

# SECTION 3iS/U: TOOLS AND WORKSPACE

While building an RV requires some investment in special tools, most builders with home workshops already own many of the basics. In addition, there are a number of tools which are nice to have, but not essential. The RV-12iS has been specifically designed to minimize the need for an extensive tool list. See the RV-12iS Required Tool List for the tools specifically required for RV-12iS construction on Page 03-02. Tools marked with an "\*" are on the required tool list.

Unless you live in a major metropolitan area, you probably have to order specialized tools by mail or online. Several mail order tool houses offer excellent quality and service. Van's surveyed RV builders about the quality and service provided by the various mail order tool houses. The results generally agreed with the old adage: "you get what you pay for." Inexpensive tools often proved to be of inferior quality, resulting in frustration and poor results. We have supplied a list of tool suppliers in our printed and online catalogs.

## STATIONARY TOOLS

**Bench Grinder:** A bench grinder with a Scotchbrite polishing wheel is extremely useful. While the edges of sheet metal parts can be deburred and/or sanded smooth, the grinder will save many hours. Grinders with totally enclosed motors will endure the abrasive dust better.

**Belt sander:** Many builders report that a benchtop 1" belt sander is one of their most used tools. Most of the jobs it does could be accomplished with a file and sandpaper, so it is not essential, but it will save a lot of time.

**Air Compressor:** Output and tank volume are not critical, but it should be capable of 75 psi. If you plan to use rotary air tools like air drills or die grinders, a larger tank (20 gallons or more) will keep the compressor from running continuously. Any 1 1/2 to 2 hp home shop compressor with enough volume to power a spray gun will be adequate.

**Band Saw:** Another non-essential but handy tool.

**Drill Press:** One of the most useful auxiliary tools. Kit builders can manage without, but will find many uses if they have one.

## HAND TOOLS

**\*Hand Held Drill Motor:** A 1/4 or 3/8 electric hand drill will do. A variable speed reversible drill is better. Battery drills can be convenient, and some of the high power, high rpm models do an excellent job. A minimum of 1100 to 1200 rpm are necessary. Two or more electric drill motors is a good idea. For instance, you might have a drill bit in one, and a machine counter-sink in another. They are cheap enough to make this convenience affordable. Air drills are preferred by many builders because of their small size, high speed, and variable speed feature. They do use a lot of air, however, so plan on having a compressor with a larger tank.

**\*Drill Bits:** The basic tool of RV building. We have found that High Speed Steel bits work well for small holes. "Split point" drill bits, either the 118 deg or the 135 deg, work especially well, giving a clean start and a round hole. Split points almost eliminate the ugly "worm track" left when a bit does not start cleanly and spins off across the workpiece. Plexi or plastic drilling bits are designed to minimize the risk of chipping or cracking.

**\*Unibits:** Also known as stepdrills. Drilling holes larger than 1/4" in thin sheet metal with a twist drill often results in distorted holes or parts. The Unibit cuts these larger holes in sheet aluminum cleanly and quickly, and also work very well in plexiglass. They are stepped in 32nds and 16ths.

**\*Deburring Bits:** Several styles are available. A hand swiveling type is inexpensive and works well. Adapters that fit deburring bits to slow turning electric screwdrivers and hand drills have become popular for large jobs, such as deburring big skins. Three flute deburring cutters are widely available and generally work well, but they do have a tendency to chatter. Single flute deburring bits work beautifully.

**\*Dimple Dies:** Many of the skins are too thin to machine away metal for the countersunk rivets and screws, and dimpling is required. Dimple dies, made from high quality tool steel, come in male/female pairs. Used in a squeezer, they form rivet shaped depressions in sheet metal.

**\*Hand Seamer:** Required for bending small tabs and flanges, and for straightening or re-aligning major flanges.

**\*MicroStop Countersink:** Or "machine countersink cage". This tool holds a piloted cutter and has a micro-adjustable sliding sleeve to set the depth of cut. Only one is necessary, but two, set up with different cutters, are a nice convenience.

**\*Cleco Fasteners:** Cleco is a trade name which has come into common use to mean Temporary Sheet Metal Fastener. This is a little cylindrical shaped device about the size of a 45 caliber bullet. It has a spring loaded barbed pin in the end which fits into a drilled hole in two or more thicknesses of sheet and locks them together. More is better....many builders measure them by the quart.

**\*Cleco Pliers:** As the name implies, this is a pliers-like tool used for installing and removing temporary sheet metal fasteners.

**\*C-Clamps:** About 2" size.

**\*Other Clamps:** You can never have too many spring clamps. They are a quick and inexpensive way of setting up and holding assemblies together. Do not trust them to hold parts in alignment when drilling -- the springs do not provide enough clamping pressure to resist power tools. There are many types of cam clamps, almost like mini-vice grips available from different manufacturers. They hold much better than spring clamps and are usually a worthwhile investment.

**\*Metal Cutting Snips:** Right hand and left hand offset snips are required.

**\*Pop-Rivet Puller:** Used extensively in RV-12iS construction to set blind or pop-rivets. Most commonly available flush head Blind Rivets (often referred to as Pop-rivets, a trade name) have 120 degree head angles rather than the 100 degree for flush head AN rivets. Thus, special dimple die sets are needed for a perfect fit, although almost all builders we know use regular dimple dies and report acceptable results. We recommend using the "Pop" Riveter PRP-26A, USM Corp., not all rivet pullers will fit into the tighter spaces for RV-12iS construction. Although not required, a pneumatic puller is highly recommended and can be run with a small air-compressor.

**Body File:** Also known as a Vixen file or a SuperShear (Nicholson brand name.) Distinguished by the crescent shaped cutters across the width of the file. Not an absolutely essential tool, but is very useful for smoothing the edges of thicker gauges of aluminum.

**\*Fluting Pliers:** Used for crimping rib flanges, etc. to effectively shrink them and straighten the part. Several styles are available. We prefer pliers that leave a crisp indentation, and avoid the type with the large rubber tips. These make a wide shallow flute which gives less flat area for rivets.

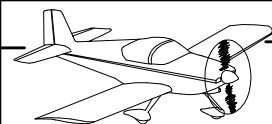
**\*Edge Deburring Tools:** A selection of tools as listed in the required parts list. Deburring tools are used for rounding and smoothing the edges of sheet metal parts.

**\*Hand Rivet Squeezer:** Used for dimpling and setting rivets near material edges. There are cheap ones on the market, but they give poor results. Spend the money.

**Paint Spray Gun/Respirator:** Priming of internal parts of an RV requires a spray gun. Almost any quality gun will do because primer finishes are not as critical as exterior painting. One of the biggest problems involved in priming is cleaning up. Often only a small amount of priming is needed. Small spray guns with disposable cup reservoirs are adequate for priming. Clean up of the spray nozzle is very simple, and the spray pattern quality is more than adequate for priming. Respiratory protection from primers and paints should not be taken lightly. Those warnings are on paint cans for a reason! A good respirator (not a dust mask) is essential. "Fresh air" spray systems, using an oil-less compressor to supply fresh air from a remote source to a respirator or spray helmet, have recently become affordable.

**\*Files:** A minimum of 3 or 4 will do. Small round, flat, and flat-face/round back.

**\*Torque Wrench:** This is a must have tool. Get one calibrated in inch-pounds, a foot pound wrench will do you no good. Aircraft nuts and bolts have specific torque values (see the Standard Aircraft Handbook or the table reprinted in Section 5 of this manual) that can only be set accurately with this tool. It is very easy to over torque the small AN3 (10-32) bolts without one.



\***Taps:** Used to add internal threads to drilled holes. See required tool list for specific sizes.

\***Tubing bender:** Although there are not a lot of aluminum tubes in the RVs, those that are there need to be bent properly. Fuel lines, pitot lines etc. need to be kink free.

\***Tubing Flaring Tool:** Fuel lines need to have the proper 37° flare on the end in order to seal properly. Buy one or borrow one, but don't try to use an automotive 45° tool.

\***Heavy soft faced hammer:** Select one between 12 and 24oz.

All required equipment can be purchased from one of the suppliers listed in our accessories catalog. While other suppliers are available, these have catalogs available which make shopping easier. These catalogs are also useful as a general information source about sheet metal tools. Several of the larger general parts suppliers such as Aircraft Spruce and Wicks publish extensive catalogs which are very valuable not only introducing the builder to the wide variety of hardware, tools, and parts available, but also including useful charts and table of aircraft standards.

Following is a list of tools compiled specifically for building the RV-12iS. While we feel that those tools we have listed are sufficient, some builders (or groups of builders) might have the resources and desire to have a super well equipped shop and should be aware that there is practically no limit to the variety of tools available. Within reason, money spent on good tools is seldom regretted.

**RV-12iS BUILDER'S TOOL REQUIREMENTS**

1X	6" bench vise	1X	1/4-28 tap
10X	Small (2") "C" clamps	1X	5/16-24 tap
4X	Large (3") spring or "pony" clamps	1X	3/8-16 tap
		1X	3/8-24 tap
1X	3/32 rivet dimple die set (with a reduced dia. female die)	1X	4-40 tap
		1X	6-32 tap
1X	1/8 protruding head rivet set (tall, 1/2" thick)	1X	8-32 tap
1X	1/8 rivet dimple die set (100°)	1X	10-24 tap
1X	#8 screw dimple die set	1X	T-handle for taps
2X	Flush head rivet set (short, 1/8" thick)		
1X	Flush head rivet set (tall, 1/2" thick)	350X	#30 clecos
		50X	#40 clecos
1X	#3 drill bit	1X	Cleco pliers
1X	#11 drill bit		
2X	#12 drill bit	1X	Deburring countersink tool with flute cutter
1X	#16 drill bit	1X	Multi-burr deburring tool (Royal style)
2X	#19 drill bit	1X	Screwdriver with #2 Phillips bit
1X	#20 drill bit	1X	Combination wrench set (1/4"-3/4" & 10mm-17mm)
1X	#27 drill bit	1X	Allen wrenches, assorted (inch & metric)
3X	#30 drill bit		
1X	#43 drill bit	1X	Feeler gauges: .012-.016in.
1X	12" extension drill #30		
1X	#36 drill bit	1X	Fish scale (0-50lbs)
5X	#40 drill bit		
1X	#52 drill bit	1X	Files (assorted)
1X	1/4" drill bit		
1X	5/16" drill bit	1X	Fluting pliers
1X	Q or 11/32nd drill bit		
1X	3/8" drill bit	1X	Hacksaw with fine tooth (32 teeth per inch) blade
1X	1/4" to 3/4" X 1/16 step drill (Unibit)		
		1X	Hand blind rivet puller "POP" Riveter PRP-26A, USM Corp
1X	100° machine countersink cutter with #12 pilot	1X	Hand solid rivet squeezer with 3" yoke
1X	100° machine countersink cutter with #19 pilot		
1X	100° machine countersink cutter with #27 pilot	1X	Hand seamer
1X	120° machine countersink cutter with #30 pilot		
1X	100° machine countersink cutter with #30 pilot	1X	Heavy soft-faced hammer
1X	100° machine countersink cutter with #40 pilot		
1X	Countersink cage		

**RV-12iS BUILDER'S TOOL REQUIREMENTS (CONTINUED)**

1X	Torque wrench (inch pounds scale)	1X	Carburetor synchronizing tool
1X	12' tape measure	1X	1/4" drive socket set (with inch & metric sockets)
1X	Needlenose pliers	1X	Socket and ratchet handle for 1 1/4" nut (big!)
1X	Diagonal cutter	1X	Socket 19mm (3/4in)
		1X	Allen Sockets: 4mm, 5mm, 8mm
1X	Olfa RTY-2/G 45mm Rotary Cutter (or equivalent)	1X	Aviation flaring tool (tube)
		1X	Tubing cutter
1X	Left hand offset metal cutting snips	1X	Tubing bender
1X	Right hand offset metal cutting snips		
		1X	Battery powered drill motor
1X	Wire crimper/stripper		
1X	D-Sub electrical connector (4 way indent) pin crimping tool	1X	Cable tensiometer
1X	Multimeter (with continuity check capability)		

**RV-12iS BUILDER'S SUPPLIES REQUIREMENTS**

SUB-KIT	QTY	ITEM	SUB-KIT	QTY	ITEM
All	1 box	Sharpie pen - fine point; blue or black	Finish	1X	Balloon (Fuel tank test)
All	1 box	Sharpie pen - extra fine point; blue or black	Finish	1X	8 x 36 Protective paper
Emp	1 roll	String	Finish	1X	8 1/2 x 11 sheet of 60 grit sandpaper
Emp	1 tube	Super glue	Finish	2X	8 1/2 x 11 sheet of 80 grit sandpaper
Avionics	1 tube	Boelube	Finish	2X	8 1/2 x 11 sheet of 100 grit sandpaper
			Finish	1X	8 1/2 x 11 sheet of 150 grit sandpaper
Fuse	1 can	Pipe Thread Sealant	Finish	2X	8 1/2 x 11 sheet of 220 grit sandpaper
Fuse	1 can	Fuel Tank Sealant			
Fuse	1 tube	Firewall Sealant	Emp	1X	Rectangle sanding block
Fuse	1 tube	Permatex 16BR Black Sil. Adhsv./Seal. #81158	Emp	1X	Cylindrical sanding block; 1 - 1 1/4 Dia.
All	1 tube	RTV Sealant			
Pwr Plnt	1 tube	Clear Silicone			
Pwr Plnt	10 ml	Loctite 221	Finish	3X	1" wide paint brush (cheap, natural bristle type)
Wing	10 ml	Loctite 243	Finish	1X	2" wide paint brush (cheap, natural bristle type)
Pwr Plnt	1 tube	High-temp nickel based anti-seize	Finish	1X	3" wide paint brush (cheap, natural bristle type)
Finish	3 yd	9oz/sq yd plain weave "E-glass" fabric			
Finish	1 yd	Peel ply (optional)			
Finish	1 qt	kit of epoxy resin & hardener			
Finish	1 qt	Acetone (for clean-up)			
Finish	25	Mixing cups (Solo™ clear plastic cups recycle code #1 or #5)			
Finish	50	Craft sticks (a.k.a. popsicle sticks)			
Finish	1/4 lb	flocked cotton fiber (a.k.a. "flox")			
Finish	1/4 lb	glass spheres (a.k.a. "micro-balloons")			
All	1 roll	Low-tack "painters" masking tape			
Finish	1 roll	Mylar Packing Tape			
Finish	1 roll	Duct tape			



## PARTS DESIGNATION SYSTEM

All parts in an RV structure (other than standard aircraft hardware items or common vendor items) have a part number assigned to them. Here is a typical part number, followed by an explanation of the numbering system: W-606A

1. The first letter designates the major portion of the airframe in which the part is used. In this instance, "W" denotes "WING". Other prefixes are: W - Wing, F - Fuselage, HS - Stabilator, VS - Vertical Stabilizer, R - Rudder, A - Flaperon, FF - Firewall Forward, T - Tank, U - Undercarriage, WD - Weldment, C - Canopy.

2. The first number, for example, "6", usually refers to the model, RV-6. Numbers have been allocated in blocks of 100 for our various models and future models. Thus, most 300 series numbers are for the RV-3, 400 series numbers for the RV-4, 1200 series numbers for the RV-12iS, etc. In some cases, however, you will find 400 or even 300 series part numbers in RV-6 plans. In these cases, the part is common to more than one aircraft and to avoid the confusion of having one part with two possible part numbers, we will use only one number.

3. The last number, or last two numbers, refer to the specific part in that airframe component. The example W-606 is the wing spar.

4. The suffix letter is used when a part, such as the wing spar in this instance, consists of two or more assembled parts. In this example, the "A" designates the spar web, to which are riveted W-606B, W-606C, etc., parts.

Raw materials use a different numbering system.

AA Aluminum Angle  
 AB Aluminum Bar  
 AS Aluminum Sheet  
 AT Aluminum Tube  
 PS Plastic Sheet/Strip  
 PT Plastic Tube  
 SS Steel Sheet  
 SSP Stainless Steel Pin  
 ST Steel Tube

The next number denotes the temper, condition or alloy:

0 Soft Aluminum  
 3 T-3 (aluminum)  
 6 T-6 (aluminum)  
 4130 Steel alloy

The number following the dash shows the thickness of the material

-025 0.025"  
 -032 0.032"

Next the size is specified: An example: AS3-032x15x20 shows a part of Aluminum Sheet, temper T-3, 0.032" thick, 15"x20"

When referring to parts for re-ordering or technical assistance purposes, please use the full number so that confusion can be avoided.

Standard aircraft hardware is listed by the most common designation, usually numbers with either AN, MS, or NAS prefixes. "AN" is for Army/Navy, "MS" is for Military Standard, and "NAS" is for National Aerospace Standard. The numbers and letter in an aircraft hardware designation all tell something about the part. For example, one of the most basic is that of aircraft bolts. One example would be an AN3-4A, which means that it is a 3/16" diameter bolt (first number) which is 4/8 (1/2) inch long, has fine threads (std. for aircraft hardware), and has an undrilled shank (A suffix).

It is not our purpose here to list information about all types of aircraft hardware used in an RV. We hope that one or more of the reference texts you purchase as construction aids will provide such listings. Catalogs from aircraft hardware suppliers listed in our accessories catalog usually have a wealth of general information of this nature, and are a valuable reference source even if they are old and prices are out of date.

## WORKSPACE REQUIRED

We rarely encounter builders who feel that they have too much workspace; it's about like having too large a bank account -- there is no such thing! The derivation of the word "Homebuilt" is obvious, and most of us have heard stories of airplanes being built in basements or attics where the walls had to be knocked down to get them out when finished. We expect that some RVs will also be built, or partially built, in some rather strained quarters. However, we suggest that the desired building space be about that of a two-car garage (about 20 x 20 ft). While this is more than enough for building individual airframe components, it will come in handy for storing completed components while others are being built, and for final assembly, etc.

One of the tougher problems is finding a place to spray paint. Some builders choose to corrosion proof their airplanes, and the two part epoxy primers usually used can be toxic, or, at best, unpleasant. A well ventilated spray area, partitioned or in a separate building from the work area is necessary. A corner of the shop cordoned off with plastic sheet and equipped with an exhaust fan is a common solution.

A firm table with a smooth, level surface of about 3' x 6' is needed for RV-12iS construction. You will probably want a larger table or tables than this to hold tools, hardware, and other completed or semi-completed surfaces. Did you ever see anything even vaguely resembling a table top which wasn't immediately cluttered beyond the point of use? Like shop space, you never seem to have enough table space either.

**MECHANICAL DRAWINGS AND MECHANICAL DRAWING READING**

While mechanical drawings are not a tool in the same sense as hammers and saws, they indeed are tools in the contribution they make to the completion of a homebuilt airplane. They are drawings which present a picture of parts and assemblies from one or more viewpoints. Like a written language, mechanical drawings are only useful if the viewer can read them. RV drawings have been prepared using a blend of accepted mechanical drawing practices and presentations which we feel can be most easily understood by the average homebuilder. Individual drawings show what can be seen from a respective viewpoint plus all hidden lines and features. Looking at the front view in Figure 1 below, one can see the presence of hidden lines which can only be clarified by the addition of one or more views. The side view provides enough information to fully understand the shape of the part. The top view provides yet more clarification.

Since a mechanical drawing is composed mostly of lines of one form or another, we must define them. Following is a description of some symbols and lines used.

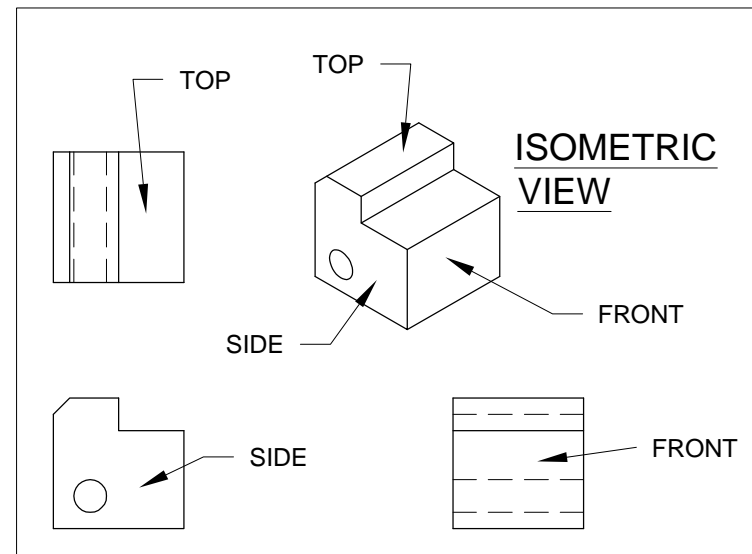
**Solid Line:** Represents a surface or an edge which is visible to the viewer.

**Hidden Line:** Is a uniform line of short dashes representing an edge or surface which cannot be seen by the viewer but is important to present in the drawing.

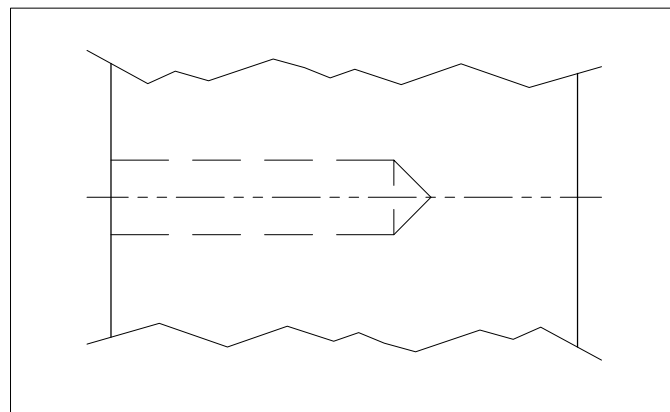
**Phantom Line:** A line of interspaced long and short dashes shows the position that another part will occupy at another state of construction or assembly. It is used to make the builder aware of the relationship of other parts of the structure, without the clutter of an assembly drawing.

**Bend Line:** Indicates the line about which a bend is to be made.

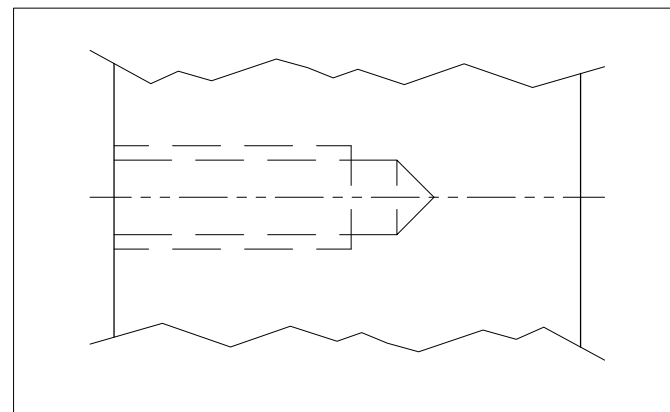
**Section Line:** This is used to indicate a view of a part which could be seen if the part were cut in two and viewed from the direction of arrows at end of the line. The letters correspond to the view located elsewhere on the drawing.



**FIGURE 1: ORTHO VIEWS**



**FIGURE 2: DRILLED HOLE**  
(NOTE THE POINTED TIP)

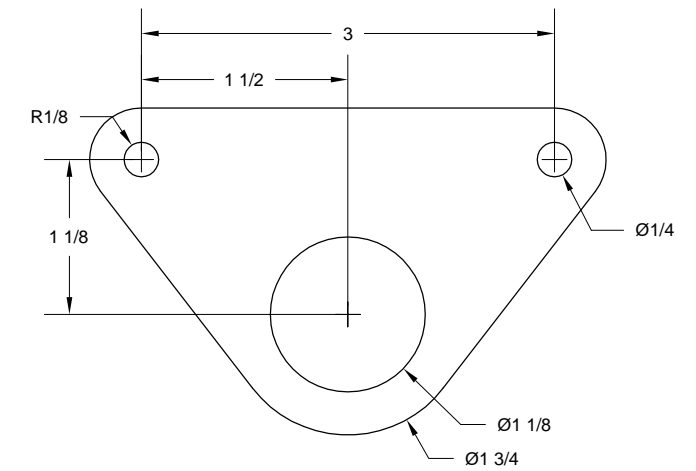


**FIGURE 3: DRILLED AND THREADED HOLE**  
(NOTE DOUBLE LINE SEGMENT INDICATING DEPTH OF THREAD)

**Center Line:** Used for the center line of holes, tubes, discs, and any other part which is symmetrical on each side of the center line. This is a series of long and short dashes.

**Detail "X":** Denotes that the portion of the drawing enclosed within the circle is shown elsewhere in greater detail.

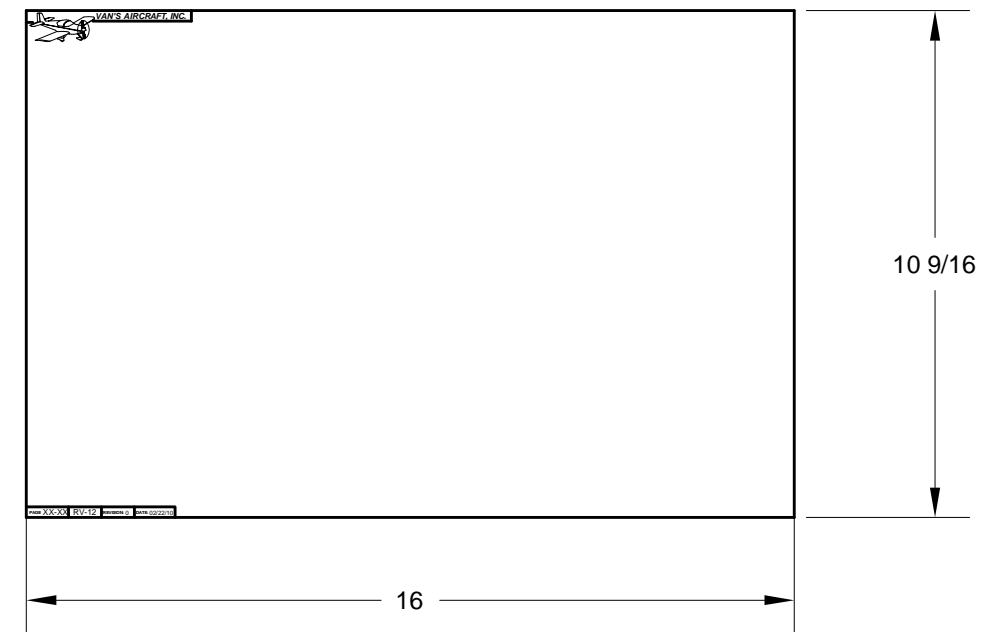
**Dimensions:** Holes and radius parts are dimensioned from the center of the hole or from the center point of the arc describing the rounded surface. Thus, the overall height of the part in Figure 4 is the base to radius center plus the arc radius. The overall height dimension is not usually given, but if it is, would be listed as a reference dimension because the other is primary.



**FIGURE 4: DIMENSIONED PART**

**PLANS PAGE TEMPLATE SCALING**

Some plans pages contain templates that are printed at a scale of 1:1. Double check that a plans page is scaled correctly by measuring the border **before using the template!** A properly scaled border is shown in Figure 5.



**FIGURE 5: BORDER DIMENSIONS**