STANDARDS/MANUALS/ GUIDELINES FOR SMALL HYDRO DEVELOPMENT

2.5
Civil Works:
Technical Specifications for Hydro Mechanical Works

Sponsor:

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Lead Organization:

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PREAMBLE

There are series of standards, guidelines and manuals on electrical, electromechanical aspects of moving machines and hydro power from Bureau of Indian Standards (BIS), Rural Electrification Corporation Ltd (REC), Central Electricity Authority (CEA), Central Board of Irrigation & Power (CBIP), International Electromechanical Commission (IEC), International Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME) and others. Most of these have been developed keeping in view the large water resources/ hydropower projects. Use of the standards/guidelines/manuals is voluntary at the moment. Small scale hydropower projects are to be developed in a cost effective manner with quality and reliability. Therefore a need to develop and make available the standards and guidelines specifically developed for small scale projects was felt.

Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee initiated an exercise of developing series of standards/guidelines/manuals specifically for small scale hydropower projects with the sponsorship of Ministry of New and Renewable Energy, Government of India in 2006. The available relevant standards / guidelines / manuals were revisited to adapt suitably for small scale hydro projects. These have been prepared by the experts in respective fields. Wide consultations were held with all stake holders covering government agencies, government and private developers, equipment manufacturers, consultants, financial institutions, regulators and others through web, mail and meetings. After taking into consideration the comments received and discussions held with the lead experts, the series of standards/guidelines/manuals are prepared and presented in this publication.

The experts have drawn some text and figures from existing standards, manuals, publications and reports. Attempts have been made to give suitable reference and credit. However, the possibility of some omission due to oversight cannot be ruled out. These can be incorporated in our subsequent editions.

This series of standards / manuals / guidelines are the first edition. We request users to send their views / comments on the contents and utilization to enable us to review for further upgradation.

Standards/ Manuals/Guidelines series for Small Hydropower Development

General	
1.1	Small hydropower definitions and glossary of terms, list and scope of different Indian and international standards/guidelines/manuals
1.2 Part I	Planning of the projects on existing dams, Barrages, Weirs
1.2 Part II	Planning of the Projects on Canal falls and Lock Structures.
1.2 Part III	Planning of the Run-of-River Projects
1.3	Project hydrology and installed capacity
1.4	Reports preparation: reconnaissance, pre-feasibility, feasibility, detailed project report, as built report
1.5	Project cost estimation
1.6	Economic & Financial Analysis and Tariff Determination
1.7	Model Contract for Execution and Supplies of Civil and E&M Works
1.8	Project Management of Small Hydroelectric Projects
1.9	Environment Impact Assessment
1.10	Performance evaluation of Small Hydro Power plants
1.11	Renovation, modernization and uprating
1.12	Site Investigations
Civil works	
2.1	Layouts of SHP projects
2.2	Hydraulic design
2.3	Structural design
2.4	Maintenance of civil works (including hydro-mechanical)
2.5	Technical specifications for Hydro Mechanical Works
Electro Mechanical works	
3.1	Selection of Turbine and Governing System
3.2	Selection of Generator
3.3	Selection of Switchyard
3.4	Monitoring, control, protection and automation
3.5	Design of Auxiliary Systems and Selection of Equipments
3.6	Technical Specifications for Procurement of Generating Equipment
3.7	Technical Specifications for Procurement of Auxiliaries
3.8	Technical Specifications for Procurement and Installation of Switchyard Equipment
3.9	Technical Specifications for monitoring, control and protection
3.10	Power Evacuation and Inter connection with Grid
3.11	Operation and maintenance of power plant
3.12	Erection Testing and Commissioning

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TECHNICAL SPECIFICATIONS FOR HYDRO MECHANICAL WORKS

1.0 GENERAL

1.1 Scope

This publication covers types, selection, specifications for fabrication, erection and testing of hydro mechanical works viz. intake gates, draft tube gates, spillway gates and their hoisting systems, trash racks and penstock.

1.2 References

R1.	IS: 4623-2000	Recommendation of structural design of radial gates.
R2.	IS:4622-2003	Recommendation for structural design of fixed wheel gates
R3.	IS:5620-1985	Recommendations for structural design criteria for low head slide gates
R4.	IS: 11793-1986	Guidelines for design of float driven hoisting mechanism for automatic gated control.
R5.	IS: 6938-2005	Code of practice for design of rope drum and chain hoists for hydraulic gates.
R6.	IS: 807-2006	Code of practice for design, manufacture, erection & testing of cranes and hoists.
R7	IS:3177-1999	Code of Practice for electric overhead traveling cranes
R8.	IS: 800-1984	Code of practice for general building construction in steel.
R9	IS: 1893-1984	Criteria for Earthquake resistant design of structures
R10	IS:7718-1991 (Pt I, II, III)	Recommendation for inspection testing & maintenance of fixed wheel & slide gates.
R11	IS:2062-2006	Specification of Steel for General Structural Purposes
R12	IS:226-1975	Structural Steel (standard Quality)
R13	IS: 1030-1998	Carbon steel castings for general engineering purposes - specification
R14	IS:1570 (Pt-5)-1985	Stainless and Heat-resisting Steels
R15	IS:875-1987	Code of practice for design loads (other than earthquake) for buildings and structures
R16	IS: 456-2000	Code of practice for plain & reinforced concrete
R17	IS:11388-1985 (Re 2005)	Recommendations for design of Trash racks for intakes
R18	IS:816-1969	Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
R19	IS:4353-1995	Recommendations-Submerged arc welding of mild steel and low alloy steel
R20	IS:813-1986	Symbols for welding
R21	IS: 822 - 1970	Code of procedure for inspection of welds
R22 .	IS: 7318-1974	Approval tests for welders when welding procedures approval is not required.
R23	IS:7310-1974 (Part 1)	Approval testing of welders working to approved welding procedures
R24	IS: 7307 (Pt1). 1979	Approval test for welding procedures
R25	IS:3658 -1999	Code of practice for liquid penetrant flaw detection

R26	IS: 3664-1981	Code of practice for Ultrasonic tube echo testing by contact and immersion methods.
R27	IS: 3703-1980	Code of practice for magnetic flaw detector
R28	IS: 2595-1978	Code of practice for radiographic testing.
R29	IS: 5334-1984	Code of practice for magnetic particle flaw detection of weld.
R30	IS: 1182-1983	Recommended practice for radiographic examination
R31	IS:4853-1982	Recommended practice for radiographic inspection fusion welded butt joints in steel pipes
R32	IS: 780-1980	Sluice valves & Gate valve
R33	IS:11855-2004	Rubber Seals
R34	IS:638-1979	Specification for Sheet Rubber Jointing and Rubber Insertion Jointing**.**
R35	IS:4870-1968	Flat gaskets for shell flanges
R36	IS:1239(Part1)-1990	Mild steel tubes, tubular and other wrought steel fittings
R37	IS:2074-1992	Ready mixed paint, air drying, red oxide zinc chrome, priming - specification**.**
R38	IS:102-1990	Specification for ready mixed paint, brushing, red lead non-setting priming
R39	IS:814-2004	Covered electrodes for manual metal. Arc welding of carbon and carbon. manganese steel
R40	IS:815-1974	Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel
R41	IS:13951-1994	Heavy item lift platform for Aircraft/Airport operations
R42	IS:2004-1991	Carbon steel forgings for general purposes-Specification
R43	IS:1570 (4)-1988	Schedules for wrought steels
R44	IS:2049-1978	Colour code for the identification of wrought steels for general Engineering purposes
R45	IS:305-1981	Specification for Aluminium Bronze Ingots and Castings
R46	IS:318-1981	Specification for leaded tin bronze ingots and castings
R47	IS:210-1993	Grey iron castings — Specification
R48	IS:808-1989.	Hot rolled low medium and high tensile structural steel
R49	IS:2485-1979	Specification for Drop Forged Sockets for Wire Ropes for General Engineering purposes.
R50	IS:2266-2002	Steel wire ropes for general engineering purposes — specification
R51	IS:1363-1992	Hexagon head bolts, screw and nuts
R52	IS:1364-1992	Hexagon head bolts, screws and nuts of product grades a and b.
R53	IS:1365-1996	Tolerances for flat-rolled steel products
R54	IS:1367-1986	Low Carbon and Alloy Steel High Tensile Bolts, Nuts, Studs,
R55	IS:2291-1990	Tangential keys and key ways
R56	IS:2292-1963	Specification for taper keys and keyways
R57	IS: 2825-1969	Code for unfired pressure vessels (Amendments 5).
R58	IS: 5330-1984	Criteria for design of anchor blocks for penstocks with expansion joints
R59	IS: 11625-1986	Criteria for hydraulic design of penstocks
R60	IS:11639(PT-I)-1986	Criteria for structural design of penstocks(Surface Penstocks)

R61	IS:11639(PT-II)-1986	Criteria for structural design of penstocks(Burried/embedded penstocks in rocks)
R62	IS:11639(PT-III)-1986	Criteria for structural design of penstocks(Specials for Penstocks)
R63	ASME SEC VIII DVISION I	Rules for Construction of Pressure Vessels
R64	CWC-1974	Manual on Design, Fabrication, Erection and Maintenance of Penstocks
R65	USBR-Engineering Monograph no. 3; 1977	Welded Steel Penstock
R66	ASCE Manual of Practice No. 79- 1994	Steel Penstock
R67	ASME-1997	Guide to Hydropower Mechanical Design
R68	ASTM D3517-2011	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe
R69	AWWA C950	Fiberglass Pressure Pipe
R70	AWWA M45	Design manual
R71	ISO 10639-2004	Plastics piping systems for pressure and non-pressure water supply - Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester resin.
R72	EN 1796-2006 published by British Standard Institution	Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin.
R73	ASTM D3035-2008	Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
R74	ASTM D3350-2012	Standard Specification for Polyethylene Plastics Pipe and Fittings
R75	IS: 8329-2000	Centrifugally cast (spun) Ductile Iron Pressure pipes for water, gas and sewage-Specifications
R76	IS: 9523-2000	Ductile Iron fittings for pressure pipes for water, gas and sewage-Specifications
R77	IS: 12288 -1987	Code practice for use and laying of ductile iron pipes

ABBREVIATIONS

ASCE	: American Society of Civil Engineers
ASME	: American Society of Mechanical Engineers
CWC	: Centre Water Commission, Govt.of India
IS	: Indian Standard, Bureau of Indian Standard
USBR	: United State Department of the Interior Bureau of Reclamation
ASTM	: American Society for Testing and Materials
AWWA	: American Water Works Association
ISO	: International Organization for Standardization
CEN	: Comité Européen de Normalisation

Reference may be made to the relevant Indian Standard specifications. However, where Indian Standards are silent/ or not available on certain specific provision(s), reference may be made to other appropriate International Standards.

Where reference is made to any of the above standards, the latest issue at the time of design shall apply.

If these specifications conflict in any way with any of the above standards or codes, these specifications and drawings may take precedence as per judgment of engineer in charge.

2.0 TYPE AND SELECTION OF HYDRO MECHANICAL COMPONENTS

2.1 Gates and Hoisting Systems

2.1.1 Gates

Gates can be classified based on head, functions, material, location of installation and operational considerations. However, terminology used to designate various types of gates has a wide variation and there is no uniformity in their nomenclature. Also there is no particular process for the selection of gates. The types of gates used in the SHP schemes are as given in Table 1.

Table 1: Type of Gates

S. No.	Function	Type of gates
1.	Intake/ draft tube gates	Slide gates
		Bulk head gates
		Fixed wheel gates
		Jet Flow Vertical Gate (Fig.-1)
		Ring Follower Vertical Gate (Fig.-2)
2.	Bye pass gates	Caterpillar or coaster gates
		Tilting gates (Godbole type)
		Float operated Radial gates (Fig.-6)
		Drum gates
		Float operated fish belly or shell type hinged gates (Fig.-7)
		Circular type gates
		Rolling gates
		Cylindrical gates (Fig.-4)
3.	Stop log gates	Vertical slide gates in several tiers placed (Fig.-8) one above the other Bulk head gate where one piece covers the passage of water Wooden stop log gates Steel leaf gates
4.	Diversion Barrage/ Dam Gates	Wheel or roller mounted gates (Fig.-3)
		Fixed Wheel Gates
		Stoney gates
		Electrical hoist operated Radial Gates
5.	Head Regulator Gates	Wheel or roller mounted gates
		Fixed Wheel Gates
		Slide gates (Fig.-5)
		Bulk head gates

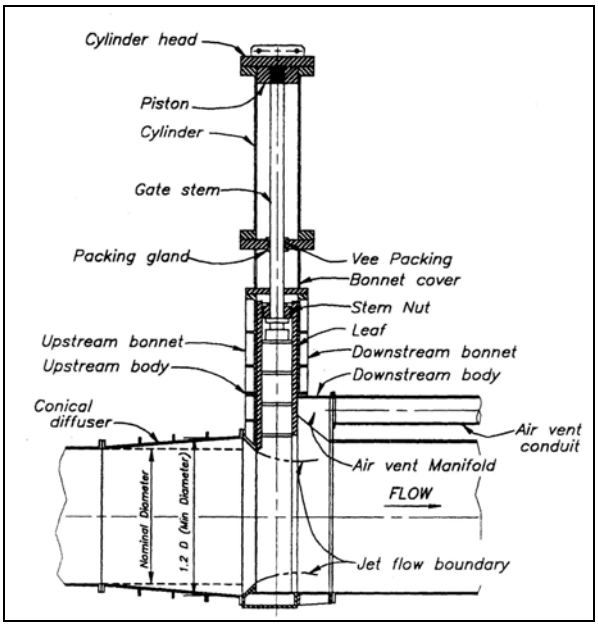

Fig 1: Jet Flow Vertical Gate
(Source: ASME-Guide to Hydropower Mechanical Design -1997)

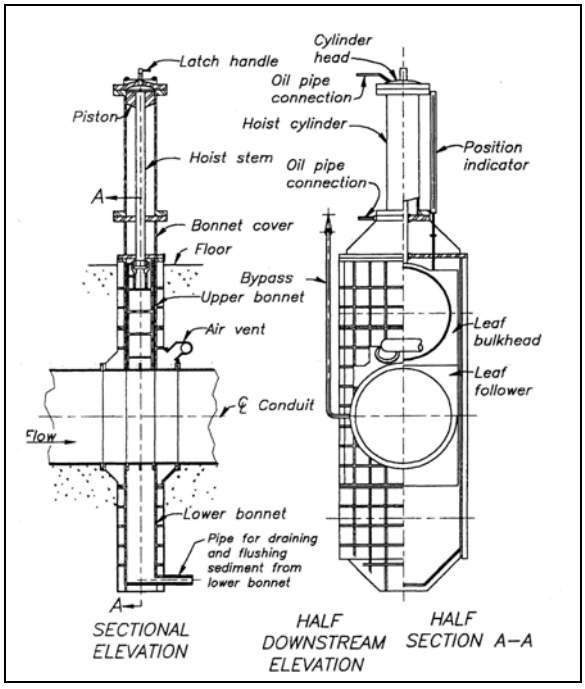

Fig 2: Ring Follower Vertical Gate
(Source: ASME-Guide to Hydropower Mechanical Design -1997)

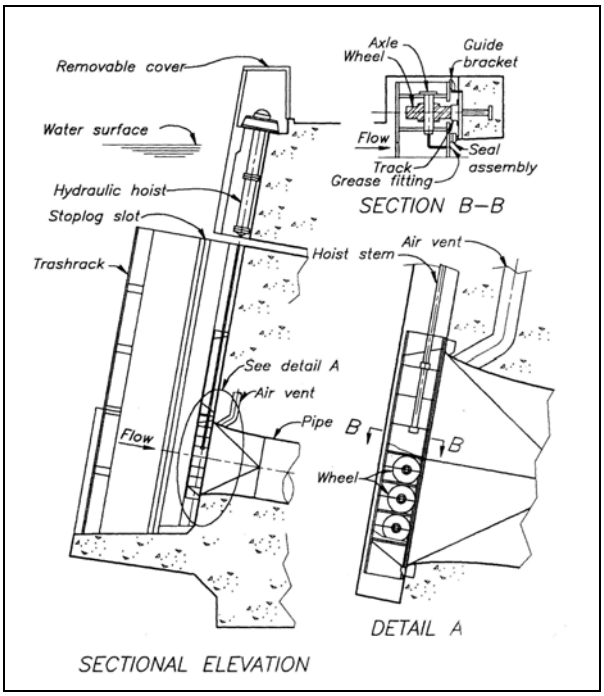

Fig 3: Wheel Mounted Gate
(Source: ASME-Guide to Hydropower Mechanical Design -1997)

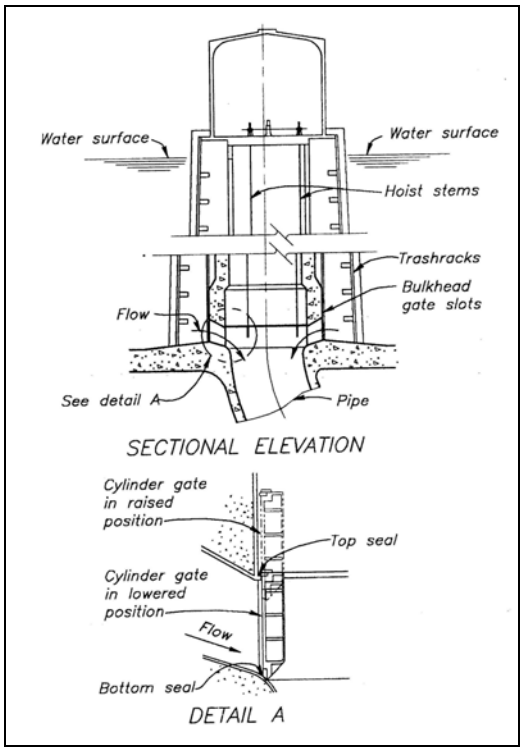

Fig 4: Cylindrical Gate
(Source: ASME-Guide to Hydropower Mechanical Design -1997)

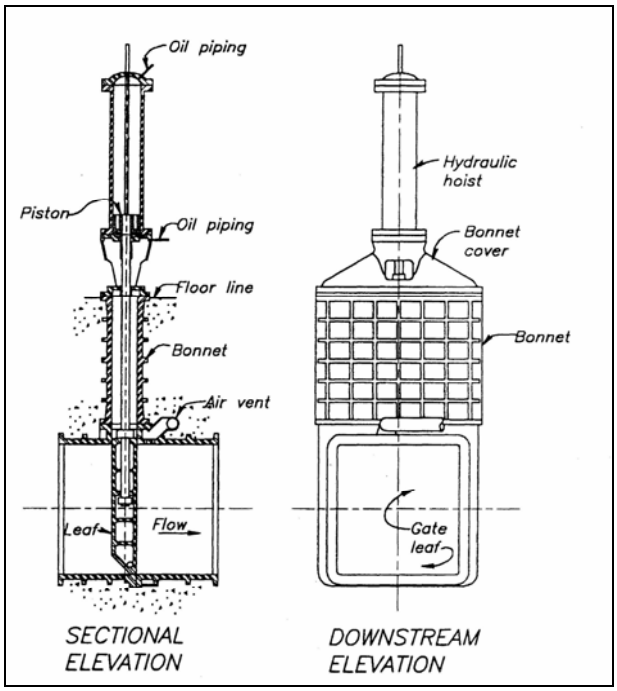

Fig 5: High Pressure Slide Gate
(Source: ASME-Guide to Hydropower Mechanical Design -1997)

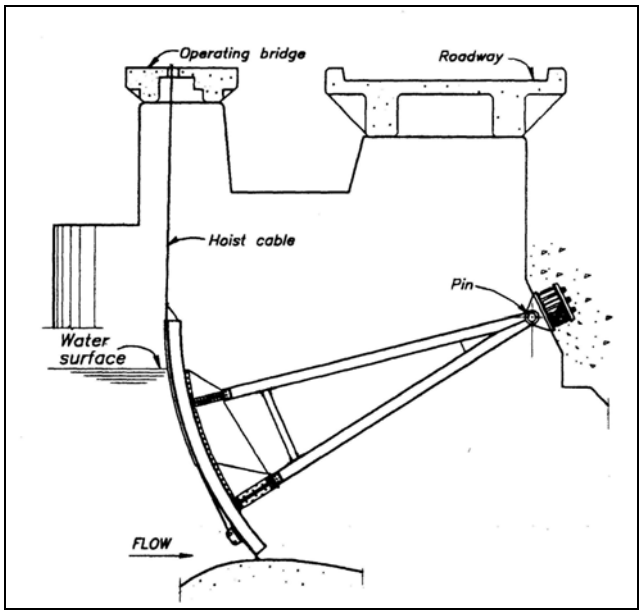

Fig 6: Radial Gate
(Source: ASME-Guide to Hydropower Mechanical Design -1997)

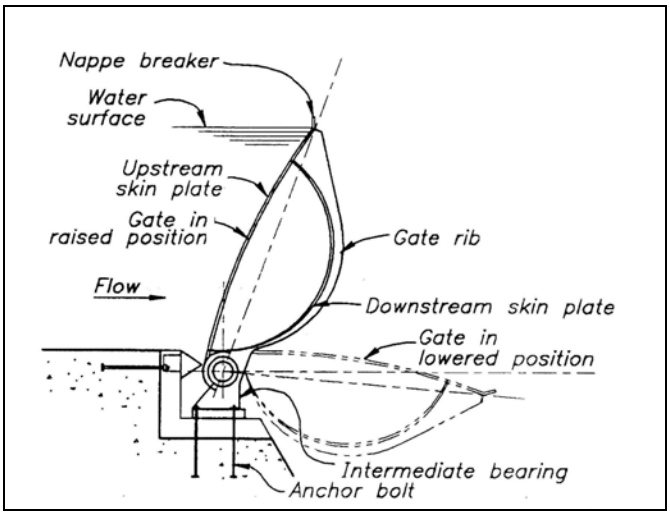

Fig 7: Shell Type Hinged Gate
(Source: ASME-Guide to Hydropower Mechanical Design -1997)

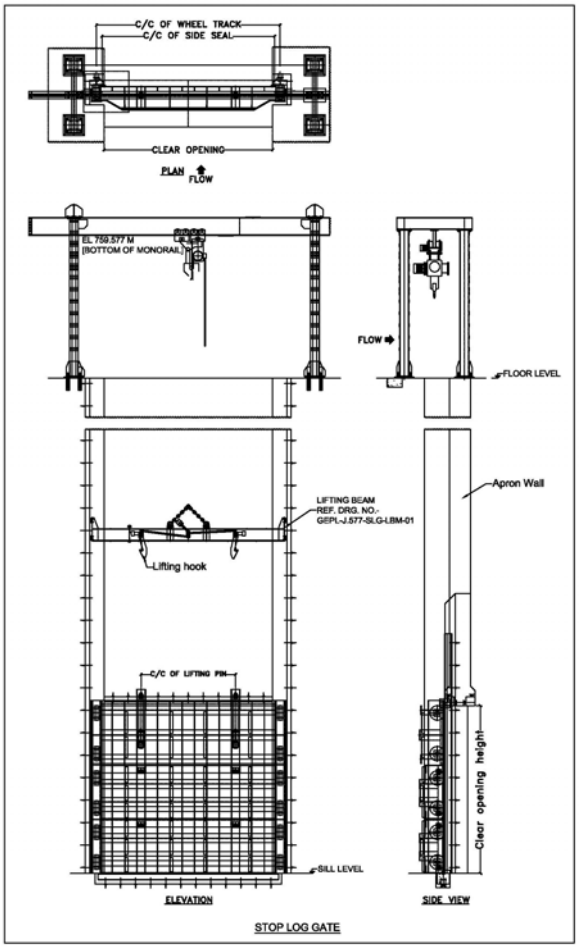

Fig 8: Stop Log Gates
(Source: A leading Indian Manufacturer)

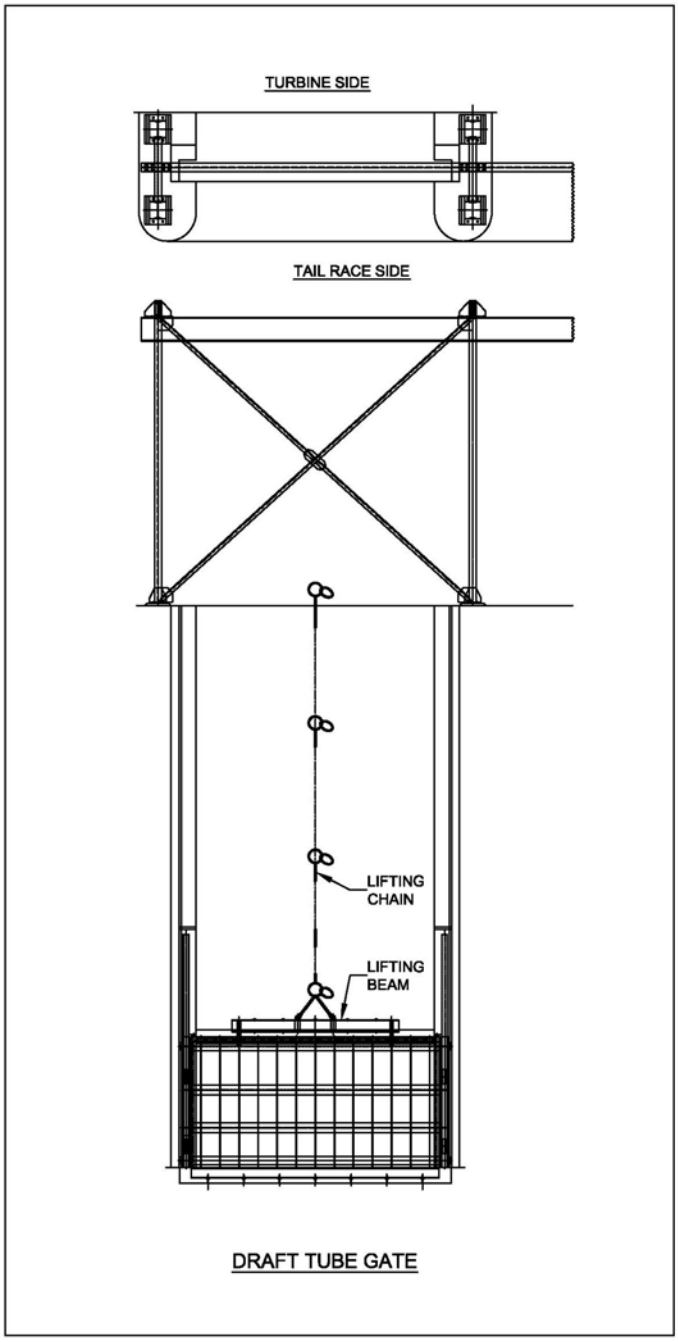

Fig 9: Draft tube Gate
(Source: A leading Indian Manufacturer)

2.1.2 Hoisting Systems

Mostly gates are operated by hydraulic hoisting systems though mechanical rope, screw or chain pulley.

The type of lifting device selected depends upon the gate size, the unbalanced head under which the gate will operate, speed of gate travel and frequency of operation. Selection of the lifting device will depend on:

- The unbalanced head under which the gate is to operate
- The frequency of operation
- The distance the slide is to be moved

There are following types of hoists.

- Hydraulic Hoist
- Power Pack
- Stationary Hoist
- Movable Hoist

2.2 Trash Racks

Trash rack is a rake to stop / prevent floating material from entering the power house / turbine. The trash rack is of a coarse type, which means that the clear spacing between bars, is such large that only drift such as ice flakes, trees, leaves and timbers are prevented from entering to the intake of the power house. The details and general construction of trash racks vary with the service required, configuration of the trash rack structure and depth of water. In canal intake where the height of rack is small, a single rack section of required length extending from the water surface to the floor of the intake is provided. Fig. 10A and 10B show trash racks of a typical SHP.

In case of dam toe installation the trash racks are submerged considerably below the water surface. In such case, trash rack is provided in multiple racks sections bolted together and are kept in position by bolts.

In run of river schemes, the trash racks are provided at the entry of penstock in the fore bay/ balancing reservoir. These trash racks are provided as a single or multiple rack section extending from the water surface to the floor as per depth of water.

2.3 Trash Rack Cleaning Machine

Intakes of hydro power plants are equipped with trash racks to prevent floating debris, leaves, trash and logs etc entry to the power house / turbine. To remove this trash and debris trash rack cleaning machines (TRCM) are required. Generally two types of TRCMs are used:

(i) Stationery TRCM

Stationery trash rack cleaners are mostly where the rake can be built with the same width as the trash rack. This condition is satisfied generally in small hydro power plants of capacity up to 1000 kW

(ii) Travelling TRCM

Travelling TRCMs are normally of following two types:

(a) Wire rope type (Fig. 11A)

This type TRCM consists of following main components:

- Base frame with travelling device
- Winch with rake
- Debrish storage/or debris disposal system

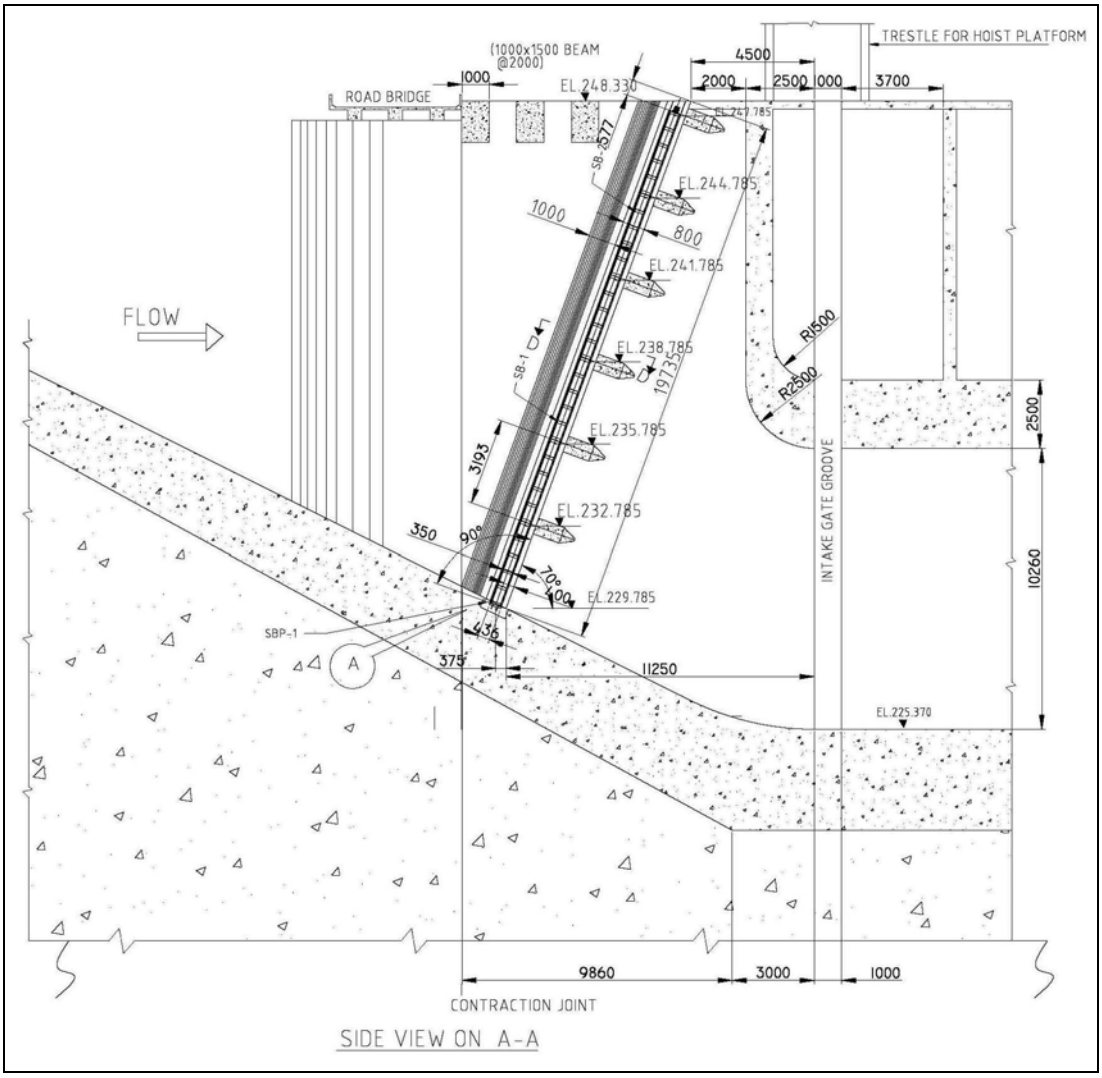

Fig 10 A: Trash Racks of a typical SHP

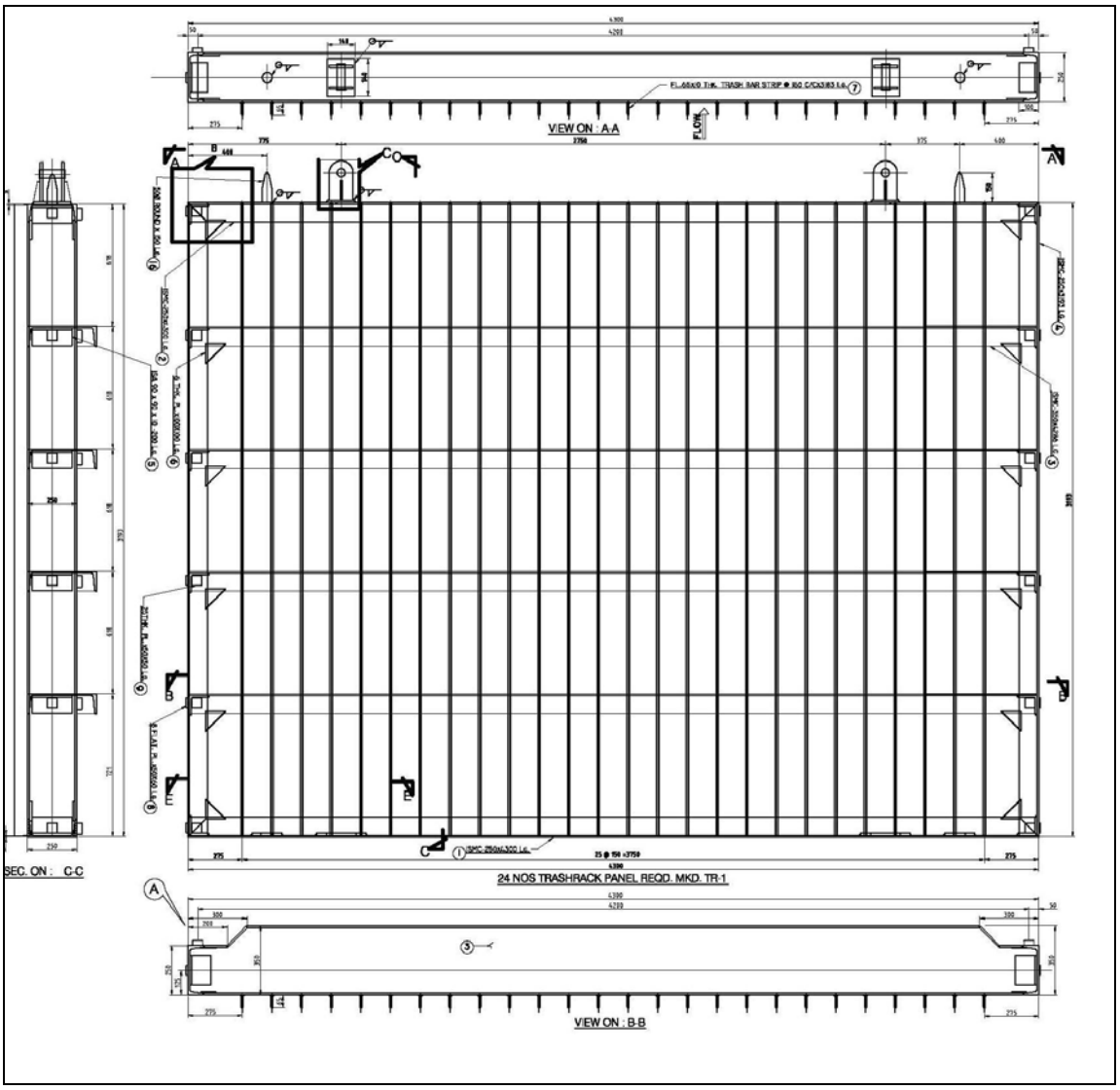

Fig 10B: Trash Racks of a Typical SHP

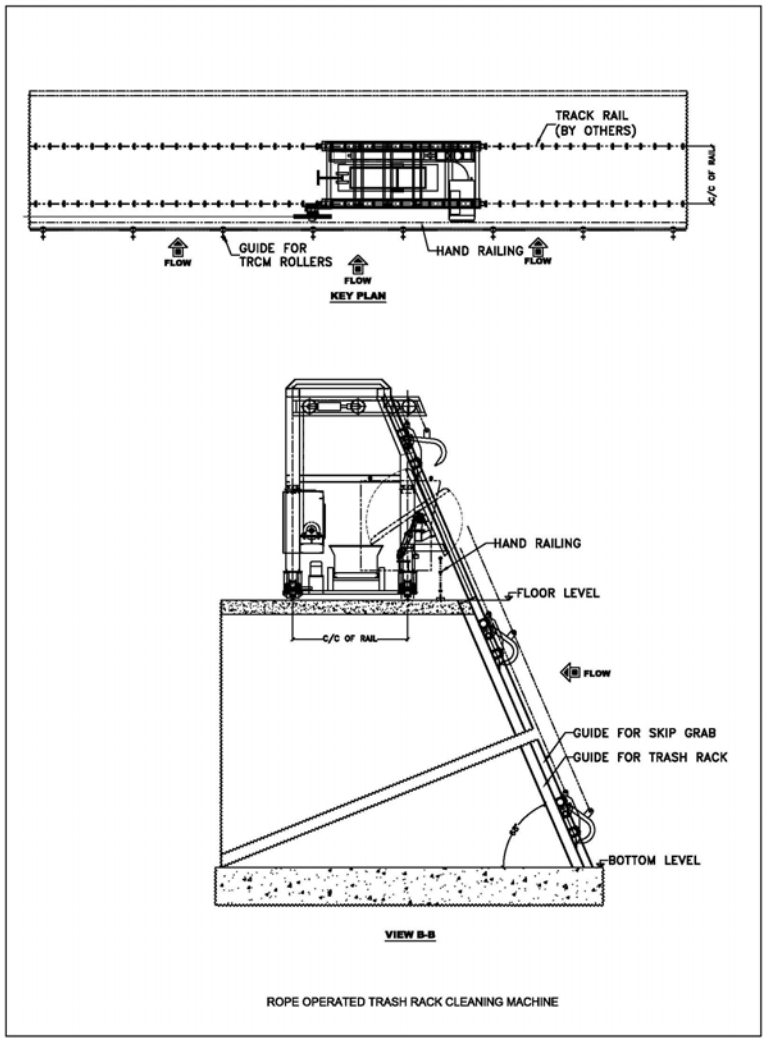

Fig 11 A: Wire rope type TRCM
(Source: A leading Indian Manufacturer)

(b) Hydraulic jib type (Fig. 11B)

This type machine consists of following components:

- Base frame with travelling device
- Pivoted machine with brooms and grab rake
- Debris storage/or debris disposal system

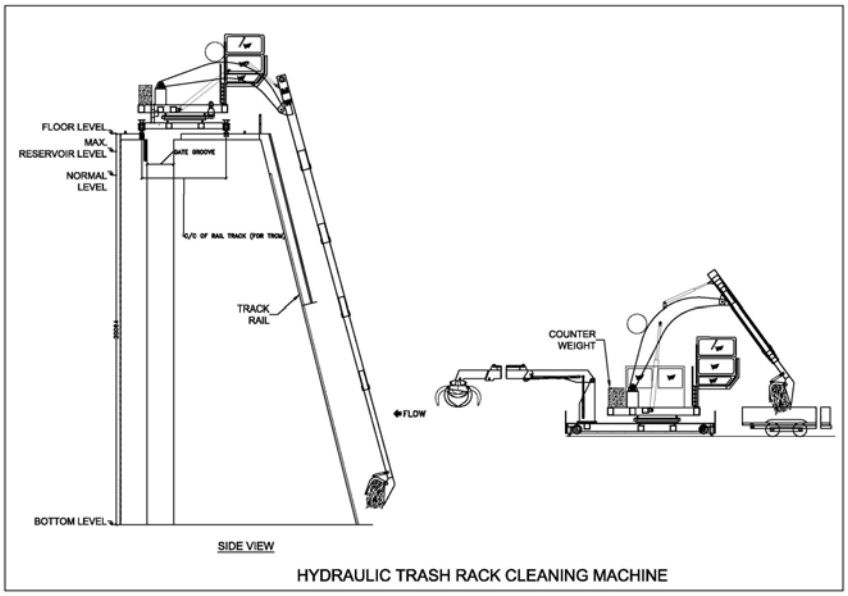

Fig 11 B: Hydraulic jib type Trash Rack Cleaning Machine
(Source: A leading Indian Manufacturer)

2.4 Ice, Log and Floating Debris Booms (Fig. 12)

Floating booms are provided at some intakes to deflect logs, trash and ice from the intake screens and sometimes to prevent boats from being carried into the intake.

Floating booms are located at an adequate distance upstream of intake to be away from high velocity zone near intake.

Boom is planned in such a way that it may divert logs, trash and ice to a suitable spill way, dam over flow or trash sluice way or navigation lock. To achieve this boom is angled between 30 to 45 deg. to the direction of flow.

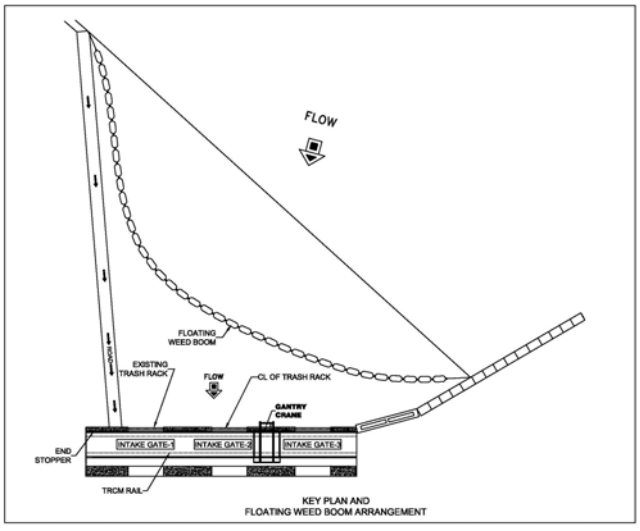

Fig 12: Floating debris boom
(Source: A leading Indian Manufacturer)

2.5 Penstocks

The penstock is the pipe which conveys water under pressure from the forebay tank/ surge tank to the hydraulic turbine. The penstock often constitutes a major expense in the total budget and it is worthwhile that its design in optimized. The trade-off is to be achieved between head loss and capital cost. Head loss due to friction in the pipe decreases with increasing pipe diameter. Conversely, pipe costs increases with increase in diameter. Therefore a compromise between cost and performance is required.

The design philosophy is first to identify available pipe options, then to select a target head loss and 5% of the gross head may be a reasonable starting point. The details of the pipes close to this target loss are compared for cost effectiveness. A smaller penstock may save on capital costs, but the extra head loss may account for loss of revenue from electricity generated each year.

2.5.1 Materials for penstocks

The factors those have to be considered for deciding the material to be used for a particular penstock are pipe surface roughness, design pressure, method of jointing, weight and ease of installation, accessibility to the site, terrain, soil type, design life and maintenance, weather conditions, availability, relative cost and likelihood of structural damage.

The following materials can be considered for use as penstock pipes in micro hydro schemes:

- Mild steel, unplastified polyvinyl chloride (uPVC), high density polyethylene (HDPE), spun ductile iron, glass reinforced plastic (GRP), prestressed concrete, wood stave and asbestos cement,

Mild steel, HDPE and GRP are the most commonly used materials in SHP applications.

2.5.2 Penstock jointing

Pipes are generally supplied in standard lengths and have to be joined together on site. There are several ways of doing this and the following factors should be considered when choosing the best joint system for a particular scheme:

- suitability for chosen pipe material,
- skill level of personnel installing the pipe,
- whether any degree of joint flexibility is required,
- relatively costs,
- ease of installation.

Methods of pipe jointing fall roughly into four categories:

- flanged,
- spigot and socket,
- mechanical,
- welded.

2.5.3 Burying or supporting the penstock

Penstock can either be surface mounted or buried underground. The decision will depend on the pipe material, the nature of the terrain and environmental considerations.

Buried pipelines should be ideally at least 750 mm below the ground level, specially when heavy vehicle are likely to cross it. Burying a pipe line reduces its visual impact and permanent land acquisition. However, it is vital to ensure that a buried penstock is properly installed towards any subsequent problems such as leakage, which are difficult to detect and rectify in the buried pipes.

Where the nature of ground renders burying the penstock, non conducive and uneconomical penstocks are laid above the ground, in which case piers, anchors and thrust blocks are needed to counteract the forces which can cause undesired pipeline movement. A typical concrete anchor is shown in Fig. 13 & Fig. 14.

The three types of forces against which penstocks need to be designed are:

- Weight of the pipes plus water,
- Expansion and contraction of the pipe,
- Fluid pressure (both static and dynamic).

Support piers are used primarily to carry the weight of the pipes and enclosed water. Anchors are large structures which represent the fixed points along a penstock, restraining all movements by anchoring the penstock to the ground. A thrust block is used to oppose a specific force, for example at a bend or contraction.

The different support structures can usually be built of rubble masonry or plain concrete. Anchor blocks may need steel reinforcement and triangulated steel frames are sometimes used for support piers.

The size and cost of support structures for a given penstock are minimised by:

- Keeping the penstock closer to the ground,
- Avoiding tight joints,
- Avoiding soft and unstable ground.

3.0 INTAKE GATES -TECHNICAL SPECIFICATIONS FOR FABRICATION, ERECTION AND TESTING

3.1 Scope of Work

The broad scope of work includes the following.

(1) Design, drawing, Manufacture, inspection, shop assembly, testing, painting.
(2) Transportation and handling, site storage, site erection, painting, testing and commissioning including provision of labour, plant and material for the above.
(3) Handing over to owner, supply of necessary spares for 5 years trouble free operation and supply and installation of all incidental not specified but are necessary for proper completion and satisfactory functioning of the system.

(4) Guarantee of the following permanent equipment, along with all auxiliary equipment in the designated location of the project as specified in the following sections of technical specifications / technical provisions.

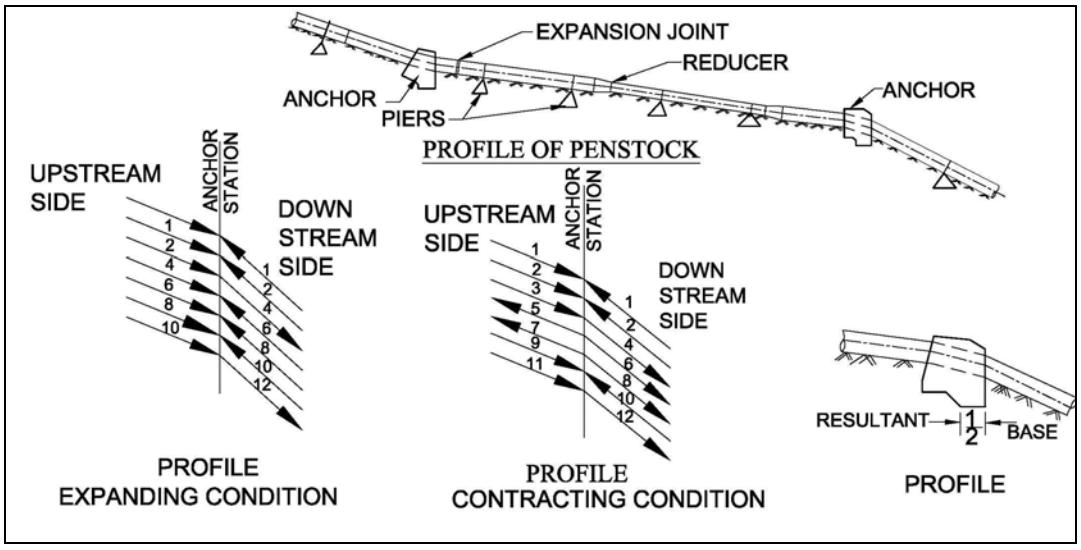

Fig. 13: Penstock Specials
(Source: USBR-Engineering Monograph 3- Welded Steel Penstocks)

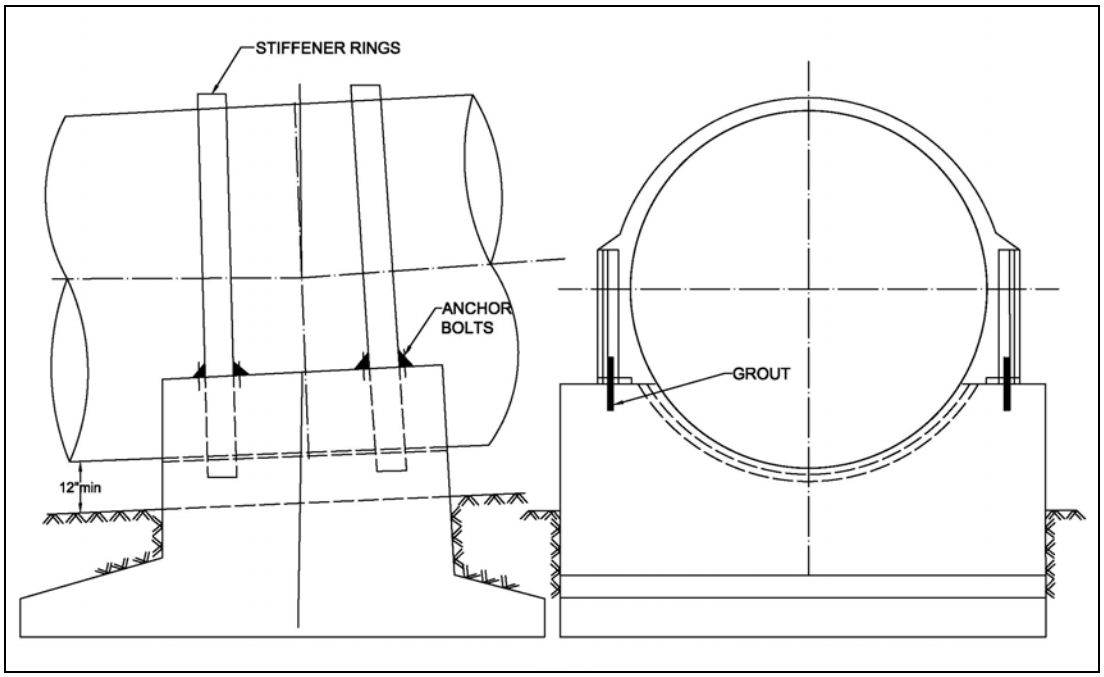

Fig 14: Typical Concrete Anchor
(Source: USBR-Engineering Monograph 3- Welded Steel Penstocks)

3.2 Design Consideration and Operation Requirements

The intake gates are designed in accordance with the provisions of the latest edition of IS: 4622 in general and in accordance with the provisions specified in these specifications in particular.

The intake gates are designed for operation under maximum head corresponding to full supply level against the normal allowable stresses. The gate shall have upstream skin plate and upstream sealing arrangement and are to be designed for unbalanced head operation.

Earthquake effects are considered and allowed in the design as per stipulations in accordance with IS: 1893. The design shall be checked for additional forces due to horizontal and vertical earthquake acceleration corresponding to relevant zone. The maximum deflection of the gate shall be limited to 1/800 of the span (centre to centre of tracks.)

The gate shall be capable of operation by alternative methods in case of power supply failure.

The gate shall satisfy the following requirements:

a) In closed position, the gate must be completely water tight with full pressure acting from upstream side and sealing must be reliable against maximum water level.
b) The sealing of the wheel assemblies should prevent entry of water to the wheel bearings to ensure trouble free operation.
c) The gate groove covers shall be design for crowd load of 500kg/m².
d) The following loads shall be considered:

    i) Full hydro-static load on upstream side of the gate with water level at highest level of fore bay
    ii) The total hydro-static and hydro dynamic forces, frictional & wind loads when the gate is raised or lowered with the upstream water level at highest level of fore bay

3.2.1 Emergency operation and remote control of intake gates

Provision are made for intake gate closing by gravity under emergency condition of unit over speeding. Over speed switch activated mechanically by means of positive coupling to the rotating elements of the turbine generator is proposed to be provided in turbine specification. In addition a manual emergency push button is also being provided on the control panels.

Emergency closing by gravity shall ensure suitable cushioning and closure delay to prevent surges in the water.

Control for remote/automatic operation of the intake gate for a typical SHP are as per Table 2:

Table 2: Control for Remote / Automatic Operation of the Intake Gate

S. No.	Location	Control
1	Unit control board	Raise/lower control switch Indicating light for fully open and fully closed position Position indicator for actual position of gate
2	Local	Raise/Lower control switch Mechanical device showing position
3	Annunciation	Failure of gate to open or close in response to automatic signal Failure of gate to maintain partial close position during sluice operation Hydraulic system position

Note: All signals shall be suitable for computerized control i.e. should be digital or analogue 4 mA-20 mA, 1-5 V

3.2.2 Ballast weight

Suitable cast iron block with suitable locking device may be provided as required, to make the gate self lowering and while computing hoist capacity, calculations shall consider ballast weight, if any, as part of gate weight.

3.2.3 Dogging device with accessories and embedments

Suitable dogging arrangement to hold the gate in suspended vertical position within the gate grove for normal storage and above the gate groove for allowing its inspection, maintenance and repairs are provided. Suitable embedments to guide the dogging beam are also provided. Dogging beam are so designed as not to cause any damage to bottom seal of gate while in dogged position. It is to be properly secured with a chain. The dogging beam is designed to withstand the dead weight and impact (30%) of gate weight and ballast.

3.3 Hoist for Intake Gates

3.3.1 Design criteria

The hoists are designed at a rated capacity capable to lift or close the gates under all eventualities for which the gate has been designed. The hoist capacity shall be calculated taking into consideration the worst combination of all frictional forces, hydrodynamic loads, dead weights etc. during both raising and lowering cycles, plus a reserve capacity of 20% over and above the worst combination of forces (while lowering, uplift forces and while raising down pull forces shall be taken into considerations) and various factors as enumerated in IS: 6938 shall be taken into consideration. While determining the hoist capacity, positive closure of gate with designed weight and seating pressure @ 1000 kg/m width of gate shall be ensured. The contractor shall submit detailed calculations in support of hoist capacity. The coefficient of friction used for working out hoist capacity shall not be less than those provided in the design criteria for gates or those specified in IS: 4622 unless otherwise specified in these specifications. Necessary down pull force shall be considered while computing the hoist capacity.

The mechanical parts of the hoist are to be designed for the specific loads with a factor of safety of five based on the ultimate strength of the materials. Under breakdown torque condition of the motor, stress in any portion of the hoist, bridge & trestles shall not exceed 80% of the yield point of the materials (or 33.33 % higher than normal stresses whichever is lower). The rope shall have a factor of safety of six for normal conditions and of 3 for breakdown torque condition. The hoist mechanism shall be covered by suitable cover frames to protect it form dust, dirt and direct exposure to moisture.

3.3.2 Hoisting arrangement and hoist capacity

The fixed hoist shall be electrically operated and shall consist of a drive unit and 2 hoist drum assembly units for each gate. The hoist shall be located on structural steel platform mounted over the steel trestles located at the top of deck. The hoist shall be of fixed type and electrically operated with provision for manual operation in case of power failure. The drive unit shall operate on 440V, 3 phases, 50 cycles AC supply. Suitable gear reduction unit shall be provided between drive unit and the rope drum assembly units. The rope drum assembly units and reduction units shall have minimum 3mm thick MS sheet covers with flat/angle non frame work. The rotary type of double acting limit switch shall be provided for automatically and positively stopping the drive motor during hoisting/lowering of the gate as soon as either end of the gate travel is reached. Each drive unit shall be capable of being actuated locally. Dial type position indicator showing the gate opening shall be provided.

The manual drive shall be capable of being operated by four operators each exerting continuous effort of 10 kg with 400mm crank radius at a continuous rating of 20 revolutions/ minute. A manual electrical interlock shall be provided in control circuit to cut off power supply to motor, while operating manual drive. The hoisting speed of manual operation should be maximum attainable. Protective Device to automatically brake the hoist in case of power failure shall be provided. On resumption of power supply the hoist shall start operation by pressing either ‘close’ or ‘open’ push buttons. Provision shall be made for normal maintenance and repairs of hoist without disconnecting rope from hoist drum and with gate resting on sill (fully closed).

Suitable chequered plate with guard railing of one meter height and toe guards shall be provided on all sides of hoisting platform. Necessary staircase arrangements shall be provided for the approach to hoist bridge.

Each electrically operated, mechanical hoist shall generally consist of the following components:-

1. Wire rope of adequate capacity with rope attachments and overload protection.
2. Balancing sheaves with attachments.
3. Rope drums
4. Spur gears reductions (End reductions).
5. Shafts.
6. Flexible couplings (gear type or bush type)
7. Plummer blocks with bearings / bushes.
8. Worm reducers.
9. Motor
10. Electromagnetic brake

11. Gate position indicator.
12. Manual hoisting arrangement with clutch type engaging/disengaging arrangement.
13. Limit switches, electrical wiring and control panels.
14. Covers for rope drum and spur gear reducers.
15. Nuts, bolts and other accessories (Fasteners).
16. Any other mechanical or electrical component/attachment considered necessary for proper assembly and operation of the hoist.

3.4 General Specifications and Technical Requirements

The broad indicative specifications and technical requirements to be more fully described by the bidder in the documents to be submitted shall include the following:

3.4.1 Materials

All materials incorporated in the equipment shall be new, unused and of first class commercial quality, free from defects and in accordance with the relevant Indian standard. The minimum requirement of materials to be adopted for various components is given in the subsequent section.

3.4.2 Design and stress levels

The hydro-mechanical equipments shall be designed in accordance with the requirements of Indian standards. The bidder shall clearly indicate the standard to which these equipment shall be designed.

For worst loading conditions such as earthquake conditions or gates jammed conditions, storm wind conditions and under brake down torque conditions of the hoist, the permissible design stresses shall be increased by 33.33 % over the normal stress but limited to 80% of the yield point. In case of fasteners, the increase in stress for worst loading cases shall be limited to 25% only.

The embedded parts of gates shall be designed to limit the bearing pressure on 2^{nd} stage concrete to 25% of compressive strength of the concrete. An increase of 33.33 % over the above stress is permitted in the case of worst loading cases.

Various lifting/ operating equipment and their supporting structure shall be designed for normal as well as storm wind conditions as per Indian Standards IS 875.

The impact factor for various structures shall be in accordance with relevant Indian standards. However minimum impact factor of 30% shall be considered for the design of dogging devices and hoists with normal allowable stresses.

A corrosion allowance of 1.5 mm shall be adopted for skin plate.

Minimum thickness for Gates, hoists and hoist supporting structures shall usually be equal to that of skin plate (clause 3.8.2 IS:800 recommends a minimum thickness of 8 mm for all parts made of steel). General practice of minimum thickness of structure is given in Table -3.

Table 3: Minimum thickness for Gates, Hoists and Hoist Supporting Structures

S. No.	Part	Minimum thickness(mm)
1	Main elements	10
2	Secondary member	8
3	Minimum thickness of Embedded parts	10
4	Parts totally embedded	8

3.4.3 Embedded parts

All the sealing faces in the embedded frame shall be of stainless steel. The wheel tracks and sliding tracks shall be of corrosion resisting steel. The BHN of wheel tracks shall be 50 points higher than the wheel rim. All the tracks (wheel as well as sliding) and seal shall be machined after welding is completed. The minimum thickness of seal seats after machining shall not be less than 10mm and thickness of roller/sliding path plate shall not be less than 16mm after machining. Roller path, seal paths and guide track shall be provided up to the full height.

3.4.4 Frictional resistance

The following frictional resistance co-efficient as shown in Table 4 in the design of gates and associated equipment.

Table 4: Frictional Resistance Co-Efficient of Different Surfaces

S. No.	Item	Static	Dynamic	Code Ref.
1	Rubber seal on Stainless steel	1.5	1.2	IS:5620-1985
2	Seals with PTFE inserts	0.2	0.15	IS:11855-2004
3	Roller bearing Factor	0.015	0.01	-
4	Self-lubricating bearings	0.2	0.15	-
5	Plain bearings	0.4	0.3	IS:14803 Part I&II
6	Steel on steel	0.6	0.4	IS:5620-1985
7	Brass or bronze on steel	0.5	0.3	IS:5620-1985

3.4.5 Painting systems

3.4.5.1 Gates

The following painting system shall be adopted for intake gates, draft tube gates and trash racks.

Perfect cleaning of all surfaces which are not to be covered with concrete shall be carried out by sand blasting to the requirements of SA 2 ½ of Swedish Standard.

Over the prepared surfaces one coat of in organic zinc silicon by spray (preferably airless spray) should be applied giving a dry film thickness of 70 to 75 microns.

The interval between surface preparation and painting shall be as short as practicable and in no case longer than 4 hours. Over the primer, two coats of solventless coal tar epoxy

paint shall be provided at an interval of about 24 hours. Each coat shall give a dry film thickness of 150 microns. The total dry film thickness of all the coats shall not be less than 350 microns.

3.4.5.2 Embedded parts

All unfinished surfaces of embedded parts exposed to atmosphere or water shall be sand blasted to 2½ of Swedish standard and given one coat of inorganic zinc silicon primer by spray (preferably airless spray) giving a dry film thickness of 70+5 microns. Two coats of solvent less coal tar epoxy paint with a dry film thickness of at least 150 microns per coat shall then be applied by brush. The total dry film thickness of all the three coats shall not be less than 350 microns.

3.4.5.3 Rope drum hoist

a) **Structural components**: Cleaning of all the surfaces shall be done by sand blasting to SA 2½. In such areas where it is not possible the parts shall be cleaned by brushing and scraping. The parts after surface preparation shall be given one coat of red lead primer paint conforming to IS 102 in the shop before despatch. One further coat of primer shall be applied after erection. The primer coats shall give a minimum dry film thickness of 40 microns per coat. The finish paint shall consist of two coats of micaceous iron oxide paint or synthetic enamel paint. Each coat of paint shall give a dry film thickness of 50 microns. The interval between coats of micaceous iron oxide paint or synthetic enamel paint shall be 24 hours. The total dry film thickness should not be less than 175 microns.

b) **Machinery**: All surfaces of machinery (except machined surfaces) including motor, gearing, housing, shafting bearing pedestals shall be given one coat of zinc chromate priming paint followed by three coats of aluminum paint, at a coverage rate of 6 sq.m/litre and 8-10sq.m/litre respectively. Unfinished interior surfaces of oil reservoir and gear boxes and unfinished surfaces of gears which will run in oil need not be painted.

3.4.5.4 Machined Surfaces

Machined surfaces shall be protected with adhesive tapes/or other suitable means during the cleaning and painting operations. All machined surfaces of ferrous metal including screw threads, which will be exposed during shipment or while awaiting installation, shall be cleaned with solvent and coated with a gasoline soluble rust preventive compound.

3.4.5.5 Colour Scheme

Colour scheme of a typical SHP is shown in Table 5.

Table 5: Colour Scheme of a Typical SHP

S. No.	Item	Colour Scheme
1	Embedded Parts, and other components immersed in water	Black
2	Super structure including columns, trestles, hoist platform and staircase etc.	Grey
3	Hoist Machinery	Grey
4	Trash rack	Orange

3.4.5.6 Touch-Up Paint

Suitable quantities of various types of paints shall be supplied along with equipment/ structure for site touch up of the damaged surfaces during transportation.

3.5 Materials

Materials for gates and embedded parts are given in Table 6.

Table 6: Different Materials for Gates and Embedded Parts

S. No.	Component Part	Recommended Materials	Standard reference
i)	Structural Parts of gate leaf including skin plate, stiffeners, horizontal girders, diaphragms, track base, seal base, seal seat base, liners, seal clamp, lifting lugs, structural parts of lifting beam, rail guide, sill beam, anchor bolts, load carrying anchors etc.	Structural Steel	IS 2062
ii)	a) Wheels	Cast steel Forged steel	IS1030 Gr27-54 IS 2004 CL. IV
	b) Self aligning spherical roller bearings	Standard make SKF or equivalent approved make	—
	c) Wheel pins	Corrosion resistant steel Forged steel	IS:1570(5) Gr.15 Cr.13 IS:2004 with 40 microns hard chromium plating
	d) Retainers	Structural steel	IS 2062
	e) Sleeves for pin (distant pieces)	Corrosion resistant steel Structural steel Hard chromium plated to 20 microns	IS:1570(5) Gr.15 Cr.13 IS: 2062
iii)	a) Guide roller	Cast steel	IS 1030 Gr.27-54 or Gr. 26-52
	b) Guide roller pin	Corrosion resistant steel carbon steel hard chromium plated to 40 microns	IS:1570(5) Gr.15 Cr.13 IS: 1570(4) C-40.
	c) Bushing	Bronze	IS: 305 / IS: 318
iv)	Track base/sill base/side seal base/ guide roller track/ bumper track	Structural steel	IS: 2062
v)	Rubber Seals	Rubber	IS: 11855
vi)	Track	Corrosion resistant steel	IS:1570(5) Gr.20 Cr.13

S. No.	Component Part	Recommended Materials	Standard reference
		Stainless steel	04 Cr.19 Ni9 or 07 Cr.19 Ni 9
vii)	Seal seats (side, bottom & top)	Stainless steel	IS1570(5) 04 Cr.19 Ni9 or 07 Cr.19 Ni 9
viii)	Seal fasteners	Stainless steels	IS:1570 (5) 04 Cr.19 Ni9 or 07 Cr.19 Ni9
ix)	Ballast if any	Cast iron	IS : 210

Material for Components of Hoist Bridge, Trestles, Walkway and Railing etc. are shown in Table 7.

Table 7: Material for Components of Hoist Bridge, Trestles, Walkway and Railing etc.

S. No.	Component Part	Recommended Materials	Standard reference
i)	Base plate, anchors bridge bears, columns stiffeners, bracings, lugs, gantry girders etc.	Structural steel Rolled sections	IS: 2062 IS: 808
ii)	Walkway	Chequered plate/grating	IS: 2062
iii)	Bridge Bearings	Neoprene or plate bronze	Standard IS 305/IS 318
iv)	Hand rails & Ports	M S Black	IS:1239 (Medium)

Materials for Rope Drum Hoists are shown in Table 8.

Table 8: Materials for Rope Drum Hoists

S. No.	Component Part	Recommended Materials	Standard reference
i)	Wire rope	Improved plow	IS : 2266
ii)	Trun buckles	Galvanised forged steel	IS: 2004
iii)	Dead end/open end wire rope sockets	Forged steel	IS :2485
iv)	Drums	Cast steel Structural steel	IS:1030Gr.27-54 IS : 2062
v)	a) Gears	Cast steel	IS 1030 Gr. 27-54
	b) Pinions	Carbon steel forged steel	IS:1570 C40 IS:2004 CI. IV
vi)	Sheaves and pulleys	Cast steel	IS 1030 Gr. 27-54
vii)	Shafts	Forged steel carbon steel	IS 2004 CI. IV IS:1570 C 40
viii)	Speed reducer, motor electromagnetic	Standard	_

S. No.	Component Part	Recommended Materials	Standard reference
	brakes plummer blocks couplings chains, bearings, limit switch, control equipment etc.	approved manufacturers of repute	
ix)	Gate position indicator	Non rusting metal or enamelled plate or thick plastic sheet	_
x)	Electrical bought out items	Standard approved makes.	_
xi)	Threaded Fasteners		IS: 1363 / IS: 1364 / IS: 1365 / IS: 1367 Relevant IS Codes
xii)	Keys & Keyways		IS: 2048 / IS: 2291 IS: 2292
xiii)	Bushing	A1-Bronxe	IS: 305-Gr.1
xiv)	Steel for shrunk fit gear rims	Forged steel/ alloy steel	IS: 2004 IS: 1570
xv)	Structural Steel	Structural steel	IS : 2062

3.6 Technical Provisions

3.6.1 General

The purpose of these provisions is to provide the contractor with the general technical requirements applicable to the equipment called for in the Technical Specifications and Drawings.

3.6.2 Intent of specifications

Certain performance requirements, materials, features and design requirements are specified herein. Experience and practice of manufacturer shall meet, in all respects, the specified requirements in regard to performance, durability and satisfactory operation. However, certain features, materials and design requirements are specified to establish minimum standards for the work.

3.6.3 Responsibility of contractor

Contractor shall guarantee and be responsible for:

- Design of the complete work for submission, to Engineer-in charges for approval, showing all principle forces, analysis of all components, centers of lift and gravity, and hoist forces, uplift and downward forces.
- The quality of all materials and workmanship of the complete work.
- Rigid adherence to the dimensions of parts as shown on accepted drawings, except for deviations specifically authorized in writing by Engineer-in-Charge.
- Strength of all parts to withstand all mechanical, hydraulic and other forces which may be experienced in the specified operation or during shipment of the equipment.

- Delivery within the period of time given or subsequently fixed by contract. Satisfactory performance of the entire work under all specified operations conditions without signs of undue strain, and without breakdown, damage, or deterioration of any of the parts due to faulty or unsuitable material, workmanship, installation or design.
- Freedom from abnormal vibrations of any part or parts under the most severe operating conditions.
- The water tightness of the gate seals.
- The strength, accuracy and adequacy in all respects of the installation of all machinery and equipment supplied under this Contract.

It is Contractor's responsibility to ensure that all components supplied in accordance with these specifications shall fit correctly to each other. In the event of any field modifications being required due to errors in shop fabrication.

To ensure timely approval of the design and drawings, these should be submitted by the contractor strictly as per schedule, in proper sequence and in accordance with the requirements of the technical specifications supported by technical documents, literature etc, as required in one lot after complete scrutiny and checking from his end so that the comments from Engineer-in-charge and number of resubmission are kept to a minimum.

3.6.4 Drawing data to be submitted with the tender by the bidder

1. Technical data
2. Basic design, estimated weight, hoist/crane capacity calculations and general arrangement drawings for each of the equipment to be supplied.
3. Detailed schedule of submission of design calculations, drawings, fabrication, erection, testing and commissioning.
4. Deviations from technical specifications, if any.
   (i) Any item not specifically mentioned or covered but necessary to complete the job shall be considered included in the scope of work by the contractor.
   (ii) Any item or services which the bidder desires to be supplied / provided by the purchaser shall be specifically mentioned failing which it shall be presumed that such item / services are included in the scope of supplies / work by the contractor.

3.6.5 Contractor's drawings/documents

Contractor shall submit required sets for each detailed design computations and drawings to the Engineer-in-charge for approval which shall include complete details of the equipment. All drawings shall be carefully checked by Contractor for accuracy, completeness and clarity before submission for review and approval. Contractor shall be responsible for correctness and adequacy of the design in relationship to the specifications.

3.6.6 Inspection & tests

All materials shall be of tested quality and all work performed shall be subject to rigid inspection and no article or material shall be dispatched until all tests, analysis and shop inspection have been completed or certified copies of reports or results of test and analysis have been accepted. Copies of manufacturer's test certificates including chemical analysis and mechanical properties shall be made available for all materials. In case test certificates are not available for any of the material, the same shall be got tested and only those materials

which fulfill the requirements of these specifications shall be used. From any part / item, it should be possible to locate its manufactures batch/lot mark, which shall be achieved by transferring the batch marks before parting the materials.

All castings shall be annealed and forging shall be normalized.

3.6.6.1 Shop assembly and testing

During the course of manufacture, the equipment included in the scope of supply shall be subject to rigorous inspection and testing.

All components, sub-assemblies and assemblies will be dimensionally and functionally checked against the relevant drawing.

All gate units shall be fully shop assembled (with temporary bolting where necessary), and checked for dimensional and flatness checks with all fitments such as wheels, guides, seals, etc, attached. The correct C.G shall be established during shop assembly before final welding of lifting lugs.

Embedment frames and guides shall be assembled on the shop floor for dimensional and straightness checks, also alignment of connecting members within the required tolerances.

In all cases the various connecting parts shall be match marked to facilitate site erection.

Hoisting units shall be fully assembled on the hoist platform and test run to at least 20 minutes and load tested to 1.25 times the rated capacity. During test run all the components of the hoist shall be tested for their performance.

3.6.6.2 Site testing and commissioning

All embedded reception frames and support frames etc, shall be erected and checked for dimensional accuracy and alignment in accordance with the assembly drawing within the required tolerances and level limits before and after concreting.

After site assembly of the gate units within their respective embedded frames, all gates will be checked for roller alignment, seal compression and guide clearances.

The operating equipment will be checked for correct positioning and alignment, and undergo full functional tests over the operation range of the particular gate, checking operating speeds and performance of the mechanical and electrical control systems.

Hoists shall be load tested, all in accordance with standard’s requirements, and all hoist and travel motions checked, including brakes, interlocks and safety devices.

All gates shall be dry tested before impounding of water to ensure that there is no clearance between seals and seal seats, all rollers are in contact with roller path, the clearance between guide rollers/ guide shoes and guide is within the prescribed limits and the gate travels smoothly in the groove up and down without excessive sway throughout the travel.

Wet test of all gates and associated equipment after impounding will include checking of seal efficiency and full operational test under maximum design water load.

3.6.6.3 Non destructive test

The fabricated gate, embedded parts, hoist components and other load carrying members shall be subjected to the Non destructive tests. General practice followed for NDT isshown in table 9.

Table 9: Non Destructive Test

S. No.	Item	Test	Percentage
1	Butt welds	Radiography	100%
2	All fillet welds in the gate beam, particle end plate and lifting point	Magnetic particle	100%
3	Other fillet welds	Magnetic particle	100%
4	Root runs of important load bearing joints.	Dye- penetrant	100%

3.6.6.3.1 Stress relieving

Welded plates thicker than 28 mm will be stress relieved. The procedure for stress relieving shall be as per ASME section VIII Division I/ IS: 2825.

3.7 Spare Parts for Intake Gates and Hoists

a) The mandatory spares for various intake gate and hoists shall be as under:

b) In addition to these mandatory spare parts the bidder may recommend additional spare parts for five years trouble free operation of the equipment and shall include itemized price list.

3.7.1 Spares for intake gates

1. Two complete sets of rubber seals along with stainless steel fasteners
2. One no. wheel assembly with bearing and pin etc complete.
3. One no. guide roller assembly with bushing & pin etc. complete.

Notes

1. All spare parts shall be interchangeable with and of the same material and workmanship as the original parts of the equipment furnished.

   Spare parts supplied shall be packed in such a manner as to be suitable for storage in the climate at the site for a period of 5 years and each part shall be clearly marked with its description and purpose on the outside of the packing.
2. Owner reserves the right to purchase any or all of the spare parts listed above or suggested by manufacturer.
3. Spare parts required for field trials and acceptance testing shall be provided by the manufacturer at no additional cost to the owner.

4.0 DRAFT TUBE GATES -TECHNICAL SPECIFICATIONS OF ABRICATION, ERECTION AND TESTING

4.1 Scope of Work

Same as given in para 3.1.

4.2 Design Considerations and Operation Requirements

The gates shall be designed in accordance with the provision of IS: 5620 (latest edition) in general and in accordance with theses specifications in particular. The gates and embedded parts shall be designed to withstand a head of water corresponding to max tail race water level with a dry draft tube for normal allowable stresses.

Earthquake effects shall also be considered and allowed in the design as per stipulation in accordance with IS: 1893. The design shall be checked for additional forces due to horizontal and vertical earthquake acceleration corresponding to zone IV with increased stresses. The maximum deflection of the gate shall be limited to 1/800 of the span (i.e. centre to centre of tracks)

The gates shall satisfy the following requirements:-

a) In closed position, the gate must be completely water tight with full water pressure, acting from tailrace side and the sealing must be reliable.
b) The gates shall be operated (raised or lowered) as a single unit.
c) The gate groove covers shall be designed for crowd load of 500kg/m².

4.3 Moveable Gantry Crane for Handling Draft Tube Gates

4.3.1 General

The gantry crane shall be used for handling the draft tube gates. The design of various components of the crane shall be done in accordance with the provisions of Indian standard specification IS: 3177 and IS: 807.

4.3.2 Characteristics

The moveable gantry crane will have the following characteristics:

i) Class of crane: Class II as per IS: 807 outdoor electrically operated with rope drum hoist.

ii) Rated capacity: as computed, considering that the draft tube gates shall be operated under balanced head condition created by filing-in-valve. Hoist capacity computed shall include dead weight of gate, dead weight of lifting beam and its attachments including rope etc. seal assembly friction due to initial interference etc. plus 20% reserve capacity.

iii) Centre to centre of track rails (gauge) : To be fixed by designer

iv) Minimum wheel base of crane : To be fixed by designer

v) Total length of rail track (crane level) : As per site requirement

vi) Operation speeds (Loaded)

a) Hoist 1 m per minute
b) Long travel 4 to 6 m per minute

vii) Hook travel Minimum lift of hook above deck floor will be as per site requirement

viii) Electrical Details:

a) Power supply : 3 phase, 50 cycles, 440 volts, AC power supply from plug points suitably spaced along with the crane runaway.

b) Controls : Controls in operator's cabin.

c) Drives:
   i) Hoist Drive: Slip ring motor, with electromagnetic brake and thruster type brake, with limit switches for extreme positions of hook and for filling-in-valves opening position of the top unit.
   ii) Long Travel: squirrel cage induction motors with electromagnetic brakes, connected to at least one driving wheel on each side of end carriage, through gearing and shafting having synchronized operation having limit switches for extreme position of travel and corresponding to centre of each span.

d) Interlocks: In addition to usual protective gear the following interlocks shall be provided:
   i) Suitable interlocks for preventing more than one drive to be in operation simultaneously.
   ii) Interlock in LT drives to prevent long travel unless the hook is in its highest position.

4.3.3 Lifting beam

4.3.3.1 General arrangement

The lifting beam shall be made from rolled structural steel I-beam/channel or fabricated from angle iron frames. The depth of lifting beam /frame should be sufficient to prevent bending of lifting beam in between the side guides. It shall have suitable spring loaded flanged guide shoes at both ends.

The automatic engaging and disengaging shall be ensured and that once the hooks are engaged, they do not get unlocked due to excessive vibration/lifting forces during lowering and raising operation etc.

It should be assembled in shop and its operation specially that of automatic engaging and disengaging hook shall be checked for its correct operation.

4.3.3.2 Design criteria

It shall be designed in accordance with IS: 13951 and shall cater to the following.

Double point lifting shall be envisaged in the design of lifting frame.

Counter weights or any suitable means like tag line etc. shall be provided for automatic grappling and ungrappling.

The hook shall be checked for automatic grappling and ungrappling and shall be suitably designed for the dead weight of draft tube gate with adequate margin of impact or hoist capacity whichever is more. The pin of hook shall be suitably designed for load for which hook is being designed.

The top pin of the lifting frame/beam shall be designed for hoist capacity with adequate margin of impact.

Two guide shoes on either side shall be provided for guiding the lifting frame into the slot and clearance of guide and guide shoes shall be kept the same as adopted in the draft tube gate.

Pilots shall be provided at the bottom of lifting frame to prevent rotation of draft tube gate during handling.

The lifting frame shall be checked for it's vertically and for satisfactory operation of grappling and ungrappling of its hook, and proper locking to withstand vibrations and tilting forces.

4.4 Spares

a) The mandatory spares for various gates and hoists shall be as under:

c) In addition to these mandatory spare parts the bidder may recommend additional spare parts for five years trouble free operation of the equipment and shall include itemized price list.

4.4.1 Draft tube gate

One complete set of rubber seals along with stainless steel fasteners.

One no. guide shoe assembly with bushing and pin etc. complete.

4.4.2 Moveable gantry crane

1. One set of limit switch assembly of each type
2. One set of wire ropes
3. One set of brakes, motor bushes and bearings
4. Two sets of fuses, relays, contacts, push buttons and indicating lamps. Each type comprises one piece of each type.

Notes

1. All spare parts shall be interchangeable with and of the same material and workmanship as the original parts of the equipment furnished.
2. Spare parts supplied shall be packed in such a manner as to be suitable for storage in the climate at the site for a period of 5 years and each part shall be clearly marked with its description and purpose on the outside of the packing.
3. Owner reserves the right to purchase any or all of the spare parts listed above or suggested by manufacturer.

4. Spare parts required for field trials and acceptance testing shall be provided by the manufacturer at no additional cost to the owner.

4.5 General Specifications and Technical Requirements

As per para 3.5.

4.6 Materials

As per para 3.6.

4.7 Technical Provisions

As per para 3.7.

5.0 BYE PASS GATES- TECHNICAL SPECIFICATIONS OF FABRICATION, ERECTION AND TESTING

5.1 Scope of Work

The broad scope of work shall include the following.

(i) Design, drawing, Manufacture, inspection, shop assembly, testing, painting.

(ii) Transportation and handling, site storage, site erection, painting, testing and commissioning including provision of labour, plant and material for the above.

(iii) Handing over to owner, supply of necessary spares for 5 years trouble free operation and supply and installation of all incidentals not specified but are necessary for proper completion and satisfactory functioning of the system.

(iv) Guarantee of the following permanent equipment, along with all auxiliary equipment in the designated location of the project as specified in the following sections of technical specifications / technical provisions.

5.1.1 Bye pass radial gates

(a) Required nos. float operated automatic type bye pass radial gates of size 7.300m wide x 4.400m (approx.) high.
(b) Required sets of 1st stage and 2nd stage embedded parts and anchors of radial gates.
(c) Required sets of rope drum hoists of adequate capacity along with support frames etc.

5.1.2 Bye pass stop logs

Required sets of groove liners and sill beam etc. for stop log gates.

5.1.3 Spares

Mandatory spare parts for gates and hoists as listed in these specifications.

Additional spares recommended by bidder for 5 years trouble free operation.

5.1.4 Tools

One or two sets (depending upon the remoteness and size of the power plant) of tools and equipment including special tools required for repair and maintenance.

5.1.5 Operation and maintenance manual

Two sets and one CD of operation and maintenance manual including as built drawings, all catalogues and brochures for bought out items.

Note:- Remote control system for operation of bye pass radial gates and hoists is not including in this package.

5.2 Radial Gates

The bye pass channel will have required no. automatic float operated radial gates of required size. The radial gates shall be of welded steel fabrication with cylindrical skin plate supported by stiffeners, main girders, arms and trunnion assembly designed to withstand and operate against the normal unbalanced upstream full reservoir level. Provision should also be made to approach various components of the gate through ladders for inspection and maintenance. The trunnion shall be equipped with self-lubricated bushings (lubrite or equivalent). The fabrication should be such that easy exchangeability of sealings is possible. The gates shall be provided with a minimum of two guide roller assembly on each side. The parallel arms of the radial gate shall be extended beyond the trunnion point. Counter weight comprising of fix and variable components shall be attached to the extended portion, which in turn is connected to the floats in the float well through a system of wire ropes and pulleys. One / two numbers of inter connected float well / wells shall be provided in the piers for each gate.

As a standby mode of operation, each gate shall be equipped with independent electricity operated rope drum hoist having facility for manual operation also.

5.2.1 Embedded parts

The radial gate embedded parts shall consist of steel sill beam and fabricated radial pier guide members with stainless steel faced sealing surfaces and roller support beams It shall also include, latching devices and the trunnion bearing foundation plates, trunnion anchor rods, etc. Embedded parts shall include anchor bolts, plate & nuts for all beams, roller paths, sealing faces, latching devices, etc.

The hoists shall be mounted on hoist support frame at the top of the diversion channel structure.

5.2.2 Particulars of bye pass radial gates

Particulars of bye pass Radial Gates for a typical SHP are shown in Table 10.

Table 10: Particulars of Automatic float Operated Radial Gates

No. of spans	As required
Full supply level	As per site design
Centre of trunnion assembly	As per design
Crest level	As per design
Sill level	As per design
Inside radius of skin plate	As per design
Operation	The gate shall be in fully closed position when the water level is at FSL or below. The gate shall start opening when the water level rises above FSL and shall be in partial / fully open position to pass the excess water. This shall automatically close down fully when FSL is maintained in the channel. As a standby mode of operation electrically operated rope drum hoist is also provided for controlled operations.
Type of arms	Parallel arms.
Type of side seals.	Music note (Rubber)
Type of bottom seal	Wedge type (Rubber)
Lowering /raising speed of hoists.	0.5 m/ minute.

5.2.3 Design considerations and operation requirements

The radial gate and embedded parts shall be designed in accordance with the provisions of IS: 4623 and IS: 11793 in general and in accordance with the provisions specified in these specifications in particular. The gate shall be designed for a total head of 4.400m (approx) against the normal allowable stresses.

Earthquake effects shall also be considered and allowed in the design as per stipulations in accordance with IS: 1893. The design shall be checked for additional forces due to horizontal and vertical earthquake acceleration corresponding to zone IV with increased stresses.

The float operated radial gate shall normally be in fully closed position to store water up to FSL or below. The gate shall start opening when the water level rises above FSL and shall be in fully open position when the water level is at sill level. In between these two elevations, the gate may be in intermediate position.

The gate is required to be operated under unbalanced head conditions against water level upto and above FSL. The gate when lowered against this head shall, therefore, be able to go down under its own weight (self closing). For meeting this requirement, the closing moment provided by the moving parts of gate in any position shall always be greater than the moment of forces opposing the closure of gate.

The gate shall satisfy the following requirements:

a) The float operation of the gate shall be pre-set to maintain the desired FSL in the channel automatically.

b) The gate when required to be operated by rope drum hoist shall be required to be operated (open or close) at a speed of 0.5m/ minute.
c) In closed position, the gate must be completely water tight with full pressure acting from upstream side and sealing must be reliable.
d) The gate and its components shall be so designed that the stresses in different members due to dynamic loads do not exceed the permissible stresses. The gate and its components shall also be designed for the effect of sill pressure (due to self weight and due to thermal variation), hoist load, bending moment in arms due to effect of temperature variation, friction between trunnion pin and bearing etc.
e) The gates shall be designed for the following loads:

   i) The fully hydrostatic load on u/s side of gate with water level at top gate level and gate closed.
   ii) The total hydrostatic, hydro-dynamic and frictional forces occurring when the gates are raised, lowered or maintained partially open with the upstream water level at any elevation between top gate level and crest level and wind load on the gates in raised position.
   iii) The dead weight of the gates.

5.3 Rope Drum Hoists for Radial Gates

5.3.1 Design criteria

The hoists shall be designed at a rated capacity capable to lift or close the gates under all eventualities for which the gate has been designed. The hoist capacity shall be calculated taking into consideration the worst combination of all frictional forces, hydrodynamic loads, dead weights etc. during both raising and lowering cycles, plus a reserve capacity of 20% over and above the worst combination of forces and various factors as enumerated in IS: 6938 shall be taken into consideration. While determining the hoist capacity, positive closure of gate with designed weight and seating pressure @ 1000 kg/m width of gate shall be ensured. The contractor shall submit detailed calculations in support of hoist capacity. The coefficient of friction used for working out hoist capacity shall not be less than those provided in the design criteria for gates or those specified in IS: 4623 unless otherwise specified in these specifications.

The mechanical parts of the hoist shall be designed for the specific loads with a factor of safety of five based on the ultimate strength of the materials. Under breakdown torque condition of the motor, stress in any portion of the hoist, bridge & trestles shall not exceed 80% of the yield point of the materials (or 33.33 % higher than normal stresses whichever is lower). The rope shall have a factor of safety of six for normal conditions and of 3 for breakdown torque condition. The hoist mechanism shall be covered by suitable cover frames to protect it form dust, dirt and direct exposure to moisture.

5.3.2 Hoisting arrangement and hoist capacity

The fixed hoist shall be electrically operated and shall consist of a drive unit and 2 hoist drum assembly units for each gate. The hoist shall be located on structural steel platform mounted over the steel trestles located at the top of deck. The hoist shall be of fixed type and electrically operated with provision for manual operation in case of power failure. The drive unit shall operate on 440V, 3 phase,50 cycles AC supply. Suitable gear reduction

unit shall be provided between drive unit and the rope drum assembly units. The rope drum assembly units and reduction units shall have minimum 3mm thick MS sheet covers with flat/angle non frame work. The rotary type of double acting limit switch shall be provided for automatically and positively stopping the drive motor during hoisting/lowering of the gate as soon as either end of the gate travel is reached. Each drive unit shall be capable of being actuated locally. Dial type position indicator showing the gate opening shall be provided.

The manual drive shall be capable of being operated by four operators each exerting continuous effort of 10kg with 400mm crank radius at a continuous rating of 20 revolutions/ minute. A manual electrical interlock shall be provided in control circuit to cut off power supply to motor, while operating manual drive. The hoisting speed of manual operation should be maximum attainable. Protective Device to automatically brake the hoist in case of power failure shall be provided. On resumption of power supply the hoist shall start operation by pressing either 'close' or 'open' push buttons. Provision shall be made for normal maintenance and repairs of hoist without disconnecting rope from hoist drum and with gate resting on sill (fully closed).

Suitable chequered plate with guard railing of one meter height and toe guards shall be provided on all sides of hoisting platform. Necessary staircase arrangements shall be provided for the approach to hoist bridge.

Each electrically operated, mechanical hoist shall generally consist of the following components:-

1. 6 x 37 construction wire rope of adequate capacity with rope attachments and overload protection.
2. Balancing sheaves with attachments.
3. Rope drums
4. Spur gears reductions (end reductions).
5. Shafts.
6. Flexible couplings (gear type or bush type)
7. Plummer blocks with bearings / bushes.
8. Worm reducers.
9. Motor
10. Electromagnetic brake
11. Gate position indicator.
12. Manual hoisting arrangement with clutch type engaging/disengaging arrangement.
13. Limit switches, electrical wiring and control panels.
14. Covers for rope drum and spur gear reducers.
15. Nuts, bolts and other accessories (Fasteners).
16. Any other mechanical or electrical component/attachment considered necessary for proper assembly and operation of the hoist.

5.4 Spare Parts

a) The mandatory spares for bye pass radial gates and rope drum hoists shall be as under.

d) In addition to these mandatory spare parts the bidder may recommend additional spare parts for five years trouble free operation of the equipment and shall include itemized price list.

5.4.1 Byepass radial gates

1. Two complete sets of rubber seals including stainless steel fasteners.
2. Two sets of self lubricating bush and washers for trunnion assembly.
3. One no guide roller assembly.

5.4.2 Rope drum hoists

1. One set of limit switch assembly of each type
2. One set of wire ropes
3. One set of brakes, motor bushes and bearings
4. Two sets of fuses, relays, contacts, push buttons and indicating lamps. Each type comprises one piece of each type.

Notes:

1. All spare parts shall be interchangeable with and of the same material and workmanship as the original parts of the equipment furnished.
2. Spare parts supplied shall be packed in such a manner as to be suitable for storage in the climate at the site for a period of 5 years and each part shall be clearly marked with its description and purpose on the outside of the packing.
3. Owner reserves the right to purchase any or all of the spare parts listed above or suggested by manufacturer.
4. Spare parts required for field trials and acceptance testing shall be provided by the manufacturer at no additional cost to the owner.

5.5 General Specifications and Technical Requirements

Same as given in para 3.5 above.

5.6 Materials

Same as given in para 3.6 above

5.7 Technical Provisions

Same as given in para 3.7 above

6.0 TRASH RACKS –TECHNICAL SPECIFICATION FOR FABRICATION AND ERECTION

6.1 Scope of Work

Same as given in clause 3.1 above.

6.2 Design Considerations and Operation Requirements

The trash rack shall be designed in accordance with the design criteria given in IS: 11388. The trash rack shall be designed to fail at 6 meter differential head.

Earthquake effect shall also be considered and allowed in the design in accordance with IS: 1893. The design shall be checked for additional forces due to horizontal and vertical

earthquake acceleration corresponding to relevant zone. An increase of 33.33 % over the normal allowable stresses may be allowed for the structural members and 25% for bolts and nuts etc. for earthquake condition. However, stresses in excess of 80% of yield stress shall not be allowed.

The trash racks shall normally remain in position, under water, to prevent entry of objectionable large debris into intake bays.

Trash racks shall be lowered and lifted only under balanced head conditions. The lifting operation shall be only for maintenance/painting requirements or for cleaning of racks in case of excessive chocking.

The vertical trash bars shall be spaced at 150 mm centre to centre and shall be supported by means of horizontal steel beams which transfer the load to the piers. At lintel and sill the trash bar frames shall rest against bearing plates provided in concrete and embedded with help of anchors. To reduce the unsupported length of trash bars suitable tie bars at interval shall be provided and shall be connected to end frame. The connection of these trash rack units to the embedded beams shall be through stainless steel bolts and nuts. The nuts shall be welded to the bearing plates and flange of beams and shall be encased by blinded pipe sleeves to prevent those from getting concreted. The trash racks for each unit shall have 2 lifting points equidistant from centre line at C.G. point. The trash rack bar section shall be rectangular with round up stream edges.

To ensure rigidity during handing, the lateral deflection of horizontal members due to dead load shall not exceed 1/300 of their span.

6.3 Spares

(i) Suitable nos. of trash racks (To be mutually decided by purchaser and bidder)
(ii) Two sets of required fasteners

In addition to these mandatory spare parts the bidder may recommend additional spare parts for five years trouble free operation of the equipment and shall include itemized price list.

Notes

1. All spare parts shall be interchangeable with and of the same material and workmanship as the original parts of the equipment furnished.
2. Spare parts supplied shall be packed in such a manner as to be suitable for storage in the climate at the site for a period of 5 years and each part shall be clearly marked with its description and purpose on the outside of the packing.
3. Owner reserves the right to purchase any or all of the spare parts listed above or suggested by manufacturer.
4. Spare parts required for field trials and acceptance testing shall be provided by the manufacturer at no additional cost to the owner.

6.4 General Specifications and Technical Requirements

Same as given in clause 3.5 above

6.5 Painting Systems

The following painting system adopted for trash racks at a typical SHP is as follows:

Perfect cleaning of all surfaces which are not to be covered with concrete shall be carried out by sand blasting to the requirements of SA 2 ½ of Swedish Standard.

Over the prepared surfaces one coat of in organic zinc silicon by spray (preferably airless spray) should be applied giving a dry film thickness of 70 to 75 microns.

The interval between surface preparation and painting shall be as short as practicable and in no case longer than 4 hours. Over the primer, two coats of solvent less coal tar epoxy paint shall be provided at an interval of about 24 hours. Each coat shall give a dry film thickness of 150 microns. The total dry film thickness of all the coats shall not be less than 350 microns.

Painting of Embedded Parts

All unfinished surfaces of embedded parts exposed to atmosphere or water shall be sand blasted to 2½ of Swedish standard and given one coat of inorganic zinc silicon primer by spray (preferably airless spray) giving a dry film thickness of 70+5 microns. Two coats of solvent less coal tar epoxy paint with a dry film thickness of at least 150 microns per coat shall then be applied by brush. The total dry film thickness of all the three coats shall not be less than 350 microns.

6.6 Materials

Same as given in clause 3.6 above.

6.7 Technical Provisions

Same as given in clause 3.7 above.

7.0 FABRICATION AND ERECTION OF PENSTOCK, AIRVENT PIPE AND FILLING PIPE

7.1 General

The scope of these specifications covers complete design, fabrication, supply, transportation to site, erection, testing and commissioning of steel penstock(s) air vent pipe and bye pass pipe of diameter, as specified, length as needed to complete the job and thickness not less than the calculated thickness as per design calculations including a reasonable allowance for corrosion, complete in all respects including shop and field painting.

All accessories listed hereunder besides pipes, reducers, bend make up pieces, steel test bulk heads, required for carrying out hydraulic pressure tests whether in shop or in the field, shall also be provided and installed by the Contractor.

i) Manholes with manhole covers
ii) Air vents
iii) Fill pipe and drainage pipe connections
iv) Expansion joints
v) Base Plates for Saddles including embedded parts, if any
vi) Flanged connections to match the turbine inlet valve
vii) Piezometric connections, if required

All these items shall be fabricated / supplied in accordance with the approved design and drawings and shall be of materials specified in the drawings.

The work of fabrication and erection of steel penstock(s), air vent pipe and bye pass pipe shall be carried out in accordance with the drawing(s) approved by the Engineer-in-Charge with additions, alternations and modifications made from time to time and also according to any other drawings that may be supplied to the Contractor, during the operation of the contract.

All operations except concreting are covered under these specifications.

7.2 Specifications

The item wise detailed specifications are intended for general description of quality, workmanship, etc. desired for the items covered in the schedule of items.

The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the spirit of the tender specifications. In the absence of specifications, the particular items of work shall be executed as per relevant IS codes.

7.3 Material Specifications

7.3.1 Steel penstocks

The penstock straight pieces, bends, air vent pipe and bye pass pipes shall be fabricated from ERW (electric resistance welded) or spiral welded steel pipes. Alternatively these could be manufactured from M.S. Plates conforming to IS: 2062 (Tested Quality) by cold rolling and welding. Reducer pieces shall in any case be manufactured from M.S. plates conforming to IS: 2062 (Tested Quality).

The materials and equipment used in the fabrication, manufacture and erection of penstocks, bye pass pipes and air vent pipes shall comply with the appropriate specifications of the Bureau of Indian Standards (formerly Indian Standard Institution).

7.3.2 GRP (Glass fiber Reinforced Polyester) penstocks

GRP is a new kind of composite materials used in the fields of water supply, drainage which can be buried or laid above ground. GRP pipes are getting popularity to be used as penstocks for small hydro power plants for following reasons:

(i) Long service life
   a) Corrosion resistant material.
   b) Low maintenance costs.
   c) Low Life Cycle Cost
   d) Less head loss
   e) Best hydraulic characteristic
   f) Low friction coefficient

(ii) Economical
   a) Competitive with other “traditionally” used materials
   b) Low installation cost, easy to assemble
   c) Low operating costs and long service life

d) GRP pipes are easily transported, low weight. (1/4 of DIP and 1/10 of concrete)
e) Environmental friendly, can be nested.

(iii) GRP pipes have unique feature for cold and hot climate.

a) The mechanical properties remain the same from +30 to -60.
b) It does not get brittle when it is cold.
c) The pipe can be installed above ground without any special UV protections.
d) GRP pipes can be easily installed on steep slopes, either buried or above ground.

7.3.3 HDPE (High Density Polyethylene) penstocks

HDPE based penstock straight pieces, bends, air vent pipe and bye pass pipes, jointing material etc are also used in SHP installation.

This type of penstock offer ease of installation and fewer joints as having following characteristics.

Long lengths (up to 100 meters)
UV resistant
Several jointing methods
High abrasive resistance
Low mass
Smooth bore
Corrosion resistance
Compatibility with other materials
Low temperature toughness

Material should be High Density Poly Ethylene conforming to ASTM D3035and ASTM D3350.

7.3.4 Ductile iron penstocks

Centrifugally Casted (spun) DI based penstock straight pieces, bends, air vent pipe and bye pass pipes and jointing material etc are also used.

The materials and equipment used in the fabrication, manufacture and erection of penstocks, bye pass pipes and air vent pipes shall comply with latest revision of IS:8329-2000, IS: 9523-2000 and IS: 12288-1987.

7.4 Permissible Stresses

Stresses in the material used for fabrication shall be limited to permissible stresses shown in Table 11:

Table 11: Permissible Stresses

S. No.	Type	Permissible stress
1	Direct compression/tension	0.45 of yield point stress
2	Tension in bending	0.45 of yield point stress
3	Shear Stress	0.35 of yield point stress
4	Bearing Stress(in steel)	0.35 of yield point stress
5	Bearing Stress (in concrete)	392 N/m^2 (40 kg/ m^2)

Source: IS: 5620-1985 Appendix B (clause 6.1.1.2)

7.5 Design

The design and plate thickness of various pipes, bends, reducers etc. shown in the specification drawings and tentative. The Contractor shall check the design and work out plate thickness based on latest/guidelines/code of practice issued by Bureau of Indian Standards and modify the design of the entire installation covered under these specifications. The maximum permissible design stresses shall be as mentioned in para 7.6.

7.6 Test Certificate

Manufacturer's test certificates in respect of all materials used in the manufacture/fabrication/erection of penstocks, shall be submitted by the Contractor before using such materials.

7.7 Layout

The setting out for all structures etc. shall be done by the Contractor, from the general grid of the plot and benchmarks given by the Engineer-in-Charge. He shall give all help with instruments, materials and men to the Engineer-in-Charge for checking the layout and levels. The Contractor is solely responsible for correctness of laying of the penstock(s).

Making benchmarks pillars and reference line pillars etc. and maintaining them till the completion of the work shall be the responsibility of the Contractor. No extra payment shall be made for such services.

The respective contractor shall complete all preliminary work at site well before the arrival of the fabricated/manufactured pipes, such as, keeping in readiness winches, mobile crane, jig poles, all tolls and tackles, welding sets etc. as part of the contractor and any other work that may be necessary to start erection immediately after the fabrication.

The Contractor shall arrange for adequate number of erection equipment, supervision, labour and other arrangement so as to carryout the work effectively and in the specified time schedule.

7.8 Drawings to be furnished by the Contractor

The Contractor shall prepare all necessary shop drawings noted below, covering the details of the fabrication of material, to be furnished under these specifications, and shall be responsible for the correct fitting of all the parts.

a. Assembly drawings giving exact sizes of sections and identification marks of various sections,
b. Dimensional drawings of bends reducer sections, manholes, closing sections, test bulk heads etc.
c. Complete bill of materials and details drawings of all sections and also their billing weights,
d. Any other drawings or calculation that may be required for checking the correctness of design and/or fabrication details.

Before fabrication is undertaken, the Contractor shall submit prints of all shop drawings covering all details of manufacture/fabrication to the Engineer-in-Charge for approval. The Engineer-in-Charge shall have the right to ask the Contractor to make any change in the Contractor's drawings, which may be necessary in his opinion, to make the furnished construction conforming to the requirements of the specifications.

7.9 Deviations from Specification

For deviation of any item of work, for any valid reason, the Contractor shall submit the proposed deviations explaining the reasons for the same for the approval of the Engineer-in-Charge, before making any change.

7.10 Fabrication

(i) Preparation

The fabrication of steel penstock, bye pass pipe and air vent pipes, shall be in accordance with these specifications and requirements of IS: 2825. Where the requirements of this code are in conflict with the requirements of these specifications, the more stringent conditions out of the two shall govern.

Each pipe section shall be made with the minimum number of welds, as the length of size of plates might permit. Normally longitudinal joints shall be located at quarter points and staggered between adjoining sections. Longitudinal joints shall not intersect manholes or other outlets, if any. In the case of bends, the longitudinal joints shall be staggered 45° to the plane of bend. The normal length of each section shall be three to five meters. The Contractor shall ensure that each shop fabricated section can be transported to site conveniently and economically and it can be handled for erection safely.

(ii) Cutting of Plates

Plates to be welded shall be cut accurately to size and shapes either by gas or machine shearing. Cold shearing may be resorted to, provide that the sheared edge is cut back by machining or chipping for a distance of one quarter of the plate thickness but in no case less than 3 mm.

(iii) Preparation of Plate Edges

All edges shall show sound metal, free from laminations, surface cracks and other defects. Any material damaged in the process of cutting plates to size or forming grooves shall be removed by machining, grinding or chipping. Flame cut edge shall be uniform and smooth and shall be free from loose scale, slag accumulations, notches and burnt metal.

The ends of the pipe sections shall be normal to the axis of the pipe within a tolerance of 2 mm on the radius. The edges of the plates of each section shall be properly prepared for field welding.

All plates shall be bent or rolled cold to true circular section, with the curvature continuous form the edges of the plates. Correction of curvature by blows will not be permitted. Particular care shall be taken in matching the edges of adjoining plates and

sections to ensure that the inner surfaces of the pipe section are in section are in continuity within a maximum allowable off set, at any point, of 2 mm. Allowance shall be made for shrinkage due to welding the circumferential joints and care shall be taken to maintain within close tolerance the lengths selected for field assembly so that when the pipes are completely assembled and erected, the overall length will be as shown on the drawings. Ends of adjoining sections to be field welded together shall fit properly and shall not vary in the inside circumference by more than 10 mm.

Ends of adjoining sections, where necessary, shall be machined before welding to make the faces in true plane normal to the axis of the pipe.

(iv) Alignment and Tolerances

The shell sections of the complete penstock(s) bye pass pipes, air vent pipe shall be circular within the limits specified. Measurements for this purpose shall be made at the surface of the parent metal and not at the weld, fitting or other raised parts. There shall be no flares or peaks at welded seems and any local departure from circularity shall be gradual.

The difference between the maximum and the minimum diameter at any cross-section of shell welded longitudinally shall not exceed 1% of the nominal internal diameter with a maximum of DI + 1250/200, where DI, is the internal diameter in mm.

Before any welding is commenced, it shall be ensured that the prepared edges are in alignment to meet the requirements of the welding process and defects in alignment at the surface plates are not more than;

(a) 10% of the nominal plate thickness with the maximum of 3 mm for longitudinal joints,
(b) 10% of the maximum nominal plate thickness plus 1 mm with a maximum of 4 mm for circumferential joints.

(v) Flanges, Bolts etc.

All flanges, including bolts, gaskets, piezometer connections and plugs as may be required shall be installed on the steel liner sections as shown on the drawings or as directed by the Engineer-in-Charge.

Bolts, nuts and studs shall be made out of steel conforming to IS: 1363, IS:1364 and IS: 1862. Gasket material shall conform to IS: 638.

Flange required to make the Turbine Inlet Valve shall either be procured from the Turbine Inlet Valve manufacturer or shall be manufactured as per the design and requirement of the Turbine Inlet Valve manufacturer. This shall also apply to bolts, nuts, gasket etc.

(vi) Bends and Fittings

All bends and reducers shall be made of short segments of pipe with mitred ends. The bends shall be made with equal deflection angles except for the end ones, which shall be half of the deflection of other sections. The number of section shall be as shown in the drawings.

(vii) Expansion Joints

Expansion joints wherever provided for the penstock shall be furnished as per approved design and drawings with bolts, studs, nuts, packing etc. The sleeves of the expansion joints shall be formed accurately to the required dimensions in order o provide close fitting stuffing boxes for the packing and to ensure water tight joints. While the inner surface f the outer sleeve of the expansion joints shall be machined, the outer surface of the inner sleeve, shall either be given a nickel cladding or machined smooth and metallised with stainless steel (for a distance of 150 mm on either side of packing) to prevent corrosion and facilitate smooth movement of packings. The longitudinal welds on outside of the inner sleeve and inside of the outer sleeve shall be ground flush. The packing material shall consist of long fiber, braided flax or rubber rings impregnated with suitable lubricant. The size of the rings shall vary from 12.5 mm to 32 mm (1/2" to 1 %") square and the number of rings to be provided shall vary from 3 to 10 depending on the size of the joints and the internal pressure of the pipe.

All the parts shall be carefully fabricated with close tolerance between the sliding surfaces and an allowance of 3 mm on the dimensions.

(viii) Anchor Blocks & Saddles

All the embedded metal other than reinforcement steel required to be embedded in anchor blocks and saddles shall be furnished under these specifications. Such material shall be furnished well in advance to match the concreting schedules.

7.11 Welding

(i) General

Surfaces to be welded shall be clean and free from mill scale, rush, paint or any other foreign matter. All welding will be performed by electric arc method using a process which will exclude the atmosphere from the molten metal and where practicable automatic welding equipment shall be used. All welding shall be done in accordance with the requirements of fabrications and specification as specified in the relevant IS codes. All welding electrodes required for the fabrication and installation of the penstock(s) and accessories covered under these specifications shall be furnished by the Contractor. Where weld is deposited in successive layers such layers shall be cleaned of all slag and other deposits before the next layer is deposited. Tack weld joints shall be chipped or flame gouged to sound metal before depositing weld metals to the back sides of the joints. Defects in welds shall be chipped or flame gouged until sound metal is reached on all sides and the resulting cavity shall be rewelded. The welding of temporary attachments to the penstock sections for the purpose of the handling or aligning of sections shall be limited to essential requirements subject to the approval of the Engineer-in-Charge. All such attachments shall be removed by careful chipping and flame cutting and any damage to sections shall be repaired by welding, if required. All longitudinal and circumferential welds in the pie shells and for the ends of stiffener rings shall be of double welds butt joint or single weld butt joint. The root of the welds shall be chipped to clean sound metal and the weld shall then be deposited to obtain full penetration. After the welding is completed, all weld spatter shall be removed by grinding. All welding shall be performed under cover and penstock sections to be welded shall be protected from excessive cold and humidity. All welds which fail to pass the

specified test(s) shall be repaired. Defects in the welds cavities shall be filled in the same manner as the original grooves were filled after gouging.

(ii) Welding Procedure

The welding procedure to be followed shall conform to IS: 4353

(iii) Qualification of Welders

All welders assigned to manual welding shall have successfully passed the test conducted by the Contractor as prescribed for welder qualification as per IS: 817.

7.12 Unit and Match Marking

Each part of the steel penstock and its auxiliary parts bye pass pipe, air vent pipe shall be legibly marked to show the unit of which it is a part and match to show its relative position in the finished structure to facilitate assembly in the field. Each section shall be marked to show top vertical diameter and the direction of flow.

The Contractor shall prepare marking drawings of the penstock assembly indicating clearly the location of each section and appurtenant part in the completed structure and shall furnish the Engineer-in-Charge with such drawings.

7.13 Dispatch and Transport

The contract shall include and provide for securely protecting and packing the material so as to avoid damage in transit and the Contractor shall be responsible for all losses or damage caused by or occasioned by any defect in packing and the Engineer-in-Charge will take no responsibility on this account.

Each pipe, sub-assembly or package dispatched separately shall have its identifications mark distinctly embossed or painted on its container and shall be labeled or tagged with description label mentioning the specification/part number, and the mark number of piece or the number of the parts grouped in such assemblies or contained in the package. Each sub-assembly or package shall be prepared so that slings for handling may be attached whenever required.

Where it is unsafe to attach slings to the box, the boxed parts shall be packed with slings attached to the parts and the slings shall project through the box so that the attachment can be made readily. All exposed finished surfaces shall be adequately protected against abrasion during transport and all long and slender piece shall be adequately supported and blocked.

All transport and handling from the Contractor's works to the site-store and from the site-store to work-site shall be done by the Contractor without any extra charge.

Before dispatch, the Contractor shall determine the net weight of each piece or assembly that is to be dispatched as a unit and finished weight, exclusive of boxes, crates or skids shall be furnished to the Engineer-in-Charge and shall be painted on the respective pieces, or assemblies or stated on tags attached thereto.

7.14 Tests during Fabrication and Erection

The Contractor shall carry out the tests specified below and submit the test reports in triplicate to the Engineer-in-Charge.

(i) Welds Tests in Shop

All longitudinal shop welds shall be subjected to dye penetration test as per IS3658 and magnetic particle test as per IS 5334 the following tests to ensure their soundness:

These tests will not be required in case tested spiral welded pipes or ERW pipes have been used by the Contractor.

All circumferential welds made in the shop irrespective of the fact whether penstocks are manufactured out of MS Plates or from spiral welded pipes or ERW pipes shall be subjected to one of the two above mentioned tests.

(ii) Weld Test in Field

(a) Radiography Examination

For quality assurance of the welding work in the field, the welded joints shall be subjected to inspection and non-destructive testing as specified below:

While all the longitudinal joints shall be radiographed for full length, the circumferential field joints shall be spot radiographed for 10% of their length. In addition, 100 mm of field circumferential joints on either side of the longitudinal joints shall also be tested radiographically as per IS: 2825, IS: 2595, IS: 1182 and IS: 4853.

(iii) Hydraulic Pressure Test in Shop

Each shop assembled penstock straight pipe section, each bend and each reducer shall be tested in the shop (manufacturer's premises) under hydrostatic pressure equal to 1.25 times the design pressure. The design pressure for the hydraulic test shall not exceed the pressure computed with the standard formula.

Each pipe shall be completely filled with water and the pressure shall be slowly and uniformly increased until the required test pressure is reached. The test pressure shall be applied and released three times successively and after each application shall be steady, for at least 15 minutes or till such time all the welded joints and plate can be examined for defects, leaks etc. Any, defects in welds or plates disclosed by the hydro-static test shall be repaired by the Contractor to the satisfaction of the Engineer-in-Charge and all repaired sections shall be retested hydrostatically.

(iv) Leakage Test at Site

This test will be carried out by filling the completely erected penstock with water from RCC barrel end with the bulk head placed at the power house end of the penstock. All field/shop joints and the expansion joints shall be thoroughly checked for leakage, expansion joint gland packing shall be tightened within the permissible limits, and suitable remedial

measures to stop leakage, if any, will be taken by the Contractor to the entire satisfaction of the Engineer-in-Charge.

(v) Thermal Stress Relieving

All specials like the penstock pipe with manholes, bends, expansion joints (ring girders, fabricated rocker support etc.) shall be stress relieved. The stress relieving shall be carried out after all welded connections have been attached to the penstock. Such stress relieving shall be done, before the hydrostatic test but after repairs of welding. When welding repairs have been done to a part which has been earlier hear treated, the same shall be heat treated again. Unless such rectification are of very minor nature. The stress relieving shall be carried out in accordance with IS code for unfired

7.15 Inspection during Manufacture and Erection

(i) General

The Engineer-in-charge and his duly authorized representative shall have, at all reasonable times, access to the contractor's premises or works/shops and shall have the power to inspect and examine the materials and workmanship of the manufactured parts during their manufacture and /or erection.

The Engineer-in-charge shall on giving seven days notice, in writing, to the contractor, setting out any grounds of the objection, which he any have in respect of the work, be at liberty to reject all or any materials, plants or workmanship, which is in his opinion is defective for any reason whatsoever, provided that if such notice be not sent to the contractor within a reasonable item after the grounds upon which such notice is based shall come to the knowledge of the Engineer-in-charge, he shall not be entitled to reject the said materials, plant or workmanship on such grounds.

Unless specifically provided otherwise, all tests shall be made to the contractor's works before shipment.

The contractor shall give the Engineer-in-charge notice of any material being ready for testing and the engineer-in-charge or his authorized representative shall, on giving twenty four hours prior notice in writing to the contractor, attend at the contractor's premises or works within fifteen days of the date on which the material is notified as being ready, failing which, the contractor may proceed with the tests, which shall be deemed to have been made in the presence of the Engineer-in-charge and duly certified copies of such tests in triplicate, shall be furnished to the Engineer-in-charge.

(ii) Test at Contractor's Premises

In all cases where the contractor provides for tests whether at the premises of the contractor or sub-contractor or work site, the contractor except where otherwise specified, shall provide free of charge, such labour, material, electricity fuel, water, storage facilities, apparatus and instruments, as may reasonably be manufactured parts/equipment in accordance with the contract. He shall also provide facilities to the Engineer-in-charge or to his authorised representative to accomplish such testing.

When the tests have satisfactorily completed at the contractor's premises or works the Engineer-in-charge shall issue a certificate to that effect.

7.16 General Details of Erection

The steel penstock(s) bye pass pipe and air vents pipe shall be assembled and installed in place accurately to line and grade subject to following deviations:

a. Alignment - not more than 6 mm in 30 m length
b. Grade - not more than 6 mm in 30 m length

and embedded in concrete or covered with backfill or held securely by means of steel straps over the anchor blocks as shown on the drawings or as diffracted by the engineer-I-charge. Bends for the penstock (s) shall be erected first and concrete anchors along with holding done bolts and straps shall be constructed and properly cured before installing the penstock sections between the anchors. Installation of the straight lengths shall then be started from the anchors. When assembled & ready for welding, the distance between the ends of adjoining sections which are to be connected together by circumferential weld shall not be greater than 6 mm and not less than 3 mm unless otherwise directed. Care shall be exercised to avoid excessive lengths, growth or shrinkage, in pipe lengths. The contractor shall furnish and install such permanent structures, temporary supports, including holding down straps and internal bracing's as may be required to support the penstock securely in place and prevent distortion during erection, welding and placing of covering material without any additional cost. However, the embedment of timber supports will not be permitted. After the penstock(s) bye pass pipe and air vide pipe have been erected and embedded or held securely in position by straps or anchor block, the contractor shall remove all internal bracings, debris and foreign matter from inside of the penstock.

Before erection is started the contractor shall supply a complete set of erection schedule and erection drawings to the Engineer-in-charge for approval.

7.17 Painting

(i) General

The penstock steel liner bye pass pipe air vide pipe shall be cleaned and painted as per provisions of IS:1477-1971 hereinafter specified. The contractor, shall furnish, prepare and supply all materials for cleaning, painting and coating of the penstock and its accessories and other pipes. Machined surfaces, screw threads rust preventive compound and if painting is require d shall be cleaned and painted in accordance with the painting schedule. Cleaning, painting or coating shall be performed prior to during or after installation of the penstocks(s) and other pipes subject to the approval of the engineer-in-Charge.

(ii) Painting schedule

Surface preparation, cleaning and painting shall be done in accordance with the schedule given in Table 12 below which is a general practice on hydropower stations:

Table 12: Painting Schedule for Steel Penstock

S. No.	Item	Method of surface preparation	Paints of coating material	No. of coats
1.	Exterior surface that will be encased in concrete	A	No painting or coating	-
2.	Machined surfaces that will be in rolling or sliding contact and that will not be lubricated.	A	Gasoline soluble rust preventive compound	
3.	Exterior surface that	B	i) Red lead priming paint-type IV ii) Phenolic resin aluminum paint	2
4.	Exterior surface that will be covered with backfill	B	Relevant American water works association specifications	-
5.	All ferrous surfaces or joints	B	Coal tar epoxy	3

(iii) Preparation of Surfaces for Painting

Surface preparation shall be in accordance with any one of the under mentioned two methods. Weld spatters; burrs of any other objectionable surface irregularities shall be completely removed or repaired by any suitable means before cleaning. Any grit or dust remaining from the cleaning operation shall be completely removed from the surfaces by brushing, air blowing, suction or other effective means. Should the surfaces become otherwise contaminated in the interval between cleaning and painting, recleaning will be required.

Method A - All oil, grease and dirt shall be removed from the surface by the use of clean mineral spirits, xylol or white gasoline and clean wiping material.

Method B - All oil, grease and dirt shall be removed from the surface by use of clean minerals spirits, xylol or white gasoline and clean wiping materials, except for surfaces, which require epoxy coatings, the cleaning solvent shall be xylol. Following the solvent cleaning, the surface to be painted shall be cleaned of all rust, mill scale and other tightly adhering objectionable substance by sand blasting or grit blasting, to base metal.

(iv) Application Procedure of Paints

Red lead priming paint shall be applied in one or more coats as herein specified. One coat of primer, except that an additional brush coat of primer shall be applied without dining over all the nuts, welds, bolts etc. Thinning shall be allowed, if necessary, to improve application properties and if permitted, shall be with mineral spirits not exceeding 1 litre of thinner per 8 litres of paint. -The coverage shall be 9 sq.m. per litre.

Rust preventing compound shall be applied by any convenient method which will ensure coverage of the surface with a heavy uniform coating.

(v) Repair and Protection of Coatings

Metal work that has been shop painted or field painted shall be handled with care so as to preserve the coating in the best possible condition. Before proceeding, Contractor shall clean and repair all areas of shop coat which are defective and damaged. Areas that are loose, weakly bounded, blistered, abraded, rusted or otherwise defective shall be removed to clean metal by scrapping, chipping, wire brushing or other effective means.

Areas thus prepare shall be cleaned of all dust, dirt and other contaminations using clean rags and clean solvent. These surfaces shall then be repainted hi accordance with the painting schedule. Hairline cracks or thin areas of coal tar epoxy which are otherwise undamaged shall be cleaned of all dust, dirt, or other contaminations and shall be recoated with additional coal tar paint/epoxy will be required to pass acceptance tests performed by the Engineer-in-Charge. The cleaning and painting of damaged areas shall be at the "Contractor's expense.

7.18 Completion and Acceptance of Works

(i) Final Acceptance

The final acceptance of the penstock(s) will be given only after the successful completion of field hydrostatic tests for leakage (leakage test) as specified earlier. This final acceptance will not in any way absolve the Contractor of his responsibility for any damage that may occur to penstock(s) within one year of its commissioning.

(ii) Taking Over

When all performance tests called for by these specifications have been successfully carried out, the plant shall be accepted and taken over. After it has been satisfactorily put into operation at site or within one month of its being ready to put into operation, whichever maybe earlier, the Engineer-in-Charge shall forthwith issue a taking over certificate.

In the event of final or any outstanding tests being held over until the plant is erected, such taking over certificate shall be issued subject to the results of such final or outstanding tests which shall be carried out in accordance with clause "Testing at site'.

When the specifications call for tests 'at site' the plant shall be taken over and the taking over certificate issued immediately after such tests have been satisfactorily carried out.

If for any reason, other than the default of the Contractor, prescribed test 'at site' cannot be carried out within one month of the notice by the Contractor to the Engineer-in-Charge the plant being ready for tests, the plant shall be deemed to have been taken over on the last day of such period and payment due to the Contractor on taking over shall be made, but the Contractor shall, if called upon to do so by the Engineer-in-Charge at the Engineer-in-Charge's expense carry out the said tests during maintenance period and accept the obligations as specified in clause - 'testing at site'.

The Engineer-in-Charge shall not delay the issue any taking over certificate contemplated by this clause on account of minor defects in the plant which do not materially

affect the commercial use thereof. It shall, however, be obligatory on the part of the Contractor to rectify such defects.

(iii) Rejection of Defective Penstock Pipe, Bye pass Pipe and Air Vent Pipe

If the completed penstock pipe bye pass pipe, air vent pipe or any portion thereof, before it is taken over, be defective, or fails to fulfill the requirements of the contract, the Engineer-in-Charge shall give the Contractor notice setting forth particulars of such defects or failures and the Contractor shall forthwith make the defective plant good or alter the same to make it comply with the requirements of the specifications/contract.

7.19 Unit Rates

The unit rate quoted and accepted shall be considered to include all costs i.e. cost of materials, fabrication, plant and equipment tools, labour, loading, unloading, handling, transport, all shop tests including hydraulic pressure tests in the Contractor's works/shop, cleaning, painting, cement wash, erection, hydraulic and other tests at site etc. complete as required for all the operations specified in addition to those specifically so provided or otherwise so specifically directed for any particular element of work.

Where materials are indicated or required by these specifications but are not defined herein by detailed specifications, the Contractor shall furnish high-class commercial grades of materials satisfactory to the Engineer-in-Charge.