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<u>BUREAU OF INDIAN STANDARDS</u>

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भारतीय मानक मसौदा

निम्न और मध्यम दबाव बॉयलरों के लिए फ़ीड पानी और बॉयलर पानी की विशिष्टता
(*पहला पुनरीक्षण*)

Draft Indian Standard

Specification for feed water and boiler water for low and medium pressure boilers
(*First Revision*)

(ICS 27.060.01)

Water Quality for Industrial Purposes Sectional Committee, CHD 13	**Last Date for Comments: 17.03.2024**

FOREWORD

(Formal clause to be added later)

Boilers require good quality water for their safe and efficient operation. Natural water accumulates impurities rendering it unfit for use in boilers without treatment. Though water treatment is costly, in the long run it is economic in terms of fuel and time savings. Treated water also increases safety of boilers during operation.

This standard lays down the specification for feed water and boiler water for low and medium pressure land boilers while IS 1680 deals with the chemical methods of attaining the conditions to be aimed at for water for land boilers operating up to 2.0 MN/m^2 (20 kgf/cm^2) pressure. IS 1680 is also generally applicable to boilers operating under medium pressure, that is, between 2.0 and 5.9

MN/m^2 (20 to 60 kgf/cm^2) but not to marine and locomotive boilers and boilers operating at pressures higher than 5.9 MN/m^2 (60 kgf/cm^2).

This standard was first published in 1982. In this first revision the following changes have been incorporated:

a) Requirements of pH, total iron, copper, and phosphates have been modified;

b) Scope has been modified;

c) Requirements for parameters for water tube boilers with super-heaters, turbine operation having process restrictions on steam purity have been incorporated;

d) Requirements for parameters for water tube boilers without super-heaters, turbine operation and with no process restrictions on steam purity;

e) Requirements for parameters for fire tube boilers have been incorporated;

f) References, ICS No. have been updated; and

g) Other editorial changes have been done to bring the standard in the latest style and format of Indian Standards.

In preparing this standard assistance have been derived from British Standard BS 02486 : 2008 'Recommendations For Treatment Of Water For Steam Boilers And Water Heaters' and ASME Standards CRTD-Vol 34 'Consensus on operating Practices for the control of Feed water and Boiler water Chemistry in Modern Industrial boilers'.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2: 2022 'Rules for Rounding off Numerical Values (*second revision*)'.

1 SCOPE

1.1 This standard lays down specifications for feed water and boiler water for low and medium pressure land boilers (boilers operating up to 5.9 MN/m^2).

1.2 Land boilers operating at pressure higher than 5.9 MN/m^2, marine boilers and locomotive boilers are not covered in this standard.

1.3 The following boilers are covered in this standard:

a) Water tube boilers with super-heaters, turbine operation having process restrictions on steam purity;

b) Water tube boilers without super-heaters, turbine operation and with no process restrictions on steam purity;

c) Fire tube boilers; and

d) Industrial coil type water tube boilers.

2 REFERENCE

The standards given at Annex-A contain provisions which through reference in this text constitute provisions of this standard. At the time of publications, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards as given in Annex-A.

3 TERMINOLOGY

For the purposes of this standard, the definitions given in IS 11671 shall apply.

4 REQUIREMENTS

4.1 The feed water, boilers water and return condensate shall comply with the requirements as specified in **Table 1 to 4** when tested by the methods prescribed in **col 6**.

4.2 The IS 1680 should be referred while referring to this standard.

5 SAMPLING

5.1 Sampling shall be done following general directions given in IS 17614 (Part 7). In particular, the following points shall be observed:

a) It is necessary that a stainless steel or monel metal coil is fitted on the sampling cock so that the temperature of the water sample will be well below the boiling point at atmospheric pressure and there is no risk of aeration and concentration due to flashing into steam; and

b) Samples of feed water should be collected from the delivery of the boiler feed pump, samples of boiler water from the top drum, and samples of condensate from the delivery of the condensate extraction pump.

6 TEST METHODS

6.1 Tests shall be carried out as prescribed in **col 6** of **Table 1**, and **Table 2**, and **col 5 of Table 3,** and **col 7 of Table 4** as indicated against characteristics in **Table 1 to 4**.

Table 1 Water Chemistry Limits for Industrial Water Tube Drum type Boilers (Includes Super heaters, Turbine operation and Process Steam Restrictions)

(*Clause 4*.1*, and* 6.1)

Sl. No.	**Characteristics**	**Requirement for boiler drum operating pressure**			**Method of Test, Ref to**
	Boiler drum operating pressure, MN/m^2	**Up to 2.0**	**2.1 – 3.9**	**4.0 - 5.9**	
(1)	(2)	(3)	(4)	(5)	(6)
1.	**Feed water at Economizer Inlet**				
i.	*pH* at 25 °C	8.5 - 9.5	8.5 – 9.5	8.5-9.5	IS 3025 (Part 11)
ii.	Total hardness (as $CaCO_3$), mg/l, *Max*	2.0	1.0	Below Detectable limit	IS 3025 (Part 21)
iii.	Dissolved Oxygen (at economizer inlet), mg/l, *Max* (*see* Note 1)	0.01	0.01	0.007	IS 3025 (Part 38)
iv.	Silica (as SiO_2), mg/l, *Max*	*see* Note 2	*see* Note 2	0.02	IS 3025 (Part 35)
v.	Total Iron (as Fe), mg/l, *Max*	0.025	0.02	0.01	IS 3025 (Part 53)
vi.	Total Copper (as Cu), mg/l, *Max*	0.025	0.02	0.005	IS 3025 (Part 42)
vii.	Non Volatile Total Organic Carbon (TOC), mg/l, *Max*	1.0	0.5	0.5	IS 3025 (Part 73)
viii.	Oily Matter, mg/l, *Max*	1.0	0.5	0.5	IS 3025 (Part 39)
ix.	Oxygen Scavenger				
	1) Hydrazine as N_2H_4, mg/l 2) DEHA, mg/l, (*see* Note 3)	0.01-0.03 0.1 – 0.25	0.01 - 0.03 0.1 – 0.25	0.01-0.02 0.1 – 0.25	Annex-B Annex-C
x.	Specific Conductance at 25 °C without neutralization	*see* Note 4	*see* Note 4	*see* Note 4	IS 3025 (Part 14)
2.	**Boiler Water Limits**				
xi.	pH at 25 °C	*see* Note 5	*see* Note 5	9.2 - 10.0 *see* Note 5	IS 3025 (Part 11)
xii.	Silica (as SiO_2), mg/l, *Max*	150	40	20	IS 3025 (Part 35)
xiii.	Alkalinity (as $CaCO_3$), mg/l, *Max*	700	500	150	IS 3025 (Part 23)
xiv.	Phosphate (as PO_4^{3-}), mg/l	30 -70	20 -50	2.0- 10.0	IS 3025 (Part 31/Sec 1)
xv.	Caustic (OH^-) Alkalinity, mg/l, *Max*	50 - 300	50 – 150	25 - 50	IS 3025 (Part 23)
xvi.	1) Sulfite residual as Na_2SO_3, mg/l	30 – 50	20 – 40	Note 6	IS 3025 (Part 28)

	2) Hydrazine as N_2H_4, mg/l	0.1 – 1.0	0.1 - 0.5	0.1 – 0.2	Annex-B
	3) DEHA, mg/l	120-160	—	—	Annex-C
	4) Tannin, mg/l, *Max*	100	100	—	IS 3025 (Part 62)
	5) Iso Ascorbic Acid, mg/l	15 — 30	15 — 30	15 — 30	Annex-D
3.	**Total Dissolved Solids in Steam**	0.2 – 1.0	0.2 – 1.0	0.2 – 1.0	IS 3025 (Part 16)

NOTES

1 The dissolved oxygen levels indicated are after mechanical de-aeration before dosing of chemical oxygen scavenger. It is recommended that the de-aerators are used for low pressure boilers also, so as to minimize blow down and reduce chemical consumption. The low total dissolved solids (TDS) (in case of sulfite dosing) also will help maintain steam purity.

2 The silica limit in feed water will vary in line with the allowable silica as SiO_2 in the boiler water operating at specific cycles of concentration. It may be important to mention here that for each 1 ppm of dissolved silica as SiO_2, a 2.5 ppm of OH^- alkalinity is required in the boiler water to keep silica in un volatized form enabling to meet steam purity target of silica as SiO_2 in steam.

3 Diethylhydroxylamine (DEHA) residuals are checked in feed water and condensate as it is volatile oxygen scavenger which does not stay fully in boiler water.

4 The Conductivities are determined on un-neutralized samples without cation exchange at 25 °C.

5 The pH of boiler water is one of the most critical parameter. It will depend upon silica levels in boiler water, the type of treatment being used, 'OH' alkalinity to be maintained and the operating pressure of the boiler. Typically its range of 9.2 to 10.0 for phosphate based treatment but is actually maintained at levels depending upon the above factors. One must also follow the limit given by boiler manufacturer or your water treatment Specialist.

6 The sulfite treatment should be used only up to boiler operating at 4.136 MN/m^2 or below. However, there should still be a need to use sulfite keeping in view of steam coming in contact with food items, the sulfite treatment can be used with caution by limiting sulfite as Na_2SO_3 to 15 ppm to 20 ppm in boiler water for boiler operating between 4.136 MN/m^2 to 6.205 MN/m^2 to and ensure levels of amines to maintain desired pH in condensate as sulfite tend to decompose leading to H_2S and SO_2 levels.

7 The pH of condensate should be maintained between 8.5 to 9.5 by using neutralizing amines, if copper is present otherwise it can be up to 9.3 if it is all ferrous system.

Table 2 Water Chemistry Limits for Industrial Water Tube Drum type Boilers (Without Super heaters, Turbine operation and Process Steam restrictions) Steam Purity Target: 1.0 mg/l TDS Max

(*Clause* 4.1 *and* 6.1)

Sl. No.	**Characteristics**	**Requirement for boiler drum operating pressure**			**Method of Tests, Ref to**
	Boiler drum operating pressure, MN/m^2	**0 - 1.96**	**2.059 - 3.92**	**4.02 - 5.88**	
(1)	(2)	(3)	(4)	(5)	(6)

1. Feed Water at Economizer Inlet					
i.	pH at 25 °C	8.5 - 9.5	8.5 – 9.5	8.5 – 9.5	IS 3025 (Part 11)
ii.	Total Hardness, mg/l as $CaCO_3$, *Max*	2.0	1.0	Below detection limit	IS 3025 (Part 21)
iii.	Dissolved Oxygen before adding Oxygen Scavenger, mg/l (*see* Note 1), *Max*	0.02	0.02	0.01	IS 3025 (Part 38)
iv.	Silica as SiO_2, mg/l, *Max*	Note 2	Note 2	0.02	IS 3025 (Part 35)
v.	Total Iron as Fe, mg/l, *Max*	0.025	0.02	0.015	IS 3025 (Part 53)
vi.	Total Copper as Cu, mg/l, *Max*	0.025	0.02	0.015	IS 3025 (Part 42)
vii.	Non Volatile TOC, mg/l, *Max*	1.0	0.5	0.5	IS 3025 (Part 73)
viii.	Oily Matter, mg/l, *Max*	1.0	0.5	0.5	IS 3025 (Part 39)
ix.	Oxygen Scavenger residuals: a) Hydrazine as N_2H_4, mg/l, or	0.01 – 0.03	0.01 – 0.03	0.01 – 0.03	Annex-B
	b) DEHA, mg/l, (Note 3)	0.1 – 0.25	0.1 – 0.25	0.1 – 0.25	Annex-C
x.	Specific Conductance at 25 °C without neutralization	*see* Note 4	*see* Note 4	*see* Note 4	IS 3025 (Part 14)
2. Boiler Water Limits					
xi.	*p*H @ 25 °C	*see* Note 5	*see* Note 5	*see* Note 5	IS 3025 (Part 11)
xii.	Silica as SiO_2, mg/l, *Max*	150	40	20	IS 3025 (Part 35)
xiii.	M Alkalinity (as $CaCO_3$), mg/l, *Max*	700	500	150	IS 3025 (Part 23)
xiv.	Phosphate (as PO_4), mg/l	30 -70	20 -50	20 - 40	IS 3025 (Part 31/Sec 1) or IS 3025 (Part 31/Sec 2) or

					IS 3025 (Part 31/Sec 3)
xv.	Caustic (OH) Alkalinity, mg/l	50 - 300	50 - 150	25 - 50	IS 3025 (Part 23)
xvi.	Oxygen Scavenger a) Sulfite residual as Na_2SO_3, mg/l	30 – 50	20 – 40	*see* Note 6	IS 3025 (Part 28)
	b) Hydrazine as N_2H_4, mg/l	0.1 – 1.0	0.1 – 0.5	0.1 – 0.2	Annex-B
	c) DEHA, mg/l (*see* Note 3)	0.1 – 0.25	0.1 – 0.25	0.1 – 0.25	Annex-C
	d) Tannin, mg/l	120-160	—	—	IS 3025 (Part 62)
	e) Iso Ascorbic Acid, mg/l	15-30	15-30	15-30	

NOTES

1 The dissolved oxygen levels indicated are after mechanical de-aeration before dosing of chemical oxygen scavenger. It is recommended that the de-aerators are also used for low pressure boilers also so as to minimize blow down and reduce chemical consumption. The low TDS (in case of sulfite dosing) also will help maintain steam purity.

2 The silica limit in feed water will vary in line with the allowable silica as SiO2 in the boiler water operating at specific cycles of concentration. It may be important to mention here that for each 1 ppm of dissolved Silica as SiO2, a 2.5 ppm of OH alkalinity is required in the boiler water to keep silica in unvolatized form enabling to meet steam purity target of Silica as SiO_2 in steam.

3 DEHA residuals are checked in feed water and condensate as it is volatile oxygen scavenger which does not stay fully in boiler water.

4 The conductivities are determined on un-neutralized samples without cation exchange at 25 °C.

5 The pH of boiler water is one of the most critical parameter. It will depend upon silica levels in boiler water, the type of treatment being used, 'OH' alkalinity to be maintained and the operating pressure of the boiler. Typically its range is 10.5 to 11.2 for phosphate based treatment but is actually maintained at levels depending upon the above factors. One must also follow the limit given by boiler manufacturer or your water treatment specialist.

6 The sulfite treatment should be used only up to boiler operating at 4.136 MN/m^2 or below. However, there should still be a need to use sulfite keeping in view of steam coming in contact with food items, the sulfite treatment can be used with caution by limiting sulfite as Na_2SO_3 to 15 ppm to 20 ppm in boiler water for boiler operating between 4.136 – 6.205 MN/m^2 to and ensure levels of amines to maintain desired pH in condensate as sulfite tend to decompose leading to H_2S and SO_2 levels.

7 The pH of condensate should be maintained between 8.5 to 9.5 by using neutralizing amines, if copper is present otherwise it can be up to 9.3 if it is all ferrous system.

Table 3 Water Chemistry Limits for Industrial Fire-tube Boilers (Without Super-heaters, Turbine operation and Process Steam restrictions) Steam Purity Target: 1.0 mg/l TDS Max

(*Clause* 4.1 *and* 6.1)

S No.	Characteristics	Requirements for boiler drum operating pressure and heat flux		
	Boiler Drum Operating Pressure (MN/m^2)	**2.94**		**Method of Test Ref to**
	Heat Flux (KW/m^2)	**Up to 300**	**Above 300**	
(1)	(2)	(3)	(4)	(5)
1. Feed Water at Economizer Inlet				
i.	pH at 25 °C	8.5 – 9.5	8.5 – 9.5	IS 3025 (Part 11)
ii.	Total hardness (as $CaCO_3$), mg/l, *Max*	5.0	2.0	IS 3025 (Part 21)
iii.	Dissolved Oxygen before adding Oxygen Scavenger, mg/l, *Max* (*see* Note 1)	0.03	0.007	IS 3025 (Part 38)
iv.	Silica (as SiO_2), mg/l, *Max*	*see* Note 2		IS 3025 (Part 35)
v.	Total Alkalinity (as $CaCO_3$), mg/l, *Max*	*see* Note 3		IS 3025 (Part 23)
vi.	Non Volatile Total Organic Carbon, mg/l, *Max*	1.0	1.0	IS 3025 (Part 73)
vii.	Oily Matter, mg/l, *Max*	1.0	0.1	IS 3025 (Part 39)
viii.	Specific Conductance at 25 °C without neutralization	Note 4		IS 3025 (Part 14)
2. Boiler Water Limits				
ix.	pH at 25 °C	10.5 – 12.0	9.5 – 10.5	IS 3025 (Part 11)
x.	Silica (as SiO_2), mg/l, *Max*	150	05	IS 3025 (Part 35)
xi.	Alkalinity (as $CaCO_3$), mg/l, *Max*	1000	100	IS 3025 (Part 23)
xi.	Caustic (OH) Alkalinity (as $CaCO_3$), mg/l, *Min*	350	20	IS 3025 (Part 23)
xiii.	Phosphate (as PO_4), mg/l	30 -60	10 -30	IS 3025 (Part 31/Sec 1)
xiv.	Oxygen Scavenger a) Sulfite residual as Na_2SO_3, mg/l	30 – 70	Note 5	IS 3025 (Part 28)
	b) Hydrazine as N_2H_4, mg/l	0.1-10	0.1-10	Annex-B
	c) DEHA, mg/l (*see* Note 6)	0.1-10	0.1-10	Annex-C
	d) Tannin, mg/l	120 – 160	Note 7	IS 3025 (Part 62)

	e) Iso Ascorbic Acid, mg/l	15 - 30	Note 8	Annex-D
xv.	Total Dissolved Solids, mg/l, *Max*	3 500	1 000	IS 3025 (Part 16)
xvi.	Suspended Solids, mg/l, *Max*	200	20	IS 3025 (Part 17)
xvii.	Conductivity at 25 °C, µS/cm before neutralization	7 000	2 000	IS 3025 (Part 14)

NOTES

1 The dissolved oxygen levels indicated are after mechanical de-areation before dosing of chemical oxygen scavenger. It is recommended that the de-areators are also used for low pressure boilers also so as to minimize blow down and reduce chemical consumption. The low TDS (in case of Sulfite dosing) also will help maintain steam purity.

2 The silica limit in feed water will vary in line with the allowable silica as SiO_2 in the boiler water operating at specific cycles of concentration. It may be important to mention here that for each 1 ppm of dissolved silica as SiO_2, a 2.5 ppm of OH alkalinity is required in the boiler water to keep silica in un-volatized form enabling to meet steam purity target of Silica as SiO_2 in steam.

3 It is recommended that feed water alkalinity be maintained below 25 mg/l. Alkalinity of 25 mg/kg and above will result in 10 mg/l carbon dioxide in the steam. This level of carbon dioxide can be economically controlled by the use of a neutralizing amine if feed alkalinity is adequate but on the lower side. If this feed water alkalinity level cannot be achieved, it is recommended that de-alkalization of the make-up water be carried out.

4 The Conductivities are determined on un-neutralized samples without cation exchange at 25 °C.
5 The sulfite treatment should be used only up to boiler operating at 600 psig or below. However, still there is a need to use sulfite keeping in view of steam coming in contact with food items, the sulfite treatment can be used with caution by limiting sulfite as Na_2SO_3 to 15 ppm to 20 ppm in boiler water for boiler operating between 600 psig to 900 psig and ensure levels of amines to maintain desired pH in condensate as sulfite tend to decompose leading to H_2S and SO_2 levels.

6 DEHA residuals are checked in feed water and condensate as it is volatile Oxygen Scavenger which does not stay fully in boiler water.

7 Tannins in High Heat Flux of High Pressure boilers (Above 30 kg/cm^2) decompose to corrosive products so is not used in these boilers

8 Iso Ascorbic acid is not recommended in high heat flux fire-tube boilers.

9 The pH of condensate should be maintained between 8.5 to 9.5 by using neutralizing amines, if copper is present otherwise it can be up to 9.3 if it is all ferrous system.

Table – 4

Water Chemistry limits for Water Tube Coil Type Boilers

S No.	Characteristics	Requirements for boiler drum operating pressure				Method of test, Ref to
	Drum Operating Pressure (MN/m^2)	**0-1.961**	**2.095-2.915**	**3.040-3.922**	**4.021-5.884**	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Steam Purity Target						
i.	Conductivity at 25 °C, µS/cm (*see* Note 1)	50	24	20	0.5	IS 3025 (Part 14)
ii.	Total Dissolved Solids, mg/l, *Max*	25	12	10	0.25	IS 3025 (Part 16)
iii.	Silica (as SiO_2), mg/l, *Max* (*see* Note 2)	—	—	—	0.03	IS 3025 (Part 35)
2. Water to Coil						
iv.	pH at 25 °C	9.0 – 11.0	9.0 – 11.0	9.0 – 11.0	9.0 – 11.0	IS 3025 (Part 11)
v.	Conductivity at 25 °C, µS/cm, *Max* (*see* Note 1)	8 000	6 000	5 000	4 000	IS 3025 (Part 14)
vi.	Total hardness (as $CaCO_3$), mg/l, *Max*	Traces	Traces	Traces	-	IS 3025 (Part 21)
vii.	Total Dissolved Solids, mg/l, *Max* (*see* Note 3)	0.07	0.07	0.07	0.07	IS 3025 (Part 16)
viii.	M Alkalinity (as $CaCO_3$), mg/l, *Max*	800	600	500	200	IS 3025 (Part 23)
	Silica (as SiO_2), mg/l, *Max*	150	100	60	30	IS 3025 (Part 35)
ix.	Total Iron as Fe, mg/l, *Max*	1.0	0.3	0.1	0.05	IS 3025 (Part 53)
x.	Total Copper as Cu, mg/l, *Max*	0.1	0.05	0.03	0.02	IS 3025 (Part 42)
xi.	Oxygen Scavenger a) Sulfite residual as Na_2SO_3, mg/l (*see* Note 4)	10 – 20	10 -20	10 -20	—	IS 3025 (Part 28)
	b) Hydrazine as N_2H_4, mg/l	0.05 – 1.0	0.05 – 1.0	0.02 – 0.05	0.02.0.05	Annex-B
	c) DEHA, mg/l (*see* Note 5)	0.025 – 0.1	0.025 – 0.1	0.02 – 0.05	0.02 – 0.05	Annex-C
3. Water Exiting Coil						
x.	Phosphate (as PO_4), mg/l	30 -70	07 - 10	05 -07	03 - 05	IS 3025 (Part 31/Sec 1)
xi.	Caustic(OH) Alkalinity (as $CaCO_3$), mg/l, *Min*	300	200	120	60	IS 3025 (Part 23)
xii.	Silica (as SiO_2), mg/l, *Max*	*see* Note 2				IS 3025 (Part 35)

NOTES

1 The conductivities are determined on un-neutralized samples without cation exchange at 25 °C.

2 The silica limit in feed water will vary in line with the allowable Silica as SiO_2 in Coil Water exit so that it is maintained at < 0.4 times of OH alkalinity so that silica is kept in un-volatized to enable meet steam purity target.

3 The dissolved oxygen levels indicated are after dosing of chemical oxygen scavenger.

4 The sulfite treatment should be used only up to boiler operating at 600 psig or below. However, should there still be a need to use sulfite keeping in view of steam coming in contact with food items, the sulfite treatment can be used with caution by limiting sulfite as Na_2SO_3 to 15 ppm to 20 ppm in boiler water for boiler operating between 600 psig to 900 psig and ensure levels of amines to maintain desired pH in condensate as sulfite decomposes to corrosive byproducts.

5 DEHA residuals are checked in feed water and condensate as it is volatile oxygen scavenger which does not stay fully in boiler water.

6 The pH of condensate should be maintained between 8.5 – 9.2 by using neutralizing amines, if copper is present otherwise it can be up to 9.5 if it is all ferrous system.

7 RECOVERY BOILERS

The boiler feed water used should be completely demineralized and also the boiler feed water and boiler water should be conditioned in accordance with high pressure boilers working at 5.9 MN/m^2 and above (*see* IS 4343).

8 SILICA IN BOILER WATER

Lower concentration of silica may be advisable for steam of turbines, which generally require less than 0.02 mg/l silica in steam.

ANNEX-A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 1680: 2022	Code of practice for Treatment of Water for Low and Medium Pressure Land Boilers (*fourth revision*)
IS 4343: 2023	Code of practice for treatment of water for high pressure boilers (*second revision*)
IS 3025	Methods of sampling and test (Physical And Chemical) for water and wastewater
(Part 11): 2022	Part 11 pH value (*second revision*)
(Part 14): 2013	Part 14 specific conductance (Wheatstone Bridge, Conductance Cell) (*second revision*)
(Part 16): 2023	Part 16 Filterable Residue Total Dissolved Solids at 180 °C (*second revision*)
(Part 17): 2022	Part 17 Non-Filterable Residue Total Suspended Solids at 103 °C-105 °C (*second revision*)
(Part 21): 2008	Part 21 hardness (*second revision*)
(Part 23):2023	Part 23 Alkalinity (*second revision*)
(Part 28): 1986	Part 28 Sulphites (*first revision*)
(Part 31/Sec 1): 2022	Part 31 Phosphorus Section 1 Determination by Vanadomolybdo-phosphoric acid, Stannous chloride Ascorbic acid and Persulphate method (*second revision*)
(Part 35): 1988	Part 35 Silica (*first revision*)
(Part 38): 1989	Part 38 Dissolved Oxygen (*first revision*)
(Part 39): 2021	Part 39 Oil and Grease (*second revision*)
(Part 42): 1992	Part 42 Copper (*first revision*)
(Part 53): 2023	Part 53 Iron (*first revision*)
(Part 62): 2023	Part 62 Tannins (*second revision*)
(Part 73): 2021	Part 73 Instrument based method for determination of total organic carbon TOC dissolved organic carbon DOC total bound nitrogen TNb and dissolved bound nitrogen DNb
11671: 2022	Glossary of terms relating to boiler water (*first revision*)
17614 (Part 7):2021	Water Quality - Sampling Part 7 Guidance on sampling of water and steam in boiler plants

ANNEX-B

(*S No. ix and S No. xvi of col 6 of Table 1, S No. ix and S No. xvi of col 6 Table 2, S No. xiv of col 5 of Table 3, S No. xi of col 7 of Table 4*)

DETERMINATION OF HYDRAZINE

B-1 DETERMINATION OF HYDRAZINE

B-1.1 Outline of the Method

In acid medium, hydrazine reacts with ρ-dimethylaminobenzaldehyde to produce a yellow colour which is matched against that obtained with a series of standard hydrazine solutions

B-1.2 Apparatus

B-1.2.1 *Nessler Tubes*, 50 ml capacity

B-1.3 Reagents

B-1.3.1 *Dilute Hydrochloric Acid*, approximately 0.5 N.

B-1.3.2 *Standard Hydrazine Solution*

Dissolve 0.328 g of hydrazine di-hydrochloride in 50 ml of approximately 0.5 N hydrochloric acid and dilute with the same acid to 1 000 ml. Before use, dilute 10 ml of the solution to 1 000 ml with the same acid (1 ml = 0.001 mg of hydrazine (N_2H_4)).

B-1.3.3 *ρ-Dimethylaminobenzaldehvde Solution*

Dissolve 4.0 g of ρ-dimethylaminobenzaldehyde (special grade for hydrazine determination) in a mixture of 200 ml of methanol and 20 ml of concentrated hydrochloric acid.

B-1.4 Procedure

B-1.4.1.1 Hydrazine tends to be destroyed in neutral or alkaline solutions in contact with air. Hence it is essential that the sampling is done properly as given below and that the test is carried out immediately thereafter:

B-1.4.1.2 Insert the outlet tube from an efficient stainless steel cooler to the bottom of a 250 ml bottle. Allow the water to flow until a representative sample is obtained, at a temperature ranging from 17 °C to 30 °C. Withdraw the outlet tube slowly and immediately stopper the bottle, avoiding trapping any air-bubbles.

B-1.4.2 Into 9 Nessler tubes, each containing 15 ml of dilute hydrochloric acid, add 0 ml, 0.5 ml, 1.0 ml, 2.0 ml, 3.0 ml, 4.0 ml, 6.0 ml, 8.0 ml and 10.0 ml of standard hydrazine solution. Make the volumes to 40 ml by adding distilled water and mix. In the 10^{th} Nessler tube containing 15 ml of dilute hydrochloric acid, pipette out a suitable volume of the sample (2 ml, 10 ml or 25 ml) and dilute to 40 ml with distilled water and mix.

B-1.4.3 Now add to each of the Nessler tubes 10 ml of ρ-dimethylaminobenzaldehyde solution. Mix and after 10 min compare the colour of the sample with those of the standards.

B-1.6 Calculation

Concentration of hydrazine (as N_2H_4), mg/l = $\frac{V1}{V2}$

where

V_1 = volume of standard hydrazine solution required for matching the colour with the sample, in ml; and

V_2 = volume of the sample taken for the test, in ml.

B-1.7 Range of Accuracy

The method is suitable in the range 0 mg/l to 5 mg/1 of hydrazine.

.3.1 *Dilute Hydrochloric Acid*, approximately 0.5 N.

B-1.3.2 *Standard Hydrazine Solution*

Dissolve 0.328 g of hydrazine di-hydrochloride in 50 ml of approximately 0.5 N hydrochloric acid and dilute with the same acid to 1 000 ml. Before use, dilute 10 ml of the solution to 1 000 ml with the same acid (1 ml = 0.001 mg of hydrazine (N_2H_4)).

B-1.3.3 *ρ-Dimethylaminobenzaldehvde Solution*

Dissolve 4.0 g of ρ-dimethylaminobenzaldehyde (special grade for hydrazine determination) in a mixture of 200 ml of methanol and 20 ml of concentrated hydrochloric acid.

B-1.4 Procedure

B-1.4.1.1 Hydrazine tends to be destroyed in neutral or alkaline solutions in contact with air. Hence it is essential that the sampling is done properly as given below and that the test is carried out immediately thereafter:

B-1.4.1.2 Insert the outlet tube from an efficient stainless steel cooler to the bottom of a 250 ml bottle. Allow the water to flow until a representative sample is obtained, at a temperature ranging from 17 °C to 30 °C. Withdraw the outlet tube slowly and immediately stopper the bottle, avoiding trapping any air-bubbles.

B-1.4.2 Into 9 Nessler tubes, each containing 15 ml of dilute hydrochloric acid, add 0 ml, 0.5 ml, 1.0 ml, 2.0 ml, 3.0 ml, 4.0 ml, 6.0 ml, 8.0 ml and 10.0 ml of standard hydrazine solution. Make the volumes to 40 ml by adding distilled water and mix. In the 10th Nessler tube containing 15 ml of dilute hydrochloric acid, pipette out a suitable volume of the sample (2 ml, 10 ml or 25 ml) and dilute to 40 ml with distilled water and mix.

B-1.4.3 Now add to each of the Nessler tubes 10 ml of ρ-dimethylaminobenzaldehyde solution. Mix and after 10 min compare the colour of the sample with those of the standards.

B-1.6 Calculation

Concentration of hydrazine (as N_2H_4), mg/l = $\frac{V1}{V2}$

where

V_1 = volume of standard hydrazine solution required for matching the colour with the sample, in ml; and

V_2 = volume of the sample taken for the test, in ml.

B-1.7 Range of Accuracy

The method is suitable in the range 0 mg/l to 5 mg/1 of hydrazine.

ANNEX-C

(*S No. ix and S No. xvi of col 6 of Table 1, S No. ix and S No. xvi of col 6 Table 2, S No. xiv of col 5 of Table 3, S No. xi of col 7 of Table 4*)

DETERMINATION OF N, N-DIETHYLHYDROXYLAMINE (DEHA)

C-1 DETERMINATION OF DEHA

C-1.1 Principle

DEHA (N, N-Di-ethyl-hydroxylamine) reacts quantitatively with ferric iron by reducing it to the ferrous state. The resulting ferrous iron reacts with PDTS [3-(2-pyridyl)-5, 6- bis (4-phenylsulfonic acid)-1, 2, 4,-triazine disodium salt], also known as ferrozine to form a pink-purple colored complex. The intensity of color developed is directly proportional to the DEHA concentration. The color can be measured using Spectrophotometer at 525nm wavelength. The test results are expressed as ppb (µg/L) or ppm (mg/L).

C-1.2 Apparatus

C-1.2.1 *Spectrophotometer to Measure Wavelength,* 525 nm

C-1.2.2 *Pipettes* 1 ml, 5 ml and 10 ml, 2 Nos. each

C-1.2.3 *Volumetric Flasks* 100 ml, 20 Nos.

C-1.2.4 *Conical Flasks* 50 ml Capacity, 10 Nos

C-1.2.5 *Analytical Weighing Balance*

C-1.3 Reagents

C-1.3.1 *Nitric Acid Solution*, 10 percent

Take 10.13 ml concentrated nitric acid in a 100 ml volumetric flask and make up to the mark using reagent grade water (see 1070).

C-1.3.2 *Ferric Nitrate Reagent*

Weigh accurately 0.25 gm of ferric nitrate and dissolve in 30 ml of 10 percent of nitric acid solution and make up to 100 ml in a volumetric flask using reagent grade water.

C-1.3.3 Ferrozine Reagent

Weigh accurately 1 gm of ferrozine (FZ) and mix with 30 gm of glycine in a pestle mortar and grind.
NOTE — Ensure the cleanliness of mortar and pestles. Wash with iron free water and dry it with nitrogen. Keep the reagents, bottles and Teflon spatula in a very clean and iron free atmosphere.

C-1.4 Preparation of Oxygen Free Water

Take 1.5 l of reagent grade water in a 2 l reagent bottle. Pass nitrogen gas for 5 min into the water. Add 2 ml of concentrated sulphuric acid slowly using glass stirrer. Then add 3 gm of sodium carbonate and adjust the pH to 7 using 5 percent of NaOH solution.

C-1.5 Preparation of Standard Solutions

C-1.5.1 Weigh accurately 1 gm of DEHA in a 100 ml volumetric flask. Make up to the mark using oxygen free water.

C-1.5.2 Pipette out 10 ml of this solution in a 100 ml volumetric flask and make it up (Concentration is 1 000 ppm).

C-1.5.3 Dilute 1 ml of this solution to 100ml in a volumetric flask (Concentration is 10ppm).

C-1.5.4 Pipette out 10 ml and make up to 100ml in volumetric flask (Solution Concentration is 1 000 ppb).

C-1.5.5 Pipette out 2ml, 4ml, 6ml, 8ml, 10ml and 15 ml separately in 100ml volumetric flasks and make up to the mark to get 20 ppb, 40 ppb, 60 ppb, 80 ppb, 100 ppb and 150 ppb solutions respectively.

NOTE — Use only oxygen free water for makeup.

C-1.6 Standardization

C-1.6.1 Take 25 ml standard DEHA solution in a 50 ml conical flask.

C-1.6.2 Add 0.5 ml ferric nitrate reagent and immediately add 0.25 gm of ferrozine reagent and dissolve.

C-1.6.3 Allow the color to develop for 5 min.

C-1.6.4 Measure the optical absorbance at 525 nm in spectrophotometer exactly after 5 min.

C-1.6.5 In a similar way, read the absorbance value for reagent blank using oxygen free water in place of standard.

C-1.6.6 Generate the standard graph for all the above concentration after deducting blank absorbance value.

C-1.6.7 Establish a linear graph by plotting the concentration (X-axis) versus the absorbance value (Y-axis).

C-1.7 Analysis of Sample

C-1.7.1 Collect 100 ml test sample in a narrow mouth glass or plastic bottle.

C-1.7.2 Fill the bottle without any air gap to avoid oxidization.

C-1.7.3 Take 25 ml sample solution in a 50 ml conical flask.

C-1.7.4 Add 0.5 ml ferric nitrate reagent and immediately add 0.25gms of ferrozine reagent and dissolve.

C-1.7.5 Allow the color to develop for 5 min.

C-1.7.6 Measure the optical absorbance at 525 nm in spectrophotometer exactly after 5 min.

C-1.7.7 Use the standard graph to get the concentration of unknown sample or generate a factor and use it to find out unknown concentration.

ANNEX-D

(*S No. ix and S No. xvi of col 6 of Table 1, S No. ix and S No. xvi of col 6 Table 2, S No. xiv of col 5 of Table 3, S No. xi of col 7 of Table 4*)

DETERMINATION OF ISOASCORBIC ACID

D-1 DETERMINATION OF ISOASCORBIC ACID

D-1.1 Principle

Iso-ascorbic acid reacts quantitatively with ferric iron by reducing it to the ferrous state. The resulting ferrous iron reacts with PDTS [3-(2-pyridyl)-5, 6- bis (4-phenylsulfonic acid)-1, 2, 4,-triazine disodium salt], also known as ferrozine to form a pink-purple coloured complex. The intensity of colour developed is directly proportional to the iso-ascorbic acid concentration. The colour can be measured using Spectrophotometer at 525nm wavelength. The test results are expressed as ppb (µg/L) or ppm (mg/L).

D-1.2 Apparatus

D-1.2.1 *Spectrophotometer to Measure Wavelength*, 525 nm

D-1.2.2 *Pipettes* 1 ml, 5 ml and 10 ml, 2 Nos. each

D-1.2.3 *Volumetric Flasks* 100 ml, 20 Nos.

D-1.2.4 *Conical Flasks* 50 ml capacity, 10Nos

D-1.2.5 *Analytical Weighing Balance*

D-1.3 Reagents

D-1.3.1 *Nitric Acid Solution*, 10 percent

Take 10.13 ml concentrated nitric acid in a 100 ml volumetric flask and make up to the mark using reagent grade water (see 1070).

D-1.3.2 *Ferric Nitrate Reagent*

Weigh accurately 0.25 gm of ferric nitrate and dissolve in 30 ml of 10 percent of nitric acid solution and make up to 100 ml in a volumetric flask using reagent grade water.

D-1.3.3 Ferrozine Reagent

Weigh accurately 1 gm of ferrozine (FZ) and mix with 30 gm of glycine in a pestle mortar and grind.

NOTE — Ensure the cleanliness of mortar and pestles. Wash with iron free water and dry it with nitrogen. Keep the reagents, bottles and Teflon spatula in a very clean and iron free atmosphere.

D-1.3.4 *Glycine, Analytical Grade*

D-1.4 Preparation of Oxygen Free Water

Take 1.5 l of reagent grade water in a 2 l reagent bottle. Pass nitrogen gas for 5 min into the water. Add 2 ml of concentrated sulphuric acid slowly using glass stirrer. Then add 3 gm of sodium carbonate and adjust the pH to 7 using 5 percent of NaOH solution.

D-1.5 Preparation of Standard Solutions

D-1.5.1 Weigh accurately 1 gm of DEHA in a 100 ml volumetric flask. Make up to the mark using oxygen free water.

D-1.5.2 Pipette out 10 ml of this solution in a 100 ml volumetric flask and make it up (Concentration is 1 000 ppm).

D-1.5.3 Dilute 1 ml of this solution to 100ml in a volumetric flask (Concentration is 10ppm).

D-1.5.4 Pipette out 10 ml and make up to 100ml in volumetric flask (Solution Concentration is 1 000 ppb).

D-1.5.5 Pipette out 2ml, 4ml, 6ml, 8ml, 10ml and 15 ml separately in 100ml volumetric flasks and make up to the mark to get 20 ppb, 40 ppb, 60 ppb, 80 ppb, 100 ppb and 150 ppb solutions respectively.

NOTE — Use only oxygen free water for makeup.

D-1.6 Standardization

D-1.6.1 Take 25 ml standard iso-ascorbic acid solution in a 50 ml conical flask.

D-1.6.2 Add 0.5 ml ferric nitrate reagent and immediately add 0.25 gm of ferrozine reagent and dissolve.

D-1.6.3 Allow the color to develop for 5 min.

D-1.6.4 Measure the optical absorbance at 525 nm in spectrophotometer exactly after 5 min.

D-1.6.5 In a similar way, read the absorbance value for reagent blank using oxygen free water in place of standard.

D-1.6.6 Generate the standard graph for all the above concentration after deducting blank absorbance value.

D-1.6.7 Establish a linear graph by plotting the concentration (X-axis) versus the absorbance value (Y-axis).

D-1.7 Analysis of Sample

D-1.7.1 Collect 100 ml test sample in a narrow mouth glass or plastic bottle.

D-1.7.2 Fill the bottle without any air gap to avoid oxidization.

D-1.7.3 Take 25 ml sample solution in a 50 ml conical flask.

D-1.7.4 Add 0.5 ml ferric nitrate reagent and immediately add 0.25gms of ferrozine reagent and dissolve.

D-1.7.5 Allow the color to develop for 5 min.

D-1.7.6 Measure the optical absorbance at 525 nm in spectrophotometer exactly after 5 min.

D-1.7.7 Use the standard graph to get the concentration of unknown sample or generate a factor and use it to find out unknown concentration.