

masEquipping a Homebuilt for IFR Operations

The Experimental/Amateur-Built (aka homebuilt) segment of general aviation has grown and expanded over the years. It's now quite common for the performance and capabilities of homebuilts to meet and often exceed that of factory-built aircraft. One area where this is especially apparent is cross-country flying.

As the cross-country capability of homebuilts has grown, the need to deal with weather has become more of an issue. Thus, more and more builders are asking the question "what equipment is required to qualify a homebuilt for IFR operations?" In order to answer that question, we need take a look at the regulations as they apply to experimental/amateur-built aircraft, as well as other documentation and guidance the FAA has provided.

Minimum requirements;

The operation of a homebuilt aircraft is most directly governed by its Operating Limitations. These Operating Limitations are issued along with and as a part of the airworthiness certificate when the aircraft is initially inspected and licensed by the FAA. This is where the pilot must look in order to verify whether the aircraft is approved for a particular type of operation (i.e., IFR, aerobatics, etc.)

In order for the aircraft to be approved for IFR operations, the Operating Limitations must contain the following or a similarly worded statement:

"After completion of phase I flight testing, unless appropriately equipped for night and/or instrument flight in accordance with § 91.205, this aircraft is to be operated under VFR, day only."

The entry specifies that the aircraft can be operated under IFR once the initial flight test period is complete, so long as it's equipped in accordance with 14 CFR Part 91, section 91.205. This is the regulation that spells out the minimum equipment required for day/VFR, night/VFR, and IFR flight operations. Normally, section 91.205 would not apply to a homebuilt because it specifically refers to "powered civil aircraft with standard category U.S. airworthiness certificates". However, the above operating limitation makes it applicable to homebuilts IF you want to use it for IFR.

Paragraph (d) of 91.205 speaks directly to IFR operations:

(d) *Instrument flight rules.* For IFR flight, the following instruments and equipment are required:

- (1) Instruments and equipment specified in paragraph (b) of this section, and, for night flight, instruments and equipment specified in paragraph (c) of this section.
- (2) Two-way radio communications system and navigational equipment appropriate to the ground facilities to be used.
- (3) Gyroscopic rate-of-turn indicator, except on the following aircraft:
 - (i) Airplanes with a third attitude instrument system usable through flight attitudes of 360 degrees of pitch and roll and installed in accordance with the instrument requirements prescribed in §121.305(j) of this chapter; and
 - (ii) Rotorcraft with a third attitude instrument system usable through flight attitudes of ± 80 degrees of pitch and ± 120 degrees of roll and installed in accordance with §29.1303(g) of this chapter.

- (4) Slip-skid indicator.
- (5) Sensitive altimeter adjustable for barometric pressure.
- (6) A clock displaying hours, minutes, and seconds with a sweep-second pointer or digital presentation.
- (7) Generator or alternator of adequate capacity.
- (8) Gyroscopic pitch and bank indicator (artificial horizon).
- (9) Gyroscopic direction indicator (directional gyro or equivalent).

While much of this regulation is straightforward and self-explanatory, there are a few areas that leave some room for confusion and/or interpretation. Most of the confusion arises from the requirement for certain “gyroscopic” instruments.

What is a gyro?

The often-asked question is, what constitutes a “gyroscopic” instrument. Is an instrument containing an actual rotating mass gyro required, or are alternatives such as ring laser gyros or accelerometer-based instruments acceptable? Unfortunately, there is no specific definition of a gyroscopic instrument to be found in any FAA regulation or guidance document.

In order to try to answer this question, the EAA contacted the FAA Small Airplane Directorate in Kansas City, MO. The Small Airplane Directorate confirmed that there is no published guidance on this subject, but indicated that the function of the instrument is the main consideration. Any instrument that performs the function of the required gyroscopic instrument and presents info to the pilot in the same manner as the gyroscopic instrument will meet the requirement of 91.205, regardless of what mechanical or electronic means are used to generate the information and display.

What about TSO's?

Another question to be answered is what, if any, of the equipment needs to be “TSO'ed”. In order to address this question, it's helpful to understand what a “TSO” is. TSO stands for Technical Standard Order, which is defined in 14 CFR Part 21, section 21.601(b)(1) as “...a minimum performance standard for specified articles (for the purpose of this subpart, articles means materials, parts, processes, or appliances) used on civil aircraft.” As you can see from this definition, a TSO is actually a performance standard to which an article can be manufactured.

When someone says an article is “TSO'ed”, what they really mean is that the unit was manufactured under a TSO authorization. Section 21.601(b)(2) says, “A TSO authorization is an FAA design and production approval issued to the manufacturer of an article which has been found to meet a specific TSO”. You'll note that the TSO and TSO authorization deal specifically with design and manufacture, and have nothing to do with installation or operation.

Now we have an idea what a TSO is, but we still haven't answered the question of whether or not our instruments and avionics in a homebuilt need to be “TSO'ed”. Our Operating Limitations state that we have to equip the aircraft in accordance with 91.205, and 91.205 lists the minimum equipment required, but nowhere is there mention of a requirement for TSO'ed equipment. Thus, the answer is NO, the instruments and equipment installed in your homebuilt under the requirements of 91.205 are not required to be “TSO'ed”.

So far, so good, but that's not the whole story. Most builders who plan to equip their homebuilt for IFR operations don't stop at the minimums, so let's take a look at some of the other commonly installed equipment and see what's required.

Transponders and related equipment;

One item that will be high on the list of desired equipment will be a transponder. It's interesting to note that 91.205 does not list a transponder as required in order to operate under IFR. While this is true, our current airspace system as well as the advantages for use in both IFR and VFR operations makes a transponder a popular choice for builders when outfitting their aircraft.

The requirements for transponder equipment and operation are found in 91.215, which has this to say:

(a) All airspace: U.S.-registered civil aircraft. For operations not conducted under part 121 or 135 of this chapter, ATC transponder equipment installed must meet the performance and environmental requirements of any class of TSO-C74b (Mode A) or any class of TSO-C74c (Mode A with altitude reporting capability) as appropriate, or the appropriate class of TSO-C112 (Mode S).

Note that, while it is required that the transponder equipment meet the performance and environmental requirements of the applicable TSO, it is not required that the equipment be manufactured under a TSO authorization. In theory, this means that you could actually build your own transponder, so long as you can document that it meets the requirements of the applicable TSO. However, the easiest way to be assured that your transponder meets the requirements of 91.215(a) is to install one that has been built under a TSO authorization.

The requirements for altitude reporting equipment associated with the transponder are called out in 91.217(c), which states that, the altimeters and digitizers must meet the standards of TSO-C10b and TSO-C88, respectively. TSO-C10b applies to the sensitive altimeter itself, and TSO-C88 applies to the automatic altitude reporting equipment. Again the equipment is required to meet the standards of the applicable TSO's, but not necessarily be produced under a TSO authorization. But as with the transponder, the easiest way for a builder to meet this requirement is to install equipment manufactured under a TSO authorization.

Remember that, in order to legally operate this equipment under IFR, you must also comply with the maintenance and testing requirements of parts 91.411 (for altimeter and altitude reporting equipment), and 91.413 (for the transponder). Note that the requirements of 91.413 apply even if the aircraft is operated only under VFR.

What about GPS?

Global Positioning System (GPS) is becoming a very popular navigation tool for both VFR and IFR flight operations. Many aircraft, including homebuilts, now sport GPS equipment in their instrument panel. Some of these units are approved for IFR operations, and the FAA has recently updated their guidance on how to approve the installation of GPS equipment in individual aircraft.

This guidance comes in the form of FAA Advisory Circular 20-138A, titled "Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment". The purpose of this AC is stated as providing "guidance material for the airworthiness approval of Global Navigation Satellite System (GNSS) equipment. Like all AC material, this AC is not mandatory and does not constitute a regulation. It is issued for guidance purposes and to outline a method of compliance with the rules. In lieu of following this method without deviation, the applicant may elect to follow an alternate method, provided the alternate method is also found by the Federal Aviation

Administration (FAA) to be an acceptable means of complying with the requirements of the federal aviation regulations (Title 14 of the Code of Federal Regulations, 14 CFR).”

It is important to note that, while GPS is being used as a stand-alone navigation system in type certificated aircraft, operators of homebuilt aircraft are still required to operate within the aircraft's operating limitations. As mentioned above, these operating limitations require us to equip the aircraft in accordance with 91.205, which included the following requirement:

“Two-way radio communications system and navigational equipment appropriate to the ground facilities to be used.”

This statement tells us that our primary navigational equipment must be based on ground facilities (primarily VOR). As this is the case, a homebuilt with only a GPS installed would not be legal for IFR operations.

The guidance contained in AC 20-138A is based on FAA regulations contained in parts 21, 23, 25, 27, 29, 43, 91, 121, and 135. Of these regulations, only part 91 applies to homebuilt aircraft. However, the info in the AC is still a valuable tool for the builder who wishes to install a GPS unit, as it contains accuracy and testing criteria that can be used to verify that the installation meets the performance requirements acceptable to the FAA.

As with transponders and other equipment discussed previously, GPS equipment must meet the performance requirements of the applicable TSO (in this case, C129), but there is no specific requirement for the equipment to be built under a TSO authorization. However, if the equipment is not built under a TSO authorization, it is up to the owner/operator to verify and document that the equipment performs within the required specifications. It is also the owner or operator's responsibility to document the necessary flight-test data showing that the installation performs within the required accuracy parameters.

The bottom line;

All of this leads us to the conclusion that none of the equipment installed in a homebuilt aircraft is required to be built under a TSO authorization. But in most cases, it's to the builder's advantage to install “TSO'ed” equipment if possible. Also, FAA guidance aimed toward type certificated aircraft can be used by the builder when installing equipment in a homebuilt, even though many of the regulations referenced in the FAA guidance do not directly apply to the homebuilt aircraft.

Legal equals safe?

So far we've been talking about the regulatory requirements of equipping a homebuilt aircraft for IFR operation. But is simply meeting the minimum requirements the way to go? Do you really want to fly your homebuilt "in the soup" with only the minimum required equipment installed? It would certainly be legal to do so, but some thought should certainly be given to overall flight safety as well as cockpit/crew resource management when deciding how to equip a homebuilt for IFR flight.

With that thought in mind, it's important to note is that the minimum equipment called out by 91.205 does not include any kind of system backup or redundancy. Most aircraft that are routinely used in instrument meteorological conditions (IMC) have a safety margin built in by using separate systems to power some instruments. This is commonly accomplished by using a vacuum or pressure system to power some instruments, while other instruments are powered by the aircraft's electrical systems. However, aircraft that are "all electric" are becoming more common. These aircraft will typically have dual (or sometimes triple) redundancy built in, with multiple power sources (alternators or generators), multiple supply systems (i.e., separate bus bars, etc.), and dual batteries. An owner/operator who plans to operate a homebuilt in IMC should give serious thought to building redundancy into the aircraft.

Summing up;

As mentioned at the outset, equipping a homebuilt aircraft for IFR flight is becoming more and more common. Avionics advances make this option even more attractive than just a few short years ago. We urge builders and owners of homebuilts to consider safety as well as regulatory requirements when choosing what equipment to install in their aircraft.