STANDARD SPECIFICATION FOR
CHEMICAL CLEANING

PART : III

VOLUME – 4

SECTION : B.13

TITLE : CHEMICAL CLEANING

DOCUMENT NO: 44LK-5100-00/N.02/0029
TABLE OF CONTENTS

1.0 SCOPE OF WORK
2.0 PURPOSE
3.0 RESPONSIBILITY
4.0 GENERAL CONDITIONS FOR CHEMICAL CLEANING
5.0 CHEMICAL CLEANING SOLUTIONS
6.0 LIST OF SPECIFICATIONS
1.0 **SCOPE OF WORK**

1.1 This document covers the requirements for field chemical cleaning, flushing the systems of shop and field fabricated equipment & piping systems. All field fabricated components and piping shall be chemically degreased or cleaned. By following this specification, a minimum acceptance standard of cleanliness shall be achieved during the pre-commissioning/commissioning of the plant/systems.

The EPCC Contractor shall procure, supply all materials and carry out at site all work related to chemical cleaning for all equipment and piping as specified in relevant sections annexed with the Bid document.

1.2 This specification is general and sets forth the basic guidelines and conditions for chemical cleaning; however, the cleaning contractor has the responsibility of developing a detailed procedure and of supervising and monitoring its use.

1.3 Exception or variations shown in the licensor's specifications take precedence over requirements shown herein.

1.4 It is not the intent of this specification to be used for unit turnaround chemical cleaning except where applicable. If used for such situations, it may be necessary to modify some of the guidelines and general conditions set forth to accommodate the particular situation where specific equipment removal is neither necessary nor desirable and/or use of equipment such as pumps is necessary. Such situations shall be determined by the Owner/PMC and/or Cleaning Contractor.

1.4 The work shall include but not be limited to:

- Procurement and supply of chemicals, test kits, lab equipments, chemical preparation, passivation, chemical cleaning, etc.
- Preparation of temporary circuits, arrangement of pumps piping valves tanks etc. for the chemical cleaning and passivation.
- Arrangement of steam, DM water, air, etc. from the battery limit or as instructed by Owner/PMC.
- Setting up of the laboratory near the job area for monitoring the chemical cleaning operation at site.

1.5 Preparation of detailed chemical cleaning scheme with loop diagram and obtain approval from Owner/PMC prior to chemical cleaning.

- Acid alkali water should not drain into the storm water drain. It is to be taken to the nearest acid/alkali sewer or as instructed by Owner/PMC.
- All pre activities for chemical cleaning such as temporary piping works, fixing of isolation valves, interconnection between piping systems, removal and refixing of existing piping, etc.
- Removal of temporary blinds and box-up of all piping spools flanges after obtaining approvals of chemical cleaning.

1.6 The scope of chemical cleaning shall include but not be limited to the following:

- Chemical cleaning and passivation of cooling water system.
- Chemical cleaning and post cleaning passivation of suction piping of compressor.
- Detergent cleaning of knockout drums / seal pot.
- Alkali boil out & chemical cleaning of boilers
- All equipment and piping as required in the Process Package.
2.0 PURPOSE

2.1 Certain equipment and piping must be chemically cleaned to remove mill scale, dirt, greases used as rust preventatives, and other foreign materials that could result in operating and maintenance problems such as plugging of adsorbents, catalyst beds, trays and screens; excessive wear and damage to reciprocating and rotating equipment and corrosion due to the reaction of scale with the process environment.

2.2 Chemical cleaning will generally be done after completion of unit construction. If cleaning is done prior to completion of construction, the cleaned equipment must be protected from atmospheric exposure and entry of any outside debris or dirt.

2.3 If hydrocarbon feed is not to be charged to the unit within a few hours after the equipment and piping is cleaned, the cleaned equipment and piping should be filled with nitrogen and blinded off. If start-up is to be delayed longer than two weeks, the nitrogen purge may be continued, provided the system is monitored daily to maintain a positive nitrogen pressure. As an alternate, the system may be filled with water containing a passivating material, which shall be drained before start-up. CAUTION: the effects of the passivating solution on the equipment and specific requirements of the process must be carefully considered.

3.0 RESPONSIBILITY

Chemical Cleaning Contractor;

3.1 Shall accept the responsibility of proposing and carrying out an acceptable and proven procedure for the entire cleaning operation. This shall cover all applicable steps in detail such as flushing, degreasing, chemical cleaning, neutralizing, passivating, clean water flushing, draining and safety. A copy of this procedure and schedule shall be submitted to Owner/PMC for record purpose.

3.2 Shall use inhibitor, detergent, emulsifier, or other addition agents in accordance with accepted practice and experience and to suit the equipment layout and metallurgy of the unit.

3.3 Shall establish and inform the Owner/PMC of the chemical or trade names and required quantities of all chemical cleaning, degreasing, neutralizing, inhibiting, and passivating agents (also the nitrogen to be used for agitation and blanketing) to be made available at the job site before the cleaning operation is to start.

3.4 Shall provide necessary skilled personnel to support the cleaning operation

3.5 Shall dispose of or recover all waste water, spent acids, degreasers, and neutralizers and inform Owner/PMC for the safe disposal or recovery of these materials.

4.0 GENERAL CONDITIONS FOR CHEMICAL CLEANING

4.1 Control valves shall be replaced by a spool assembly during chemical cleaning.

4.2 All instruments shall be protected from the chemical cleaning solution.

- Orifice plates shall not be in place in the lines
- Spool assemblies shall be substituted for all inline turbine meters.
- The valve in the pressure taps adjacent to the line or vessel of all instruments shall be closed and the drain valve on the instrument opened.
- Externally mounted liquid level instruments, such as displacement type level transmitters and gage glasses, shall have block valves adjacent to the vessel closed and drain valves opened. Internal displacement type level instruments shall not be in place and the nozzle through which they are inserted shall be blinded off.
- Thermo wells shall not be in place and their connections shall be blinded off.
Piping strainer screens shall not be in place.

4.3 All relief valves shall be removed and nozzles blanked off.

4.4 Temporary valves, \( \frac{3}{4} \)" minimum size, shall be installed at the high points of the systems to be circulated.

4.5 Reboiler or exchangers that are part of the process unit shall not be used as a means of heating any of the chemical solutions. All heating is to be external to the systems being cleaned, and by equipment furnished by the chemical cleaning contractor. Steam should never be introduced into any part of the system. Over heating must be avoided.

4.6 Process pumps shall not be used to circulate the chemical cleaning solution. All process, reciprocating and rotating equipment and their ancillary systems shall be disconnected and blinded off, and jumper lines or spools furnished as required to complete piping circuits. All transfer and circulating pumps for handling chemical cleaning degreasing, neutralizing and passivating solutions are to be furnished by the chemical cleaning contractor and should operate from a dependable power source. In order to reduce the time required for filling and circulation, the pumping rates shall be the maximum consistent with good practice and proper protection of the base metals.

4.7 The chemical cleaning solution must not be allowed to stand undisturbed in any part of the equipment and piping at any time. The filling, circulating, draining, flushing, drying and neutralizing operations are to be continuous for each of the systems to be treated.

5.0 CHEMICAL CLEANING SOLUTIONS

5.1 The following materials have been successfully used for mill scale removal and general cleaning:

- Inhibited Hydrochloric Acid
- Inhibited Phosphoric Acid
- Citric Acid (Ammoniated)

Other solutions may be used provided they have been proven by experience by a reputed cleaning contractor.

5.2 Experience has shown that the Citric Acid generally require no removal of normally encountered metal components in the circuit. However, in specific cases, the chemical cleaning contractor must determine whether any components need to be removed.

5.3 Prior to final selection of chemical cleaning method and solutions, Owner/PMC must be consulted if a vessel containing catalyst or adsorbent is in the cleaning circuit, or immediately following that circuit. This requirement is to prevent use of chemicals leaving residuals, which are poisonous for the catalyst or adsorbent and would adversely affect operations.

6.0 RECOMMENDED PROCEDURES:

6.1 RECOMMENDED PROCEDURE FOR PRE-TREATMENT CUM-ON-STREAM CLEANING OF COOLING WATER SYSTEM

1.0 GENERAL

1.1 The recommended procedure provides the measures for on-stream cleaning and passivation of metal surfaces of cooling water system. The pre-treatment involves two steps:

i) The thorough cleaning of metal surface; and

ii) The development of protective (passive) film on the metal surface.

Pre-treatment is applied to all metals but is directed primarily to carbon steel equipment. Pre-treatment applies to pipeline, coolers, condensers, and any equipment, which will come in contact with cooling water.
1.2 Normally microbiological fouling, deposits of phosphates, iron oxides and calcium carbonate scales are expected on cooling waterside. For effective film formation/maintenance by the corrosion inhibitors, the metal surfaces should be free from the foulants and deposits. Fouled surfaces can give rise to severe pitting and localised corrosion.

1.3 Pre-treatment should be applied to the entire cooling water system.

1.4 After the pre-treatment is over the system should be rapidly switched over to the normal treatment.

2.0 PRE-TREATMENT INSPECTION

2.1 Prior to pre-treatment, equipment should be inspected and if found to contain excessive corrosion products, deposits or foulants, the equipment should be cleaned with an appropriate cleaning procedure. This shall be carried out by individual EPCC contractors within their areas. Cooling water treatment vendor should check whether the inspection and cleaning has been done.

3.0 FLUSHING

3.1 Cooling tower basin and sump should be drained and cleaned. All sludge should be removed.

3.2 The cooling system should be flushed out thoroughly. All extraneous matter and debris such as loose scale, corrosion products, microbiological debris, mud, lumbers, chips, paper, etc. should be removed from the system including main horizontal headers.

3.3 Fill the system with fresh clean raw water with the blow down valve closed and circulate the water.

3.4 Open the blow down valve and flush the system with fresh raw water make up for 24 hours or till the system gets completely cleaned.

4.0 CLEANING WITH LOW pH WATER

4.1 All the equipment should be taken into circuit and the system should be put into circulation. Blow down should be stopped.

4.2 pH of circulating water should be adjusted to 6.0 – 6.2 by addition of sulphuric acid. pH should be held in this range for three days without addition of phosphate/phosphonate and without blowing down.

4.3 After three days of circulation, blow down should be started and continued till suspended solids are well under 30 ppm.

5.0 PHOSPHATE/PHOSPHONATE CLEANING CUM PASSIVATION

5.1 The pH of the circulating water should be raised to 7.5-8.0 by reducing acid dose and should be held in this range through out the phosphate/phosphonate cleaning operation. All blows down from the system should be closed.

5.2 5% organophosphonate (HEDP) should be added by gravity to build up a level of 80-100 mg/l as PO₄³⁻. HEDP – Hydroxy Ethylidene Diphosphonic Acid

Organophosphonate (HEDP) should be dosed very slowly as this will depress the pH of cooling water. If necessary, caustic soda may be added in C.W. to maintain pH in the range of 7.5-8.0.

5.3 5% Sodium Hexametaphosphate (SHMP) clean solution should be added to build up a level of 40-50 mg/l, as PO₄³⁻. Sodium Hexametaphosphate should be closed after HEDP addition is complete and pH is stabilised.
5.4 When phosphate/phosphonate level and pH are stabilized, NALCO 7308 @ 20-30 ppm or equivalent based on total hold up should be dosed. This should also be dosed at the same rate again after 24 hours. This may produce foam in the system hence precaution shall be taken for operation of C.W. pumps. This shall be added slowly.

5.5 Circulation should be continued under this condition for a period of 7 days and following levels of chemicals shall be maintained in C.W. system for this period.

- Sodium Hexametaphosphate (SHMP) as PO$_4^{3-}$: 40-50 mg/l
- Organo phosphonate as PO$_4^{3-}$ (HEDP): 50-60% active acid 80-100 mg/l
- pH: 7.5-8.0

5.6 After circulating for seven days, the system should be heavily blow down and regular treatment should be started immediately. TSS should be less than 30 mg/l before starting regular treatment.

6.0 CHLORINATION

After operation of step 5.4, shock chlorination should be practised every day to attain free residual chlorine of 68.06 mg/l in cooling water return line for ½ hr acid dosing should, however be discontinued during chlorination.

7.0 MONITORING

pH, phosphate and phosphonate level should be monitored regularly throughout the entire operation and recommended levels should be maintained. Frequency of analysis is as follows:

During cleaning with low pH water (step 4)

- pH: Once in two hours
- TSS / Turbidity: Once in four hours

During phosphate cleaning (Step 5)

- pH: Once in two hours
- Inorganic phosphate: Once in two hours
- Organic phosphate (Phosphonate): Once in four hours

8.0 PRE-TREATMENT EVALUATION

To assure that cleaning and passivation have been effective, slightly rusted carbon steel corrosion specimen can be inserted into standard coupon testing assembly fitted to the cooling water line or the specimen may be immersed in the cold water channel of the cooling water.

9.0 SPECIFICATION OF CHEMICALS

The chemicals shall conform to the following specifications:

- Organo phosphonate (HEDP) Active acid content 50-60% Testing as per ASTM D 515-72 and to be obtained from reputed manufacturer.
- Sodium Hexametaphosphate (SHMP) IS 574 (latest)
10.0 **SAFETY PRE-CAUTIONS**

Normal safety precautions should be taken for handling of chemicals. Protective clothing and safety items should be used to prevent any injury during the pre-treatment operation.

**NOTES:**

1. C.W. system should be started with above pre-treatment program prior to normal treatment.

2. Approximate chemicals requirement for 1000 m³ hold up of cooling water system:
   - Organo phosphonate (HEDP) Active acid content 50-60% 140-180 kg To maintain a level of 80-100 mg/l as PO₄
   - Sodium Hexametaphosphate (SHMP) 50-60 kg To maintain a level of 40-50 mg/l as PO₄
   - NALCO 7308 or equal As per chemical manufacturer’s recommendations

Actual requirement of chemicals shall be calculated based on actual hold-up of the system and dosed to maintain specified levels. Further additions of chemicals will depend on laboratory results and to be dosed to maintain specified levels for entire operation.

**NOTE:**

1. HEDP should only be used. ATMP (Amino trimethylene phosphoric acid) should not be used.

2. During on stream cleaning if cooling water temperature exceeds 40°C. Sodium Hexametaphosphate level as specified in item nos. 5.3 and 5.5 should be reduced to 20-25 mg/l as PO₄.
6.2 RECOMMENDED PROCEDURE FOR PRE-COMMISSIONING CHEMICAL CLEANING AND POST CLEANING PASSIVATION TREATMENT OF CARBON STEEL SUCTION PIPING OF COMPRESSORS.

1.0 SCOPE

1.1 The specification is prepared for pre-commissioning chemical cleaning and post cleaning passivation treatment of carbon steel suction piping of compressors. This specification covers the chemical cleaning of fabricated and erected carbon steel piping at plant site prior to commissioning by chemicals circulation method. The technical procedure is prepared only for carbon steel surfaces. Materials other than carbon steel should not come in contact with pickling solutions.

1.2 All valves, gaskets, control valves including butterfly valve, filters, venturies, instruments, etc. should be dropped before chemical cleaning.

2.0 OBJECT

The object of chemical cleaning of carbon steel suction piping is to remove the loose rust, dislodging the burrs, welding slag and mill scales adhering to the internal surface of the pipelines so that maintenance of compressors is reduced due to frequent choking of strainers. This procedure specifies the method of cleaning and passivation of internal surface of carbon steel piping based on use of inhibited hydrochloric acid followed by passivation with sodium Hexametaphosphate, prior to taking in service for the first time after installation/fabrication.

This cleaning will enable removal of:

a) Paint or varnish if used for protective purposes.

b) Grease or Oil

c) Mill Scales

d) Loose rust

e) Welding slag

Any deviation from this specification should be recorded and discussed with Owner/PMC prior to application. The result of this cleaning is that the metal surfaces are completely clean, dry and passivated without signs of corrosion.

3.0 PREPARATION OF TEMPORARY CIRCUITS

The cleaning may be carried out by circulating the specified solutions in the specified sequence and conditions. Temporary piping and a pump of appropriate capacity suitable for chemical cleaning may be used for this purpose as part of the circuit. All necessary temporary piping, fittings, flanges, pumps, tanks, heater coils, gaskets, thermometers, hydrometers, valves, test coupons, spares, lab facilities with all accessories required for conducting test during cleaning operation, chemicals and safety accessories for operation personnel etc., shall be made available at site prior to chemical cleaning. A loop diagram showing the details for cleaning shall be prepared by EPCC Contractor and submitted to Owner/PMC before starting the work.

4.0 SEQUENCE OF OPERATION

The sequence of operations shall be as follows:

a) Flushing with water to remove dirt, dust, loose rust and any foreign matter.

b) Degreasing

c) Inhibited acid circulation
d) Neutralisation with soda ash/caustic soda

e) Rinsing

f) Passivation
g) Drying

5.0 CHEMICALS

The following chemicals are recommended for use in chemical cleaning operation:

5.1 Caustic soda – Rayon grade or technical grade conforming to IS: 252 (latest edition)

5.2 Hydrochloric Acid – Commercial / technical grade conforming to IS: 265 (latest edition)

5.3 Corrosion Inhibitor Rodine-213 special manufactured by M/s. Agromore Ltd., or equivalent.

5.4 Glassy sodium meta phosphate (sodium Hexametaphosphate) conforming to IS: 574 (Latest edition)

5.5 Soda ash, technical grade, conforming to IS: 251 (latest edition)

5.6 Potable water should be used for preparation of chemicals solution and flushing/rinsing operation etc.

5.7 All chemicals used for chemical cleaning should be as per specifications and shall be tested prior to use for cleaning.

6.0 INSPECTION OF INHIBITOR BEFORE CLEANING

A solution of inhibitor shall be prepared in hydrochloric acid as specified by the manufacturers and shall be tested for (a) the inhibitor efficiency and (b) the effectiveness of the solution in removing mill scale.

7.0 CLEANING PROCEDURE

The chemical cleaning shall be carried out as follows:

7.1 Prior to assembly, ensure that all stainless steel, brass and bronze components are replaced with temporary bypasses such as CS Pipes or rubber hoses or spool pieces.

7.2 The circuit (loop) shall be checked with circulation of water to test its tightness. Any leakage if observed shall be attended and tightened.

7.3 Filling and circulation of sodium hydroxide solution for 2 hours (min.)

7.3.1 Temperature of sodium hydroxide solution during circulation should be 65-70°C.

7.3.2 Concentration of sodium hydroxide should be 50 gm/l (on 100% purity basis).

7.4 Drain the sodium hydroxide solution. Fill with water and drain. This operation of rinsing with water should be continued until the pH of water at inlet and outlet ends are same.

7.5 Filling and circulation of inhibited hydrochloric acid solution for 6 hours (min.)

7.5.1 Temperature of inhibited hydrochloric acid solution during circulation should be 50-60°C.

7.5.2 Concentration of hydrochloric acid solution should be 5-10% by wt. HCl (on 100% purity basis) and Rodine–213 special should be added in acid solution in the proportion of 1 litre Rodine–213 (special) to 100 litres 30-33% HCl. However, exact concentration and duration of acid solution used shall be decided based on visual inspection of carbon steel piping.

7.6 Drain the inhibited HCl solution. Fill the system with 1-2% solution of soda ash or caustic soda and circulated for 1 hour at 40-45°C.
7.7 Drain the neutralising solution. Fill with water and drain. This operation of rinsing with water should be continued till the pH of water at the inlet and outlet ends are same.

7.8 Filling and circulation of sodium Hexametaphosphate solution for 2 hrs. Then hold for 10-12 hours.

7.8.1 Concentration of sodium Hexametaphosphate solution should be 2-3% by wt. (on 67% P₂O₅ basis).

7.8.2 Temperature of sodium Hexametaphosphate solution during circulation should be 70-75°C.

Note: To prevent re-oxidation, the passivation solution must be introduced immediately after the flushing operation 7.7.

7.8.3 Drain the passivated solution without flushing with water. Then allow self-drying.

7.9 Finally, dry the circuit with clean dry air circulation.

7.10 The operations (7.1 to 7.9) in any one loop, when commenced must be completed without interruptions.

8.0 OPERATION AND MONITORING

Satisfactory performance of the chemical cleaning depends on proper operation. Following steps should be considered during preparation of loops and operation:

8.1 Full bore flow should be ensured while circulating various chemicals.

8.2 Vents should be provided in all high points including large diameter horizontal pipes for effective removal of air and acid fumes during cleaning operation. All vents should be operated intermittently to ensure full bore flow throughout the operation and no air pockets should be left in the system during pickling operation.

8.3 Drain valves should be provided at all low points for effective circulation of pickling solution and removal of sludge if any and no trapping of chemicals at time of changing of chemicals.

8.4 Suitable high-pressure pumps with necessary flow rate should be provided to maintain good velocity (preferably 1.0 m/sec) throughout operation and there should be effective return of flow from all outlets and vent lines. Minimum two pumps should be provided (one under operation and another standby). Preferably, the pumps should be 40-50 m head with 75-100m³/hr Flow rate. Actual discharge pressure of pump depends on loop arrangement and velocity to be maintained. The efficiency of pump should be checked periodically.

8.5 While preparation of loop, equipment or suction drums (CS) should not be taken into circuit. Pickling of equipment or suction drums should be done separately if required as per operations given in item no.7.

8.6 The flushing rate shall be monitored by:
   a) Flow meters
   b) Comparing the differential pressure to the pump’s head capacity curve
   c) Ammeters on the motors

8.7 The corrosion inhibitor efficiency should be determined before pickling is started.

8.8 All chemicals should be tested as per specifications before use. The contractors should also furnish the test certificates for all chemicals used for pickling operation.

8.9 Whenever acid is added the corrosion inhibitor should be added first.

8.10 Standard solutions for determination of iron in acid solution are required prior to pickling operation.

8.11 During pickling operation 2 carbon steel test coupons with mill scale and weighted test
coupons free from mill scale should be exposed, one inside the inhibited acid solution in the tank and another at outer of pipe. The mill scale free coupons should be removed after acid circulation is over for determination of loss of weight. The coupons with mill scale are intended for indicating removal of mill scale after acid circulation and can be removed after completion of operation for final inspection.

8.12 Acid strength, total iron and ferric iron should be determined every hour during operation. Periodically acid strength should also be checked from all outlets, vents and drain lines.

8.13 After acid pickling and neutralization, water flushing will be carried out and continued until a pH around 7.0 is obtained at outlets so that it facilitates the subsequent passivation with sodium Hexametaphosphate.

8.14 During sodium Hexametaphosphate circulation, presence of phosphate should be checked from all outlets, vents and drain lines.

8.15 All data should be recorded in checklist during pickling operation including chemicals consumption and observations, if any.

8.16 Segment(s) of C.S. piping if any, which cannot be conveniently cleaned by chemical circulation method, may be cleaned by filling and/or dipping/immersion method. All the conditions of above operations are generally applicable for this method.

9.0 CONTROLS FOR THE CLEANING PROCESS

9.1 Unless the system is thoroughly mechanically cleaned by continuous water flushing and approved by PMC, no chemical cleaning shall be undertaken by EPCC Contractor. All the specified parameters shall be followed during the cleaning process. All tests shall be conducted by the contractor to control the process.

9.2 The strength of the cleaning solutions shall be checked for acid concentration every hour during the cleaning operation. If the strength is found to below 5% by wt. The solution shall be drained in part and brought in the specified range 5-10% wt. by addition of fresh acid.

9.3 The total iron and ferric iron content of the cleaning solution should be monitored to avoid the attack on the metal. The total iron content shall not exceed 5000 mg as Fe in 1 litre of the cleaning solution. The limits for iron as ferric iron shall not exceed 0.4% by wt. If the limits for total iron and ferric iron are attained the cleaning solution shall be drained in part and brought in the specific range by addition of fresh unused solution.

9.4 Iron stabilisation and acid concentration should be monitored to determine the completion of pickling.

10.0 PRESERVATION

The pickled and passivated lines should be preserved in clean and dry condition. The necessary preservation procedure should be followed.

11.0 NEUTRALISATION

The necessary arrangement shall be made for complete neutralisation of pickling acid and alkali and disposal system. Prior to discharging of effluent in the sewer system, it shall be analysed and if necessary, additional chemicals shall be added for neutralisation so that discharged mixtures shall have pH 7.0 in order to prevent any damage to paving, manholes and sewers etc. The neutralised effluent prior to discharging shall conform to IS specifications.

12.0 INSPECTION

The lines required to be pickled shall be inspected visually as seen from ends before pickling. After pickling and drying operation, visual inspection of loop should be carried out at convenient location(s) as seen from ends to ensure the surfaces are completely clean, dry and free from rust giving uniform grey appearance on the original surface. The visual
observations shall be recorded.

13.0 SAFETY PRECAUTIONS

The alkali and hydrochloric acid solutions involved for chemical cleaning are corrosive for the skin and proper care shall be taken in the handling of the chemicals.

13.1 Adequate ventilation shall be provided during the acid cleaning operation to protect the health of workmen.

13.2 A competent supervisor must supervise the handling of acid preparation bath etc., and heating.

13.3 Operators and workmen shall wear safety goggles during pickling operation.

13.4 Workmen shall wear rubber aprons, protective boots and hand gloves.

14.0 TECHNICAL SUPERVISION

The chemical cleaning operation should be conducted under close chemical controls by the contractor and this operation should be supervised by experienced technical personnel selected by PMC. Extreme care must be taken to ensure that the

Only cooling water circuit shall be cleaned which is site fabricated / installed. No packaged equipment is included in the cleaning. Lube oil systems shall be cleaned and then flushed by the same grade of lube oil to be used. All rotary equipment and control valves shall be bypassed by temporary piping or spool pieces.
6.3 **RECOMMENDED PROCEDURE FOR DETERGENT CLEANING OF KNOCK OUT DRUM AND VOLUME BOTTLE**

1.0 **SEQUENCE OF OPERATION**

The sequence of operation shall be as follows:

1.1 Flushing with potable water

1.2 Circulation of LISSAPOL NX (surfactant) and caustic potash solution

1.3 Final rinsing with water (DM water for SS item)

2.0 **EQUIPMENT AND ACCESSORIES**

The equipment and accessories are designed for the circulation method and consist of a tank, temporary piping, valves and pumps of appropriate capacity suitable to maintain good velocity (about 0.5 m/s).

3.0 **CLEANING PROCEDURE**

3.1 The circuit shall be prepared and checked with circulation of water to test its tightness. Any leakage if observed shall be attended and tightened.

3.2 The circuit shall be flushed with potable water to remove all loose deposits, dirt, dust etc. Flushing shall be continued until clear water comes out.

3.3 Filling and circulation of 2% LISSAPOL NX of M/s ICI or equivalent and 0.5% KOH solution for 2 hours.

3.4 The solution shall be drained. The system shall be rinsed with potable water (DM water for SS item) to expel KOH. The rinsing operation shall be continued until clear water (pH around 7.0) comes out.

3.5 Loop diagram showing details for cleaning shall be prepared by EPCC-Contractor and submitted to Owner/PMC for review before starting the work,
6.4 RECOMMENDED PROCEDURE FOR CHEMICAL CLEANING OF STAINLESS STEEL, CARBON STEEL, LOW ALLOY STEEL AND SS-CS COMBINATION PIPING INCLUDING STEAM AND LTCS LINES PRIOR TO COMMISSIONING BY INHIBITED AMMONIATED CITRIC ACID CIRCULATION METHOD.

1.0 SCOPE

1.1 This specification covers the chemical cleaning (pickling) of the fabricated and erected stainless steel, carbon steel, low alloy steel and SS-CS combination piping at site prior to commissioning by chemical circulation method. The technical specifications describe the procedure and sequence of operations for chemical cleaning (pickling) and passivation of the piping.

1.2 All valves, gaskets, control valves including butterfly valves, filters, venturies, instruments, etc., should be dropped before chemical cleaning.

2.0 OBJECT

The objective of chemical cleaning of stainless steel, carbon steel, low alloy steel and SS-CS combination piping is to remove the loose rust, dislodging the burrs, welding slag and mill scales adhering to the internal surfaces of piping. The procedure specifies the method of cleaning and passivation of internal surface of piping based on the use of ammoniated citric acid followed by passivation with Trisodium phosphate (Na$_3$PO$_4$) + NaNO$_2$ circulation. Any deviations from this specification should be recorded and discussed with Owner/PMC prior to application.

3.0 PREPARATION OF TEMPORARY CIRCUITS:

The cleaning may be carried out by circulating the specified chemical solutions in the specified sequence and conditions. Temporary piping, pumps and suitable capacity, fittings, flanges, tanks, gaskets, heating arrangement, hydrometers, valves, test coupons, spares, laboratory facilities with all accessories required for conducting tests during cleaning operation, chemicals and safety accessories for operation, personnel etc., shall be made available at site prior to cleaning operation. Quantity of chemicals required should be calculated based on the hold-up volume of the temporary circuit. Loop diagram showing details for cleaning shall be prepared by EPCC-Contractor and submitted to Owner/PMC for review before starting the work.

4.0 SEQUENCE OF OPERATION

The cleaning of piping shall be carried out in the following sequence:

1) Flushing with potable water to remove dirt, dust, loose rust and foreign matter
2) Degreasing with Potassium Hydroxide (Caustic potash).
3) Flushing with potable water till inlet and outlet water pH is same.
4) Circulating with ammoniated inhibited citric acid
5) Flushing with potable water
6) Circulating with Trisodium phosphate (Na$_3$PO$_4$) + Sodium Nitrite (NaNO$_2$)
7) Drain, dry and take the system into service

5.0 PROCEDURE

5.1 The circuit (Loop) shall be checked with circulation of potable water to check tightness. Any leakage if observed, to be attended and tightened.
5.2 The circuit (Loop) shall be flushed with potable water to remove all extraneous matter, dirt and dust etc.

5.3 Filling and circulation of potassium Hydroxide (caustic potash) solution of 2% concentration on 100% purity basis at 70-75°C temperature for 1½ hours.

5.4 Drain the potassium Hydroxide solution. Fill with potable water and drain. The operation of rinsing with potable water should be continued until pH of water at inlet and outlet ends are same.

5.5 Filling and circulation of ammoniated citric acid of 3% concentration by weight (on 100% purity basis) with pH being adjusted to 3.5-4.0 with ammonia and 0.1% corrosion inhibitor Rodine 92 equivalent by weight. The temperature of circulating citric acid solution should be 80°C. The circulation should be continued for 6 hours.

5.6 During circulation of ammoniated citric acid, the total iron content of the circulating solution should not exceed 5000 mg/l (with 3% w/w citric acid solution) and pH should be maintained at 3.5-4.0. If at any stage total iron content exceeds 5000 mg/l the acid should be drained in part and replaced with fresh acid.

5.7 Drain the citric acid and rinse with potable water. Fill with potable water and the operation of rinsing with potable water should be continued until pH at inlet and outlet ends of water are same.

5.8 Fill with Trisodium phosphate (1%) +sodium Nitrite (0.5%) by weight (on 100% purity basis) and circulate for 2 hours drain. Allow to self-dry and finally dry with compressed air.

5.9 Suitable high-pressure pumps with necessary flow rate should be provided to maintain good velocity (preferably 0.5-1.0 m/sec) throughout operations of chemical cleaning and there should be effective return of flow from the outlet and the vent.

6.0 CHEMICALS

Chemicals used for chemical cleaning

6.1 Citric acid monohydrate, conforming to IS: 5464Gr.2

6.2 Corrosion inhibitor Rodine 92 manufactured by M/s Agromore India Limited, Bangalore, or CORONIL-92 of M/s. ARUDRA ENGG. MADRAS or equal.


6.4 Potassium Hydroxide (KOH) conforming to IS: 6831 latest editions.

6.5 Tri sodium phosphate (Na$_3$PO$_4$) technical grade as per IS: 573.

6.6 NaNO$_2$ IS: 879 Sodium Nitrite

6.7 Potable water for flushing

7.0 SAFETY PRECAUTIONS

The alkali and acid solutions involved for chemical cleaning are corrosive for the skin and proper care shall be taken in the handling of the chemicals.
6.5 PROCEDURE FOR CHEMICAL CLEANING OF STAINLESS STEEL PIPING PRIOR TO COMMISSIONING

1.0 SCOPE

1.1 This specification covers the chemical cleaning (pickling) of the fabricated and erected stainless piping at site prior to commissioning by chemical circulation method. This technical specification describes the procedure and sequence of operations for chemical cleaning (pickling) which is based on TIG/MIG welding with Argon shielding of the SS piping has been followed. The materials that will come in contact with pickling solutions are AISI-300 series only. No other materials shall come in contact with pickling solutions. The present specification covers the pickling and passivation of SS piping and does not require separate passivation of pickled surface.

1.2 All valves, Rubber/CAF gaskets, control valves including butterfly valves, filters, venturies, instruments etc. should be dropped before chemical cleaning.

2.0 OBJECT

The object of the chemical cleaning is to remove all extraneous matter, dirt, dust, grease, oil, welding slag, loose rust, oxide scales that may be present on the piping to avoid the contamination of the production mainly by way of iron pick up. The chemical cleaning is required to achieve product quality. This procedure specifies the method of cleaning and passivation of internal surfaces of SS piping based on use of acid mixture of nitric acid and hydrofluoric acid prior to taking in service for the first time after installation or fabrication.

Any deviation from this specification should be recorded and discussed with Owner/PMC prior to application. The final result of this cleaning is that the metal surfaces are completely clean, dry and in the passive state without signs of corrosion.

3.0 SEQUENCE OF OPERATION

The cleaning of piping shall be carried out in the following sequence:

a) Flushing with demineralised water to remove dirt, dust, and loose rust and foreign matter.

b) Degreasing

c) Acid cleaning

d) Final rinsing and drying

4.0 PREPARATION OF TEMPORARY CIRCUITS

The cleaning may be carried out by circulating the specified chemicals solutions in the specified sequence and conditions. Temporary piping and a pump of appropriate capacity suitable for chemical cleaning may be used for this purpose as part of the circuit with the equipment / piping to be cleaned. All necessary temporary piping, fittings, flanges, pumps, tanks, heater coils, gaskets thermometers, hydrometers, valves, test coupons, spares, lab, facilities with all accessories required for conducting test during cleaning operation. Chemicals and safety accessories for operation. Chemicals and safety accessories for operation personnel etc. shall be made available at site prior to cleaning operation.

Note: The circuits should be conveniently selected so that filling; circulation and complete draining of the acid are completed in one hour.

5.0 MATERIALS

The circuits (loops) should be checked for as fitted materials. Rubber/CAF gaskets should be removed before pickling operations. All on-line CAF/rubber gaskets will be renewed after pickling process is over with original gaskets suitable for service conditions.
6.0 PICKLING EQUIPMENT

Following equipment shall be required to carry out pickling operation of one loop at a time.

- 1 no. Stainless steel (AISI-304/316) or FRP with graphite reinforced pump for acid mixture circulation.
- 1 no. CI Pump for alkali circulation
- 1 no. CI pump for D.M. water flushing/rinsing operation
- 1 no. Stainless steel (AISI-304/316) tank for acid mixture solution
- 1 no. MS Tank for alkali solution tank
- 1 no. M.S.R.L. tank for DM water storage
- 2 nos. large capacity MS tanks for neutralisation of pickling acid and alkali
- Immersion type electric heaters suitable for alkali heating (min 2 nos. 9.0 kW/each for heating up to 1000 litres solution)
- Polypropylene / PVC/SS valves with sufficient spares
- Spare SS pump and C.I. pump
- Spare impellers, gaskets, bolts, gland packing etc.
- SS flanges, blind flanges with suitable gaskets, nipples, pipes, etc.
- Thermometers, hydrometers
- Pump suction line strainers
- PVC sheets
- Plastic baskets of all sizes (12 nos. small size and 6 nos. large size)
- Plastic buckets
- Stainless steel test coupons
- HDPE & PVC pipes (various sizes) with all fittings etc.
- Discharge and suction headers with valves for pumps.
- Any other equipment, if necessary.

The common CI pump can be used for alkali circulation and DM water flushing/rinsing operation. The one-set of SS pump/FRP with graphite reinforced pump and CI pump shall be kept as spare in case of failure. The min. capacity of SS tank, MS tank, and M.S.R.L. Tank shall be 1.0 m³, 1.50 m³ and 2.0 m³ respectively. The HDPE pipe shall be connected at inlet to SS loop and PVC pipes shall be connected at outlet of SS loop. The suction line strainers or protective SS wire mesh screen shall be provided to prevent entry of foreign objects into pump suction. The tank should be elevated so that flooded suction is available for all pumps at all the time to prevent the entry of air in the loop as well as to avoid cavitations problem in the pump. The minimum of 300 mm liquid level shall be maintained all the time in tank from top of suction pipe throughout the operation so that flooded suction is available. The levels shall be marked in all tanks.

7.0 CHEMICAL

The following chemicals shall be used for degreasing and cleaning operation.

7.1 Caustic potash Rayon grade or technical conforming to IS: 6831 (latest edition)

7.2 Nitric acid technical grade conforming to IS: 264 (latest edition)
7.3 Hydrofluoric acid conforming to ASTM or equivalent. In any case, purity should not be less than 50% HF by weight.

7.4 Demineralised water should be used for flushing and rinsing operation at room temperature.

7.5 Demineralised water should be used for preparation of chemical solutions.
Note: Cold steam condensate can be used in place of DM water if available.

7.6 All chemicals used for chemical cleaning should be as per specifications and shall be tested prior to use for cleaning. All chemicals shall be analysed at owner’s lab for purity, sp.gr. chlorides, iron and other impurities if any and shall be certified by owner for use in pickling.

8.0 TEST COUPONS
7.5 cm x 5 cm x 2 mm cleaned and dried test coupons (duplicate) of the same SS material as the pipe shall be exposed to the acid mixture cleaning solution under simulated condition in the laboratory and weight loss shall be determined. The corrosion rate shall be 50-80 mpy. Acids strength shall be accordingly optimised.

9.0 PICKLING PROCEDURE
The pickling procedure shall be carried out as follows:

9.1 The circuit (loop) shall be checked with circulation of demineralised water to check tightness. Any leakage if observed shall be attended and tightened.

9.2 The circuit (loop) shall be flushed with DM water to remove all extraneous matter, dirt and dust etc.

9.3 Filling and circulation of potassium hydroxide solution for 1½ to 2 hours.

9.3.1 Temperature of potassium hydroxide solution during circulation should be 50-55°C in no case the temperature shall exceed 55°C.

9.3.2 Concentration of potassium hydroxide should be 50 gm/l (100% purity basis).

9.4 Drain the potassium hydroxide solution. Fill with demineralised water and drain. This operation of rinsing with D.M. water should be continued till pH of water at the inlet and outlet ends are same.

9.5 Filling and circulation of acid mixture (HNO₃+HF) solution.

9.5.1 Composition of the pickling solution should be 10-15% conc. HNO₃ by volume (on 100% purity basis) and 0.3% - 0.5% conc. HF by volume (on 100% purity basis), preferably 15% conc. HNO₃ by volume (on 100% purity basis) and 0.3% conc. HF by volume (on 100% purity basis) may be used for pickling. However, exact conc. Of acid mixture and duration shall be decided based on coupon test.

9.5.2 The pickling solution (HNO₃+HF) should be circulated at room temperature.

9.5.3 The acid mixture (HNO₃+HF) circulation should be stopped in between for some time for better results as follows:

<table>
<thead>
<tr>
<th>Size</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 mm to 50 mm SS pipes</td>
<td>10 Min.</td>
</tr>
<tr>
<td>65 mm to 100 mm SS pipes</td>
<td>15 Min.</td>
</tr>
<tr>
<td>125mm and above SS pipes</td>
<td>20 Min.</td>
</tr>
</tbody>
</table>

9.5.4 The duration of the acid mixture (HNO₃+HF) circulation including stop over shall be as follows:

<table>
<thead>
<tr>
<th>Size</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 mm to 50 mm SS pipes</td>
<td>30 min 15, 10(Stop), 5</td>
</tr>
<tr>
<td>65 mm to 100 mm SS pipes</td>
<td>45 min 15, 15(Stop), 15</td>
</tr>
<tr>
<td>125mm and above SS pipes</td>
<td>60 min 20,20(Stop), 20</td>
</tr>
</tbody>
</table>
However, total acid mixture contact time in SS piping should not be more than 60 min.

9.5.4 Drain the acid mixture solution. Fill with DM water and drain. This operation of rinsing with DM water should be continued until pH of DM water at the inlet and outlet ends are same.

9.6 Finally, dry the circuit by passing clean dry instrument air.

9.7 The operations (9.1 to 9.6) in any one loop, when commenced must be completed without interruptions.

NOTES:

1. The above pickling procedure includes passivation and does not require separate passivation of pickled surface.

2. The chemically cleaned and dried piping shall not be taken into operation within 72 hours after the final drying operation is completed.

10.0 OPERATION AND MONITORING

Satisfactory performance of the chemical cleaning depends on proper operation, monitoring and chemical controls during pickling operation. Following steps should be considered during preparation of loops and operation.

10.1 Full bore flow should be ensured while circulating various chemicals.

10.2 Vents should be provided at all high points for effective removal of air and acid fumes during cleaning operation. All vents should be operated intermittently to ensure full bore flow throughout the operation and no air pockets should be left in the system during pickling operation.

10.3 Drain valves should be provided at all low points for effective circulation of pickling solution and removal of sludge if any and no trapping of chemicals at time of changing of chemicals. No stagnant condition should exist during pickling.

10.4 During pickling operation, all blind ends, low point drains, high points and vents etc. shall be bled twice during alkali and acid mixture circulation to achieve satisfactory pickling. The adequate checks should be made so that system is completely filled and drained.

10.5 No leakage / drippage / spillage of alkali or acid mixture solution shall be allowed on floors or equipment or piping or any other instruments. The adequate protection shall be provided for all bare mechanical equipment / instrument/piping, etc.

10.6 Suitable high-pressure pumps with necessary flow rate should be provided to maintain good velocity (min. 1.0 m/sec) throughout operation and there should be effective return of flow from all outlets and vent lines. Minimum 3 pumps should be provided. Preferably the pumps should be of 30-50 m head with 50-100 m³/hr, flow rates. Actual discharge pressures of pump depend on loop arrangement and velocity to be maintained. The efficiency of pump should be checked periodically.

10.7 All data should be recorded in checklist during pickling operation including chemicals consumption and observations, if any.

11.0 CONTROL FOR THE CLEANING PROCESS

11.1 All the specified parameters shall be followed during the cleaning process. All tests should be conducted by the contractor to control the process.

11.2 The strength of pickling solution shall be checked for every loop during pickling operation. If the strength is found below 10% conc. solution, then entire solution shall be drained off, no topping with fresh acid mixture is allowed. It shall be refilled with fresh acid mixtures. The acid mixture samples shall be drawn from tank before and after acid mixture circulation for each loop to check up the drop in acidity as well as total iron pick in the solution. Initially, the acidity
will be higher and as the de-scaling process continues, acidity drop down to a level when it is showing constant and reaction comes to almost standstill. At that level total iron pick up in the solution should also be checked. If total iron pick up exceed 5 gm/l, the acidic solution should be drained and thereafter thoroughly flushed off with DM water. The useful life of a pickling solution is determined by the amount of contamination of iron pick up and a pickling solution is discarded after specific limits are reached. Preferably pickling solution shall be discarded after every loop.

11.3 Duplicate test coupons (75mm X 50mm X 2mm size) of same material as the piping, cleaned and dried shall be exposed to acid mixture solution in the tank for duration of cleaning for each loop. After pickling operation is over, the test coupons shall be removed and flushed with DM water and dried. The weight Loss of coupons shall be determined and recorded.

11.4 Determination of metal loss in pickling solution
The weight Loss of the coupons shall be determined and corrosion rates shall be calculated.

\[
\text{Mills per year (mpy)} = \frac{22.30 \times \text{weight loss in milligrams}}{\text{sp.gr. of metal} \times \text{exposed area of coupons in sq.inch} \times \text{time in days}}
\]

12.0 NEUTRALISATION
The necessary arrangement shall be made for complete neutralisation of pickling acids and alkali and disposal system. Prior to discharging effluent in the sewer system, it shall be analysed and if necessary additional chemicals shall be added for neutralisation so that discharged mixtures shall have pH 7.0 in order to prevent any damage to paving, manholes and sewers. The neutralised effluent prior to discharging shall confirm to IS specifications.

13.0 INSPECTION
The loops, which are required to be pickled, shall be inspected visually as seen from ends before pickling. After pickling and drying operation, visual inspection of loop should be carried out at convenient locations(s) and as seen from ends to ensure that surfaces are completely clean, not over-etched, dry free from rust and passivated. The visual observations shall be recorded.

14.0 PRESERVATION
14.1 The chemically cleaned and dried piping shall not be taken into operation within 72 hours after the final drying operation is completed. The pickled and passivated lines should be preserved in clean and dry condition with slight positive pressure using dry instrument air to prevent entry of moisture, dust or dirt. Prior to filling with instrument air, piping must be checked to ensure that all impurities (that might remain) have been removed. Suitable closures (polythene papers) must be placed on the ends of the piping and all openings to prevent entrance of moisture or dirt or dust etc. in the cleaned and dried pipes. Any dust/dirt/sand particles etc. may cause pitting type corrosion to the cleaned pipes during the pre-commissioning period.

14.2 It is advised that at the time of boxing the pickled lines, these should be thoroughly inspected and any open ends should be covered to prevent entry of dust, dirt and moisture. It should be ensured that brown rusts or black spots of bitumen (due to bituminous mastic lining work) and all extraneous matter in nozzles not chemically cleaned are thoroughly removed.

15.0 SAFETY PRECAUTIONS
The alkali and acid mixture solutions involved for pickling are corrosive for the skin and proper care shall be taken in the handling of the chemicals.
15.1 Adequate ventilation shall be provided during the acid cleaning operation to protect the health of workmen.

15.2 A competent supervisor must supervise the handling of acid preparation baths etc. and heating.

15.3 Operators and workmen shall wear safety goggles during pickling operation.

15.4 Workmen shall wear rubber aprons, protective boots and hand gloves.

16.0 TECHNICAL SUPERVISION

The chemical cleaning operation should be conducted under close chemical controls by the contractor and this operation should be supervised by experienced technical personnel selected by Owner/PMC.

6.6 PROCEDURE FOR PRE-COMMISSIONING, CHEMICAL CLEANING AND POST-CLEANING PASSIVATION OF BOILER (ABOVE 24 kg/cm² g PRESSURE)

1.0 SCOPE

The specification covers the method of pre-commissioning chemical cleaning and post-cleaning passivation treatment of carbon steel internal heat transfer surfaces of HP boiler at plant site prior to commissioning. The technical procedure applies to carbon steel surfaces; materials other than carbon steel should not come in contact with cleaning solution.

All valves, gaskets, control valves, filters, instruments, etc. should be dropped before chemical cleaning.

2.0 OBJECT

The object of pre-commissioning chemical cleaning of boilers is to remove oil, grease and other organic matter, dislodging burrs, welding slag, mill scales adhering to internal surfaces to avoid initial corrosion during commissioning activities and provide uniform protective layer on the surface. This procedure specifies the method of cleaning and passivation of boilers prior to taking in services for first time after fabrication/erection.

This cleaning will enable removal of

- Paint or any protective coating used
- Grease or oil
- Loose rust
- Mill scales
- Welding slag

Any deviation from this specification should be recorded and discussed with Owner/PMC prior to application. The result of this cleaning is that the metal surfaces are completely clean, dry and in the passive state without signs of corrosion.

3.0 SEQUENCE OF OPERATION

The sequence of operation shall be as follows:

3.1 Flushing with potable water to remove dirt, dust, loose rust and any foreign matter

3.2 Alkali boil out

3.3 Rinsing with D.M. water after alkali boil out

3.4 Inhibited acid circulation

3.5 Citric acid rinse
3.6 DM water rinse
3.7 Neutralisation with soda ash
3.8 Passivation

4.0 CHEMICALS

Chemicals used for chemical cleaning should conform to the following specifications:

4.1 Trisodium phosphate (Na$_3$PO$_4$) technical grade conforming to IS: 573
4.2 Caustic soda, Rayon-grade or technical grade conforming to IS: 252
4.3 Soda ash, technical grade, conforming to IS: 251
4.4 Hydrochloric acid, commercial/technical grade, conforming to IS: 265
4.5 Corrosion inhibitor Rodine-213 special manufactured by M/s Agromore Ltd., Bangalore
4.6 Citric acid, monohydrate, conforming to IS: 5464 Grade 2
4.7 Ammonia liquor, technical grade, conforming to IS: 799
4.8 Hydrazine
4.9 DM water (to be used for all flushing /rinsing operation and preparation of chemicals solution etc.)
4.10 Potable water for general washing etc.
4.11 Steam for heating purpose
4.12 Nitrogen

5.0 PREPARATION OF TEMPORARY CIRCUITS

5.1 The cleaning may be carried out by filling and circulating the specified solutions in the specified sequence and conditions. Temporary piping and pump of appropriate capacity suitable for chemical cleaning may be used for this purpose as part of the circuit. All necessary temporary piping, fittings, flanges, pumps, tanks, heater coils, gaskets, thermometers, hydrometers, pressure gauges and temp. gauges, valves, test coupons, spares, lab facilities with all accessories required for conducting test during cleaning operation, chemicals and safety accessories for operation personnel, etc. shall be made available at site prior to chemical cleaning.

5.2 The equipment and accessories consists of tanks, temporary piping, valves and pumps of appropriate capacity. The tank should be large enough to fill up the circuit and charge acid into the system in shortest possible time. The capacity of tank may vary from 10 m$^3$ to 20 m$^3$ depending on size/hold-up of boilers.

5.3 The degasifying header connections to be made in the drum.
5.4 Bottom ring header connections to be made through handholds.
5.5 Super heaters are to be plugged before commencement of chemical cleaning and should be kept pressurised with ammoniated hydrazine solution (300 mg/l of hydrazine and pH 9.60 with ammonia).
5.6 Down comers are to be orificed suitably before chemical cleaning.
5.7 Safety valve connections should be plugged from inside the drum.

6.0 INSPECTION OF INHIBITOR BEFORE CLEANING
A solution of inhibitor shall be prepared in hydrochloric acid as specified by the manufacturer and shall be tested for (a) the inhibitor efficiency and (b) the effectiveness of the solution in removing mill scale.

7.0 CLEANING PROCEDURE OF BOILERS WITH ECONOMISER BUT WITHOUT SUPERHEATER

Chemical cleaning shall be carried out as follows:

7.1 FLUSHING WITH POTABLE WATER

7.1.1 Filling of the boiler with potable water up to the top of the drum and then drain the water by opening all the drain valves to remove all loose deposits, dirt and dust, etc.

7.1.2 Repeat this process of filling and draining until the clear water is obtained from all the drains.

7.2 ALKALI BOIL OUT

7.2.1 Alkali boil out shall be carried out with 0.5% by wt. Trisodium phosphate (Na₃PO₄) + 0.30% by wt. Caustic soda (NaOH) under actual firing condition of the boiler at half the working pressure for about 24 hours.

a) Filling of the boiler with DM water up to the bottom of the drum

b) Addition of alkali solution into the boiler drum from top manhole

c) Filling of boiler up to normal operating level.

d) Fire the boiler and raise the pressure gradually to half the working pressure or 40 kg/cm² whichever is less.

e) Alkali solution of specified concentration should be held for this pressure for about 24 hours with hourly blow down from all individual valves intermittently for 1-2 minutes to remove accumulated sludges and deposits, etc. The normal level in the drum to be maintained with make up water.

f) Boiler water samples to be taken every two hours for analysis of pH, alkalinity, phosphate, oil, conductivity and silica.

g) After alkali boil-out boiler is cooled down to 80 °C and the alkali solution is drained. Flushing and rinsing with DM water until pH of inlet and outlet is same.

Note: Economised can be degreased by hot alkali circulation method (with 0.05% Teepol) separately.

7.3 INHIBITED ACID CLEANING

7.3.1 After alkali boil out, circuit to be prepared for acid circulation.

7.3.2 The circuit shall be checked with circulation of DM water to test its tightness. Any leakage if observed to be attended and tightened. The circulation with DM water shall be established.

7.3.3 Temperature of the circulating water shall be maintained at 60-65°C with steam injection

7.3.4 Addition of the required quantity of the corrosion inhibitor (1 lit. Rodine 213 special or equivalent per 100 litres of 30-33% by wt. HCL) into the system;

7.3.5 Gradual addition of hydrochloric acid to the circulating water to attain a concentration of 4% by wt. The circulation of 4% by wt. Inhibited hydrochloric acid solution shall be for 8-12 hours. However, exact duration of acid solution used shall be decided based on analysis.

7.3.6 Stop circulation of inhibited acid after stabilization of acid concentration and iron content in the circulating solution and drain the acid under nitrogen blanketing.
7.3.7 After draining the acid solution, rinsing shall be done with 0.20% by wt. Citric acid solution ammoniated to pH 3.50-4.0 to prevent the precipitation of iron. The rinsing /flushing with citric acid solution shall be continued till iron content in rinse water drop down and become uniform. The draining shall be under nitrogen blanketing.

7.3.8 Filling and circulation of D.M. water for one hour and draining under nitrogen blanketing. Repeat this process until Fe content of the circulating solution drops below 25 ppm and pH approaching neutral.

7.3.9 Filling and circulation of 1% by wt. of sodium carbonate solution for 4-6 hours at 85°C then draining the system completely.

7.4 PASSIVATION

Purpose of passivation is to protect the surface from rusting and provide a suitable uniform coating of magnetite (1\textsuperscript{st} stage), which gets strengthened in the subsequent firing of the boiler (2\textsuperscript{nd} Stage). If boiler is to be opened for inspection after chemical cleaning or it is necessary to carry out fitting of internals or repairs, it is necessary to carry out 1\textsuperscript{st} stage passivation before the boiler is opened to prevent after rusting of the boiler metal on exposure to air.

7.4.1 1\textsuperscript{st} stage passivation

Passivation shall be carried with hydrazine and ammonia at 90-95°C. Passivation solution shall contain 200-300 ppm of hydrazine and 50-100 ppm of Ammonia to raise pH of solution to 9.60.

a) Filling of system with D.M. water and establish circulation.

b) Raise the temperature of D.M. water to 90-95°C.

c) Raise pH of the circulating water to maintain pH 9.6 by adding ammonia. However it should not exceed pH 10.0.

d) Addition of hydrazine to attain a concentration of 200 ppm.

e) Circulate the passivation solution at 90-95°C for 20 hours.

f) After 20 hours, draining of the solution without rinsing/flushing.

7.4.2 2\textsuperscript{nd} Stage Passivation

a) Preparation of II-stage Passivation

- Inspect the drum thoroughly and clean manually all loose debris.
- Remove super heater plugs and orifice plates from down comers.
- Refit drums internals. Dismantle all provisional equipment and reinstall all original fittings and mountings. The boiler should be ready for regular operation.

b) Procedure for II-stage Passivation

Passivation shall be carried with hydrazine and ammonia passivation solution shall contain 200-300 ppm of hydrazine and 50-100 ppm of Ammonia to maintain pH of solution to 9.60. However, it should not exceed pH 10.0.

- Fill the boiler with feed pump to normal operating level and ammonia and hydrazine solution to be charged from the dosing tank.
- Fire the boiler and gradually raise the steam pressure to half the working pressure or 40 kg/cm² whichever is less and maintain this pressure and pH 9.60.
- Keeps the boiler in service for 24 hours maintaining the hydrazine concentration more than 20 ppm. This is the end of chemical cleaning process.
- The boiler can be put into regular operation after the above circulation.
If the boiler is to be kept idle for a long time, the system has to be kept completely filled up with 200-ppm hydrazine at pH 9.6 under cold condition.

If the boiler is started within seven days, the solution after II-stage passivation can be drained under permissible condition.

8.0 **OPERATION AND MONITORING**

Satisfactory performance of the chemical cleaning depends on proper operation, monitoring and chemical control during cleaning operation. Following steps should be considered during preparation of circuit and operation.

8.1 Full bore flow should be ensured while circulating various chemicals.

8.2 Vents should be provided at all high points for effective removal of air and acid fumes during cleaning operation. The vent should be operated intermittently to ensure full bore flow throughout the operation.

8.3 Draining of solutions during cleaning operations should be done from the lowest point for effective removal of sludge and chemicals.

8.4 Suitable high-pressure pump with necessary flow rate should be provided to maintain good velocity (preferably 0.50 – 1.0 m/sec.) throughout operation and there should be effective return of flow from the outlet and the vent. Minimum two pumps should be provided (one under operation and another standby). The efficiency of pump should be checked periodically. The gland packing should be of pure PTFE.

8.5 Flushing should be done with high velocity water for effective removal of dirt, dust, loose rust and any other foreign matter.

8.6 Whenever acid is added corrosion inhibitor should be added first.

8.7 An established laboratory facility should be made available to carry out the analysis during the operation acid strength, total iron and ferric – iron and other parameters, as described in the procedure.

8.8 All data should be recorded in checklist during cleaning operation including chemicals consumption and observations if any.

8.9 Before alkali boil out all major piping in the pre-boiler system shall preferably be flushed and cleaned.

8.10 Before commencing chemical cleaning sufficient storage of DM water and transfer of DM water for chemicals cleaning operation should be ensured.

9.0 **CONTROL FOR THE CLEANING PROCESS**

9.1 All the specified parameters shall be followed during the cleaning process. All necessary tests should be conducted to control the process.

9.2 The strength of the cleaning solutions shall be checked for acid concentration every hour during cleaning operation. If the acid strength falls below 3% by wt. The solution shall be drained in part and brought in the specified range of 4% by wt. With addition of fresh acid.

9.3 The total iron and ferric iron contents of the acid cleaning solution shall be determined at the intervals of every one-hour. The total iron content shall not exceed 150 gm as Fe in 1 litre of the cleaning solution. The ferric iron content of the cleaning solution shall not exceed 0.4% by wt., if the limits for total iron and ferric iron are attained the cleaning solution shall be drained in part and brought in the specified range by addition of fresh unused solution.

9.4 Iron stabilisation and acid conc. Should be monitored to determine the completion of acid cleaning.

10.0 **NEUTRALISATION**
Prior to discharge, the acids and alkali shall be properly neutralised so that discharged mixtures shall have pH 7.0 in order to prevent any damage of paving, manholes and sewers. Storage tank/drums of adequate capacity shall be arranged for collection and neutralisation of spent acid and alkali. Suitable pump and piping shall be arranged for pumping out the neutralised acid into sewer.

Note: Floor area shall be protected by covering it with plastic sheets.

11.0 SAFETY PRECAUTIONS

The alkali and acid solutions involved for chemical cleaning are corrosive for the skin and proper care shall be taken in the handling of the chemicals.

11.1 Adequate ventilation shall be provided during the acid cleaning operations to protect the health of workmen.

11.2 A competent supervisor must supervise the handling of acid preparation bath etc., and heating.

11.3 Operators and workmen shall wear safety goggles during pickling operation.

11.4 Workmen shall wear rubber aprons, protective boots and hand gloves.

12.0 TECHNICAL SUPERVISION

The chemical cleaning operation should be conducted under close chemical controls by the contractor and this operation should be supervised by experienced technical personnel selected by PMC.
6.7 RECOMMENDED PROCEDURE FOR PRE-COMMISSIONING CHEMICAL CLEANING AND POST CLEANING PASSIVATION TREATMENT OF CARBON STEEL STEAM PIPING

UTILITY DISTRIBUTION SYSTEM

1.0 SCOPE

1.1 This specification is prepared for pre-commissioning chemical cleaning and post-cleaning passivation treatment of carbon steel steam piping of utility distribution system. This specification covers the chemical cleaning of fabricated and erected carbon steel steam piping at plant site prior to commissioning by chemical circulation method. The technical procedure is prepared only for carbon steel and low alloy carbon steel such as 1¼Cr-½Mo, 1Cr-½Mo & 2¼Cr-½Mo materials other than above should not come in contact with pickling solutions.

1.2 All valves, gaskets, control valves including butterfly valves, filters, rupture discs, venturies, instruments etc. should be dropped before chemical cleaning.

2.0 OBJECT

The object of chemical cleaning of carbon steel steam piping is to remove the loose rust, dislodging the burs, welding slag and mill scales adhering to the internal surfaces of piping. This procedure specifies the method of cleaning and passivation of internal surface of steam piping based on use of inhibited hydrochloric acid followed by passivation with ammoniated hydrazine solution.

This cleaning will enable removal of
a) Paint or varnish if used for protective purposes
b) Grease or Oil
c) Mill scales
d) Loose rust
e) Welding slag

Any deviation from this specification should be recorded and discussed with Owner/PMC, prior to application. The result of this cleaning is that the metal surfaces are completely clean, dry and passivated without signs of corrosion.

3.0 PREPARATION OF TEMPORARY CIRCUITS

The cleaning may be carried out by circulating the specified solutions in the specified sequence and conditions. Temporary piping and a pump of appropriate capacity suitable for chemical cleaning may be used for this purpose as part of the circuit. All necessary temporary piping, fittings, flanges, pumps, tanks, heater coils, gaskets, thermometers, hydrometers, valves, test coupons, spares, lab facilities with all accessories required for conducting test during cleaning operation, chemicals and safety accessories for operation personnel etc. shall be made available at site prior to chemical cleaning.

4.0 SEQUENCE OF OPERATION

The sequence of operations shall be as follows:

a) Flushing with water to remove dirt, dust, loose rust and any foreign matter
b) Degreasing
c) Inhibited acid circulation
d) Neutralization with caustic soda
e) Rinsing
5.0 CHEMICALS
The following chemicals are recommended for use in chemical cleaning operation:

5.1 Caustic Soda-Rayon grade or technical grade conforming to IS: 252 (latest edition)
5.2 Hydrochloric acid commercial/technical grade conforming to IS: 265 (latest edition)
5.3 Corrosion inhibitor Rodine-213 special manufactured by M/s Agromore Ltd. or equivalent.
5.4 Ammonia liquor, technical grade, conforming to IS: 799
5.5 Hydrazine Hydrate
5.6 Potable water should be used for preparation of chemicals solution and flushing/rinsing operation etc; preferably, DM water should be used for passivation.
5.7 All chemicals used for chemical cleaning should be as per specifications and shall be tested prior to use for cleaning.

6.0 INSPECTION OF INHIBITOR BEFORE CLEANING
A solution of inhibitor shall be prepared in hydrochloric acid as specified by the manufacturer and shall be tested for (a) the inhibitor efficiency and (b) the effectiveness of the solution in removing mill scale.

7.0 CLEANING PROCEDURE
The chemical cleaning shall be carried out as follows:

7.1 The circuit (loop) shall be checked with circulation of water to test its tightness. Any leakage if observed shall be attended and tightened.

7.2 The circuit (loop) shall be flushed with water to remove all extraneous matter, dirt and dust etc.

7.3 Filling and circulation of sodium hydroxide solution for 2 hrs (minimum)
   Temperature of sodium hydroxide solution during circulation should be 65-75°C.
   Concentration of sodium hydroxide should be 50gm/l (on 100% purity basis)

7.4 Drain the sodium hydroxide solution. Fill with water and drain. This operation of rinsing with water should be continued till the pH of water at inlet and outlet ends are same.

7.5 Filling and circulation of inhibited hydrochloric acid solution for 6 hrs (minimum).
   Temperature of inhibited hydrochloric solution during circulation should be 50-60°C.
   Concentration of hydrochloric acid solution should be 5-10% by wt HCl (on 100% purity basis) and Rodine-213 special should be added in acid solution in the preparation of 1 litre Rodine-213 special to 100 litres 30-33% HCL. However exact concentration and duration of acid solution used shall be decided at site based on visual inspection of piping prior to chemical cleaning.

7.6 Drain the inhibited HCl solution. Fill the system with 1-2% solution of caustic soda and circulated for 1 hour.

7.7 Drain the neutralising solution. Fill with water and drain. This operation of rinsing with water should be continued until the pH of water at the inlet and outlet ends are same.

7.8 Passivation with filling and circulation of ammoniated hydrazine solution for 20-24 hours.
Passivating solution containing 200-300 mg of hydrazine and 50-100 mg of ammonia to raise pH of solution to 9.6 (minimum)

Temperature of passivating solution during circulation should be 80-90°C.

Note: To prevent re-oxidation, the passivating solution must be introduced immediately after the flushing operation 7.7.

Drain the passivating solution without flushing with water and blind the lines to prevent ingress of air.

7.9 The operations (7.1 to 7.8) in any one loop, when commenced, must be completed without interruptions

8.0 OPERATION AND MONITORING

Satisfactory performance of the chemical cleaning depends on proper operation, monitoring and chemical controls during pickling operation. Following steps should be considered during preparation of loops and operation.

8.1 Full bore flow should be ensured while circulating various chemicals.

8.2 Vents should be provided at all high points, including large diameter horizontal pipes for effective removal of air and acid fumes during cleaning operation. All vents should be operated to ensure full bore flow throughout the operation and no air pockets should be left in the system during pickling operation.

8.3 Drain valves should be provided at all low points for effective circulation of pickling solution and removal of sludge if any and no trapping of chemicals at the time of changing of chemicals.

8.4 Suitable high-pressure pumps with necessary flow rate should be provided to maintain good velocity (Preferably 10m/s) throughout operation and there should be effective return of flow from all outlets and vents lines. Minimum two pumps should be provided (one under operation and other stand by). The preferable pumps should be of 10-50 m head with 75-100 m³/hr flow rate. Actual discharge pressure of pump depends on loop arrangement and velocity to be maintained. The efficiency of pump should be checked periodically.

8.5 Flushing should be done with high velocity water in reverse direction for effective removal of dirt, dust, loose rust and any foreign matter etc.

8.6 The corrosion inhibitor efficiency should be determined before pickling is started.

8.7 All chemicals should be tested as per specifications before use. The contractor should also furnish the test certificates for all chemicals used for pickling operation.

8.8 Whenever acid is added the corrosion inhibitor should be added first.

8.9 Standard solutions for determination of iron in acid solutions are required prior to pickling operation.

8.10 During pickling operation 2 carbon steel test coupons with mill scale and weighted test coupons free from mill scale should be exposed, one inside the inhibited acid solution in the tank and another at outer of pipe. The mill scale free coupons should be removed after circulation is over for determination of loss of weight. The coupons with mill scale are intended for indicating removal of mill scale after acid circulation and can be removed after completion of operation for final inspection.

8.11 Acid strength, total iron and ferric iron should be determined every hour during operation. Periodically acid strength should also be checked from all outlets, vents and drain lines.

8.12 After acid pickling and neutralization, water flushing will be carried out and continued till a pH around 7.0 is obtained at outlets.
8.13 During circulation of passivation solution presence of hydrazine should be checked from all outlets, vents and drain lines.

8.14 All data should be recorded in checklist during pickling operation including chemical consumption and observations if any.

8.15 Segment(s) of piping if any which can not be conveniently cleaned by chemicals circulation method maybe cleaned by filling and/or dipping/immersion method. All the conditions of above operations are generally applicable for this method.

9.0 CONTROLS FOR THE CLEANING PROCESS

9.1 All the specified parameters shall be followed during the cleaning process. All tests should be conducted by the contractor to control the process.

9.2 The strength of the cleaning solutions shall be checked for acid concentration every hour during the cleaning operation. If the strength is found to below 5% by weight the solution shall be drained in part and brought in the specified range of 5-10% weight by addition of fresh acid and inhibitor.

9.3 The total iron and ferric iron contents of the cleaning solutions shall be determined at the intervals of every one hour. The ferric iron contents of the cleaning solutions shall be monitored to avoid the attack on the metal. The total iron content shall not exceed 150 gm as Fe in 1 litre of the cleaning solution. The limits for iron as ferric iron shall be brought in the specified range by addition of fresh un-used solution.

9.4 Iron stabilization and acid concentration should be monitored to determine the completion of pickling.

10.0 PRESERVATION

The pickled and passivated lines should be preserved in clean, dry and airtight condition. The necessary preservation policy should be followed.

11.0 NEUTRALISATION

The necessary arrangement shall be made for complete neutralization of pickling acid and alkali and disposal system. Prior to discharging of effluent in the sewer system, it shall be analysed and if necessary, additional chemicals shall be added for neutralization so that discharge mixtures shall have pH 7.0 in order to prevent any damage to paving, manholes and sewers etc. The neutralized effluent prior to discharging shall conform to IS specifications.

12.0 INSPECTION

The lines required to be pickled shall be inspected visually as seen from ends before pickling. After pickling and passivation operation, visual inspection of loop should be carried out at convenient location(s) as seen from ends to ensure the surfaces are completely clean, dry and free from rust and scales. The visual observations shall be recorded.

13 SAFETY PRECAUTIONS

The alkali and hydrochloric acid solutions involved for chemical cleaning are corrosive for the skin and proper care shall be taken in the handling of the chemicals.

a) Adequate ventilation shall be provided during the acid cleaning operations to protect the health of workmen.

b) The handling of acid preparation bath etc. and heating must be supervised by a competent supervisor,

c) Operators and workers shall wear safety goggles during pickling operation.
d) Rubber aprons, protective bolts and hand gloves shall be worn by worker.

14 TECHNICAL SUPERVISION

The chemical cleaning operation should be conducted under close chemical controls by the contractor and this operation should be supervised by experienced technical personnel selected by PMC.