

Name : \_\_\_\_\_

(To be written by the candidate)

**SIXTH EXAMINATION FOR RECOGNITION OF COMPETENT  
PERSONS FOR INSPECTION & CERTIFICATION OF  
BOILERS – 2<sup>nd</sup> FEBRUARY 2020**

**BOILER DESIGN, MANUFACTURING, MATERIALS, ERECTION,  
COMMISSIONING, OPERATION AND MAINTENANCE, INSPECTION  
& CERTIFICATION DURING MANUFACTURE OR OPERATIONS AND  
HIGH PRESSURE WELDING INSPECTION**

Date : 02/02/2020

Time : 14:00 - 17:00 Hrs.

Max. Marks : 150

**GENERAL INSTRUCTIONS:**

1. This Question paper contains two parts - Part-A & B.
2. Part - A contains multiple choice questions. Please use OMR sheet to answer these questions.
3. Part - B contains descriptive questions. Please use answer paper to answer.

**Part-A****(50 X 1 = 50 marks)**

- (i) Answer all the **50** questions
- (ii) Each question carries **one** mark
- (iii) Use OMR Sheets to answer

1. As per IBR the design metal temperature for P91 pipes shall not exceed

- |          |          |
|----------|----------|
| a. 648°C | b. 552°C |
| c. 610°C | d. 710°C |

2. Which of the following is creep resistant steel?

- |                            |                          |
|----------------------------|--------------------------|
| a. 1 1/4 Cr - 1/2 Mo steel | b. 2 1/4 Cr - 1 Mo steel |
| c. Both (a) & (b)          | d. None of the above     |

3. Which of the following material is selected for boiler components in service in the creep range?

- |                            |                        |
|----------------------------|------------------------|
| a. Cr - Ni Stainless steel | b. Cr - Mo Alloy steel |
| c. Both (a) & (b)          | d. None of the above   |

4. 9 Cr-1Mo-V steel is selected instead of 2 1/4 Cr - 1 Mo steel for main steam piping of a 250 MW boiler by the designer. Which of the following is true?
- Thickness of the piping will be reduced
  - Thickness of the piping will be increased
  - Thickness of the piping will remain the same
  - Nothing can be said about change in the thickness of the piping
5. Stress Relieving Heat Treatment after welding of boiler components is performed under which of the following condition?
- Above Upper Critical Temperature of the steel
  - Above Lower Critical Temperature of the steel
  - Below Upper Critical Temperature of the steel
  - Below Lower Critical Temperature of the steel
6. A boiler drum is fabricated out of two shells. Longitudinal seams of each shell are welded using Shielded Metal Arc Welding & Submerged Metal Arc Welding. Circumferential seam is welded with Flux Cored Arc Welding & Submerged Metal Arc Welding. Which of the following is mandated by Indian Boiler Regulations, 1950?
- Two test plates for longitudinal seams & one test plate for circumferential seam
  - One test plate for longitudinal seam & one test plate for circumferential seam
  - Two test plates for longitudinal seams
  - One test plate for longitudinal seam
7. With regard to a dry back shell type boiler, which of the following is a pressure part?
- |                   |                      |
|-------------------|----------------------|
| a. Shell          | b. Furnace           |
| c. Both (a) & (b) | d. None of the above |
8. The circular furnace of a dry back shell type boiler can be mechanically strengthened against implosion by providing
- |                   |                     |
|-------------------|---------------------|
| a. Stiffner rings | b. Corrugations     |
| c. Bowling hoops  | d. All of the above |

9. The end plate of a wet back shell type boiler can be stayed by
- a. Tubes
  - b. Rods
  - c. Gussets
  - d. All of the above
10. Horizontal tubes of a horizontal multi-tubular dry back shell type boiler carry
- a. Water
  - b. Steam
  - c. Flue gas
  - d. None of the above
11. Steam test is conducted for a boiler to assess
- a. Steaming capacity of the boiler
  - b. Steam relieving capacity of the safety valves of the boiler
  - c. Steam passing capacity of the main steam stop valve of the boiler
  - d. None of the above
12. During the operation of a bi-drum water tube boiler, which of the following is true?
- a. Upper Drum contains steam
  - b. Lower Drum contains water
  - c. Upper Drum contains water
  - d. All of the above
13. Bed evaporator coil of a fluidized bed combustion boiler is designed with studs with a purpose of
- a. Minimizing erosion of the coil
  - b. Improving heat transfer through the coil
  - c. Both (a) & (b)
  - d. None of the above
14. The dished end of steam drum of a bi-drum water tube boiler shall be of the following geometry:
- a. Semi-Ellipsoidal
  - b. Partial-Spherical
  - c. Hemi-Spherical
  - d. Any one of the above

15. In which of the following cases, post weld heat treatment is required in arc welded butt joints of pipes?
- Carbon Steel Pipe Thickness  $< 20$  mm and carbon  $\leq 0.25\%$
  - Carbon Steel Pipe Thickness  $< 9$  mm and carbon  $\leq 0.30\%$
  - P11 Pipe Thickness  $> 13$  mm, OD  $> 127$  mm
  - All of the above
16. How many transverse tensile test specimens are required for a 120 mm thickness drum shell test plate?
- One
  - Two
  - Four
  - Any number of specimens that shall cover full thickness of weld joint
17. The waterside corrosion caused due to high alkaline water is known as
- Hydrogen embrittlement
  - Caustic gauging
  - Pitting
  - Stress corrosion cracking
18. Fibroscopic inspection of headers is carried out as a preventive measure to avoid boiler tube failure due to
- Long term overheating
  - Short term overheating
  - Thermal fatigue
  - Blockages
19. The factor responsible for the formation of bonded ash deposits on heating surface of boiler
- Furnace temperature
  - Flue gas composition
  - Heating rate
  - All of the above
20. Mechanical rubbing of boiler tubes with adjacent circuits, or with adjacent pressure part components resulting in boiler tube failure during their relative motions is called
- Fretting
  - Fatigue
  - Erosion
  - Stress rupture

21. Deposit quantity analysis from water wall tubes in high flux zone of furnace is required to be carried out
- To ensure the need of alkali boiling out
  - To ensure the need of second stage passivation
  - To ensure the need of chemical cleaning
  - To ensure the need of wet/dry preservation
22. Inside Oxide scale Thickness measurement technique used for condition assessment studies for pressure part components is useful in avoiding boiler tube failure due to
- Short term overheating
  - Long term overheating
  - Stress corrosion cracking
  - Hydrogen embrittlement
23. During cold start-up of boiler, the air vent is to be closed after
- The boiler is cut-in on the line
  - Steam is formed and all the air is vented
  - The economizer drain is closed
  - All burners have been lit and firing normally
24. Over pressure during steam test in a safety valve means
- Increase in pressure over the set pressure of the safety valve
  - Increase in pressure over the nozzle when safety valve is chattering
  - Pressure at which the safety valve lifts
  - None of the above
25. What are the different methods of controlling the temperature of superheated steam?
- Combined radiant & convective super heater with attemperator
  - Tilting burners
  - Flue gas recirculation
  - All of the above

26. Steam line water hammer can best be prevented by
- a. Keeping steam line drained and insulated
  - b. Replacing all 90° elbows with capped tees
  - c. Always opening steam valves rapidly
  - d. Keeping steam temperature below saturation point
27. Boiler preservation can be done using
- a. Nitrogen gas
  - b. Carbon Monoxide gas
  - c. Oxygen gas
  - d. Natural gas
28. A system in which the boiler operates with FD and ID fans is called
- a. Natural draft
  - b. Forced draft
  - c. Induced draft
  - d. Balanced draft
29. The presence of silica in the boiler water causes
- a. Steam carryover
  - b. Corrosion
  - c. Scale formation
  - d. None of the above
30. Which of the following affects the combustion performance?
- a. Time
  - b. Temperature
  - c. Turbulence
  - d. All of the above
31. Tube holes are to be drilled on the long seam of a boiler drum. The seam will be 100% radiographed prior to drilling. What ligament efficiency is to be considered in this case during design?
- a. 80%
  - b. 90%
  - c. 95%
  - d. 100%
32. What is the minimum number of safety valves required for a boiler fitted with integral superheaters?
- a. 1
  - b. 2
  - c. 3
  - d. Safety valve is not mandatory

33. What should be the minimum seat bore of a boiler safety valve?
- a. 13 mm
  - b. 19 mm
  - c. 25 mm
  - d. 50 mm
34. What is the negative tolerance permitted on the wall thickness of an SA106 grade B pipe?
- a. 1%
  - b. 10%
  - c. 12.5%
  - d. 22%
35. What effect does Viscosity have on the Penetrating Properties of a Penetrant used for LPI?
- a. It has no effect
  - b. It influences the rate of penetration
  - c. It influences the brightness in penetrant
  - d. It produces variation in the dye concentration in visible dye penetrant
36. In MPI Non-relevant indications can be caused by
- a. Over magnetization
  - b. Structural design of the article
  - c. Difference in permeability within the article
  - d. All of the above
37. The dB difference between a signal 25% FSH (Full Screen Height) to 100% FSH is
- a. 6 dB
  - b. 8 dB
  - c. 12 dB
  - d. 14 dB
38. An acceptable radiograph is obtained under given exposure conditions with a tube current of 5 mA and an exposure time of 12 minutes. If other conditions are not changed, what exposure time would be required if the X-ray tube current could be raised to 10 mA?
- a. 24 minutes
  - b. 12 minutes
  - c. 6 minutes
  - d. 3 minutes







46. In case of notched bar Impact test, the axis of the notch shall be
- Parallel to the surface of plate
  - Perpendicular to the surface of plate
  - Parallel or perpendicular to the surface of plate
  - None of the above
47. Hydro test of fusion welded drums is done
- Before PWHT
  - After PWHT
  - Not required
  - None of above
48. Boiler drum & other cylindrical components shall be hydro tested at the makers works
- When internal diameter is greater than 400 mm
  - When internal diameter is greater than 600 mm
  - When internal diameter is greater than 450 mm
  - When internal diameter is greater than 500 mm
49. Are butt welds permitted within bends?
- Not permitted
  - Permitted
  - Permitted with Radiography of butt joints
  - Permitted with hydro test of butt joints
50. Steel shall not contain more than 0.05% of the following for boiler application:
- Sulphur
  - Phosphorus
  - Carbon
  - Sulphur & Phosphorus

**Part-B**

**(5 X 20 = 100 Marks)**

- (i) Answer only any **five** questions.
- (ii) Each Question may have many sub-sections. Write the Question number and sub-section number clearly against each answer.
- (iii) Total number of answered question should not exceed five. Only first five answered question will be evaluated and additional answered questions will not be evaluated. Choose wisely and answer only any five questions.
- (iv) Each question carries **Twenty** marks

**Question No. 1**

- a. What are the precautions to be taken during dry preservation of boiler? **(5 Marks)**
- b. Explain three element feed water control? **(5 Marks)**
- c. What procedure is adopted for the normal shutdown in case of pulverised fuel fired drum type boilers **(7 Marks)**
- d. What is BMCR of a boiler? **(3 Marks)**

**Question No. 2**

- a. What steps precede internal inspection of boilers? **(5 Marks)**
- b. What is the purpose of tube deposit sampling? **(3 Marks)**
- c. How to determine when a boiler requires chemical cleaning? **(3 Marks)**
- d. What is the effect of dissolved oxygen in boiler? How to minimize dissolved oxygen? What is the target value of dissolved oxygen in feed water? **(6 Marks)**
- e. What is outage corrosion? How does this corrosion arise? **(3 Marks)**

**Question No. 3**

- a. How are boilers classified? Explain briefly any two types of boilers? **(10 Marks)**
- b. What are the differences between superheater and reheater? Explain in detail with pressure and temperature parameters and the reason for installing re-heater in a thermal power plant. **(10 Marks)**

#### Question No. 4

- a. Explain briefly the natural circulation and forced circulation boilers. **(10 Marks)**
- b. Explain with the help of block diagram the water circuit and steam circuit of a natural circulation boiler. **(10 Marks)**

#### Question No. 5

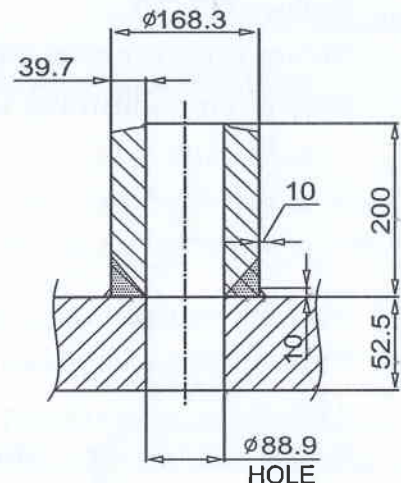
- a. Explain the conditions under which boiler needs immediate shutdown. **(5 Marks)**
- b. What is blow down in the boiler? Explain the purpose, advantages and impact on water steam cycle. **(15 Marks)**

#### Question No. 6

**(20 Marks)**

Consider the following details of the shell,

- a. Shell ID : 218.9 mm  
b. Shell minimum thickness : 52.5 mm  
c. Shell material : SA335P12  
d. Shell design pressure : 292.8 kg/cm<sup>2</sup> (g)  
e. Shell design temperature : 446°C  
f. Allowable stress : 1055.2 kg/cm<sup>2</sup>  
g. Nozzle OD : 168.3 mm  
h. Nozzle thickness : 39.7 mm  
i. Nozzle material : SA182F12CL2  
j. Nozzle allowable stress : 1320.3 kg/cm<sup>2</sup>



For the above configuration, confirm whether compensation is required and if compensation check is required, confirm whether the configuration satisfies the compensation requirements. (Assume ligament efficiency of shell as 100%)

#### Question No. 7

Answer the following,

- a. For a convective superheater tube, the steam temperature is 431°C. What is the working metal temperature for the tube? **(4 Marks)**
- b. For a tube of OD 44.45 mm, the tube is bent with a mean radius of 100 mm. What is the permissible reduction in minimum calculated thickness permitted as per IBR? **(4 Marks)**

c. Explain how to arrive at permissible working stress for shells subjected to temperature below 454°C.

**(4 Marks)**

d. The following are the design parameters of a superheater tube; determine whether the tube satisfies the requirements of IBR?

**(8 Marks)**

Tube OD	:	38.1 mm
Thickness	:	9.1 mm
Design pressure	:	292.8 kg/cm <sup>2</sup>
Design temperature	:	460°C
Allowable stress @460°C	:	1042.1 kg/cm <sup>2</sup>

**Question No. 8**

**(20 Marks)**

Boiler is having the following parameters:

Boiler capacity	:	170,000 kg/hr
Steam pressure at superheater outlet	:	108 Kg/cm <sup>2</sup> (g)
Steam temperature at superheater outlet	:	510°C

Boiler is provided with three safety valves on two steam drums and one number at outlet of superheater header.

Assume saturation temperature at Superheater safety valve set pressure	:	322°C
Assume valve constant, C	:	0.48
Steam side pressure drop across the superheater system	:	11.3 kg/cm <sup>2</sup>
Steam drum safety valve no.1 orifice area	:	9.22 cm <sup>2</sup>
Steam drum safety valve no. 2 orifice area	:	16.41 cm <sup>2</sup>
Superheater safety valve orifice area	:	9.22 cm <sup>2</sup>

1. What is the superheater safety valve set pressure, steam drum no. 1 safety valve pressure, steam drum no. 2 safety valve pressure?
2. Calculate the relieved capacity of superheater safety valve, steam drum no.1 safety valve, steam drum no. 2 valve?
3. Above three safety valves meeting the relieved capacity of boiler as per IBR?

**Question No. 9****(20 Marks)**

Shell type boiler of welded construction following specifications:

Maximum working pressure	: 12 kg/cm <sup>2</sup> (g)
Outside tube diameter	: 76.2 mm
Tube material	: SA210 Gr.A1
Allowable stress value for tube material	: 785 kg/cm <sup>2</sup>
Reversing chamber end plate material	: SA516 Gr 70
Allowable stress value for end plate	: 1375 kg/cm <sup>2</sup>
Diameter of largest circle taken between staying points	: 410 in mm

Plain end strength welded on the outside

1. Calculate the minimum tube thickness required under external pressure
2. Calculate the thickness for reversing chamber end plate

**Question No. 10****(20 Marks)**

Natural gas boilers fin tube integral economizer with following specifications:

Maximum working pressure	: 131.5 kg/cm <sup>2</sup> (g)
Maximum feed water outlet temperature	: 295°C
Economizer coil outside tube diameter	: 51 mm
Mean radius of the bend to the center line of tube R	: 57 mm
Material specification (tube)	: SA 210 GR A1

Temperature °C	Allowable stress kg/cm <sup>2</sup> - SA 210 GR A1
250	1202.85
300	1202.85
350	1192.66

1. Calculate the minimum thickness of economizer coil
2. Calculate the allowable thinning of bends

**Question No. 11****(20 Marks)**

Explain Radiographic techniques along with suitable sketches for radiographing plate, pipe, tube and shell weldments.

**Question No. 12**

- a. Define requirements of SA335 grade 91, 50 mm thickness pipe to pipe butt weld joint with respect to **(10 Marks)**
- i. Preheating
  - ii. Post weld heat treatment
- b. What are the essential variables in procedure qualification of C Mn steels of 100 mm thickness SA299 by SAW? What are the tests to be conducted on the test coupon and acceptance criteria? **(10 Marks)**

**Question No. 13**

- a. Briefly Explain what information the manufacturer must maintain in the quality-control record file. **(16 Marks)**
- b. Explain the principle of liquid penetrant testing and magnetic particle testing? **(4 Marks)**

**Question No. 14**

Prepare a checklist with applicable IBR requirements for manufacturing superheated coil from SA 213 T22 tubes with respect to raw materials, manufacturing, inspection and certification. **(20 Marks)**

**Question No. 15**

What is SMAW, SAW, GTAW and GMAW? Explain each one with its advantages? **(16 Marks)**

What is the importance of low hydrogen electrode in arc welding? **(4 Marks)**

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