

## **Compressed Air System Specialist Certification Program Knowledge, Skills, and Abilities**

The Systems Assessment Section of CAGI has developed certification programs for compressed air system professionals and compressed air system assessors (practitioners who perform assessments or “audits” of compressed air systems). CAGI’s goal is to provide certification based on tested knowledge that will allow customers, utilities, employers, the US Department of Energy, and others to have confidence in the skills and abilities of the specialists and assessors. The programs will be accredited and will comply with the ISO 17024 standard.

The Certified Compressed Air Systems Specialist program is designed to make certain that a certified individual has a full and complete understanding of compressed air systems. The Compressed Air System Assessor program is designed to make certain that a certified individual can perform compressed air system assessments in accordance with ANSI/ASME EA4 and ISO 11011. Certification as a Compressed Air System Specialist is a prerequisite to the Compressed Air System Assessor program.

A group of subject matter experts compiled a list of Knowledge, Skills, and Abilities (KSA) that an individual should possess to fulfill the requirements of a Compressed Air System Specialist. A number of useful equations that certificants should know is included with the KSA. Candidates for the exam can check their own knowledge, skills, and abilities against the list outlined below to help them determine whether they are ready for the exam:

- 1) Theory and Base Knowledge
  - a. The gas laws as they apply to compressed air systems.
  - b. Basic Electrical Calculations and Knowledge
    - i. kW, Amps, Volts, HP (etc.)
    - ii. Energy Cost Calculations (from power measurements)
    - iii. Various starter types and applications (Wye-Delta, Full Voltage, Reduced Voltage, Solid State, VSD)
    - iv. Various motor types, service factor, NEMA rating
    - v. Basic Electrical Safety and Applicable Codes (not knowing specifics about the code but what the NEC dictates - wire size, breaker size, etc.)
- 2) Compressors
  - a. Understand the operating characteristics of both positive displacement and dynamic compressors
    - i. Power
    - ii. Flow
    - iii. Pressure
    - iv. Full load
    - v. Trim
    - vi. Ambient conditions
    - vii. Duty cycle
  - b. Understand the proper application of each type of compressor.

- i. Positive displacement
      - 1. Reciprocating
        - a. Single-acting
        - b. Double-acting
        - c. Lubricated
        - d. Non-lubricated
        - e. Oil less
      - 2. Rotary Screw
        - a. Single-stage
        - b. Multi-stage
        - c. Lubricated
        - d. Non-lubricated
      - 3. Rotary vanes
      - 4. Liquid ring
      - 5. Booster
      - 6. Diaphragm
      - 7. Scroll
    - ii. Dynamic
      - 1. Centrifugal
      - 2. Axial
  - c. Understand the various control methods for each type of compressor and the control's effect on
    - i. Part load efficiency
    - ii. Performance
    - iii. Turn Down
    - iv. Signal locations, set points, and differentials
    - v. Maintenance and longevity
  - d. Understand the installation and maintenance requirements of each type of compressor
    - i. Cooling requirements
    - ii. Ventilation
    - iii. Heat recovery
    - iv. Required auxiliary equipment or connections (i.e. sealing water for liquid rings, pulsation dampers, blow off routing, etc.)
    - v. Routine maintenance
    - vi. Preventative maintenance
    - vii. Predictive maintenance
    - viii. Compressor lubricants
  - e. Stay abreast with changes in compressor technology
  - f. Understand how to calculate life cycle costs of each type of compressor under various operating scenarios
- 3) Air Treatment
- a. Dryers
    - i. Understand the operating characteristics of the various types of dryers
      - 1. Refrigerated
        - a. Cycling

- i. Load/unload
        - ii. Head unloading
        - iii. Thermal mass
        - iv. Variable speed
      - b. Non-cycling
    - 2. Desiccant
      - a. Heatless
      - b. Heated
        - i. Exhaust purge
        - ii. Blower purge
        - iii. Vacuum purge
      - c. Heat of compression
    - 3. Membrane
    - 4. Deliquescent
  - ii. Understand the proper application of the various types of dryers
    - 1. Main air system
    - 2. Point of use
  - iii. Understand the control methods of each type of dryer
  - iv. Understand how to calculate operating costs
- b. Filtration / Separation
  - i. Understand the various types of filtration
    - 1. Mechanical separation
    - 2. Barrier
    - 3. Coalescing
    - 4. Vapor adsorption
    - 5. Sterile
  - ii. Understand the liquid loading capacity of each type of filter
  - iii. Understand flow and pressure drop characteristics of each type of filter
  - iv. Understand the proper application of each type of filter
    - 1. Pre/post dryer
    - 2. Point of use
  - v. Understand how to apply proper drains to each type
- c. Drains
  - i. Understand the different types of drains
    - 1. Manual
    - 2. Zero loss
    - 3. Timed
    - 4. Float
  - ii. Understand the proper application of each type of drain
- d. Condensate treatment
  - i. Understand the different types of condensate treatment products and their proper application
    - 1. Chemical adsorption
    - 2. Gravity separation
    - 3. Mechanical separation
    - 4. Vaporization

- 5. Semi-permeable membrane
- e. Air quality requirements and standards

#### 4) Systems

##### a. Piping

- i. Understand the different piping materials and their proper application
  - 1. Stainless Steel
  - 2. Black Iron
  - 3. Copper
  - 4. Aluminum
  - 5. Galvanized
  - 6. Plastic
- ii. Understand the different distribution system designs
  - 1. Supply
    - a. Manifold
  - 2. Demand
    - a. Loop
    - b. Branch
- iii. Understand how to properly size pipe for a given flow and pressure
  - 1. Friction tables
  - 2. Air velocity
- iv. Understand the use of drip legs and drains
- v. Understand the proper installation of drops to the point of use
- vi. Understand proper valving
- vii. Sealants

##### b. Receiver

- i. Understand the proper application of receivers
  - 1. Wet
  - 2. Dry
  - 3. Remote
  - 4. Point of use
  - 5. Safety aspects
- ii. Understand how to size storage based on demand profile and pressure differential.

##### c. Master controls (What is it, in general what does it do, etc.)

NOTE: There are many different master controls on the market that provide varying levels of automation and sophistication. There is not an expectation that candidates will be knowledgeable on the different controllers.

##### d. Pressure / flow controls

- i. Understand the basic principles of operation
- ii. Understand the proper use and application
- iii. Understand how to calculate storage and pressure differential required to make the control work properly

##### e. System pressure requirements

- i. Understand the difference between perceived minimum pressure and actual minimum pressure

- ii. Be able to identify drivers of pressure requirements
    - iii. Understand and quantify artificial demand
  - f. Leaks
- 5) Applications
  - a. Point of use connection practices
    - i. Understand various forms of connections
    - ii. Understand proper use of sealants for connections
    - iii. Understand sizing of connections
  - b. Potentially inappropriate uses
    - i. Be able to identify inappropriate uses
    - ii. Be able to make recommendations for other power sources
  - c. Understand safety considerations as they relate to compressed air system design
  - d. Develop and understand compressed air specifications
    - i. For supply side equipment
    - ii. For demand side equipment

List of Subjects not Covered by this KSA

1. Breathing Air or Medical Air Applications or Code
2. Safety Codes (NFPA, OSHA, MSHA, NEC, etc.)
3. ASME or PED codes
4. Vacuum Systems
5. Low Pressure Systems (Blowers) below 30 psig
6. High Pressure (above 250 psig systems)
7. Portable (Fossil Fuel Driven) Compressors

## Commonly Used Equations and Relationships for Compressed Air Systems

There are 7.48 gallons to the cubic foot.  
Convert gallons to cubic feet: Gallons/7.48

**Cubic feet of free air required to raise a receiver from some pressure greater than 0 gage to a final higher pressure:**

Receiver volume in cu. ft. x  $\frac{(\text{final psig} - \text{initial psig})}{\text{Atm. pressure}}$

**\*Usable cubic feet of stored air:**

Receiver volume (ft<sup>3</sup>) x  $\frac{(\text{final psig} - \text{required operating psig})}{\text{Atm. pressure}}$

\*Assumes no compressor supply during demand event.

**Fill time for an air receiver:**

$\frac{\text{Receiver volume in cu. ft. x (final psig - initial psig)}}{\text{Atm. pressure x compressor cfm}}$

**If the demand in cfm is known, the size of an air receiver can be calculated as follows:**

$$V = T \times \frac{C \times P_a}{p_1 - p_2}$$

Where:

V = Receiver volume, in cubic feet.

T = Time allowed (minutes) for pressure drop to occur.

C = Air demand, cfm of free air

P<sub>a</sub> = Absolute atmospheric pressure, psia

p<sub>1</sub> = Initial receiver pressure, psig

p<sub>2</sub> = Final receiver pressure, psig

**3-phase Electric Power:**

$$P_{kW} = \frac{V_{avg} \times A_{avg} \times \sqrt{3} \times p.f.}{1,000}$$

**Air Velocity in a Pipe:**

$$V = \frac{cfm \times P_a}{60 \times a \times (P_2 + P_a)}$$

Where:

$V$  = velocity in ft/sec

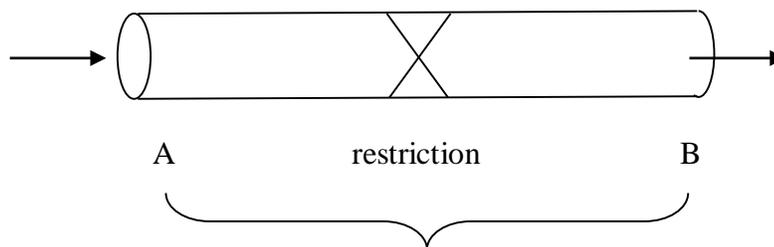
$cfm$  = air flow, free air, in ft<sup>3</sup>/min

$P_a$  = local barometric pressure in psia

$P_2$  = gauge pressure in header or pipe

Air temperature in the pipe is presumed to be ambient.

$$a = \text{cross sectional area of the pipe bore in ft}^2 \quad a = \frac{\Pi \times d^2}{4 \times 144}$$

**Pressure Drop:**

$\Delta p$  = pressure drop

$$\Delta p_2 = \Delta p_1 \times \left( \frac{v_2}{v_1} \right)^2$$

Where:  $V$  = velocity.

Note: with the same pressure and pipe diameter,  $V$  can be replaced with Flow (cfm)

**Calculate Flow or Leakage from Cycle Time on a Load/No-load compressor:**

$$\text{Leakage (\%)} = \left( \frac{T}{T + t} \right) \times 100$$

Where: T = loaded time (seconds)  
t = unloaded time (seconds)

Note: In general, this formula only applies to a trim compressor which operates in load/unload or start/stop mode. This formula can also be used to determine the average airflow contribution of the trim (cycling) compressor. To do so, omit the base loaded compressor contributions