TABLE 14.35 AIA Guidelines for Vacuum and Air Systems for Hospital Facilities Station Outlets for Oxygen, Vacuum (Suction), and Medical Air Systems in Hospitals*

Location	Oxygen	Vacuum	Medical Air
Patient rooms (medical and surgical)	1/bed	1/bed	—
Examination/treatment (medical, surgical, and postpartum care)	1/room	1/room	—
Isolation—infectious and protective (medical and surgical)	1/bed	1/bed	—
Security room (medical, surgical, and postpartum)	1/bed	1/bed	—
Critical care (general)	3/bed	3/bed	1/bed
Isolation (critical)	3/bed	3/bed	1/bed
Coronary critical care	3/bed	2/bed	1/bed
Pediatric critical care	3/bed	3/bed	1/bed
Newborn intensive care	3/bassinet	3/bassinet	3/bassinet
Newborn nursery (full-term)	1/4 bassinets†	1/4 bassinets[2]	1/4 bassinets[2]
Pediatric and adolescent	1/bed	1/bed	1/bed
Pediatric nursery	1 /bassinet	1/bassinet	1/bassinet
Psychiatric patient rooms	—	—	—
Seclusion treatment room	—	—	—
General operating room	2/room	3/room	—
Cardio, ortho, neurological	2/room	3/room	—
Orthopedic surgery	2/room	3/room	—
Surgical cysto and endo	1/room	3/room	—
Postanesthesia care unit	1/bed	3/bed	1/bed
Anesthesia workroom	1 per workstation	—	1 per workstation
Phase II recovery‡	1/bed	3/bed	—
Postpartum bedroom	1/bed	1/bed	—
Cesarean/delivery room	2/room	3/room	1/room
Infant resuscitation station§	1 /bassinet	1/bassinet	1 /bassinet
Labor room	1/room	1/room	1/room
OB recovery room	1/bed	3/bed	1/room
Labor/delivery/recovery (LDR)¶	2/bed	2/bed	—
Labor/delivery/recovery/postpartum (LDRP)[5]	2/bed	2/bed	—
Initial emergency management	1/bed	1/bed	—
Triage area (definitive emergency care)	1/station	1/station	—
Definitive emergency care exam/treatment rooms	1/bed	1/bed	1/bed
Definitive emergency care holding area	1/bed	1/bed	—
Trauma/cardiac room(s)	2/bed	3/bed	1/bed
Orthopedic and cast room	1/room	1/room	—
Cardiac catheterization lab	2/bed	2/bed	2/bed
Autopsy room	—	1 per workstation	1 per workstation

*For any area or room not described above, the facility clinical staff shall determine outlet requirements after consultation with the authority having jurisdiction.
†Four bassinets may share one outlet that is accessible to each bassinet.
‡If Phase II recovery are is a separate area from the PACU, only one vacuum per bed or station shall be required.
§When infant resuscitation takes place in a room such as cesarean section/delivery or LDRP, then the infant resuscitation services must be provided in that room in addition to the minimum service required for the mother.
¶Two outlets for mother and two for one bassinet.

TABLE 14.36 Station Outlets for Oxygen, Vacuum, and Medical Air in Outpatient Facilities

Location	Oxygen	Vacuum	Medical air
Examination	0	0	—
Treatment	0	0	—
Isolation	0*	0*	—
Pre-procedure examination	0*	0*	—
Operating room		1	
Class A—minor surgical	1		—
procedure room		2	
Class B—intermediate	2		—
surgical procedure room		3	
Class C—major surgical	2		—
procedure room		1	
Postanesthesia recovery	1	0*	—
Step-down recovery area	0*	3	—
Cysto procedure	1		—
Emergency		1	
Trauma/cardiac room	1	0*	1
Cast room	0*	2	—
Catherization room	1	2	2
Birthing room			—
Endoscopy	2	3	
Procedure room		—	—
Decontamination room	2	0*	—
Holding/prep/recovery area	—		—
	0*		

*Portable or hard-piped source should be available for the space.

There is a generally accepted "allowable" maximum friction loss for the piping distribution system (after the source) of 5 psig (34 kPa). This figure is considered a reasonable one for design purposes, but there is no code or other mandate that prevents a small deviation from this figure. For short runs of branch piping, another generally used figure is 10 percent of the available pressure. All of the above deviations shall provide a minimum of 50 psig (340 kPa) at the outlet. It is recommended that nitrous oxide gas be initially set and maintained at 5 psig (35 kPa) below normal operating pressures of oxygen. It has been found that the blending of anesthesia gases in anesthesia machines might cause a backflow.

High-Pressure Nitrogen and Compressed Air. The minimum pressure required at the most remote outlet with maximum flow rate is dependent on the specific tools utilized by health care personnel. Currently used surgical room equipment requires a pressure range of from 160 to 200 psig (1000 to 1360 kPa) at the tool. There are also some tools used for precision work that use a much lower pressure of 25 to 50 psig (75 to 345 kPa). Dental pneumatic tools require 30 to 50 psig pressure.

There is a generally accepted average friction loss for the entire piping distribution system (after the source) of 10 percent of the design source pressure psig (136 kPa). Since the source of high-pressure gases is often a cylinder supply, the regulator installed should be capable of being adjusted over a wide range of pressure in the event that higher or lower operating pressures are required in the future. For high-pressure air compressors, the system regulator shall have the same capability.

There are no mandated purity requirements for gases used to operate surgical pneumatic tools. Oil-free air should be used and tool manufacturers consulted regarding maximum

TABLE 14.37 Flow Rate and Diversity Factor for Oxygen Outlets

Location	Simultaneous use factor, %	Volume, Lpm
First OR	100	50 per OR
Second OR	100	30 Lpm
Each additional OR (on a section of piping)	100	10 per OR
Emergency rooms	100	Same as OR
Trauma rooms	100	Same as OR
LDRP rooms	100	20 per room
Delivery rooms	100	Same as OR
Cystoscopy and special procedure rooms	100	Same as OR
Recovery rooms (postanesthesia recovery)		10 per outlet
1–8 outlets	100	
9–12 outlets	60	
13–16 outlets	50	
additional outlets	45	
Intensive care (ICU) rooms	100	30 per outlet
Neonatal		
Pediatric		
Medical-surgical		
Coronary care (CCU) rooms	100	30 per outlet

Simultaneous use factors for other spaces*

The first outlet on the end section of piping is 20 Lpm. For additional outlets on the section of piping, add 10 Lpm with the flollowing use factors.

No. of outlets	Simultaneous use factor, %	Volume, minimum Lpm
1–3	100	—
4–12	75	45
13–20	50	115
21–40	33	125
40 and over	25	155

*"Other spaces" include the following: patient rooms (medical and surgical) (bedside outlets), labor rooms, nurseries, examination and treatment rooms, OR bed holding areas, surgical preparation rooms, blood donor rooms, anesthesia workrooms, plaster (fracture) rooms, cardiac and heart catheterization rooms, deep therapy rooms, inhalation therapy rooms, electroencephalogram (EEG) rooms, electrocardiogram (ECG) rooms, electromyogram (EMG) rooms, fluoroscopy rooms, high-level radioisotope rooms, low-level radiation rooms, x-ray rooms, and endoscopy rooms.

TABLE 14.38 Flow Rate and Diversity Factor for Carbon Dixode

Room	Factor	Use
Or	75%	1.0 cfm

particulate size and dew points that are acceptable. NFPA-99 requires copper type "K" for pressures over 200 psig.

Pipe Sizing

The piping network is sized using the flow rate along each pipe run that has been adjusted by the diversity factor and the allowable friction loss for the system. Following is a system sizing procedure:

TABLE 14.39 Flow rate and Diversity Factor for Nitrous Oxide Outlets

Location	Volume, Lpm
First OR (far end of piping and all individual branches to ORs)	30 per OR
Second OR (on a section of piping)	20 per OR
Each additional OR (on a section of piping)	15 per OR
Delivery rooms	20 per room
Emergency rooms	20 per room
Trauma rooms	20 per room
Anesthesia workrooms	15 per room
Plaster (fracture) rooms	20 per room
Endoscopy rooms	15 per room
Dental surgery	5 per room

1. Locate all of the outlets and uses for each system on plans.
2. For each system, start with the most remote point, and work toward the mains. Count the number of outlets, determine the flow rate required from each outlet, and establish the diversity factor (Tables 14.37 to 14.41) This information should be recorded in a convenient form for later use when using the pipe sizing tables.
3. Calculate the adjusted flow rates from all outlets of each system by multiplying the flow rates by the diversity factors. Add all of the adjusted flow rates for the entire system together to find the required system capacity. It is now possible to select the source equipment capacity and the physical equipment sizes for each of the systems.
4. Locate the gas storage area and physically lay out the cylinders, manifolds, tanks, and so on. All necessary separation, ventilation, and venting requirements shall be followed.
5. Establish a general layout of the system from the storage area to the farthest outlet or use point. Measure the actual distance along the run of pipe. To the actual run add an additional 50 percent of the measured distance to allow for fitting allowance. If a more accurate calculation is desired, use Table 14.15 to calculate the loss through each fitting. This is the total equivalent run of pipe.
6. Determine all of the necessary regulators, filters, purifiers, and so on necessary for each system in order to establish a combined allowable pressure drop through each of them and the assembly as a whole.
7. Establish the gas pressure required at the farthest outlet for each system and the allowable pressure loss for the entire system.
8. Dividing the total run of pipe (in hundred of feet) by the allowable system friction loss will establish the allowable friction loss per 100 ft of pipe.
9. Calculate the adjusted flow rate of gas through each branch, starting from the farthest outlet back to the source (or main) using the allowable flow rate from each station outlet and the appropriate diversity factor. For specific equipment, obtain the probable diversity of use from the end user.
10. Depending on the type of compressed gas, enter the appropriate pipe sizing table. Table 14.42 provides pipe sizing data for low-pressure oxygen, nitrous oxide, and compressed air. Table 14.43 provides pipe sizing data for 125 psig (1100 kPa) nitrogen and compressed air. Table 14.44 provides pipe sizing data for 175 psig (1500 kPa) nitrogen and compressed air. Table 14.45 provides pipe sizing data for nitrogen and compressed air at 225 psig. Using the adjusted flow rate, read across to find a figure that equals but does not exceed the allowable friction loss. Then, read up to find the size. In some cases, the diversity factor for the next highest range of outlets may result in a smaller size pipe than the range previously calculated. If this occurs, do not reduce the size of the pipe—keep the larger size previously determined.

TABLE 14.40 Flow rate and Diversity Factor for Low-Pressure Medical Air Outlets and Proportioned Air

Air outlet/equipment	Design flow in scfm (free air)				
	Per unit	Per room	Per bed	Per outlet	Simultaneous-use factor, %
Anesthetizing Locations:					
Special surgery and cardiovascular		0.5			100
Major surgery and orthopedic		0.5			100
Minor surgery		0.5			75
Emergency surgery		0.5			25
Radiology		0.5			10
Cardiac catheterization		0.5			10
Ventilators	3.5				100
Delivery rooms		0.5	0.5		100
Cystoscope					100
Acute Care Locations:					
Recovery room/surgical (postanesthesia)			2		25
ICU/CCU			2		50
Emergency rooms			2		10
Neonatal ICU			1.5		75
Dialysis units			0.5		10
Recovery rooms/OB		2			25
Ventilators	6				100
Subacute Care Locations:					
Nursery			0.5		25
Patient rooms (where shown)			0.5		10
Exam and treatment		1			10
Preop holding				1.5	20
Respiratory care		1			50
Pulmonary function lab				1	50
EEG and EKG				1	50
Birthing and LDRP		1			50
Patient isolation room			0.5		25
Other:					
Anesthesia workroom		1.5			10
Respiratory care workroom	1.5			10	
Nursery workroom		1.5			10
Equipment repair		1.5		1.5	10
Med. laboratory				1.5	25
Autopsy		0.5			100
Sterile supply		0.5			10
Plaster room		0.5			50
Pharmacy		0.5			10
Dental, high pressure (50 psig)		2 per chair		2	100
Dental, low pressure (30 psig)		1 per chair		3	100

1 scfm = 0.03 m^3/min.

VACUUM AIR SYSTEMS

TABLE 15.10 Preliminary Medical Vacuum Source Sizing

Enter the quantity of the units requested:	Counting Units		Use in scfm		Simul. Use %		Total Usage
Surgical Procedures.							
PreOp Holding	Bed(s)	@	1.5	ea. ×	15%	=	
Major Invasive	Room(s)	@	3.5	ea. ×.	100%	=	
Minar Invasive	Room(s)	@	3.5	ea. ×	100%	=	
Trauma and Emergency	Room(s)	@	3	ea. ×	100%	=	
Catherization & Lab Work	Room(s)	@	1	ea. ×	10%	=	
Endoscopy	Room(s)	@	1	ea. ×	10%	=	
Recovery	Bed(s)	@	1.5	ea. ×	50%	=	
WAGD (If into the Med-Surg. Vacuum)	Room(s)	@	1	ea. ×	100%	=	
Tests and Outpatient Procedures							
X-ray, CAT, NMR, PET scans	Room(s)	@	1.5	ea. ×	30%	=	
Dialysis	Bed(s)	@	1.5	ea. ×	30%	=	
Exam and Minor Treatment	Room(s)	@	1	ea. ×	10%	=	
EEG/EKG	Room(s)	@	1	ea. ×	10%	=	
Pulmonary Function	Bed or static	@	1.5	ea. ×	30%	=	
Respiratory Care	Bed or static	@	1.5	ea. ×	30%	=	
Observation	Bed or static	@	1	ea. ×	10%	=	
Perinatal and Pediatric							
Birthing or LDRP	Room(s)	@	1	ea. ×	100%	=	
Delivery Room	Room(s)	@	1	ea. ×	100%	=	
Nursery	Inlet(s)	@	1	ea. ×	10%	=	
NICU	Bed(s)	@	1	ea. ×	25%	=	
Intensive Care							
Adult ICU, CCU, etc.	Bed(s)	@	2	ea. ×	75%	=	
Pediatric ICU (except NICU)	Bed(s)	@	2	ea. ×	75%	=	
Emergency (not surgical)	Bed(s)	@	1	ea. ×	100%	=	
Equipment Maintenance							
Workrooms	Station(s)	@	1.5	ea. ×	10%	=	
Laboratory							
Medical Lab Uses	Station(s)	@	1.5	ea. ×	25%	=	
Other							
Patient rooms	Room(s)	@	1	ea. ×	10%	=	
				Overall Base Total			0
Ventilators							
Ventilator add in	Unit(s)	@	0.5	ea. ×	10%	=	0
Peak Calculated Demand		scfm (Lpm) at 19 inHg					

3. For laboratory outlets, use the diversity figure found in Fig. 15.22 for the actual flow rate.
4. To calculate the actual total system scfm, multiply the scfm from each of the inlets by the appropriate use factors. Add the anesthetizing locations and scfm together to find the required medical requirement. To this, add the laboratory and WAGD figures to find the total system scfm. Adjust the scfm figure for altitude if necessary.
5. The pump scfm ratings are selected based on a multiple-pump arrangement. If duplex pumps are selected, each pump shall be sized for 100 percent of the load. For a