CHAPTER 5

FIBERGLASS REINFORCED PLASTIC FABRICATION AND REPAIR FACILITIES

5-1 **FUNCTION**. Fiberglass reinforced plastic (FRP) shops and facilities primarily fabricate and repair aircraft and shipboard components. Both include a shop area, a mechanical equipment area, and a decontamination area (for protective clothing).

5-2 **OPERATIONAL CONSIDERATIONS.** FRP fabrication and repair operations include sanding, buffing, fabric cutting, grinding, lay up, and wet spray up. These operations produce dust and vapor that constitute health hazards. The protective clothing that the workers wear and the physical nature of the work creates a potential for heat stress.

a. Consider using airless spray equipment to reduce hazardous vapors in the shop. Initial cost for this equipment is greater than traditional compressed air systems. Benefits include overspray reduction and less accumulation of resin and fiberglass over the life of the equipment. A disadvantage of these systems is their limited pattern and flow adjustment capability.

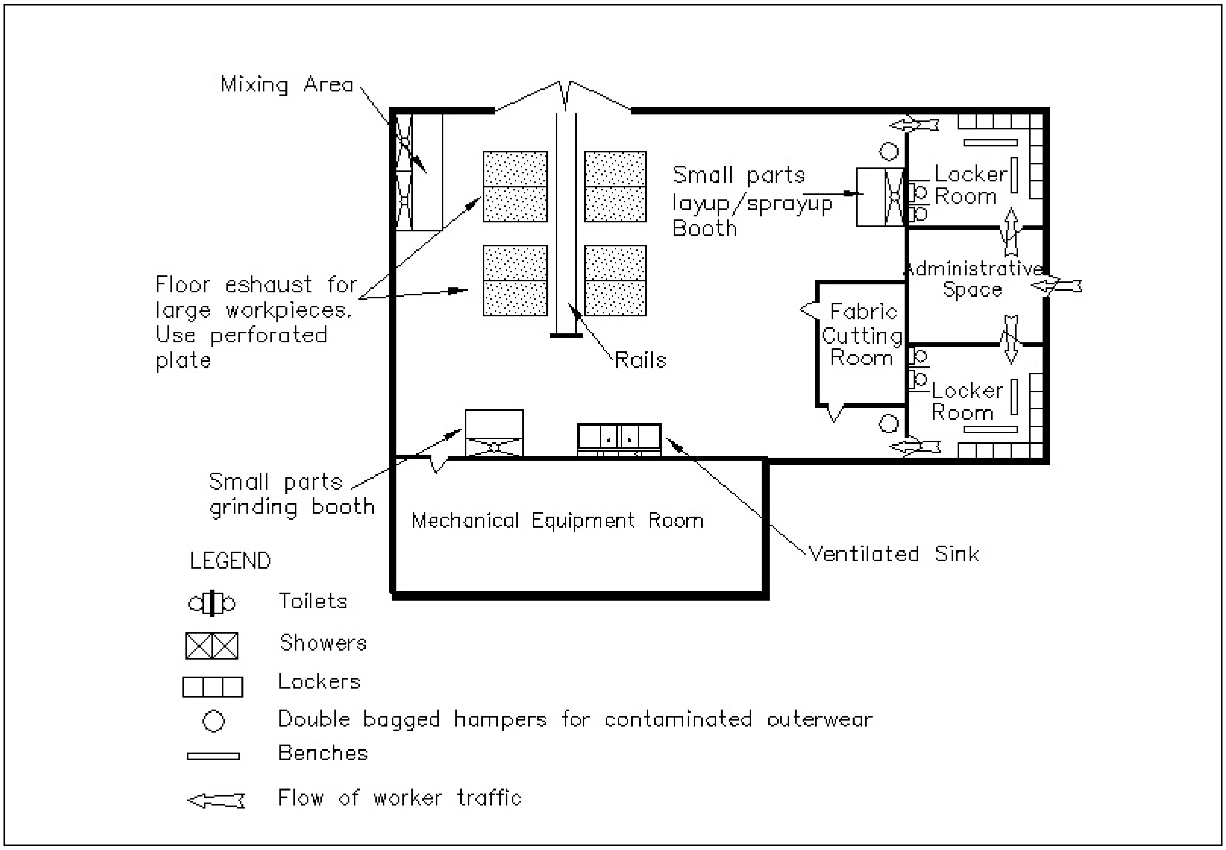
b. Consider using low monomer polyester material, closed molding systems or low-VOC resin systems, and airless and air-assisted spray equipment to avoid the need for expensive air pollution devices.

c. Isolate conventional grinding operations from the mixing areas and the lay up and spray up areas. The combined hazard of dust and flammable vapors is potentially explosive. Post signs in the lay up and spray up areas and the mixing area without low volume-high velocity (LVHV) connectors that read:

DANGER
DO NOT GRIND, CUT, OR SAW
FIBERGLASS IN THIS AREA

5-3 **FLOOR PLAN.** Figure 5-1 shows a typical floor plan for a fabrication and repair facility. The workers enter the clean locker rooms through the administrative area. They put on protective outerwear and proceed to the shop area. After performing their work, shop personnel vacuum, then discard their protective outerwear in containers near the entrances to the locker rooms. The workers then enter the locker rooms where they remove the remainder of their work garments.

Figure 5-1. Floor plan for FRP facility.



5-4 **DESIGN CRITERIA.** Design the facility using general technical requirements in Chapter 2 of this UFC and the specific requirements in this Chapter.

5-4.1 **Exhaust Air System**. Provide an exhaust system that captures contaminated air generated during FRP fabrication and repair operations. Refer to Chapter 2 of this UFC; UFC 3-600-01; NFPA 33, *Standard Spray Application Using Flammable and Combustible Materials*; NFPA 68, *Guide for Venting Deflagrations*; NFPA 91,*Standard for Exhaust Systems for Air Conveying of Materials*; NFPA 654, and the specific requirements of this Chapter.

5-4.2 **Hood Design**. The sizes and shapes of work pieces in FRP fabrication and repair facilities vary. Design separate hoods for processes producing only particulate and only vapor, and both particulate and vapor. Consider a molding system that completely encloses the work piece if the facility repeatedly manufactures the same work piece. Design exhaust hoods to enclose all processes to the greatest possible extent without inhibiting operations. Baffle all exhaust hoods to reduce cross drafts and improve hood efficiency. Table 5-1 summarizes recommended exhaust hoods, capture velocities, and air pollution control devices for each operation.

Table 5-1. Recommended Hood, Capture Velocity, and Air Pollution Device

Operation (expected contaminant)	Hood Type	Recommended Capture Velocity (m/s (fpm))	Air Cleaning Device (see notes)
Chemical Mixing (vapors)	Workbench (Figure 5-2)	0.51 m/s (100)	1
Lay up (Vapors)	Workbench/Floor Exhaust (Figure 5-3)	0.51 m/s (100)	1
Spray up (Vapors)	Spray up Booth (Figure 5-4)	0.51 m/s (100)	1
Grind,Cut,Saw (Particulate)	Workbench/Floor Exhaust (Figure 5-3)	0.76 m/s (150)	2
Cleanup (Vapors)	Ventilated Sink (Figure 5-5)	0.51 m/s (100)	3 or 1
Hand Tools (Particulate)	LVHV Vacuum System	Not applicable	2

NOTES: (1) Determined by the local air pollution regulatory agency,
(2) fabric collector, and
(3) substitute an aqueous emulsion cleaner for acetone.

5-4.2.1 **Plenum Velocity**. Design the plenum velocity at least one-half, but no greater than, the velocity through the perforated plate or layered prefilter to create an even airflow over the hood face. Design the hood-to-duct transition with an included angle of no more than 90 degrees.

5-4.2.2 **Hood Length**. Specify that the length of the hood served by each exhaust plenum will not exceed 2.44 m (8 ft). For example, hoods between 2.44 and 4.88 m (8 and 16 ft) in length will have two exhaust takeoffs. Provide cleanout doors in the plenum to allow removal of accumulated particulate.

5-4.2.3 **Portable Hand Tools**. Use portable hand tools with LVHV vacuum systems for sawing, cutting, and grinding on all work pieces. Ensure that the tools, with their vacuum hoses, are properly sized for the work piece internal angles and curvature. LVHV systems are described in paragraph 5-4.7.

Figure 5-2. Workbench hood.

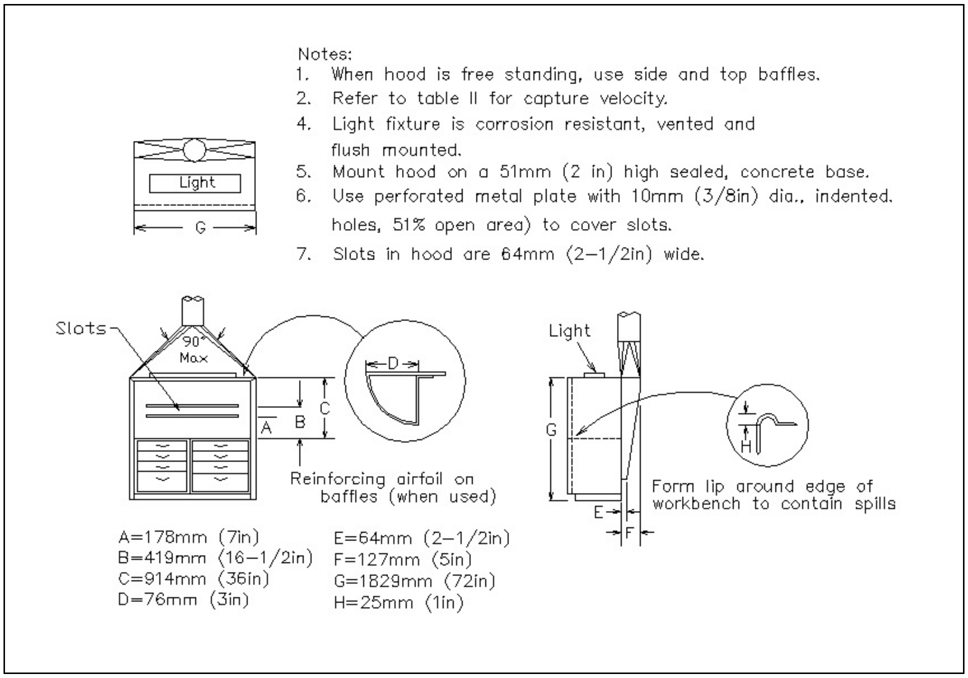
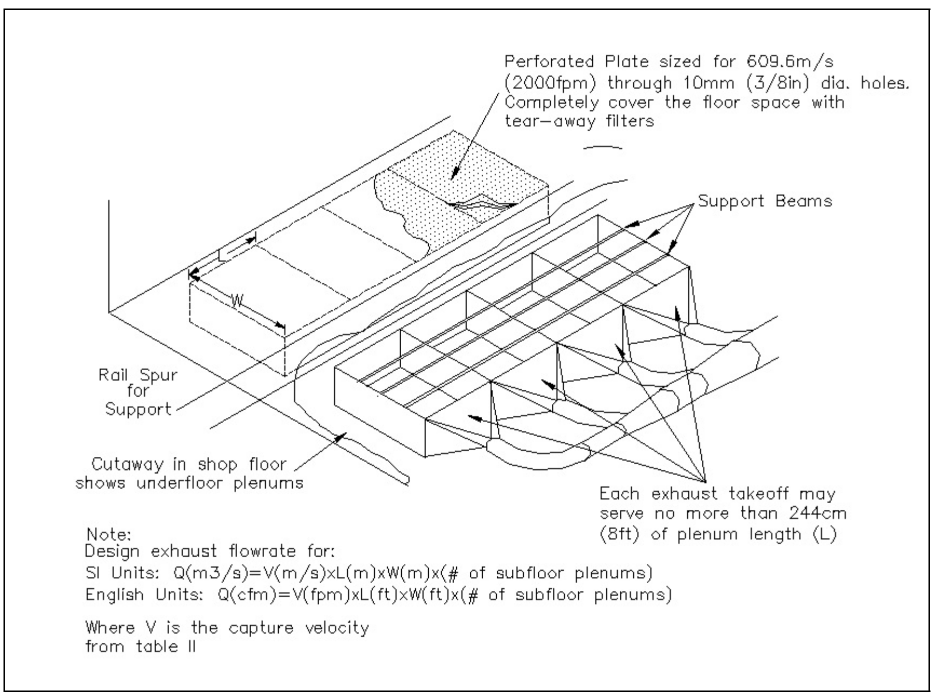


Figure 5-3. Floor exhaust.



NOTE: Mount the work piece on a mechanism for easy rotation. This will reduce the dead air space that occurs when working on raydomes, boat hulls, and other large objects.

Figure 5-4. Spray up booth.

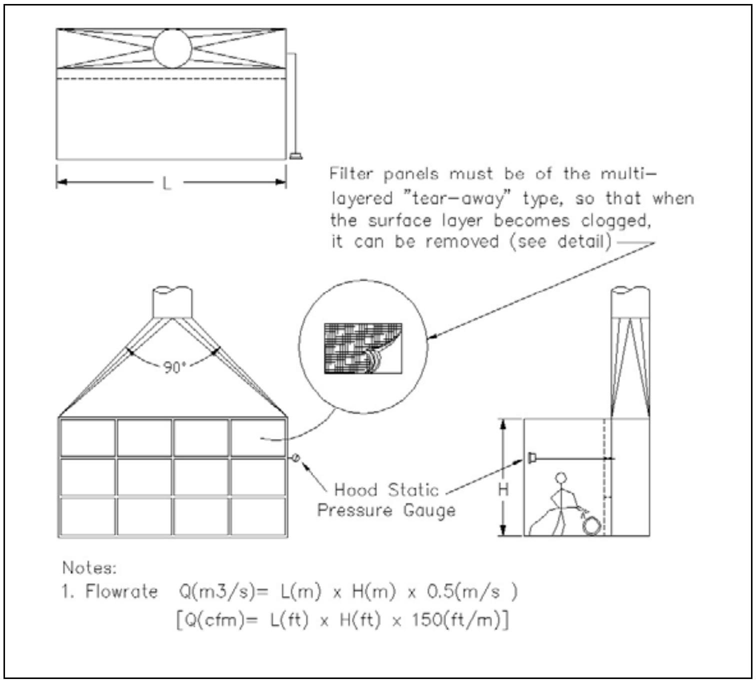
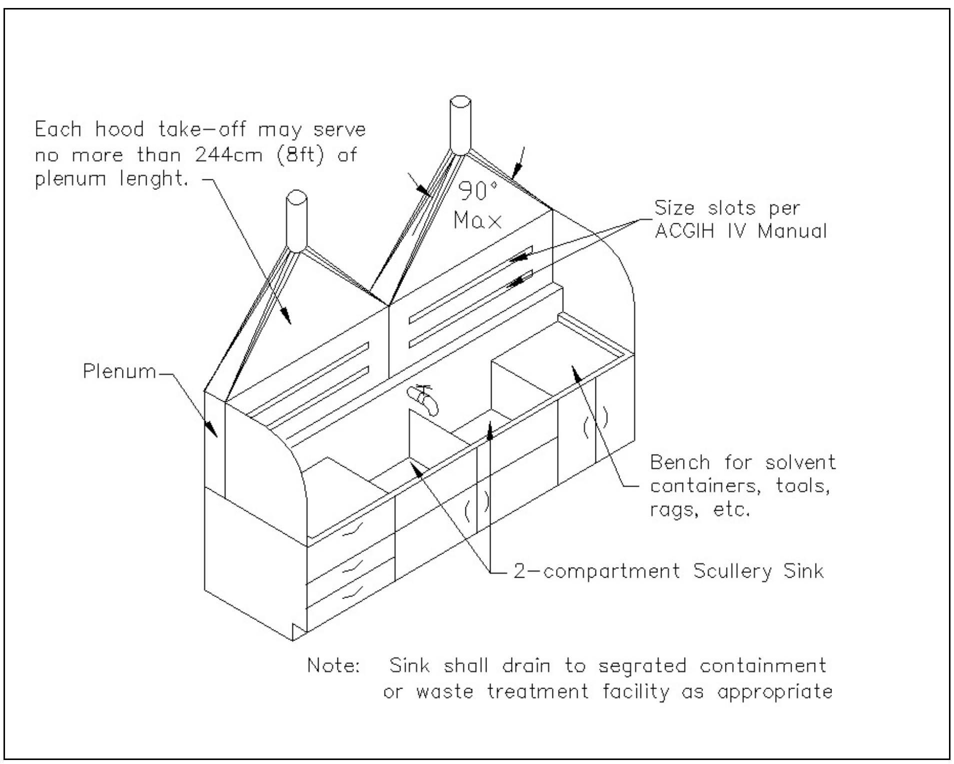


Figure 5-5. Ventilated sink.



5-4.2.4 **Spray Up Booths**. Design a spray up booth as shown on Figure 5-4. Use the spray up hood design in shops where spray up and lay up are performed in the same booth. Separate operations in this booth from any cutting, grinding, and sawing operations when conventional hand tools are used.

5-4.2.5 **Ventilated Workbench and Sink**. Design a ventilated workbench as shown in Figure 5-2 for small work pieces. Use a similar workbench for resin preparation and mixing as shown on Figure 5-5. Eliminate the drawers and increase the size of the hood face by extending it to the floor if 55-gallon drums are used during resin preparation. Use aqueous emulsion cleaners to reduce styrene and acetone exposure.

5-4.3 **Ductwork**. Design a 17.8 m/s (3,500 fpm) minimum transport velocity for LVHV hand tools, and grinding and spray up operations to prevent particulate material from collecting in the ductwork.

a. Size the ductwork carrying vapor generated during lay up and mixing operations for a minimum transport velocity of 12.7 m/s (2,500 fpm). Use sheet metal as duct material since it is non-combustible. Route the ductwork directly to fans located outdoors. See paragraph 2-4.1 for further information on ductwork.

b. Consult with a fire protection engineer and use UFC 3-600-01 to design a fire protection system for the ductwork when required. Condensation of flammable vapors, i.e. styrene and acetone, may occur and pool in the ductwork as it passes through an area with a lower temperature.

5-4.4 **Fans**. See paragraph 2-4.2 for general considerations.

5-4.5 **Weather Stack Design and Location**. See paragraph 2-4.3 for exhaust stack design guidance.

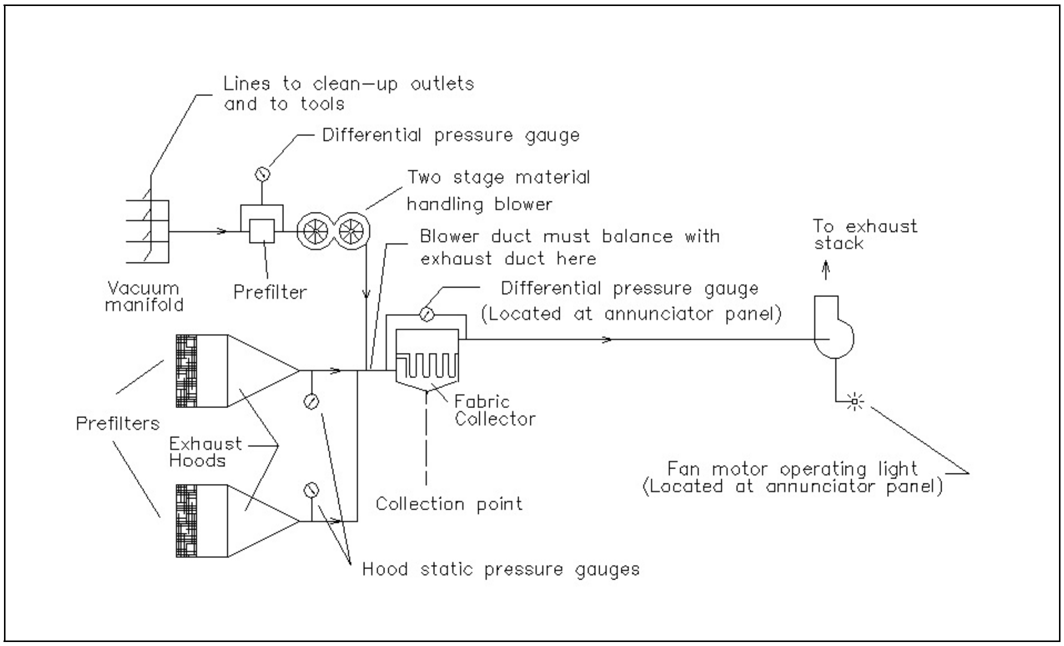
5-4.6 **Air Cleaning Devices**. Use separate air cleaning devices for grinding, buffing and polishing operations where particulate material is generated. Use separate air cleaning devices for lay up and mixing operations where flammable vapors are generated. Consult the air pollution control authorities for details on local requirement.

5-4.6.1 **Grinding Operations and Hand Tools**. Use a fabric collector for grinding operations and LVHV hand tools. Consider using a disposal chute with a motor-driven rotary air lock in shops with a large particulate volume.

5-4.6.2 **Spray Up Operations**. Spray-up operations release a combined contaminant of wet resin laden fiber and organic vapors. Therefore, separate spray up operations from all other operations. Install an air-cleaning device for vapors. Install layered prefilters on the spray up hood face instead of the perforated plate to prevent wet airborne resin from hardening in the ductwork and collectors. Peel off and discard a layer of the prefilter when its surface becomes loaded as indicated by the hood static pressure gauge. This continues until only the base filters remain. After that, replace the entire prefilter section. Specify a filter material that is not damaged by the styrene and acetone vapor produced in FRP facilities.

5-4.7 **Industrial Vacuum System**. Install a vacuum system; see Figure 5-6, to exhaust fibers, dry resin and dust from LVHV hand tools when they are used. The vacuum system also allows workers to conduct shop cleanup and to decontaminate their protective outerwear. ACGIH IV Manual, Chapter 10, gives design details and illustrates power tools using LVHV vacuum systems. The large size and high terminal velocity of the particulates produced by the hand tools requires a high velocity vacuum take-off hood for each tool. Generally, design the takeoff hood into the tool's safety guard.

Figure 5-6. Exhaust system schematic.



5-4.7.1 **Vacuum System Design**. Design the vacuum system in accordance with the following criteria:

a. Ensure each take-off hood produces the proper capture velocity. This is the most important consideration in designing the vacuum system. Design the hood to capture contaminants as close as possible to the point of generation. Design vacuum systems to capture contaminants within 12.7 mm (1/2 inch) of the source.

b. Design the capture air-stream to have a velocity of two to three times the generation velocity for particles of 20 to 30 micrometers (20 to 30 microns.) Design for an additional velocity of:

1. Four to five times the generation velocity to pull the particles up through 300 U.S. standard mesh, or

2. Six to eight times the generation velocity to pull particles up through 20 U.S. standard mesh.

c. Design the air volume for no less than two parts of air to one part of material to be captured by weight.

d. Design the vacuum hose length less than 7.6 m (25 ft). Locate inlet valves 9 to 10.7 m (30 to 35 ft) apart when a 7.6-m (25-ft) length of hose is used. Locate the tool vacuum hose connection on the ends of the workbench underneath the stands. Size the hose based on the following:

1. Air volume per hose.

2. Number of hoses to be used simultaneously.

3. Transport velocities.

e. Use a multistage centrifugal blower for the vacuum system. Size the blower according to the following:

1. The total system pressure loss associated with the total number of hoses to be used simultaneously.

2. The maximum exhaust flow-rate entering the inlet of the blower.

f. Feed the blower directly into the dirty side of the fabric collector, see Figure 5-6, used by the industrial exhaust system to minimizes the number of FRP collection points.

g. Use the manufacturer's data to complete the design because the LVHV system design data is largely empirical.

5-5 **REPLACEMENT AIR.** Design replacement air systems to maintain a pressure (relative to the atmosphere) ranging from -4.97 to -14.9 Pa (-0.02 to -0.06 in wg) in the shop space and the protective clothing decontamination areas. Maintain the clean spaces at a positive pressure relative to dirty spaces. See paragraph 2-4.5 for further details. Provide each ventilated space with a dedicated replacement air system. Conduct a study of the curing requirements of the resin before specifying temperature and humidity ranges. Do not re-circulate exhaust air.

5-6 **SYSTEM CONTROLS.** Design system controls in accordance with paragraph 2-5 and the following:

a. Position the annunciator panel at the entrance to the dirty space so operators can monitor operating gauges.

b. Install static pressure sensors at locations that are representative of the average static pressure in each controlled space. This will ensure that desired differential pressures are maintained.

c. Interlock the hand tool power supply with the ventilation system's on/off switch. This will prevent the use of hand tools without ventilation controls.

5-7 **SAFETY AND HEALTH CONSIDERATIONS.** See paragraph 2-7. Provide combination emergency eyewash and deluge showers in the workspace. See UFC 3-420-01 for performance requirements on combination units.