Automatic Indexing**, and **Manual Indexing**. Most of the time you will operate the FS-460 in the Automatic indexing mode. When you first turn on the power the FS-460 starts in the Manual indexing mode, but will enter the Automatic indexing mode after a minute. Tapping the AUTO button will begin the Automatic Indexing Mode.

Alarms

The FS-460 has programmable alarms. When the remaining amount of fuel falls below the alarm limit the lower display will show the amount of fuel REMaining and REM will flash on the lower right display.

When the remaining time falls below the alarm limit the lower display will show the MINutes of fuel remaining and HR^{MN} will flash on the lower right display.

When an alarm is displayed, tapping the STEP button will temporarily disable the alarm indication for the next ten minutes.

When an alarm is displayed, holding the STEP button until the word OFF appears will disable that alarm indication for the remainder of the flight.

Section 4 - Operation

Diagnostic Testing on Startup and During Flight

When your FS-460 is first turned on, all digits light up in each display for a short time, permitting you to check for non-functional segments. Then the FS-460 tests internal components, and integrity of the system.

Start Up Fuel

After initial self-test, you will be asked to inform the FS-460 of start up fuel. The FS-460 will display FUEL IN GALLONS (or LITERS or POUNDS) for one second, and then flash FILL? NONE.

During flight you may also inform the FS-460 of startup fuel using the pilot program mode, beginning on page 8, if you forgot to do so at start up.

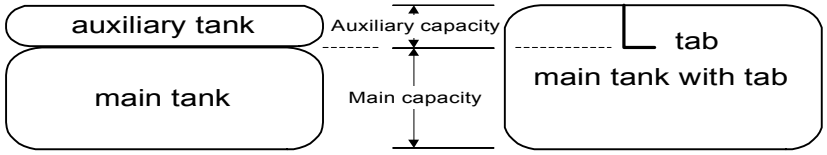
Refer to the column in the chart below corresponding to your fuel tank configuration. Tap the AUTO button to select one of the four following fueling choices on the left column of the chart.

AUTO to choose⇓	Main tanks only, no tabs	Main tanks with tabs	Main & Auxiliary tanks
FILL? NONE	Did not add any fuel since last shutdown.		
* FILL 75	Topped the main tanks.	Filled only to the tabs.	Topped the main tanks. The auxiliary tanks are empty.
* FILL 125	(not applicable)	Topped the main tanks.	Topped both the main and auxiliary tanks.
FILL ADD	Did not top, but added additional fuel to the aircraft, or removed fuel from the aircraft.		

* These values are examples and will be customized for your aircraft.

Then tap the STEP button to complete the entry and advance to the Manual indexing mode.

Adding Fuel and Auxiliary Tanks



If your aircraft has tank fill tabs and no auxiliary tanks, you can use the auxiliary tank feature to select either filling to the tank tabs or topping the tank. See "Main Tank Capacity" and "Auxiliary Tanks" beginning on page 15 to program the FS-460 for this feature. The FS-460 does not differentiate fuel flow between the main and auxiliary tanks; it considers only total fuel in the aircraft.

If you added less than full fuel, then tap AUTO to select FILL ADD. Then tap STEP. The next display will ask you how much you added: ADD °GALS (or selected units). Hold the AUTO button to count up, tap the AUTO button to count down. The count up will stop at full tanks, since you cannot add more fuel than would top the tanks. Tap STEP to complete the entry and advance to the Manual indexing mode.

If you removed fuel from the aircraft or wish to correct the total quantity of fuel on board, you can "add" a negative amount of fuel.

Accumulate Total—Trip Total

You may either display total fuel used

- since the last time you informed the FS-460 that the aircraft was refueled, or
- for an extended trip with multiple fuel stops.

This selection affects only the USed parameter,  . How to select whether to accumulate for a extended trip or reset at each refueling is described in "Pilot Programming" beginning on page 8.

Resetting "USed"

Every time you inform the FS-460 that the aircraft is refueled, the amount of fuel used is set to zero, unless the instrument is programmed to accumulate for an extended trip. The display of fuel used pertains only to the fuel used since the last time you informed the FS-460 that the aircraft was refueled.

In the manual mode with left and right engine USed displayed, holding the AUTO button for three seconds will reset the left, right and total used to 0.

Parameter Indexing

The FS-460 steps through the engine parameters in a specific sequence. Listed below is the indexing sequence, parameter description and example of the digital display. The display will pause at each parameter for a few seconds in the Automatic indexing mode. In the Manual indexing mode, tap the STEP button to advance to next parameter. Holding the STEP button will display the previous parameters in the sequence (rapidly backwards).

Parameter Indexing Sequence

Fuel flow rate is always shown on the top display.

Fuel Flow Rate	144 137	GPH (or LPH, or PPH)

The lower display shows the following parameters in this sequence.

Parameter Description	Example	Comments
Total fuel used	673 TOTL	Total used by both engines
Fuel USed by each engine	345 328	Left and right engines shown separately.
Time to Empty	0245 HRMN	Hours[Minutes] Remaining at current fuel burn
Fuel required to next GPS WPT or Destination	258 REQ	Present with GPS interface Valid signal and way point
Fuel Reserve at next GPS WPT or Destination	319 RES	Present with GPS interface Valid signal and way point
Nautical Miles per Gal	203 MPG	Present with GPS interface and valid signal or MPL, MPP
Fuel Remaining	577 REM	In gallons, liters or pounds

Note that liter and pound parameters are displayed as whole numbers without the decimal fraction.

Section 5 - Personalizing

Pilot Programming

You can program the Automatic Indexing rate (1 to 9 second wait periods or 0 for no Automatic Indexing), the K-factor, and whether to accumulated fuel used or reset at each refueling.

To start the Pilot Programming Procedure, simultaneously hold the STEP and AUTO buttons for five seconds. You will see the words PROGRAM MODE for two seconds and then the sequence

shown in the chart below. Tap the STEP button to advance to the next item in the list. Tap the AUTO button to select alternate values of that item.

Tap STEP to advance to the next item	Tap AUTO to sequence	Comments
FUEL? N	N ⇔ Y	Y—Yes—to change fuel status (see page 5
RATE= 4	0 … 9	Indexing rate in the Automatic Indexing Mode. Selecting 0, disables the Automatic Indexing Mode.
2900=KF LEFT		Used to set and fine tune the K factors. To adjust the K-factors, hold both STEP and AUTO buttons for five seconds. See “Setting the K-factors” below.
2900=KF RIGHT		
TRIP ? N	N ⇔ Y	N—No—Upon informing the FS-460 that you refueled the aircraft, reset total fuel used to 0. Y—Yes—accumulate total fuel used rather than reset to 0.
GPS C= 2	0 … 6	GPS Com Format.
END Y	N ⇔ Y	Y—Yes to exit; N—No to review list again.

Start Up Fuel FUEL? N

During flight you may also inform the FS-460 of startup fuel using the pilot program mode. See page 5 for the steps to take to set the start up fuel if you did not set it during power up.

Indexing Rate RATE= 4

In the automatic mode the display will automatically index through each parameter and pause for a period of time. The pause time can be set from between 1 and 9 seconds. Set the rate to 0 to inhibit the automatic indexing mode.

Fuel Flow Parameters

The pilot may set three parameters:

- K Factors—the fuel flow transducers calibration constants.
- Accumulate for extended trip—default is OFF: reset the fuel used to 0 every time you inform the FS-460 that the aircraft was refueled. With accumulate ON fuel used will not be reset to 0 when you inform the FS-460 that the aircraft was refueled.
- GPS Communications fuel data format.

K Factors

The K factor is shown on each fuel flow transducer as a four digit number, which is the number of pulses generated per gallon of fuel flow. **Before installing the transducer, write down the K factors here: Left_____ Right_____.** To enter the number, move the decimal point three places to the left. For example if the K factor on the fuel flow transducer is 29,123, enter 29.12 in the K factor parameter.

The K factor can be changed in the pilot programming procedure. When the K factor is changed during a trip, calculations of fuel used, fuel remaining and time to empty are not retroactively recalculated.

Fine Tuning the K Factors

The K factor shown on the fuel flow transducer does not take into account your aircraft's particular installation. Fuel hose diameters and lengths, elbows, fittings and routing can cause the true K factor to be different from that shown on the fuel flow transducer.

Setting the K factors

Use the following procedure to determine the new K factors.

1. Make at least three flights of about two to three hours each. Note the actual fuel used (as determined by topping the tanks) and the FS-460 calculation of the fuel consumed for each flight = USD L and USD R.

	Fuel USED shown by FS-460		*Actual fuel used by topping tanks*	
Flight	*USed L*	*USed R*	*filled left*	*filled right*
1	❶		❷	
2				
3				
Total				

2. Total ❶ the FS-460 fuel used and ❷ the actual fuel used for each tank.
3. Record the current K factor here ❸ left_____ right_____ and in the table below.
4. Calculate the New K Factor as follows:

New K Factor = (❶FS-460 fuel used) x (❸Current K factor)
(❷actual fuel used)

New K Factor (L) = (❶(L)) x (❸(L))
(❷(L))

New K Factor (R)= (❶(R)) x (❸(R))
(❷ (R))

Every time you fine tune the K factors, record the measurements here:

Date	❶FS-460 fuel used	❷actual fuel used	❸Current K factor Left	❸Current K factor Right	New K factor = ❶x❸/❷ Left	New K factor = ❶x❸/❷ Right

If you haven't already done so, start the pilot programming procedure, simultaneously hold the STEP and AUTO buttons for five seconds. You will see the words PROGRAM MODE for two seconds.

1. Tap STEP button twice to advance to the display
   2900=KF
   LEFT
2. Hold STEP and AUTO buttons simultaneously for five seconds.
3. Press STEP button. First digit blinks: 29.00
4. Tap or Hold the AUTO button to change flashing digit: I9.00
5. Tap STEP button for next digit: I9.00
6. Tap or Hold the AUTO button to change flashing digit: I8.00
7. Tap STEP button for next digit: I8.00
8. Repeat items 6 and 7 for the remaining digit.
9. To exit, hold STEP and AUTO buttons simultaneously for five seconds.
   2900=KF
10. See RIGHT
11. Repeat steps 1 through 8 for the right engine K factor.

Setting the GPS-C Comm settings GPS C= 2

The GPS-C setting selects the format of the fuel data output of the FS-460.

GPS-C	Input to GPS; output of FS-460
0	No fuel data output
1 *	Garmin (Shadin Miniflow format)
2 *	Allied Signal (format B)
3	Arnav/EI fuel data
4	Allied Signal (format C)
5	(Not used)
6 *	UPS fuel/air data

* Recommended formats.

FS-460 Set Up

Factory Default Set Up

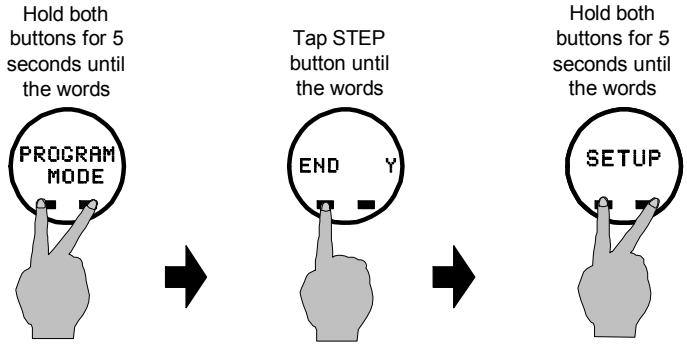
The factory default fuel measurement units are gallons and the alarm limits are 45 minutes for the low time alarm, and 10 gallons for the low fuel alarm. The K-factor defaults are K=29.00 (29,000).

Changing the FS-460 Set Up

You may need to change the fuel measurement units, the fuel tank capacity, and may prefer to set your own alarm limits. Follow the procedure outlined below to change any of the factory default settings.

To start the Set Up procedure, after power up, wait until the FS-460 completes its self test and is in the Automatic or Manual indexing mode. If in doubt, tap the STEP button a few times. Then follow the steps illustrated below. The display will then sequence as shown in the chart below. Tap the STEP button to advance to the next item in the list. Tap the AUTO button to select alternate values of that item. Hold AUTO button to increase a numerical value; tap the AUTO button to decrease a numerical value.

Procedure—Changing the Set Up:



Tap **STEP** to next item	**Hold or tap AUTO to sequence through these values**	**Description**
FUEL GALLONS	GALLONS ⇒ POUNDS ⇒ LITERS	Selects fuel units
MAIN= 50	Hold or tap AUTO to select	Main tank capacity, in units selected
AUX? N	N ⇔ Y	Y—Yes—aircraft has auxiliary tanks (next step)
AUX = 0	Hold or tap AUTO to select	Auxiliary tank capacity (skipped if AUX? is no)
MIN = 45	Hold or tap AUTO to select low time limit	Alarm limit in minutes for low time in tanks
REM = 10	Hold or tap AUTO to select low quantity limit	Alarm limit for low fuel quantity in tanks, in units selected
CARB ? N	N ⇔ Y	Y—Yes—carbureted advances to next step
FILTR= 1 CARB	FILTR = 1, 2 or 3	Higher is smoother filter
END Y	N ⇔ Y	Y—Yes to exit; N—No to

		review list again

Fuel Measurement Units, Fuel Capacity, Alarm Limits

Fuel Measurement Units

Selects the units in all parameters where fuel quantity or fuel rate is displayed. If you change this parameter, it does not change the numerical value of the fuel tank capacity. You must do this manually. For example if you change from gallons to pounds, the tank capacity will be interpreted as 50 pounds rather than 50 gallons; the FS-460 will not convert 50 gallons to equivalent pounds.

Main Tank Capacity

Enter the total capacity of the main tanks in the fuel flow units selected. If you have tank tabs (but no auxiliary tanks) and sometimes fill only to the tabs, set the main tank capacity to the capacity up to the tabs.

Auxiliary Tanks

If you do not have auxiliary tanks or tank tabs, answer "No." If you answer "Yes," you will be asked to input the capacity of the auxiliary tanks in the fuel flow units selected. If you have tank tabs and sometimes fill only to the tabs, set the auxiliary tank capacity to the difference between full tank capacity and tab capacity. The FS-460 does not differentiate fuel flow between the main and auxiliary tanks; it tracks only total fuel in the aircraft.

Low Time Alarm Limit

Select the value of the time remaining, in minutes, that triggers the alarm. Time remaining is calculated at the current fuel flow rate.

Low Fuel Alarm Limit

Select the value of the fuel remaining, in the selected fuel flow units, that triggers the alarm. Fuel remaining is calculated at the current fuel flow rate.

Carburetor?

Different response filters are used depending on whether your engines are carbureted or fuel injected. The filters for a carbureted engine have a slower response time to reduce sudden fluctuations in readings. Select FILTR=1, 2 or 3 where higher number is more smoothing. Pick the lowest number that gives steady readings.

Flow Only

If you want to display only fuel flow, TOTaL and USed without any alarms and without displaying HR^{MN}, REQ, RES, MPG and REM, enable the *flow only* setting. To do this, when you see END Y at the completion of the setup procedure, simultaneously hold the STEP and AUTO buttons for five seconds. You will see FLOW ONLY? N. Change the N to a Y by tapping AUTO. Then tap SET to exit.

Section 6 - Data Formats, Diagnostics

Navigation Data Input Formats

Output of GPS; input to FS-460. The FS-460 automatically configures itself for one of three industry standard data formats:

Format	Baud rate	
NMEA-183 (Marine Navigation Data Format)	4,800	This is the format for most handheld GPS receivers. Loran must have sentences RMA & RMB. GPS must have sentences RMB & RMC.
Aviation Data	9,600	"Output sentence type 1" Required sentences are: A, B, C, D, E, I and L

Format		first character identifier byte. Sentence terminator may be either <CR><LF> or <CR> alone.
Northstar (Northstar binary)	1,200	M1 setup select “NO EXTENDED”, “NAV ONLY”

Setting GPS-C Communications Output Format

GPS-C Input to GPS; output of FS-460

0	No fuel data output
1 *	Garmin (Shadin Miniflow format)
2 *	Allied Signal (format B)
3	Arnav/EI fuel data
4	Allied Signal (format C)
5	(Not used)
6 *	UPS fuel/air data

* Recommended formats.

GPS Interface Diagnostic Messages

Parameters REQ - RES - MPG are all missing from the scan.	No communications from GPS receiver to FS-460. Possibly no connection or aircraft GPS is off, or GPS not enabled to output data.
GPS -COM message and parameters REQ - RES - MPG are missing from scan.	Communications are received by FS-460 and the Auto-Protocol setup is in process. Verify correct output format setup in GPS receiver; check GPS connections.
GPS -SIG message and parameters REQ - RES - MPG are missing from scan.	GPS receiver has insufficient signal for valid data.
GPS -WPT message and parameters REQ - RES are missing from scan.	No waypoints are programmed into the aircraft GPS receiver.
--- replaces REQ or RES	Number is larger than can be displayed.

Navigation Data (output of GPS; input to FS-460)

Compatible with RS-232, TTL, RS-423, RS-422 SDA.

Serial data format 8 data, 1 start, no parity. Baud rates: 1,200, 4,800, or 9,600 depending on the GPS data output format. The FS-460 automatically detects the GPS data output format and is independent of the GPS-C setting.

Fuel Data (input to GPS; output of FS-460)

Serial data format 8 data, 1 start, no parity. Baud rate: 9,600.

Output format is determined by the GPS-C setting, but may be over-ridden by the GPS navigation format: If the FS-460 senses Northstar or NMEA-183 navigation data input, there will be no fuel data output.

Section 7 - Rear Panel Connector Pin Assignments

Rear Fuel Flow 9-pin connector

Pin no.	Function
1	Power 12-28VDC (red)
2	Ground (black)
3	FF transducer power (red)
4	Remote alarm
5	FF transducer ground (black)
6	RS-232 out (to GPS)
7	Left FF transducer signal (white)
8	Right FF transducer signal (white)
9	RS-232 in (from GPS)

Interface connections to selected GPS models

EDM	P4 conn Pin 1	P4 conn Pin 2
Arnav 5000	Pin 4	Pin 5
Garmin 195	(nc)	Pin 4
Garmin 430 / 430	Pin 57	Pin 56
Northstar M3P	(nc)	Pin 6 (leave pin 11 open)

UPS GX50 / 60	Pin 4	Pin 5

Section 8 - Technical Support

JPI offers both e-mail and telephone technical support. Have your model and serial number ready when you call. Call **JPI** for a return authorization number before returning any equipment.

J.P.INSTRUMENTS
3185B Airway, Costa Mesa, CA 92626
800 345-4574
714 557-3805
www.jpinstruments.com

Limited Warranty

J.P. Instruments, Inc. (JPI), warrants all parts in your new FS-460 to be free from defects in material and workmanship under normal use. Our obligation under this warranty is limited to repair or exchange of any defective part of this unit if the part is returned, shipping prepaid, within two years for electronics and one year for probes from the date of original purchase. Installation labor is the responsibility of the aircraft owner. Homebuilt aircraft warranty starts when the aircraft is certified for flight. Replacement parts carry a warranty for the balance of the warranty period.

Under this warranty, JPI is not responsible for any service charges, including removal, installation, nor any other consequential damages. JPI incurs no obligation under this warranty unless a Warranty Registration Certificate describing the warranted product has been completed and mailed to JPI with all information requested.

This warranty is void on any product which has been subject to misuse, accident, damage caused by negligence, damage in transit, handling or modification which, in the opinion of JPI, has altered or repaired the product in any way that effects the reliability or detracts from the performance of the product, or any product whereon the serial number has been altered, defaced, effaced or destroyed.

This warranty is in lieu of all other warranties expressed or implied and other obligations of liability on JPI's part, and it neither assumes nor authorizes any other person to assume for JPI any other liability in connection with the sale of JPI products.

To initiate this warranty, the aircraft owner must submit a completed Data Logging Worksheet to JPI. Upon receiving a completed worksheet, JPI will initiate the warranty from the date of original purchase. Any replacement parts carry a warranty that extends for the balance of the period of the original warranty. For homebuilt aircraft the warranty period begins when the aircraft is certificated for flight and noted on the warranty card.

Index

H

I

K

L

M

N

O

P

R

S

T

U

W

Z

FS-460 Specifications

FAA Approved
Fuel Flow Transducer:
STC SA00432SE

Operating Temperature Range:
-40 to 195 ^{O}F

Display Size:
2 1/4 in panel mount
2.6 in. sq., 2.5 in. deep incl. conn.

Resolution and Display Range

display	maximum display value	resolution
K factor range:	5,000 to 99,990	10
Fuel flow:	Accuracy (8 to 60 GPH)	1 %
	140.0 GPH at K factor 85,000	0.1 GPH
	410.0 GPH at K factor 29,000	0.1 GPH
	820 PPH at K factor 85,000	1 PPH
	2400 PPH at K factor 29,000	1 PPH
	560 LPH at K factor 85,000	1 LPH
	1640 LPH at K factor 29,000	1 LPH
Fuel Remaining:	999.9 gal	0.1 gallons
	999 pounds., liters	1 pound., liter
Fuel Used:	999.9 gal.	0.1 gallons
	9999 pounds., liters	1 pound., liter

Time to Empty:	50 hours	1 minute

FS-460 Quick Reference Card

Reset Alarm

Temporary reset (next 10 minutes): tap STEP.

Reset for remainder of flight: hold STEP until the word OFF appears.

Reset Fuel Used

1. Tap STEP until USD indicator lights up.

2. Hold AUTO for 3 seconds to reset fuel used to 0.

No Fuel Added

1. On initial power up see:

FILL?
NONE

2. Tap STEP to exit.

Totalize Fuel Used

1. Hold both STEP and AUTO until you see:

PROGRAM
MODE

immediately followed by:

FUEL? N

2. Tap STEP four times and see:

TRIP ? N

3. If you want to accumulate the fuel used, tap AUTO and see:

TRIP ? Y

4. Tap STEP a few times to exit.

FS-460 Quick Reference Card

Filled Tanks

In flight do steps 1, 2, 3 first (on power up skip to step 4)

1. Hold both STEP and AUTO until you see:

PROGRAM
MODE

immediately followed by:

FUEL? N

2. Tap AUTO and see:

FUEL? Y

3. Tap STEP.

4. See:

FUEL IN GALLONS

immediately followed by:

FILL?
NONE

5. Tap AUTO and see:

FILL
75*

(with aux tanks or tabs, Tap AUTO again and see:

FILL
125*

6. Tap STEP to exit.

(* Your tank capacity)

Added or Removed Fuel

In flight do steps 1, 2, 3 first (on power up skip to step 4)

1. Hold both STEP and AUTO until you see:

PROGRAM
MODE

immediately followed by:

FUEL? N

2. Tap AUTO and see:

FUEL? Y

3. Tap STEP.

4. See:

FUEL IN GALLONS

immediately followed by:

FILL?
NONE

5. Tap AUTO 2 or 3 times, see:

FILL
ADD

6. Tap STEP and see:

ADD 0GALS

Hold AUTO to increase;
Tap AUTO to decrease.

7. Tap STEP to exit.