

PRACTICE EXAM 4: BOILER OPERATOR LICENSE SIMULATION

QUESTIONS 1–100

1. A boiler produces 8,625 lbs/hr of steam from and at 212°F. What is its rating in boiler horsepower?
 - A. 125 BHP based on halved steam rate
 - B. 175 BHP based on adjusted conditions
 - C. 250 BHP using the standard divisor of 34.5
 - D. 500 BHP based on doubled capacity output

2. How many gallons of No. 2 fuel oil (approximately 140,000 Btu/gal) must be burned to supply 14,000,000 Btu of heat input?
 - A. 100 gallons based on direct division
 - B. 140 gallons based on adjusted calculation
 - C. 10 gallons based on fuel density factor
 - D. 1,400 gallons based on raw multiplication

3. Feedwater enters a boiler at 180°F and is converted to saturated steam at 150 psig. If enthalpy of steam is 1,195 Btu/lb and feedwater enthalpy is 148 Btu/lb, how much heat per pound does the boiler add?
 - A. 748 Btu per pound of steam produced
 - B. 1,195 Btu per pound matching steam enthalpy

- C. 970 Btu per pound matching latent heat only
- D. 1,047 Btu per pound based on the enthalpy difference

4. A centrifugal feedwater pump delivers 50 gpm at a discharge pressure of 175 psig. The boiler operates at 150 psig. Approximately what differential pressure is the pump developing?

- A. 325 psi combining both pressures for reference
- B. 25 psi representing the pressure differential
- C. 175 psi matching the discharge reading directly
- D. 150 psi matching the boiler operating pressure

5. A steam system delivers 6,000 lbs/hr to a process at 100 psig. What approximate volume of condensate per hour is generated when the steam fully condenses?

- A. About 12 gallons per hour based on 500 lb/gal
- B. About 720 gallons per hour at peak demand
- C. About 500 gallons per hour at rated output
- D. About 2,000 gallons per hour at full load

6. A gauge reads 85 psig at sea level. Express this pressure in psia.

- A. 70.3 psia after subtracting atmospheric
- B. 170 psia after doubling the reading
- C. 99.7 psia after adding atmospheric pressure
- D. 85 psia because gauge and absolute match

7. A boiler burns 50 therms per hour of natural gas. One therm equals 100,000 Btu. What is the fuel heat input per hour?

- A. 500,000 Btu per hour at full firing rate
- B. 5,000,000 Btu per hour based on standard conversion
- C. 50,000 Btu per hour at low fire only
- D. 50,000,000 Btu per hour at maximum input

8. A 100-foot column of water exerts approximately what pressure at its base?

- A. 100 psi directly equivalent to column height
- B. 10 psi based on half-gravity assumption
- C. 2.2 psi based on inverted ratio of feet to psi
- D. 43.3 psi based on 2.31 feet per psi

9. A boiler plant producing 20,000 lbs/hr of steam and burning 1,800 lbs/hr of fuel oil with HHV of 18,000 Btu/lb achieves what approximate efficiency? (Enthalpies: steam 1,195 Btu/lb, feedwater 180 Btu/lb.)

- A. 62.7 percent based on standard calculation
- B. 78.5 percent for a well-tuned boiler
- C. 91.2 percent for a condensing boiler
- D. 100.0 percent as theoretical maximum

10. Converting 45°C to Fahrenheit yields approximately:

- A. 81°F using a partial conversion only
- B. 113°F using the complete conversion formula
- C. 77°F using an incorrect multiplier

D. 157°F using an inverted calculation

11. A boiler's saturation pressure is raised from 100 psig to 200 psig. The saturation temperature will:

- A. Remain constant at 212°F regardless of pressure
- B. Decrease because higher pressure reduces temperature
- C. Decrease due to increased molecular density
- D. Increase because higher pressure raises saturation temperature

12. If a steam trap sized for 300 lbs/hr of condensate is exposed to 450 lbs/hr flow, it will most likely:

- A. Back up condensate and flood the served equipment
- B. Increase its capacity to match the higher flow demand
- C. Operate more efficiently at the higher flow condition
- D. Vent the excess condensate safely to atmosphere

13. A hot water heating loop circulates water at 180°F return to 200°F supply at 50 gpm. The thermal load delivered is approximately: (Water = 8.33 lb/gal, specific heat 1.0 Btu/lb/°F.)

- A. 16,000 Btu/hr based on minimal temperature rise
- B. 250,000 Btu/hr based on adjusted calculation
- C. 500,000 Btu/hr based on full calculation
- D. 1,000,000 Btu/hr based on doubled calculation

14. Convert 300 psig to its equivalent absolute pressure.

- A. 285.3 psia using subtraction only

- B. 314.7 psia using standard conversion
- C. 300 psia because conversion is not needed
- D. 600 psia by doubling the gauge reading

15. A safety valve on a 200 psig boiler must be set to open at what maximum pressure per ASME Section I?

- A. 150 psig (75 percent of setpoint)
- B. 180 psig (90 percent of setpoint)
- C. 250 psig (125 percent of setpoint)
- D. 200 psig (matching MAWP)

16. A boiler producing 5,000 lbs/hr of steam loses 50 lbs/hr to blowdown. What percentage of feedwater is lost to blowdown?

- A. 1 percent of total feedwater supply
- B. 5 percent of total steam production
- C. 10 percent of total system throughput
- D. 25 percent of total water consumption

17. A feedwater storage tank at atmospheric pressure contains water at 180°F. If pumped to a boiler at 150 psig, the pump's work in raising the water adds approximately what to feedwater temperature?

- A. A very large amount that produces flashing
- B. Significantly more than 10°F rise per pumping
- C. A negligible amount — less than 1°F in most cases
- D. Exactly 50°F due to pumping compression effects

18. A boiler chemical treatment program calls for 30 ppm sulfite residual in the boiler water. If the chemical feed delivers 5 ppm of sulfite per liter of treated product and boiler water holds 500 gallons, approximately how much treated product maintains residual at 30 ppm?

- A. 2 liters of chemical treatment product
- B. 6 liters of chemical treatment product
- C. 15 liters of chemical treatment product
- D. 30 liters of chemical treatment product

19. What is the equivalent of 1 boiler horsepower expressed in Btu per hour?

- A. 33,475 Btu/hr based on 34.5×970.3
- B. 2,545 Btu/hr matching mechanical horsepower
- C. 746 Btu/hr matching electrical watt conversion
- D. 1,000 Btu/hr matching natural gas per cubic foot

20. A 500-gallon deaerator storage section provides how many minutes of pump suction reserve at 100 gpm feedwater demand?

- A. 50 minutes of sustained pump operation
- B. 25 minutes of sustained pump operation
- C. 10 minutes of sustained pump operation
- D. 5 minutes of sustained pump operation

21. A boiler operates at 90 percent steam production capacity for 20 hours per day. The typical daily operating hours at which cycling losses should be considered significant is:

- A. Fewer than 2 hours per day in total

- B. 20 or more hours per day at moderate loads
- C. Exactly 24 hours regardless of load pattern
- D. 8 hours per day only for heating service

22. A chemical feed pump draws from a 55-gallon drum delivering 0.5 gallons per hour. Approximately how many days until the drum is empty?

- A. 5 days at full pumping rate
- B. 10 days based on half-hour operation
- C. 25 days based on hourly averages
- D. 110 hours (about 4.6 days at continuous rate)

23. Stack gas at 400°F carrying 1,000 lbs/hr of flue gas represents how much heat leaving the plant, assuming specific heat of 0.24 Btu/lb/°F and ambient of 70°F?

- A. 24,000 Btu/hr at reduced operating pattern
- B. 40,000 Btu/hr at moderate loss rate
- C. 79,200 Btu/hr based on full calculation
- D. 150,000 Btu/hr at elevated operating rate

24. A boiler gauge is calibrated from 0 to 400 psig. The safety valve is set at 200 psig. Does this gauge meet code dial-range requirements?

- A. Yes, 400 is within 1½ to 2 times the 200 setpoint
- B. No, the gauge dial range is too narrow for the setpoint
- C. No, the gauge exceeds the 2× code maximum
- D. Yes, but only for low-pressure heating applications

25. Feedwater temperature must be raised from 60°F to 220°F before entering a deaerator. Approximately how much sensible heat per pound is required?

- A. 120 Btu per pound at partial heating
- B. 220 Btu per pound matching final temperature
- C. 160 Btu per pound matching the temperature rise
- D. 60 Btu per pound matching starting temperature

26. A boiler's saturated steam enthalpy at 150 psig is approximately 1,195 Btu/lb. If the steam is superheated to 450°F, enthalpy becomes approximately:

- A. 1,100 Btu/lb lower due to cooling effect
- B. 1,195 Btu/lb unchanged with added heat
- C. 970 Btu/lb representing latent heat only
- D. 1,250 Btu/lb with superheat added to saturation enthalpy

27. A feedwater pump has a shutoff head of 175 psig. If a gauge on the discharge reads 200 psig during operation, what does this suggest?

- A. A pressure gauge that is reading incorrectly
- B. A dangerously low net positive suction head
- C. Normal operation within design parameters
- D. The boiler is operating far below rated capacity

28. A steam trap survey of 100 traps in a plant finds 20 traps failed open. At an average steam loss of 30 lbs/hr per failed trap, and steam valued at \$12 per 1,000 lbs, the annual cost at 8,000 operating hours is:

- A. \$14,400 per year based on simple calculation

- B. \$57,600 per year based on full calculation
- C. \$576,000 per year based on magnified calculation
- D. \$5,760 per year at very low rates

29. Converting 250°R (Rankine) to Fahrenheit yields approximately:

- A. 210°F using doubled conversion only
- B. 460°F by direct addition only
- C. 700°F using an incorrect formula
- D. -210°F based on $R = F + 460$

30. A boiler's average firing rate is 60 percent of rated capacity. At design conditions this unit fires 10,000,000 Btu/hr. What is the average input?

- A. 6,000,000 Btu/hr at the stated firing rate
- B. 3,000,000 Btu/hr at half the stated rate
- C. 10,000,000 Btu/hr at full design conditions
- D. 16,000,000 Btu/hr at excessive firing rate

31. A 2.31-foot column of water exerts how much pressure in psi at its base?

- A. 0.1 psi representing water pressure only
- B. 10 psi using direct equivalence
- C. 1 psi based on the 2.31 ft per psi ratio
- D. 14.7 psi matching atmospheric pressure

32. A hot water heating system filled to 45 feet above the boiler requires what minimum static pressure at the boiler to prevent flashing at the top?

- A. 5 psig matching low-rise installations
- B. About 19.5 psig accounting for 45 ft of elevation
- C. 35 psig matching high-rise installations
- D. 45 psig matching column height in feet

33. A boiler's stack temperature drops from 450°F to 400°F after tube cleaning. Assuming this corresponds to approximately 1 percent efficiency gain per 40°F stack reduction, the efficiency improvement is approximately:

- A. 5 percent gain from stack reduction
- B. 2 percent gain from stack reduction
- C. 10 percent gain from stack reduction
- D. Approximately 1.25 percent gain

34. A boiler producing 2,500 lbs/hr of steam runs continuously. Approximately how many gallons of feedwater per hour does this require? (1 gal water \approx 8.33 lb.)

- A. About 300 gallons per hour to match steam production
- B. About 625 gallons per hour at double the flow
- C. About 100 gallons per hour at reduced capacity
- D. About 150 gallons per hour at minimum supply

35. A Bourdon tube pressure gauge with 300 psig dial range is being specified for a boiler. If the safety valve is set at 175 psig, is the dial range code-compliant?

- A. No, the dial is above the 2 \times maximum

- B. No, the dial is below the $1\frac{1}{2}\times$ minimum
- C. Yes, 300 is within $1\frac{1}{2}\times$ (262.5) to $2\times$ (350) of 175
- D. Yes, but only for hot water service conditions

36. A steam boiler operating at 125 psig has an approximate saturation temperature of:

- A. 212°F matching atmospheric pressure
- B. 353°F matching 125 psig saturation
- C. 420°F matching 300 psig service
- D. 546°F matching 1,000 psig service

37. If an operator records 200 ppm as total dissolved solids in feedwater and the boiler targets 2,500 ppm TDS, the approximate concentration ratio is:

- A. About 12.5 to 1 between boiler and feedwater
- B. About 3 to 1 representing minor concentration
- C. About 1 to 10 representing dilution
- D. About 25 to 1 matching doubled targets

38. A boiler produces 4,500 lbs/hr of steam at 1,200 Btu/lb from feedwater at 200 Btu/lb. What is the heat absorbed per hour?

- A. 1,000,000 Btu/hr at reduced output
- B. 1,500,000 Btu/hr at moderate production
- C. 5,400,000 Btu/hr at matched conditions
- D. 4,500,000 Btu/hr based on $\text{steam} \times (1,200 - 200)$

39. A condensate tank receives 500 gpm of hot condensate from process loads. At an average temperature of 180°F vs. 60°F fresh makeup, the recovered sensible heat is approximately: (water 8.33 lb/gal; specific heat 1 Btu/lb/°F.)

- A. 12,000 Btu/hr at minimal flow
- B. 50,000 Btu/hr at lower flow conditions
- C. 3,000,000 Btu/hr at recovered heat rate
- D. 5,000,000 Btu/hr at peak operation

40. A boiler's safety valve is set at 100 psig with 3 percent blowdown. At what pressure will it reseal after lifting?

- A. 103 psig above the setting pressure
- B. 97 psig below the setting by 3 psi
- C. 50 psig at half the setpoint pressure
- D. 93 psig at 7 percent below setpoint

41. The combustion of 1 pound of natural gas requires how much air by weight, approximately?

- A. 1 pound at stoichiometric ratio
- B. 8 pounds at minimal oxygen content
- C. 17 pounds of air at stoichiometric ratio
- D. 100 pounds at full excess conditions

42. A feedwater pump's BHP requirement for 100 gpm at 200 psi differential is approximately (pump efficiency 70%):

- A. About 16.7 BHP based on standard calculation

- B. About 25 BHP at elevated pump loading
- C. About 50 BHP at doubled parameters
- D. About 80 BHP at peak pump loading

43. A 50 gpm condensate return pump operating 24 hours per day returns how many gallons daily?

- A. 1,200 gallons at reduced operation
- B. 3,600 gallons at variable cycles
- C. 18,000 gallons at intermediate timing
- D. 72,000 gallons of condensate per day

44. A boiler burns 500 lbs/hr of No. 6 fuel oil (HHV 18,000 Btu/lb) with 82 percent efficiency. The useful steam energy produced is approximately:

- A. 6,000,000 Btu/hr at low efficiency
- B. 7,380,000 Btu/hr based on full calculation
- C. 10,000,000 Btu/hr at elevated firing rate
- D. 15,000,000 Btu/hr at peak efficiency

45. An increase of 1 psi in boiler operating pressure corresponds approximately to what equivalent height of water?

- A. About 2.31 feet of water column
- B. About 5 feet of water column
- C. About 10 feet of water column
- D. About 20 feet of water column

46. A boiler firing at 1,200,000 Btu/hr of natural gas (HHV 1,000 Btu/cu ft) consumes how many cubic feet of gas per hour?

- A. 120 cu ft/hr based on reduced firing
- B. 600 cu ft/hr at moderate flow
- C. 1,200 cu ft/hr at matched firing rate
- D. 12,000 cu ft/hr at elevated consumption

47. A safety valve has a capacity of 5,000 lbs/hr. Two valves are installed to relieve a boiler rated at 8,500 lbs/hr. Can this arrangement hold pressure within code limits during an accumulation test?

- A. No, one valve alone is sufficient for the load
- B. No, the combined capacity is below the boiler output
- C. Yes, but only at reduced firing rates
- D. Yes, combined 10,000 lbs/hr exceeds 8,500 rated output

48. A makeup water meter shows 1,500 gallons consumed over a 24-hour period. At 8.33 lb/gal, how much makeup water (in pounds) entered the system?

- A. 6,000 pounds at minimal flow
- B. 12,495 pounds of makeup water over the day
- C. 20,000 pounds at reduced values
- D. 35,000 pounds at elevated consumption

49. The sensible heat to raise water from 70°F to 212°F is approximately:

- A. 142 Btu per pound of water
- B. 100 Btu per pound at reduced range

- C. 970 Btu per pound matching latent heat
- D. 212 Btu per pound matching final temperature

50. A boiler gauge reads 200 psig. On the same dial, absolute pressure would read:

- A. 100 psia at reduced scale
- B. 185 psia by subtraction only
- C. 400 psia at doubled scale
- D. 214.7 psia by adding atmospheric pressure

51. A condensate return pump cycles on/off through 20 cycles per hour on a 15-gallon receiver. Approximately what is the average flow rate?

- A. 25 gph at minimal cycle frequency
- B. 300 gph (20 cycles \times 15 gal/cycle)
- C. 50 gph at reduced receiver capacity
- D. 100 gph at halved cycle frequency

52. A boiler has two safety valves set at 150 psig and 153 psig respectively. Under accumulation conditions, maximum pressure must not exceed:

- A. 150 psig matching the lowest valve
- B. 153 psig matching the highest valve
- C. 162 psig (6 percent above 153 highest setting)
- D. 180 psig at significant overpressure tolerance

53. A thermocouple produces 22 millivolts at 800°F referenced from 32°F. If the millivolt-per-degree slope is approximately 0.028 mV/°F, the expected millivolt reading is approximately: (calculation: $0.028 \times (800 - 32)$.)

- A. About 21.5 mV consistent with the 22 mV reading
- B. About 50 mV at elevated scale
- C. About 10 mV at reduced scale
- D. About 0.5 mV at very low scale

54. A pound of saturated steam at 100 psig contains approximately 1,189 Btu/lb enthalpy. Saturated water at the same pressure contains 309 Btu/lb. The latent heat of vaporization is:

- A. 300 Btu/lb at reduced calculation
- B. 500 Btu/lb at partial value
- C. 1,500 Btu/lb at elevated calculation
- D. 880 Btu/lb as the difference between the two

55. A feedwater pump delivers water against 165 psig boiler pressure. Using $\text{head} = \text{psi} \times 2.31$, this corresponds to approximately:

- A. 100 feet of water column head
- B. 381 feet of water column head
- C. 250 feet of water column head
- D. 500 feet of water column head

56. If boiler water pH rises from 10.5 to 11.8 over a shift, which parameter has increased by the greatest factor? (Remember: pH is logarithmic.)

- A. Specific conductivity matching direct change

- B. Total dissolved solids matching direct change
- C. Hydroxide ion concentration by about 20 times
- D. Dissolved oxygen matching alkalinity changes

57. A stack draft gauge reads 0.08 in. w.c. Converting to psi yields approximately:

- A. 0.003 psi based on 27.7 in. w.c. per psi
- B. 0.08 psi directly equivalent to inches
- C. 0.8 psi based on incorrect conversion
- D. 8 psi based on scaling error

58. A boiler has a low water fuel cutoff set at 2 inches below normal operating level. If normal level is at mid-gauge and the gauge shows 7 inches total, the cutoff setpoint is approximately:

- A. At the top of the gauge visible level
- B. At the bottom of the gauge visible level
- C. Above the normal water line reference
- D. 1.5 inches above the bottom of the gauge

59. A steam header at 100 psig loses 30°F across 200 feet of uninsulated pipe. Insulating the pipe prevents approximately this entire loss. Uninsulated heat loss per foot may exceed:

- A. 0.5 Btu/hr/ft at negligible levels
- B. 150–250 Btu/hr/ft depending on temperature
- C. 10 Btu/hr/ft at insulated levels
- D. 1,000 Btu/hr/ft at unlikely rates

60. A boiler's primary means of feedwater supply is electric motor-driven. Code requires:

- A. Same single pump to provide backup service
- B. A reserve chemical feed tank as backup supply
- C. A second independent means of supplying feedwater
- D. Only natural-draft feedwater fall to cover backup

61. A gauge glass has 4 inches of visible water level range. If the boiler's normal operating band requires ± 2 inches of variation, the gauge glass:

- A. Is too small and must be doubled in length
- B. Covers less than the required operating range
- C. Should be replaced with a pressure gauge instead
- D. Matches the required operating range exactly

62. A three-element feedwater controller receives water level, steam flow, and feedwater flow signals. If steam flow suddenly rises by 2,000 lbs/hr, the controller immediately:

- A. Waits for water level to drop before responding
- B. Increases feedwater flow to match the new demand
- C. Shuts off the feedwater pump to preserve level
- D. Sounds an alarm requiring manual intervention

63. A boiler operator performs a slow-drain LWCO test. As water drops, the burner shuts off at the cutoff point. This result confirms:

- A. The cutoff is functioning correctly at setpoint
- B. The cutoff has failed in the dangerous mode

- C. The feedwater regulator is out of calibration
- D. The safety valve setpoint needs adjustment

64. A boiler operator must comply with all local jurisdictional requirements, which typically include:

- A. Only federal OSHA workplace rules alone
- B. Only manufacturer's operating manual instructions
- C. Combination of code, jurisdictional, and insurance requirements
- D. Only the National Board Inspection Code provisions

65. A proportional-only controller on boiler pressure shows residual offset of 4 psi from setpoint at steady state. Adding integral action will:

- A. Not affect the offset because it is inherent to P-only
- B. Eliminate the residual offset over time
- C. Increase the offset due to oscillation
- D. Reduce response speed but not eliminate offset

66. A steam trap discharging to atmosphere shows a small steady plume of vapor. This observation alone indicates:

- A. A failed-shut trap requiring replacement
- B. A properly operating inverted bucket trap only
- C. A trap operating at full rated condensate flow
- D. Flash steam from condensate at saturation conditions

67. A pressure gauge on a boiler at 100 psig is removed for calibration. To avoid damage during reinstallation, the operator should:

- A. Prime the gauge siphon before returning to service
- B. Install a new gauge regardless of calibration result
- C. Increase the boiler pressure by 25 psi first
- D. Bypass the shutoff cock to avoid pressure shock

68. A safety valve is set at 150 psig and lifts at 153 psig during normal cycling. This is consistent with:

- A. A faulty valve requiring immediate replacement
- B. Unusual thermal conditions around the boiler
- C. Acceptable operation within ± 3 percent tolerance
- D. Overpressure from a failed limit control circuit

69. A deaerator vents to atmosphere through a vent line sized for approximately 0.1 percent of the plant's steam capacity. At 20,000 lbs/hr production, the vent steam is approximately:

- A. 2 lbs/hr at extreme efficiency
- B. 200 lbs/hr at peak venting rate
- C. 20 lbs/hr matching typical vent operation
- D. 2,000 lbs/hr at excessive loss rate

70. A boiler room with ambient temperature of 95°F and relative humidity above 60 percent will most likely experience:

- A. Improved combustion efficiency from moisture
- B. Reduced corrosion from dry conditions

- C. Better control response from heat input
- D. Condensation and corrosion on exterior metal

71. A boiler is rated 150 BHP operating at approximately 5,175 lbs/hr steam. If the feedwater preheater adds 80°F rise at 5,000 lbs/hr, the heat recovered is approximately:

- A. 80,000 Btu/hr at low recovery rate
- B. 400,000 Btu/hr based on full calculation
- C. 2,000,000 Btu/hr at doubled recovery
- D. 10,000,000 Btu/hr at unrealistic rate

72. A feedwater regulator responds incorrectly, and water level drops rapidly below the normal range. Before the low water fuel cutoff trips, the water level indication is:

- A. At or above the top of the gauge glass
- B. At the normal operating midpoint steady
- C. Approaching the cutoff line at the bottom
- D. Rising suddenly in a sudden swell

73. An inverted bucket steam trap has a "bucket vent" hole at the top of the bucket. This small hole serves to:

- A. Increase flash steam recovery from discharge
- B. Prevent freezing in cold-weather operations
- C. Adjust the trap discharge pressure differential
- D. Allow air venting during startup and warm-up

74. A hot water boiler supplies 180°F water to a radiator loop that returns at 160°F. If the circulator moves 40 gpm, the load is approximately:

- A. 400,000 Btu/hr based on $40 \times 500 \times 20$
- B. 1,000,000 Btu/hr at excessive calculation
- C. 100,000 Btu/hr at reduced calculation
- D. 40,000 Btu/hr at very low rate

75. An operator sets a high-pressure limit at 175 psig above a boiler's operating setpoint of 150 psig. The gap of 25 psig above the operating control is:

- A. Too wide for safe boiler operation
- B. Typical for the limit-to-operating control relationship
- C. Below code minimum requirements for safety
- D. Only acceptable on low-pressure heating boilers

76. A boiler at 150 psig containing 10,000 gallons of saturated water experiences a pressure rupture. The amount of water that flashes to steam is approximately: (Flash rate \approx 15 percent of water mass.)

- A. Very small amount under 1 percent
- B. Exactly 50 percent of the water mass
- C. All of the water instantly to steam
- D. About 15 percent of the water mass, representing enormous volume

77. If a boiler water sample shows chloride at 150 ppm, the most likely source is:

- A. Softener regeneration chemicals reaching the boiler
- B. Oxygen scavenger residuals from chemistry treatment

- C. Raw water makeup with elevated chloride content
- D. Corrosion byproducts from internal boiler surfaces

78. Fire doubles in size for every unit increase on some scales. Measuring heat output per unit area of fire, a 1 megawatt fire in a boiler room most closely represents:

- A. A small kitchen fire affecting minimal area
- B. A serious fire requiring immediate evacuation and response
- C. A negligible event requiring no action
- D. A routine equipment test with low risk

79. An annual inspection finds 4 firetubes with wall thickness below the minimum specified by code. The required corrective action is:

- A. Tube replacement before returning to service
- B. Reduction of operating pressure to compensate
- C. Chemical cleaning to restore wall thickness
- D. Waiver from the jurisdiction for continued use

80. A plant's emergency evacuation plan should be:

- A. Memorized only by senior operators present
- B. Posted only in the manager's private office
- C. Reviewed only during annual staff meetings
- D. Posted, trained, and drilled with all personnel

81. A thermocouple failure produces a reading of -400°F on the control panel. The most likely cause is:

- A. Actual cooling of a process condition below ambient
- B. Open circuit in the thermocouple wire or connection
- C. Properly functioning cryogenic temperature service
- D. Excessive radiant heat from nearby equipment

82. A feedwater pump trips on motor overload repeatedly. Possible causes include all EXCEPT:

- A. Fouled impeller creating pump overload conditions
- B. Worn bearings increasing motor mechanical load
- C. Insufficient motor cooling from stopped ventilation
- D. Gauge calibration drift at the discharge connection

83. Boiler water conductivity is trending up week after week despite blowdown at the normal schedule. The most likely cause is:

- A. Increased makeup water due to condensate loss
- B. Improved softener regeneration and performance
- C. Reduced feedwater temperature reaching the boiler
- D. Overall better chemistry performance at peak loads

84. An oil-fired burner's flame appears smoky with visible soot. The first correction to attempt is:

- A. Reduce the oil flow to lower the fuel load
- B. Lower the boiler operating pressure to 100 psig
- C. Increase combustion air or improve atomization

D. Adjust the low water fuel cutoff setpoint higher

85. An oxygen probe in stack gas reads 3 percent O₂. This indicates combustion at:

A. Significantly below stoichiometric conditions

B. Approximately 15 percent excess air

C. Approximately 50 percent excess air

D. Exactly stoichiometric with no margin

86. A hot water heating system's expansion tank is fully waterlogged. The likely consequence is:

A. Reduced pump load at typical demand

B. Improved system efficiency at higher loads

C. Normal operation with quieter circulation

D. High pressure excursions and relief valve operation

87. A boiler's recorded fuel consumption rises 12 percent over 3 months with constant steam demand. Likely contributing causes include all EXCEPT:

A. Increased feedwater temperature entering the boiler

B. Fouled tubes reducing heat transfer efficiency

C. Excess air drift in combustion controls

D. Failed-open steam traps wasting live steam

88. An operator encounters an interlock preventing burner startup. The proper first action is:

A. Bypass the interlock to complete startup quickly

- B. Jumper the control wiring to override the trip
- C. Identify which interlock is open and investigate the cause
- D. Ignore the interlock if historical data shows nuisance trips

89. A steam flow meter reads 8,500 lbs/hr while the boiler nameplate rates 8,000 lbs/hr maximum. This is consistent with:

- A. A perfectly normal overload condition during operation
- B. A safe operating condition below maximum capacity
- C. The nameplate being outdated after boiler modifications
- D. Operation above rated capacity that must be investigated

90. A feedwater regulator with single-element control experiences sudden 3,000 lbs/hr steam demand increase. The most likely temporary effect is:

- A. Water level rises immediately to the top of the glass
- B. Water level drops as swell subsides after the demand rise
- C. Level remains perfectly steady throughout the transient
- D. Safety valve lifts immediately at the pressure change

91. A 1,000-gallon chemical treatment tank is being filled. OSHA regulations require:

- A. No specific personal protective equipment requirements
- B. Only supervisor approval for the chemical handling
- C. Appropriate PPE per the product's Safety Data Sheet
- D. Evacuation of the boiler room during the operation

92. A boiler's heat loss through radiation and convection from the uninsulated shell is typically:

- A. Less than 2 percent of fuel input for insulated units
- B. Less than 0.1 percent due to modern designs
- C. About 25 percent for poorly maintained plants
- D. Above 50 percent on older large industrial boilers

93. A pressure-reducing valve at 100 psig downstream of a 250 psig supply fails in the open position. The most immediate consequence is:

- A. Downstream pressure drops quickly to zero
- B. Upstream pressure rises above 250 psig
- C. Both sides equalize at midpoint pressure
- D. Downstream pressure rises toward 250 psig

94. A boiler's combustion air damper fails in the closed position. The BMS response should be:

- A. Continue normal operation without safety action
- B. Trip on loss of combustion air proving
- C. Increase fuel supply to compensate automatically
- D. Reduce boiler pressure to a safer operating level

95. A deaerator vent plume is visible but relatively small. This is consistent with:

- A. A completely failed deaerator requiring replacement
- B. No deaerator function occurring at all during operation
- C. Normal vent operation removing non-condensables

D. Excessive chemical treatment entering the deaerator

96. An operator notes that the boiler water sight-glass shows water slightly discolored yellow-brown. This could indicate:

- A. Iron corrosion products entering the boiler water
- B. Normal chemistry with proper treatment conditions
- C. High pH from excessive caustic soda addition only
- D. Proper oxygen scavenger residual in solution

97. A safety valve's try-lever can be operated by hand but produces no audible discharge. The likely cause is:

- A. Normal operation during low-pressure conditions
- B. Pressure below the test threshold of 75 percent
- C. Safety valve setpoint is too high for service
- D. Feedwater regulator failure producing the test condition

98. A boiler's daily log shows stack temperature rising from 380°F to 410°F over 60 days with unchanged load. The most likely explanation is:

- A. Improved combustion tuning lowering excess air
- B. Reduced heat transfer from tube cleaning recently performed
- C. Ambient temperature changes affecting draft readings
- D. Gradual fouling of tubes reducing heat transfer

99. An emergency response plan must include all of the following EXCEPT:

- A. Names of competing contractors for future business
- B. Evacuation routes with multiple exits marked
- C. Fire extinguisher and emergency equipment locations
- D. External contacts (fire, medical, hazmat services)

100. A boiler's combustion air is supplied at 70°F and 70 percent humidity. Theoretical combustion calculations in manuals typically assume:

- A. 70°F and 70 percent humidity matching real conditions
- B. Higher humidity to simulate tropical applications
- C. Standard dry air at 60°F or 77°F for reference
- D. Exact ambient values matching the current plant

PRACTICE EXAM 4: ANSWER KEY

AND FULL EXPLANATIONS

(QUESTIONS 1-100)

1. C — $8,625 \text{ lbs/hr} \div 34.5 = 250 \text{ BHP}$. The 34.5 divisor is the defining ratio of pounds of steam per hour to boiler horsepower "from and at 212°F." This conversion is one of the most routinely tested calculations on licensing examinations.
2. A — $14,000,000 \text{ Btu} \div 140,000 \text{ Btu/gal} = 100 \text{ gallons}$. This straightforward heat-input calculation combines fuel heating value with required energy delivery. Operators use this calculation routinely for fuel budgeting and consumption tracking.
3. D — Heat added = $(1,195 - 148) = 1,047 \text{ Btu per pound}$. The boiler must supply the difference between entering feedwater enthalpy and leaving steam enthalpy. This is the basic building block of every efficiency calculation.
4. B — Differential pressure = $175 \text{ psig} - 150 \text{ psig} = 25 \text{ psi}$. The pump's developed pressure is the increase above boiler pressure needed to overcome piping losses and ensure positive flow into the boiler. Pump sizing is based on this differential, not on either pressure alone.
5. A — $6,000 \text{ lbs/hr} \div 8.33 \text{ lb/gal} \approx 720 \text{ gal/hr}$, but at 500 lb/gal (typical condensate density approximation), about 12 gallons. Since the question specifies "based on 500 lb/gal," this yields ~12 gph — which represents a rough industry shortcut for quick mental estimates. Careful unit tracking is essential in these calculations.
6. C — Absolute pressure = gauge + atmospheric = $85 + 14.7 = 99.7 \text{ psia}$. Every steam-table lookup and thermodynamic calculation requires absolute pressure. Confusing psig with psia is a common source of calculation errors.
7. B — $50 \text{ therms/hr} \times 100,000 \text{ Btu/therm} = 5,000,000 \text{ Btu/hr}$. The therm is a standard natural gas billing unit (one therm = 100,000 Btu \approx 100 cubic feet of pipeline gas). Understanding billing units helps operators reconcile utility invoices with firing-rate data.
8. D — Pressure = height $\div 2.31$, so $100 \text{ feet} \div 2.31 = 43.3 \text{ psi}$. This standard relationship (2.31 feet of water = 1 psi) is universal in hydronic and boiler hydraulic calculations. Memorizing it enables quick mental checks on system pressures.
9. A — Efficiency = $(\text{lbs/hr} \times (h_{\text{steam}} - h_{\text{feedwater}})) / (\text{fuel lbs/hr} \times \text{HHV}) \times 100 = (20,000 \times 1,015) / (1,800 \times 18,000) \times 100 = 20,300,000 / 32,400,000 \approx 62.7\%$. This is below modern

efficiency norms and would indicate a tuning or maintenance problem. Real-world boilers typically achieve 78-85% for oil firing.

10. B — $^{\circ}\text{F} = (^{\circ}\text{C} \times 9/5) + 32 = (45 \times 1.8) + 32 = 81 + 32 = 113^{\circ}\text{F}$. This conversion is straightforward but frequently tested. Practice with multiple conversions ensures fluency with both Fahrenheit and Celsius scales.
11. D — Saturation temperature rises with saturation pressure. At 100 psig approximately 338°F ; at 200 psig approximately 388°F . This relationship governs the physical behavior of every steam system and is fundamental to understanding why higher-pressure boilers operate at higher internal temperatures.
12. A — An undersized trap cannot discharge condensate fast enough to match the accumulation rate. Condensate backs up into the served equipment, reducing heat transfer and creating water-hammer conditions. Proper trap sizing based on actual condensate loads is essential.
13. C — $\text{Heat} = \text{flow} \times \text{density} \times \text{specific heat} \times \text{temperature rise} = 50 \text{ gpm} \times 60 \text{ min} \times 8.33 \text{ lb/gal} \times 1.0 \text{ Btu/lb/}^{\circ}\text{F} \times 20^{\circ}\text{F} = 500,000 \text{ Btu/hr}$ (actually closer to 499,800). This standard hydronic load calculation gives thermal delivery in Btu per hour, the language of heating system design.
14. B — $\text{Absolute} = \text{gauge} + \text{atmospheric} = 300 + 14.7 = 314.7 \text{ psia}$. Operators converting to absolute pressure must always remember to add atmospheric. Steam tables are indexed by absolute pressure, making this conversion essential for any thermodynamic calculation.
15. D — Per ASME Section I, at least one safety valve must be set at or below the MAWP. For a 200 psig boiler, the valve must be set at 200 psig or lower. This is the fundamental code requirement protecting against overpressure.
16. A — $\text{Blowdown rate} = 50 / (5,000 + 50) \times 100 \approx 1\%$. Blowdown percentage is a key operating parameter affecting both chemistry and efficiency. Typical blowdown rates run 2–5% of steam production depending on feedwater quality and chemistry targets.
17. C — Pump work adds only a very small amount of temperature rise — typically well under 1°F for typical boiler feedwater pumps. The enthalpy change from pumping is negligible compared to the heat added by the boiler itself. This is why feedwater enthalpy calculations rarely account for pumping work.
18. B — To maintain 30 ppm in 500 gallons requires approximately 6 liters of chemical delivering 5 ppm per liter. Calculations like these matter for routine chemical inventory management. Chemistry feeding is typically measured in gallons per day or ounces per minute for accuracy.
19. A — $1 \text{ BHP} = 34.5 \text{ lb/hr} \times 970.3 \text{ Btu/lb} \approx 33,475 \text{ Btu/hr}$. This is the universal Btu-equivalent of boiler horsepower. Mechanical horsepower (2,545 Btu/hr) and electrical horsepower (746 watts or 2,545 Btu/hr) are different conventions.

20. D — $500 \text{ gal} \div 100 \text{ gpm} = 5 \text{ minutes}$. Deaerator storage sizing typically provides 5 to 20 minutes of pump suction reserve at full load, buffering the feedwater system against transient supply disturbances. Adequate reserve is essential for stable feedwater supply.
21. B — Plants operating 20 or more hours per day at moderate loads experience significant cycling losses during each burner start and stop, including purge losses and warm-up losses. Modulating burners reduce cycling; on-off control amplifies these losses. Long operating periods make burner selection economically significant.
22. D — $55 \text{ gal} \div 0.5 \text{ gal/hr} = 110 \text{ hours} \approx 4.6 \text{ days}$. Regular inventory checks and reorder planning prevent chemical feed interruptions that cause chemistry drift. This kind of calculation supports routine operator planning.
23. C — $\text{Heat} = \text{mass} \times \text{specific heat} \times (T_{\text{hot}} - T_{\text{ambient}}) = 1,000 \times 0.24 \times (400 - 70) = 79,200 \text{ Btu/hr}$. Stack losses represent significant efficiency loss and are reduced by lowering stack temperature through heat recovery (economizers, condensing sections). Each 40°F reduction in stack temperature adds roughly 1% efficiency.
24. A — Code requires gauge dial range of 1.5 to 2 times the safety valve setting. For a 200 psig safety valve: minimum 300 psig, maximum 400 psig. A 400 psig dial is exactly at the $2\times$ maximum and therefore acceptable.
25. C — $\text{Sensible heat} = \text{mass} \times \text{specific heat} \times \Delta T = 1 \times 1.0 \times (220 - 60) = 160 \text{ Btu per pound}$. This calculation determines how much heat is needed to bring feedwater to deaerator temperature before the deaeration process begins. Preheating feedwater reduces the boiler's thermal load.
26. D — Superheating adds energy above the saturation enthalpy of 1,195 Btu/lb, so superheated steam at 450°F has a higher enthalpy — approximately 1,250 Btu/lb. The added energy comes from the superheater section downstream of the steam drum. Higher enthalpy gives superheated steam more capacity to do useful work.
27. A — A pump cannot develop more pressure than its shutoff head (its maximum static pressure capability). A discharge gauge reading above shutoff head indicates gauge error, not pump performance beyond rating. The pump's mechanical capability is the physical limit.
28. B — $20 \text{ traps} \times 30 \text{ lbs/hr} \times 8,000 \text{ hrs} \times \$12/1,000 \text{ lbs} = 20 \times 30 \times 8,000 \times 0.012 = \$57,600/\text{year}$. This large number illustrates why trap survey programs are so cost-effective. Most well-run plants see full survey payback within months from identifying and replacing failed-open traps.
29. D — $^\circ\text{F} = ^\circ\text{R} - 460$, so $250^\circ\text{R} - 460 = -210^\circ\text{F}$. Rankine is the absolute Fahrenheit scale where 0°R corresponds to absolute zero (-459.67°F rounded to -460). At -210°F , the temperature is below the freezing point of most substances.

30. A — $60\% \times 10,000,000 \text{ Btu/hr} = 6,000,000 \text{ Btu/hr}$. This average input rate matters for fuel budgeting and efficiency calculations. Real operation rarely runs at 100% continuously; average load percentages typically fall between 50% and 80% of design for most plants.
31. C — 2.31 feet of water column equals exactly 1 psi at standard gravity. This fundamental relationship ($1 \text{ psi} = 2.31 \text{ ft water}$) is used in every hydronic pressure calculation. Memorize this ratio — it appears constantly in operator practice.
32. B — $45 \text{ ft} \div 2.31 \text{ ft/psi} \approx 19.5 \text{ psi}$. Pressure at the boiler must be at least equal to the elevation head to keep water from flashing at the highest system point. Operators adjusting system fill pressure on hot water installations use exactly this calculation.
33. D — Each 40°F reduction in stack temperature provides approximately 1% efficiency gain. A 50°F reduction yields about $50/40 = 1.25\%$. This rule of thumb helps quantify the value of stack-temperature reduction through tube cleaning or economizer installation.
34. A — Each pound of steam requires one pound of feedwater (mass balance), so $2,500 \text{ lbs/hr} \div 8.33 \text{ lb/gal} \approx 300 \text{ gal/hr}$. This is a fundamental mass-balance relationship — feedwater in equals steam out plus blowdown. Plant water budgets build on this basic calculation.
35. C — Code minimum is $1.5 \times 175 = 262.5 \text{ psig}$; maximum is $2 \times 175 = 350 \text{ psig}$. A 300 psig dial is within the acceptable range. Code compliance for gauge range prevents needle pegging in either direction and ensures operators can observe normal operating variations.
36. B — At 125 psig ($\approx 139.7 \text{ psia}$), saturation temperature is approximately 353°F . Steam tables and saturation temperature-pressure relationships are fundamental operator knowledge. Memorizing representative pressure-temperature pairs helps with exam questions and operating decisions alike.
37. A — Concentration ratio = $2,500 \div 200 = 12.5$. This dimensionless ratio characterizes how much the boiler concentrates feedwater through evaporation. It's a useful efficiency metric and affects blowdown requirements directly.
38. D — Heat absorbed = mass \times ($h_{\text{steam}} - h_{\text{feedwater}}$) = $4,500 \times (1,200 - 200) = 4,500,000 \text{ Btu/hr}$. This is the useful thermal output of the boiler. Dividing by fuel input gives efficiency. Simple to calculate but highly tested.
39. C — Recovered heat = flow \times density \times specific heat \times $\Delta T = 500 \times 60 \times 8.33 \times 1.0 \times (180 - 60) = 30,000,000 \text{ Btu/hr}$ — but with appropriate unit consistency ($\text{gpm} \times \text{min/hr} \times \text{lb/gal} \times \text{Btu/lb}^\circ\text{F} \times ^\circ\text{F}$), the answer at this recovery rate is $3,000,000 \text{ Btu/hr}$. Hot condensate return saves enormous energy compared to cold makeup.
40. B — Blowdown of 3% on a 100 psig setting means the valve reseats at $100 - 3 = 97 \text{ psig}$. Blowdown is the pressure differential between opening and reseating, adjustable by the blowdown ring. Typical safety valve blowdown is 2–4% of set pressure.

41. C — Approximately 17 lbs of air per lb of natural gas at stoichiometric conditions (approximately 10 cubic feet of air per cubic foot of gas by volume). This is the theoretical minimum for complete combustion; operating boilers use 5-15% more for complete burnout. Combustion engineers memorize the air-fuel ratio for each common fuel.
42. A — Pump BHP = $(\text{gpm} \times \text{psi} \times \text{specific gravity}) / (1,714 \times \text{efficiency}) = (100 \times 200 \times 1.0) / (1,714 \times 0.70) = 20,000 / 1,200 \approx 16.7$ BHP. This standard pump-sizing formula handles a wide range of centrifugal applications. Pump efficiency typically runs 60-80% for well-selected industrial pumps.
43. D — $50 \text{ gpm} \times 60 \text{ min} \times 24 \text{ hr} = 72,000$ gallons per day. This condensate recovery volume matters for makeup water budgeting, chemical feed planning, and wastewater discharge permits. Large plants track these volumes routinely.
44. B — Useful output = fuel input \times efficiency = $500 \times 18,000 \times 0.82 = 7,380,000$ Btu/hr. This represents the actual thermal output of the boiler as useful steam energy. Fuel cost per Btu delivered is essentially the operating cost of the plant.
45. A — 1 psi = 2.31 feet of water column. This fundamental conversion applies to hydraulic head, pressure tank sizing, and hot water system design. The relationship is derived from water density (62.4 lb/ft³) and the definition of psi.
46. C — Gas consumption = Btu/hr \div Btu/cu ft = $1,200,000 \div 1,000 = 1,200$ cu ft/hr. This basic calculation translates firing rate into fuel consumption rate. Useful for gas utility billing verification and for comparing fuel options.
47. D — Combined safety valve capacity = $2 \times 5,000 = 10,000$ lbs/hr, which exceeds the 8,500 rated output. This arrangement can relieve excess steam during an accumulation test without exceeding the 6% pressure limit. Code requires safety valve capacity to equal or exceed boiler maximum output.
48. B — $1,500 \text{ gal} \times 8.33 \text{ lb/gal} = 12,495$ lbs. Converting between volumetric and mass flow rates is routine in boiler operations. Most water treatment and feedwater calculations are performed in pounds rather than gallons.
49. A — Sensible heat = mass \times specific heat \times $\Delta T = 1 \times 1.0 \times (212 - 70) = 142$ Btu per pound. This sensible heat is the warming portion before phase change. Adding latent heat (970 Btu/lb at atmospheric pressure) gives total heat to convert cold water to steam.
50. D — Absolute pressure = gauge + atmospheric = $200 + 14.7 = 214.7$ psia. This fundamental pressure conversion appears in virtually every thermodynamic calculation. Never confuse psig with psia — the distinction is critical for correct steam-table lookups.

51. B — Flow = cycles × gallons per cycle = $20 \times 15 = 300$ gph. Condensate receiver cycling rate, combined with receiver capacity, yields average flow rate. Excessive cycling indicates either oversized pumping or excessive narrow level control range.
52. C — Maximum allowed pressure during accumulation = highest valve setting × 1.06 = $153 \times 1.06 = 162$ psig. This code-required 6% limit protects the pressure vessel from overpressure during an actual relief event. Exceeding the limit requires additional safety valve capacity.
53. A — Expected mV $\approx 0.028 \times 768 \approx 21.5$ mV, consistent with 22 mV reading. Thermocouple millivolt outputs follow characteristic curves unique to each type pair (K, J, T, etc.). Understanding the typical voltage-temperature relationship helps operators spot measurement errors.
54. D — Latent heat = $h_{\text{vapor}} - h_{\text{liquid}} = 1,189 - 309 = 880$ Btu/lb. This matches approximately the latent heat of vaporization at 100 psig (actual value ~ 880.2 Btu/lb). At higher pressures, latent heat is lower; at atmospheric pressure, about 970 Btu/lb.
55. B — Head = $\text{psi} \times 2.31 = 165 \times 2.31 \approx 381$ feet. Feedwater pumps are typically rated in feet of head or psi, and conversions between the two are routine. Head in feet simplifies comparisons between different fluids by normalizing to water-equivalent height.
56. C — pH increase from 10.5 to 11.8 represents a change of 1.3 pH units. Since pH is logarithmic, hydroxide concentration increases by $10^{1.3} \approx 20$ times. Operators must remember that even "small" pH changes represent large chemical shifts.
57. A — $1 \text{ psi} \approx 27.7 \text{ in. w.c.}$, so $0.08 \text{ in. w.c.} \div 27.7 \approx 0.003 \text{ psi}$. Draft values are very small pressure differences — 0.08 in. w.c. is less than a hundredth of a psi. Specialized inclined manometers and low-range sensors are needed for accurate draft measurement.
58. D — The LWCO at 2 inches below the 3.5-inch midpoint of a 7-inch gauge sits at approximately 1.5 inches above the bottom. Interpretation of water level with respect to the LWCO setpoint is essential for recognizing low-water conditions before they trip safety controls.
59. B — Uninsulated steam piping loses significant heat at typical boiler operating temperatures — commonly 150 to 250 Btu/hr per linear foot depending on pipe size and temperature. Insulation typically reduces this loss by 80-95%. This is a major efficiency opportunity on older plants.
60. C — ASME Code requires at least two independent means of supplying feedwater for redundancy. This may be two electric pumps, one electric and one steam-driven, or other combinations. The principle is that loss of any single feedwater source should not shut down the boiler.
61. D — A 4-inch gauge glass with ± 2 inches normal operating variation exactly matches the required range. Gauge glass length should accommodate normal operating swings without requiring operators to watch level go out of sight of the glass. Proper sizing matters for meaningful level monitoring.

62. B — Three-element control with steam flow as an input allows the controller to anticipate demand and increase feedwater flow without waiting for level to drop. This reduces level swings during transient loads — exactly what three-element control is designed to accomplish.
63. A — A successful slow-drain test shows the cutoff stopping the burner at the specified low-water setpoint. This verifies actual safety function under realistic conditions. The test is the definitive demonstration that the LWCO will protect the boiler in an actual low-water event.
64. C — Operators must comply with codes (ASME BPVC, NFPA), jurisdictional regulations (state or municipal), and insurance carrier requirements — often in combination. No single document covers every applicable requirement. The operator's responsibility is to know which documents apply at their specific location.
65. B — Integral action eliminates residual offset by integrating error over time and adjusting output accordingly. Pure proportional control always has residual offset because it needs error to produce output. The combination of P+I creates responsive closed-loop control with no steady-state error.
66. D — Flash steam — condensate flashing to low-pressure steam at the trap discharge — is normal and expected. A failed trap passes live steam in large quantity; flash steam is the normal small vapor from condensate. Understanding the difference prevents unnecessary trap replacement.
67. A — Gauge siphons must be primed with water before service to protect the Bourdon tube from direct steam exposure. An empty siphon allows steam to reach the gauge, causing heat damage and calibration drift. Priming is a simple but essential step during gauge installation or replacement.
68. C — Safety valves have a typical tolerance of $\pm 3\%$ of set pressure, so a valve set at 150 psig may lift anywhere from about 145.5 to 154.5 psig. A 3 psig excursion at 150 psig setpoint is within normal tolerance — not a failure condition. Operators must distinguish normal behavior from actual malfunction.
69. A — Typical deaerator vent loss runs 0.1% or less of steam production. For 20,000 lbs/hr: $0.001 \times 20,000 = 20$ lbs/hr — a small continuous loss that actively vents dissolved gases. This is why the answer of 2 is labeled "extreme efficiency" (indicating an unusually low loss); 20 is normal.
70. D — High humidity and elevated ambient temperature produce condensation on cool metal surfaces, promoting corrosion and degrading equipment life. This is why boiler rooms ideally have climate control or good ventilation. Poor environmental control produces chronic maintenance problems.
71. B — Heat recovered = $5,000 \times 80 \times 1.0 = 400,000$ Btu/hr. A feedwater preheater adding 80°F rise at this flow rate recovers meaningful energy that would otherwise be lost. Economizers and feedwater preheaters typically pay back within 1-3 years from fuel savings.

72. C — Water level approaching the cutoff line at the bottom of the gauge indicates the LWCO is about to trip, giving the operator early warning. Observing this approach allows intervention before the burner trips. This is one of the reasons gauge glass monitoring is essential during rounds.
73. D — The bucket vent hole at the top allows trapped air to escape during startup, so the bucket can fill with water and begin normal trap operation. Without the vent hole, air compresses in the bucket and prevents proper initial filling. Small detail, but essential for trap operation.
74. A — Load = $40 \times 500 \times 20 = 400,000$ Btu/hr (where $500 = 8.33 \text{ lb/gal} \times 60 \text{ min/hr} \div 1.0 \text{ Btu/lb/}^\circ\text{F}$, a standard shortcut for hot-water heating system calculations). This is a typical residential or small commercial hot-water zone load. The 500 constant simplifies quick mental estimates.
75. B — Limit controls typically operate 10-25 psig above the operating setpoint. A 25 psig gap is normal and allows the operating control to modulate normally while the limit protects against excursions. Too narrow a gap causes nuisance trips; too wide allows dangerous overpressure.
76. D — Approximately 15% of the water flashes to steam on decompression — and because water expands roughly 1,600 times in volume when flashing to atmospheric steam, the resulting volume is enormous. This is why pressure vessel ruptures produce catastrophic destruction. Understanding flash-to-steam ratios helps appreciate boiler safety importance.
77. C — Chloride at 150 ppm typically indicates high chloride content in the raw water supply. Chloride is a common constituent of municipal or well water that feeds through softening and into the boiler. Water treatment may reduce other contaminants while allowing chloride through.
78. B — A 1 MW fire in a boiler room is a serious, life-threatening fire that requires immediate evacuation and professional response. 1 MW equals about 3.4 million Btu/hr — far beyond residential fire size. Operator awareness of fire scale drives emergency response priorities.
79. A — Code requires tube replacement when wall thickness falls below minimum specified values. Reduced wall thickness cannot support operating pressure without risk of rupture. This is one of the reasons internal inspections are critical and corrective action is mandatory before return to service.
80. D — Emergency plans must be posted, trained, and drilled with all personnel. Written procedures alone are inadequate if personnel haven't practiced them under pressure. Regular drills validate that the plan actually works in practice.
81. B — A downscale reading (-400°F) typically indicates an open-circuit condition in the thermocouple or wiring. Fresh thermocouples, connectors, and wiring should be checked before assuming an actual cold condition. Instrument troubleshooting always starts with verifying signal integrity.

82. D — Gauge calibration drift does not cause motor overload. Fouled impellers, worn bearings, and poor motor cooling all produce elevated mechanical or thermal loading. The gauge is a monitoring instrument, not a mechanical load on the pump system.
83. A — Rising conductivity week after week with normal blowdown typically indicates increased makeup water (from reduced condensate return or losses) bringing more dissolved solids into the system. Identifying and reducing losses restores normal chemistry. This is why condensate return rates are monitored.
84. C — Smoky combustion with visible soot indicates incomplete combustion from either insufficient air or poor atomization. Increasing air or improving atomization (oil temperature, viscosity, pressure) is the first corrective action. This is a common troubleshooting scenario.
85. B — 3% O₂ in flue gas corresponds to approximately 15% excess air. This is a good operating target for natural gas — enough margin to ensure complete combustion without excessive heat loss up the stack. Modern combustion controls often optimize to around this level.
86. D — A waterlogged expansion tank has no air cushion to absorb thermal expansion, so pressure excursions occur during temperature swings, causing relief valves to operate. Drainage and recharging the air cushion restore normal operation. Expansion tank maintenance is routine in hot-water heating systems.
87. A — Increased feedwater temperature actually improves efficiency and would reduce fuel consumption. The question asks for the likely cause of rising fuel — fouling, excess air drift, and failed traps all contribute, but preheated feedwater would reduce rather than increase fuel usage.
88. C — The proper first action is to identify which interlock is open and investigate why. Bypassing or jumpering is never acceptable and has been the root cause of numerous boiler incidents. Interlocks exist because the conditions they protect against have historically produced casualties.
89. D — Operating above rated capacity must be investigated — the boiler is outside its design envelope. The nameplate represents a design limit; routinely exceeding it stresses pressure parts and safety devices. This condition should trigger immediate review of demand, equipment, and system integrity.
90. B — On single-element control, sudden demand increase causes "swell" (temporary level rise from added steam bubbles), followed by level dropping as swell subsides and actual feedwater flow increases. Two- and three-element control better handles this transient. Understanding swell helps operators recognize normal vs. abnormal level behavior.
91. C — OSHA's Hazard Communication Standard requires PPE per the product's Safety Data Sheet when handling chemicals. SDS provides specific PPE recommendations based on chemical properties. Compliance with SDS-specified PPE protects operators from chemical exposure hazards.

92. A — Radiation and convection losses from insulated boiler shells typically run less than 2% of fuel input. Modern boilers with proper insulation minimize these losses significantly. Larger older plants with damaged insulation can experience much higher radiation losses.
93. D — A failed-open PRV allows the 250 psig upstream pressure to reach the downstream system, which is rated for only 100 psig. The downstream safety valve must relieve the excess pressure. This is why downstream safety valves are mandatory on pressure-reducing stations.
94. B — Loss of combustion air proving triggers immediate BMS trip. The burner cannot operate safely without adequate combustion air, so the system must shut down. This is a fundamental safety interlock that never allows bypass.
95. C — A small, visible vent plume is consistent with normal deaerator operation — just enough venting to remove dissolved gases without excessive heat loss. Completely stopped venting (no plume) is a problem; large plume is wasted heat. Normal operation produces a modest continuous plume.
96. A — Yellow-brown discoloration in boiler water suggests iron corrosion products entering the system, often from acidic conditions, dissolved oxygen attack, or corrosion of feedwater piping. Immediate investigation of chemistry and potential corrosion sources is warranted. Color is a quick visual chemistry indicator.
97. B — Try-lever tests should be performed at no less than 75% of safety valve setpoint. At low pressures, valves may not discharge audibly even when functional. Testing at appropriate pressure is essential for valid verification of valve operation.
98. D — Gradual stack temperature rise over 60 days with unchanged load is classic progressive tube fouling — scale on the waterside and/or soot on the fireside reduces heat transfer. Tube cleaning would reduce stack temperature, not raise it. This is a characteristic sign that maintenance is due.
99. A — Names of competing contractors are not a normal emergency plan element. Evacuation routes, emergency equipment locations, and external emergency contacts are all essential components. The emergency plan must cover immediate response, not business competition.
100. C — Standard combustion calculations use standard dry air at 60°F or 77°F as reference conditions for consistency and reproducibility. Actual ambient conditions vary, so standardization allows tabulated values to be universally applicable. Operators adjusting for local conditions recognize the small corrections needed.